Praise & Summary

The Chittagong Hill Tracts is not merely a medical geography. It is one of the world's most biologically diverse, culturally rich, historically complex, and humanly beautiful territories, and its people are among the most resilient, most knowledge-deep, and most deserving of the full realization of their potential for health and flourishing. This textbook has been written in the conviction that medicine, practiced with rigorous science, philosophical depth, ethical commitment, and human solidarity, can make a real and lasting difference in the health of the people of this extraordinary place. Whether it does so depends on the choices made by the students and professionals who have read it. **The covenant is offered. The decision is yours.**

S M Nazmuz Sakib is an interdisciplinary scholar, researcher and author bridging IT, business analytics, and applied research. He is a Fellow of the Scholars Academic and Scientific Society, a Member of IAENG, a lifetime member of BELTA, and a Bangladeshi Arena Grand Master (AGM) recognized by FIDE. His credentials include extensive certifications across AWS, Google/SAS analytics, UX, project management, digital marketing, and finance. Sakib has published several peer-reviewed articles and book chapters with Springer Nature, CRC Press/Taylor & Francis, and IGI Global on various topics.

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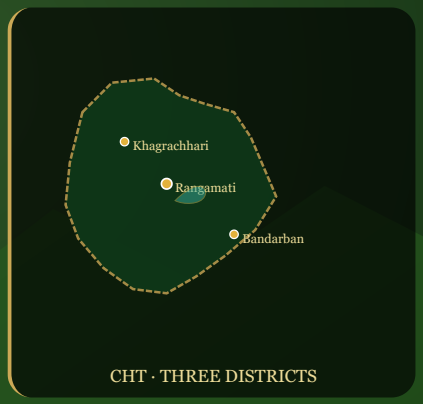
GEOMEDICINE OF THE CHITTAGONG HILL TRACTS · SAKIB

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GEOMEDICINE OF THE CHITTAGONG HILL TRACTS

Landscape, Disease & Healing at the Southeast Asian Frontier

by S M Nazmuz Sakib



Geomedicine of the Chittagong Hill Tracts: Landscape, Disease and Healing at the Southeast Asian Frontier

by

S M Nazmuz Sakib

Edited and Compiled for Medical, Public Health, and Allied Health Sciences Students

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S M Nazmuz Sakib

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This textbook is dedicated to the children of Kurukpata and to every child in every valley and ridge of the Chittagong Hill Tracts who has waited too long for a health system that would reach them.

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Foreword to Part One

This textbook emerges at a time of profound urgency. In April and May of 2025, the world watched as more than 220 children perished from measles in Bangladesh, with the most devastating concentration of deaths occurring in the remote Kurukpata Union of Alikadam upazila, deep within the Chittagong Hill Tracts. The children of the Mro community, who had remained outside routine immunization coverage for generations, bore the burden of a structural failure that is centuries old. This textbook is a response to that silence. It is written for the clinician who will one day work in Rangamati, for the public health officer who will plan campaigns in Bandarban, for the epidemiologist who will model disease burden in Khagrachhari, and for every student who understands that medicine is not merely the study of the body but the study of the body within its landscape, its history, its politics, and its philosophy. The Chittagong Hill Tracts represents one of the most complex and consequential medical geographies in South Asia, and it has been studied far less than it deserves. This work is an attempt to begin a sustained and rigorous academic conversation about the health of the hill peoples of Bangladesh, a conversation grounded in the best available science, in respect for indigenous knowledge systems, and in a commitment to justice.

PART ONE: FOUNDATIONS, HISTORICAL IDENTITY, AND GEOMEDICINAL ECOLOGY OF THE CHITTAGONG HILL TRACTS

CHAPTER ONE: THE GEOGRAPHIC, DEMOGRAPHIC, AND GEOMEDICINAL IDENTITY OF THE CHITTAGONG HILL TRACTS

1.1 Defining the Medical Geography of the Chittagong Hill Tracts

The Chittagong Hill Tracts, referred to throughout this textbook as the CHT, is a bio-geopolitical territory occupying the southeastern corner of the People's Republic of Bangladesh, bounded to the east by Myanmar and India, to the south by Myanmar, and to the west and north by the plains of greater Chittagong and Sylhet. The CHT is not a uniform geographic entity. It is a cascade of ridges, river valleys, forest belts, and highland plateaus that span approximately 13,295 square kilometers, representing roughly ten percent of the total land area of Bangladesh. Its three administrative districts are Rangamati, the largest district in Bangladesh by area; Bandarban, the most physiographically diverse; and Khagrachhari, the most northerly and in many respects the most ecologically transitional. Elevation ranges from near sea level at the river mouths to over nine hundred meters at the summit of Keokradong in Bandarban, making the CHT the only truly montane territory within Bangladesh proper. The geomedicinal significance of this landscape is enormous. The concept of geomedicine, understood here as the systematic study of how the spatial properties of land, water, air, altitude, soil chemistry, and ecological composition shape the distribution, character, severity, and treatability of disease in human populations, is nowhere more richly illustrated than in the CHT. The hill territory creates a fundamentally different

disease ecology from the coastal and deltaic plains of Bangladesh. Malarial vectors behave differently at altitude. Water sources are chemically distinct from those of the Bengal delta. The nutritional landscape changes with the season and the slope. Vector breeding patterns respond to forest density, river velocity, and the presence of jhum fields. The interaction between the built environment, the natural environment, and the human body produces a unique constellation of morbidity and mortality that demands its own epistemological framework and its own clinical protocols. This chapter lays that foundation.

The concept of a geomedicinal identity, as developed and applied in this textbook, refers to the aggregate of all spatially determined biological, ecological, and anthropological forces that condition the health trajectory of a population across generations, shaping not only the diseases that prevail in a given territory but the biological responses, immune profiles, nutritional baselines, stress physiology, and behavioral health patterns of the people who live within it. The CHT's geomedicinal identity has been shaped by its geology (primarily Miocene-Pliocene sedimentary formations with abundant tertiary sandstone and shale), its hydrology (including the Karnaphuli, Sangu, Matamuhuri, and Feni river systems and the vast Kaptai Lake reservoir), its ecology (which spans tropical monsoon forest, semi-evergreen hill forest, and grassland savanna at higher elevations), and its centuries-long patterns of human habitation, agricultural practice, and migration. Each of these factors exerts a measurable and clinically significant influence on the disease burden experienced by the CHT's resident populations. Understanding the CHT not merely as a political or administrative unit but as a geomedicinal territory is the foundational intellectual commitment of this textbook.

1.2 Population, Ethnicity, and Demographic Structure

The CHT is inhabited by an estimated 1.8 million people, of whom approximately 52 percent belong to indigenous ethnic communities collectively referred to in Bengali as Pahari (hill people) and in international discourse as indigenous peoples or Jumma peoples, the latter term deriving from the word "jum" or "jhum," referring to the rotational slash-and-burn agriculture that historically defined the livelihood of most CHT communities. The remaining population consists largely of Bengali settlers who migrated to the CHT in significant numbers following a government resettlement program initiated in the 1970s and 1980s, and to a lesser extent earlier. Eleven distinct indigenous ethnic communities are formally recognized as resident in the CHT: the Chakma, the Marma, the Tripura (also called Tipra), the Tanchangya, the Bawm, the Pangkhua (or Pankho), the Chak, the Khumi, the Lushai (also called Mizo or Lusi), the Khyang, and the Mro (or Murong). Each of these communities has distinct linguistic, cultural, dietary, agricultural, and health-seeking behavioral profiles, and each represents a different level of integration with the national health system. The Chakma are the largest single ethnic community in the CHT, constituting approximately half of the indigenous population, and they are the most researched group in the medical literature. The Marma are the second largest group and are predominantly settled in Bandarban and parts of Rangamati. The Mro, who gained tragic international visibility during the 2025 measles crisis, are among the most geographically isolated and economically marginalized communities in the entire CHT, living primarily in the deep valleys of Alikadam upazila in southern Bandarban. Understanding the demographic diversity of the CHT is a clinical prerequisite of the highest order. It is not possible to practice

effective medicine in this territory without understanding that the same disease may present differently, progress differently, respond to treatment differently, and be interpreted and narrated differently by patients from different ethnic backgrounds. The physician who treats a Chakma child for malaria in Rangamati is working in a different cultural and linguistic context from the one who treats a Mro child for the same illness in Alikadam, even though the parasitology may be identical.

The age-demographic structure of the CHT population presents several features of public health significance. The indigenous communities of the CHT have a relatively young age structure, with a high proportion of children under fifteen years, which increases the population's vulnerability to vaccine-preventable diseases, protein-energy malnutrition, acute respiratory infections, and waterborne diarrheal illnesses. Fertility rates among CHT indigenous communities are higher than the national average in Bangladesh, though they have been declining steadily since the late 1990s. Maternal age at first birth is relatively low in several communities, particularly among those with lower levels of female education and limited access to family planning services. The elderly population (sixty years and above) faces a specific set of challenges related to healthcare access that are distinct from those faced by younger cohorts. A qualitative study conducted in three districts of the CHT and published in the peer-reviewed literature documented that elderly indigenous individuals cited lack of knowledge about healthcare needs, geographical barriers, poor financial conditions, higher cost of medical services, scarcity of nearby hospitals, and communication barriers as the primary determinants of their inadequate access to healthcare services. These findings are not merely sociological observations. They represent clinical risk factors. An elderly person who cannot access timely medical care for early-stage cardiovascular disease, respiratory illness, or diabetes will present later, with more advanced disease, and will require more complex, more expensive, and less effective treatment. The delay-to-care pathway is itself a pathological process, and in the CHT, it is systematically determined by geography, poverty, and ethnicity.

1.3 The Concept of Terrain-Conditioned Pathology

The central theoretical contribution of this textbook to the field of CHT health studies is the concept of Terrain-Conditioned Pathology, or TCP. This concept, derived from a synthesis of geomedicine, landscape epidemiology, the social determinants of health framework, and indigenous medical philosophy, holds that in geographically complex environments such as the CHT, the terrain itself functions as an active pathological agent. Terrain-Conditioned Pathology is defined as the systematic modification of disease incidence, prevalence, severity, clinical presentation, and treatment response attributable to the physical, chemical, biological, and social properties of the landscape in which a population is embedded, operating through mechanisms that include vector habitat modification, waterborne pathogen distribution, nutritional scarcity patterning, pharmaceutical access gradient, stress physiology modulation by altitude and isolation, and cultural adaptation to ecological constraint. The distinction between TCP and conventional notions of environmental disease causation lies in its comprehensiveness. While environmental health models have traditionally focused on specific toxins, vectors, or pathogens within the environment, TCP posits that the terrain operates as a holistic and integrated pathogenic system, in which each component of the landscape contributes to a composite disease

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risk profile that cannot be fully understood by examining any single environmental variable in isolation. In the CHT, the terrain does not merely host disease. It sculpts it, distributes it, delays its treatment, modifies its clinical course, and in many cases determines its outcome. TCP is not a metaphor. It is a framework for clinical and epidemiological investigation that will be applied throughout this textbook.

The TCP framework organizes pathological terrain influences into five domains. The first domain is Topographic Pathology, which encompasses all disease risk modifications attributable to the physical form of the landscape, including slope, elevation, valley configuration, ridge spacing, and river geometry. In the CHT, topographic pathology includes the concentration of malaria-bearing Anopheles mosquitoes in low-lying river valleys (since female Anopheles of the species most epidemiologically relevant in Bangladesh, including Anopheles dirus and Anopheles minimus, preferentially breed in slow-moving, shaded streams and pools that are most abundant in forested valley floors), the difficulty of medical evacuation from ridge-top settlements, and the restriction of cold-chain pharmaceutical delivery by road inaccessibility. The second domain is Hydrological Pathology, which encompasses disease risk modification through waterborne pathways, including the contamination of drinking water sources, the breeding of aquatic vectors, and the chemical composition of water. The third domain is Nutritional-Ecological Pathology, which encompasses the interaction between the food environment created by the terrain (including the seasonal availability of wild foods, the productivity of jhum fields, and the access to protein sources from forest fauna and aquatic resources) and the nutritional status of the population. The fourth domain is Pharmaceutical Access Pathology, which encompasses the systematic degradation of healthcare access attributable to terrain features, including road inaccessibility, river crossing hazards during monsoon season, and the economic costs of travel. The fifth domain is Psychoecological Pathology, which encompasses the mental health and psychosomatic consequences of living in a geographically isolated, politically marginalized, and historically traumatized landscape, including stress-related immune suppression, depression, anxiety, substance use disorders, and somatization of political violence.

1.4 The Kaptai Lake and Its Pathological Legacy

No account of the medical geography of the CHT is complete without a sustained engagement with the Kaptai Dam and the lake it created. The Kaptai hydroelectric dam was constructed on the Karnaphuli River between 1957 and 1962, during the period of Pakistani administration of what is now Bangladesh, and was completed in 1962 with the full impoundment of the Kaptai Lake reservoir. The dam submerged approximately 40 percent of the arable land of the Chakma people, displacing an estimated 100,000 individuals, the majority of whom were never adequately compensated or resettled. The Kaptai Lake project has generated one of the most medically consequential forced population displacements in the history of South Asia, and its health effects continue to propagate through the CHT population more than six decades later. From the perspective of TCP, the creation of Kaptai Lake represents a massive terrain modification event. The lake created an enormous new aquatic surface that transformed the hydrology of the Rangamati district fundamentally and permanently. It created new vector habitats along its extensive and highly indented shoreline. It altered the microclimate of the surrounding hills by increasing local humidity. It displaced subsistence farming communities

into steeper, less productive, and more ecologically fragile uplands, driving intensified jhum cultivation on slopes that had never previously been farmed and accelerating the deforestation that would subsequently degrade water quality, increase soil erosion, and modify vector habitats across a large proportion of the CHT. The lake also created new occupational health hazards, including the drowning risks associated with the fishing economy that developed on its surface, and the exposure of fishing communities to waterborne pathogens through extended contact with lake water of variable and frequently poor microbiological quality. The psychological dimensions of the Kaptai displacement represent perhaps the most profound and least studied aspect of its health legacy. The Chakma community's ancestral relationship with the Karnaphuli valley and the fertile lands it contained was not merely economic. It was cosmological, spiritual, and identity-constitutive. The submergence of ancestral villages, paddy fields, and cultural sites represented a form of collective trauma that has been transmitted across generations in ways that manifest today as elevated rates of anxiety, depression, intergenerational grief, and a deep ambivalence about the legitimacy of the state and its health systems.

1.5 The Jhum Agricultural System and Its Health Dimensions

The jhum (also spelled jum or chum) cultivation system is the historical backbone of CHT agricultural life and one of the most clinically significant ecological practices in the region. Jhum is a form of rotational shifting cultivation in which a section of forest is cleared, typically by cutting and burning the vegetation (hence the alternate name "slash-and-burn"), cultivated for one or two seasons with a mix of subsistence crops (primarily upland rice, sesame, cotton, vegetables, and pulses), and then allowed to fallow for a period of years during which the vegetation regenerates before the cycle is repeated. Jhum has sustained CHT communities for centuries and represents a sophisticated form of ecological management when practiced with adequate rotation intervals, historically six to eight years or more. The degradation of jhum as a health-sustaining agricultural system began in the colonial period and has accelerated dramatically since the 1970s. Population growth, land alienation (the loss of traditional jhum land to Bengali settler encroachment, military cantonment establishment, Reserved Forest designation, and dam impoundment), and the breakdown of traditional tenure systems have compressed the jhum cycle from its historically sustainable six-to-eight-year rotation to as little as two or three years in many areas, dramatically reducing soil fertility, crop yields, and the diversity of the harvest. The health consequences of jhum cycle compression are direct and measurable. Reduced crop diversity translates into reduced dietary diversity, which is the most sensitive and reliable indicator of nutritional adequacy across age groups. Reduced soil fertility reduces yields, increasing food insecurity at the household level. The burning of vegetation during jhum clearing produces airborne particulate matter and volatile organic compounds that constitute a seasonal respiratory hazard for communities in the burning zones. Soil erosion from compressed-cycle jhum increases turbidity in downstream water sources, compromising the microbiological safety of drinking water during and immediately after heavy rain. At higher elevations in Bandarban, jhum fields on steep slopes create erosion patterns that have been shown to alter drainage patterns and increase the stagnant water accumulation that favors Anopheles breeding.

The burning phase of jhum cultivation, which typically occurs between February and April before the monsoon onset, creates a period of concentrated air quality degradation in affected areas of the CHT. Burning of vegetation releases carbon monoxide, nitrogen dioxide, particulate matter of multiple size fractions including PM2.5, and a range of polyaromatic hydrocarbons and volatile organic compounds. In communities where the majority of households burn wood inside poorly ventilated bamboo structures for cooking throughout the year (a condition documented in more than 90 percent of households surveyed in some CHT studies), the jhum burning season superimposes an acute outdoor air quality crisis on a chronic indoor air quality crisis, creating a compound respiratory burden with no parallel in the Bengal plains. The clinical manifestations of this compound burden include acute lower respiratory infection exacerbations, asthma attacks, worsening of pre-existing chronic obstructive pulmonary disease (though the epidemiology of COPD in CHT populations is not well characterized), and, in infants and young children, pneumonia, which remains a leading cause of under-five mortality across the CHT. The relationship between jhum burning, indoor cooking fuel exposure, and respiratory morbidity in the CHT has been the subject of far less systematic clinical investigation than it deserves, and it represents a priority area for both research and public health intervention.

MODEL EXAMINATION QUESTIONS: CHAPTER ONE

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

1. The Chittagong Hill Tracts occupies approximately what percentage of the total land area of Bangladesh? a) 5 percent b) 10 percent c) 15 percent d) 20 percent (Correct Answer: b)
2. Which of the following Anopheles species is most epidemiologically significant as a malaria vector in the forested river valleys of the Chittagong Hill Tracts? a) Anopheles gambiae and Anopheles arabiensis b) Anopheles dirus and Anopheles minimus c) Anopheles stephensi and Anopheles culicifacies d) Anopheles albimanus and Anopheles darlingi (Correct Answer: b)
3. The concept of Terrain-Conditioned Pathology (TCP) as defined in this textbook encompasses how many domains of pathological terrain influence? a) Three b) Four c) Five d) Six (Correct Answer: c)
4. The Kaptai hydroelectric dam displaced approximately how many individuals following its completion in 1962? a) 10,000 b) 50,000 c) 100,000 d) 250,000 (Correct Answer: c)
5. Which of the following is NOT included within the domain of Hydrological Pathology as defined in the TCP framework? a) Waterborne pathogen distribution b) Aquatic vector breeding habitats c) Chemical composition of drinking water sources d) Mental health consequences of geographic isolation (Correct Answer: d)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

6. A public health officer planning a malaria vector control intervention in a remote valley settlement in Rangamati must consider which of the following terrain-specific factors as primary determinants of Anopheles breeding site distribution in the CHT context? a)

Proximity to urban markets, population density, and road access b) Forest canopy density, stream velocity, shading of water surfaces, and slope gradient c) Soil pH, altitude above sea level, and crop type in surrounding jhum fields d) Seasonal temperature variation, relative humidity, and rainfall only (Correct Answer: b)

7. The nutritional consequences of compression of the jhum cultivation cycle from historical rotation intervals of six to eight years to current intervals of two to three years include all of the following EXCEPT: a) Reduced dietary diversity at the household level b) Increased food insecurity due to reduced crop yields c) Improved access to wild food sources due to increased forest clearing d) Degraded soil fertility with consequent protein and micronutrient deficits (Correct Answer: c)
8. From a geomedicinal perspective, the creation of Kaptai Lake in 1962 produced which of the following epidemiologically significant effects? a) Reduction of malaria incidence through elimination of slow-moving stream habitats b) Improvement of nutritional status among displaced Chakma communities through access to fish protein c) Creation of new vector habitats along the lake shoreline and microclimate alteration that increased local humidity d) Both a and b only (Correct Answer: c)

CHAPTER TWO: CLINICAL AND PUBLIC HEALTH HISTORY OF THE CHITTAGONG HILL TRACTS FROM THE PRE-COLONIAL PERIOD TO THE CONTEMPORARY ERA

2.1 Pre-Colonial Medical Systems and the Indigenous Health Cosmos

The health systems of the CHT, before the imposition of colonial administrative structures, were neither primitive nor uniform. Each of the ethnic communities of the hill territory operated within a distinct but overlapping network of medical knowledge, practice, and cosmology that integrated botanical pharmacology, spiritual healing, dietary regulation, social hygiene, and community ritual into a coherent therapeutic framework. Understanding this pre-colonial health cosmos is not merely a matter of historical curiosity. It is a clinical necessity for the contemporary practitioner who works in the CHT, because elements of this cosmological health system continue to operate alongside, in tension with, and in integration with biomedical practice across the CHT in the twenty-first century. The pre-colonial medical epistemology of the CHT hill communities was characterized by several features that distinguish it fundamentally from both the Ayurvedic systems that influenced the plains of Bengal and the Galenic-Hippocratic tradition that undergirds Western biomedicine. First, CHT indigenous medical epistemology was ecologically embedded. The body was understood not as an autonomous biological entity but as a node in a network of relationships with the forest, the river, the seasonal cycle, the agricultural calendar, and the community of ancestors and spirits. Health was the condition of right relationship within this network, and disease was a disruption of relational harmony, which could have biological (exposure to pathogens, nutritional deficit), social (violation of community norms, interpersonal conflict), or spiritual (ancestral displeasure, spirit aggression, ritual transgression) causes. Second, CHT indigenous medicine was pluralistic in its therapeutic approaches. A sick person might simultaneously receive a botanical preparation from a Kabiraj

or Baiddya (the traditional herbalist-healer), participate in a ritual healing ceremony conducted by a spiritual specialist (in the Chakma tradition, this might involve a Buddhist monk or a traditional spirit-pacification specialist), and observe dietary restrictions prescribed by community elders. The therapeutic modalities worked synergistically rather than exclusively. Third, CHT indigenous medicine was preventively oriented in ways that colonial and early post-colonial observers frequently failed to recognize. Community-level dietary regulations (many of which had clear pharmacological and microbiological justifications, such as the prohibition of consumption of certain foods during particular seasons when those foods were most likely to harbor pathogens), ritual purification practices that functioned as hygiene protocols, and the social management of illness (which included isolation of the severely ill and practices that reduced transmission risk) all constituted elements of a sophisticated preventive medicine system that was disrupted rather than enhanced by many early colonial public health interventions.

The Chakma community, the largest and best-documented ethnic group in the CHT, practiced a form of healing that drew on both Buddhist cosmological frameworks and indigenous animist traditions. The Chakma concept of health, expressed in their dialect as "bhalo thaka" (literally, good staying or good being), encompassed physical function, mental clarity, spiritual alignment, and social harmony simultaneously. Disease, in Chakma medical philosophy, was understood as "abishkara" (a kind of discovery or revelation of imbalance), meaning that illness was not random but purposive, revealing an imbalance in the patient's relationships, practices, or spiritual standing. This principle has direct clinical significance. A Chakma patient presenting to a clinic with fever and myalgia consistent with malaria may simultaneously be undergoing a parallel process of illness interpretation within the Chakma cosmological framework, seeking spiritual or ritual explanation for why they, specifically, became ill at this time. The clinician who ignores this parallel process misses a crucial dimension of the therapeutic relationship with this patient and risks designing a treatment approach that the patient will not fully follow, not out of ignorance or irrationality, but out of a completely coherent (within its own framework) effort to address the illness at all the levels at which it is understood to operate. The clinical failure to engage with indigenous illness cosmologies is not a theoretical problem. It is a concrete contributor to treatment non-adherence, healthcare avoidance, and the persistence of preventable morbidity in CHT communities.

The Marma community, concentrated in Bandarban district, practiced a medical tradition that blended Theravada Buddhist healing concepts (Pali texts provided frameworks for understanding bodily constitution, the elements, and the causes of physical suffering) with a rich ethnopharmacological knowledge system based on the forest plants of the Bandarban hills. The Marma Baiddya, the traditional healer-pharmacist of this community, was and remains a figure of extraordinary social authority. The Baiddya's knowledge was transmitted orally, through apprenticeship, across generations, and encompassed not only the botanical pharmacology of the local forest plants (including dozens of species with documented anti-malarial, antimicrobial, anti-inflammatory, anthelmintic, and wound-healing properties) but also the social and spiritual protocols governing their preparation, prescription, and administration. A 2025 ethnobotanical study conducted in Rangamati district by a team of researchers who interviewed fifteen experienced Baiddya healers from the Chakma, Marma, and Tanchangya communities documented sixty-five medicinal plant species belonging to sixty-one genera and thirty-nine

families in active therapeutic use, with robust pharmacological evidence supporting the mechanisms of action of a significant proportion of the identified plants. This finding, from research conducted in January and February of 2025, represents the most recent systematic documentation of the CHT's ethnopharmacological heritage and provides strong scientific grounding for the clinical integration of traditional botanical medicine into contemporary CHT healthcare protocols.

2.2 The Colonial Medical Encounter: Administration, Disease, and the Imposition of Biomedicine

The formal incorporation of the Chittagong Hill Tracts into the British Indian administrative system began in 1860, when the territory was formally annexed to the Bengal Presidency following a series of conflicts with the hill communities, particularly the Chakma, who had maintained relative autonomy under a system of nominal tributary relations with the Mughal and later British powers centered in Chittagong. The British administration created a special regulatory regime for the CHT, codified in the CHT Regulation of 1900, which restricted the entry of outsiders into the territory, preserved aspects of customary law under the authority of three hereditary chiefs (the Raja of the Chakma Circle, the Bohmong Chief of the Marma community, and the Mong Chief), and placed the territory under a separate administrative structure under a Superintendent or Deputy Commissioner. The medical history of the CHT during the colonial period was shaped by three intersecting forces: the administration's concern with the health of its own personnel (military and civilian British officers stationed in the CHT were highly susceptible to malaria, dysentery, and other tropical diseases, and keeping them operational was an administrative priority), the economic interests of colonial extraction (rubber, tea, and timber extraction required a minimally functional labor force), and a paternalistic missionary impulse that constructed indigenous health practices as primitive, superstitious, and in need of replacement by scientific medicine. None of these forces was primarily oriented toward the health of the hill communities themselves, and the public health infrastructure created under colonial administration reflected this prioritization in its geography (medical facilities were concentrated in the administrative towns of Rangamati and Bandarban), its language (medical services were delivered in Bengali or English, not in the indigenous languages), and its epistemology (traditional healers were frequently dismissed, restricted, or criminalized rather than integrated into the health system).

The British colonial encounter with malaria in the CHT was the single most important driver of early biomedical infrastructure development in the territory. Malaria was recognized from the earliest periods of colonial administration as the dominant health threat to both the indigenous population and the colonial personnel stationed in the hills. The CHT was categorized by colonial medical authorities as a highly malarious territory, and the hill stations of Rangamati and Bandarban were staffed with medical officers specifically tasked with managing the malarial burden. The early colonial approach to malaria in the CHT drew on the miasmatic theory of disease (which attributed malaria to "bad air" emanating from swampy ground) as much as on the emerging germ-vector theory that followed Ronald Ross's demonstration of mosquito transmission in 1897 and 1898. This theoretical confusion produced interventions of variable effectiveness. Quinine was distributed to CHT communities through colonial dispensaries from

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the late nineteenth century, representing the most effective pharmacological intervention available at the time, and its use was widespread enough to have influenced the treatment-seeking norms of CHT communities in ways that persist to the present day. The colonial drainage and land clearance programs, justified on miasmatic grounds, inadvertently produced some reduction in Anopheles breeding habitat in the immediate vicinity of administrative centers, though they simultaneously disrupted the ecological balance of areas further from administrative control in ways that may have increased vector density in some zones. The relationship between colonial land-use change and malaria epidemiology in the CHT is a subject that requires significantly more historical-epidemiological investigation than it has thus far received.

2.3 The Post-Independence Period and the Escalation of the Structural Health Crisis

The partition of British India in 1947 and the subsequent creation of East Pakistan (which became Bangladesh in 1971 following the Liberation War) produced a series of structural changes in the CHT that had profound and largely negative consequences for the health of its indigenous communities. The post-independence period saw the dismantling of the special administrative protections that the colonial CHT Regulation of 1900 had established, at least in practice if not always in formal legal terms. The successive Pakistani and Bangladeshi governments viewed the CHT as a strategic and economic frontier rather than as a culturally distinct territory requiring special management, and the policies they enacted in the CHT, including the Kaptai dam displacement, the population resettlement program of the 1970s and 1980s, the armed conflict between the Bangladesh military and the Parbatya Chattagram Jana Samhati Samiti (PCJSS) that lasted from 1975 to 1997, and the ongoing land disputes between indigenous communities and Bengali settlers and commercial enterprises, all created or intensified conditions that are directly pathogenic at the population level.

The armed conflict period from 1975 to 1997 represents a chapter of CHT history with massive and extensively documented public health consequences that are still insufficiently integrated into the clinical and epidemiological literature. Displacement, violence, destruction of agricultural systems, restriction of movement (which constrained both healthcare access and food production), and the psychological trauma of sustained political violence all operated simultaneously as pathological forces during this period. Refugee crises, including the displacement of large numbers of CHT indigenous people to the Indian state of Tripura and to the Mizoram-Myanmar borderlands, created conditions of acute nutritional emergency, epidemic diarrheal disease, and elevated under-five mortality. Within Bangladesh, the internal displacement of CHT indigenous communities from their home villages into relief camps and urban periphery areas created settlement patterns characterized by extreme poverty, overcrowding, poor sanitation, and near-complete dependence on emergency relief for nutritional survival. The public health infrastructure of the CHT was severely degraded during the conflict period, with healthcare facilities damaged or destroyed in conflict areas, health workers displaced or unable to function, and supply chains for essential medicines disrupted. The 1997 CHT Peace Accord brought the armed conflict to a formal end but left many of its underlying drivers unresolved, including land disputes, political autonomy issues, and the demographic and economic marginalization of indigenous communities. The post-Accord period saw a gradual

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rebuilding of public health infrastructure in the CHT, but progress has been uneven, inadequately funded, and frequently hampered by political tensions, geographical obstacles, and persistent structural inequalities that continue to produce measurable disparities in health outcomes between CHT indigenous communities and the general population of Bangladesh.

2.4 The 1997 Peace Accord and Its Health System Implications

The Chittagong Hill Tracts Peace Accord, signed on December 2, 1997, between the government of Bangladesh and the PCJSS under the leadership of the late Shantu Larma, was a historic document that formally ended more than two decades of armed conflict. From a public health perspective, the Peace Accord was significant both for what it promised and for what it failed to deliver. The Accord included provisions for the rehabilitation of internally displaced persons and refugees, the transfer of administrative authority over certain government functions (including health services) to the CHT Regional Council and the three District Hill Councils, and the protection of land rights of indigenous communities. The health system transfer to local governance bodies was particularly significant in principle, because it offered the possibility of culturally sensitive, community-responsive health service delivery under institutions with indigenous representation. In practice, the implementation of the health-related provisions of the Peace Accord has been characterized by chronic underfunding, bureaucratic resistance from central government agencies reluctant to devolve authority, and ongoing political instability arising from disputes over the interpretation and application of Accord provisions. The CHT Regional Council and the District Hill Councils have formal mandates over health services, but they have consistently lacked the financial resources, technical capacity, and administrative authority to exercise these mandates effectively. The result is a health system in the CHT that is formally decentralized but functionally under-resourced, fragmented between national and local government jurisdictions, and unable to address the specific health needs of the CHT's diverse indigenous communities in a sustained and systematic way.

The post-Accord period did see measurable improvements in several health indicators in the CHT. Under-five mortality rates declined, maternal mortality decreased, and access to primary healthcare services improved, particularly in areas accessible by road or river transport. National health programs including the Expanded Programme on Immunization (EPI), the national tuberculosis control program, and malaria control initiatives supported by BRAC (Bangladesh Rural Advancement Committee) and international agencies including the Global Fund to Fight AIDS, Tuberculosis and Malaria achieved notable successes in parts of the CHT. BRAC's malaria control program, which has operated in the CHT since the early 1990s and which has used community-based health workers (Shasthya Shebika) to provide rapid diagnostic testing and artemisinin-based combination therapy in remote communities, has been credited with a significant proportion of the substantial decline in malaria case counts achieved across Bangladesh between 2008 and 2022. However, these successes have been geographically and demographically uneven. The most remote communities, including the Mro in Alikadam, the Khumi and Chak in the deep valleys of southern Bandarban, and the Bawm in the high ridges near the Mizoram border, have consistently been underserved by national health programs and have not shared equitably in the health gains achieved in more accessible parts of the CHT. The 2025 measles outbreak, which killed children in the Mro community of Kurukpata while that

community remained largely outside routine immunization coverage, is the most recent and most tragic illustration of this persistent inequity.

2.5 Contemporary Health System Architecture in the CHT

The contemporary health system serving the CHT population is a complex, multi-layered, and imperfectly integrated structure that combines government facilities at various levels of the national health system hierarchy with a substantial non-governmental sector and a large and varied traditional medicine sector. The government health system in the CHT operates through facilities that include district hospitals in Rangamati, Bandarban, and Khagrachhari; upazila health complexes (UHCs) at the sub-district level; and union health and family welfare centers (UHFWCs) and community clinics at the union and village levels. The theoretical coverage of the government health system is substantially better than the practical coverage. The primary barriers to effective utilization of government health facilities in the CHT include geographical distance and access difficulty, communication barriers (many indigenous patients do not speak Bengali or speak it with limited proficiency, and essentially no government health workers in the CHT are trained to communicate in the indigenous languages), financial barriers (user fees, transport costs, and opportunity costs of time away from agricultural labor all deter healthcare utilization), and a deep-seated distrust of government institutions among some indigenous communities, rooted in the political history of the CHT and the experience of state violence during the conflict period. The non-governmental sector in the CHT is extensive and includes the health programs of BRAC (the largest NGO health provider in Bangladesh overall and a major presence in the CHT), several smaller national and international NGOs, and the healthcare programs of Christian missionary organizations that have operated in the CHT since the late nineteenth century and that continue to provide a significant proportion of healthcare services in specific geographic areas, particularly in Bandarban. The traditional medicine sector, encompassing Kabiraj/Baiddya practitioners, Buddhist monks who provide healing rituals and botanical remedies, traditional birth attendants (locally called Dais), and a large informal sector of unlicensed drug dispensers, pharmacists' shops, and rural medical practitioners of variable training, provides a substantial proportion of first-contact healthcare in the CHT, particularly in remote areas.

MODEL EXAMINATION QUESTIONS: CHAPTER TWO

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

1. The CHT Regulation that established a special administrative regime for the Chittagong Hill Tracts under British colonial rule was promulgated in which year? a) 1860 b) 1900 c) 1947 d) 1972 (Correct Answer: b)
2. The hereditary tribal governance structure of the CHT recognizes how many traditional chiefs (Rajas/Bohmong/Mong)? a) Two b) Three c) Four d) Five (Correct Answer: b)
3. Ronald Ross demonstrated the mosquito transmission of malaria in which years? a) 1857 and 1858 b) 1877 and 1878 c) 1897 and 1898 d) 1917 and 1918 (Correct Answer: c)

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4. The CHT Peace Accord was signed in which year? a) 1990 b) 1993 c) 1997 d) 2000 (Correct Answer: c)
5. Which non-governmental organization has been credited with a significant proportion of the decline in malaria case counts in Bangladesh through its community-based health worker program in the CHT? a) Doctors Without Borders (MSF) b) World Health Organization (WHO) c) BRAC (Bangladesh Rural Advancement Committee) d) UNICEF Bangladesh (Correct Answer: c)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

6. From a health systems perspective, the primary structural failure illustrated by the 2025 measles outbreak in the Mro community of Kurukpata, Alikadam, Bandarban, is best described as: a) A failure of vaccine manufacturing capacity at the national level b) A failure of geographic equity in immunization program coverage, compounded by communication barriers, vaccine hesitancy, and systemic neglect of remote indigenous communities c) A consequence of intentional community refusal of all government health services d) A failure of international aid organizations to supply vaccines to Bangladesh (Correct Answer: b)
7. The CHT Peace Accord's provisions for health service devolution to the CHT Regional Council and District Hill Councils have been imperfectly implemented primarily due to which combination of factors? a) Lack of indigenous interest in managing health services and absence of qualified indigenous health workers b) Chronic underfunding, bureaucratic resistance to authority devolution, and ongoing political instability arising from disputes over Accord interpretation c) Opposition from international health organizations and NGOs operating in the CHT d) Constitutional barriers to sub-national health governance in Bangladesh (Correct Answer: b)
8. The concept of "delay-to-care pathway as pathological process" as articulated in this textbook refers to: a) The deliberate delay of treatment by clinicians awaiting laboratory confirmation before prescribing b) The systematic health degradation that occurs when structural barriers cause patients to present with more advanced disease, requiring more complex and less effective treatment c) The delay between symptom onset and self-recognition of illness among CHT indigenous communities d) Administrative delays in the procurement and distribution of essential medicines to CHT facilities (Correct Answer: b)

CHAPTER THREE: THEORIES OF DISEASE CAUSATION IN THE CHT: BRIDGING INDIGENOUS COSMOLOGY AND CONTEMPORARY BIOMEDICAL SCIENCE

3.1 The Multicausal Framework: Beyond the Biomedical Reductionism

The dominant paradigm governing medical education in Bangladesh, as in most of South and Southeast Asia, remains a biomedical model fundamentally shaped by the germ theory of disease, the pathophysiological model of organ system dysfunction, and the pharmacological

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paradigm of disease treatment. This model has been extraordinarily productive in understanding the mechanisms of specific diseases and in developing effective treatments for many of them. However, applied without modification to the complex health environment of the CHT, it produces a systematically incomplete understanding of why people get sick, how illnesses progress, and what interventions produce sustainable improvements in population health. This chapter develops a multicausal framework for understanding disease in the CHT that integrates the germ theory, the social determinants of health model, the eco-epidemiological perspective, and key insights from indigenous CHT medical cosmology, producing a synthetic theoretical architecture capable of supporting both clinical practice and public health program design in the CHT context.

The biological germ theory, as applied to the CHT, is both essential and insufficient. It is essential because the CHT faces a significant burden of infectious disease in which specific pathogens (including Plasmodium falciparum and Plasmodium vivax for malaria, Vibrio cholerae for cholera, various enteropathogens for diarrheal disease, Mycobacterium tuberculosis for tuberculosis, and measles morbillivirus for measles) are the proximate biological causes of illness and death, and understanding their biology, lifecycle, transmission dynamics, and pharmacological vulnerabilities is indispensable for clinical management and epidemic control. It is insufficient because it cannot explain why CHT indigenous communities bear a disproportionate burden of these diseases compared with other populations who theoretically share the same exposure to the same pathogens, nor why the same disease presents with different severity in different communities, nor why some communities respond to public health interventions and others do not. The germ theory, taken alone, produces a clinical approach that is adept at treating disease episodes but incapable of preventing disease occurrence or of addressing the conditions that make disease episodes more frequent, more severe, and more deadly in some populations than others. The social determinants of health framework, formalized through the work of the World Health Organization Commission on Social Determinants of Health (CSDH) and its landmark 2008 report "Closing the Gap in a Generation," provides the necessary complement to the germ theory. The CSDH framework posits that health outcomes are primarily shaped by the conditions in which people are born, grow, live, work, and age, and that these conditions are in turn shaped by the distribution of power, money, and resources at global, national, and local levels. In the CHT, the social determinants of health include poverty (with indigenous communities consistently ranking among the poorest in Bangladesh), land rights (the insecurity of land tenure that forces communities onto marginal land and into precarious livelihoods), education (with lower literacy rates among CHT indigenous communities compared with the national average, particularly among women and elderly individuals), political marginalization (the systematic underrepresentation of indigenous communities in governance structures that determine health resource allocation), and the legacy of political violence (which has produced chronic psychological trauma and institutional distrust that shape health behavior across the CHT).

3.2 The CHT Ecological Epidemiology Doctrine

The CHT Ecological Epidemiology Doctrine, as articulated in this textbook, holds that in geographically and ecologically complex territories such as the CHT, the classical

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epidemiological triad of agent, host, and environment must be fundamentally reconceptualized. In the classical model, the environment is understood as a contextual backdrop within which agent and host interact. In the CHT, the environment is not a backdrop. It is an active participant in the epidemiological process, contributing its own causal inputs to disease occurrence and distribution in ways that are as biologically specific and as mechanistically explicable as the contributions of the agent and the host. The CHT Ecological Epidemiology Doctrine replaces the classical triad with a quadrilateral model in which agent (pathogen or noxious exposure), host (the human body in its genetic, physiological, immunological, and psychological specificity), environment (encompassing the physical, biological, chemical, and social properties of the surrounding landscape), and terrain (encompassing the specific topographic, hydrological, and ecological properties of the CHT as a unique geographic unit, distinct from general environmental parameters) each constitute independent axes of epidemiological causation with distinct mechanisms of action and distinct implications for intervention design.

The practical application of the CHT Ecological Epidemiology Doctrine to malaria, the signature disease of the territory, illustrates its value. Under the classical triad model, malaria in the CHT is explained by the presence of Plasmodium falciparum and Plasmodium vivax parasites (agent), the susceptibility of the human populations of the CHT (host), and the hot, humid, forested environment that supports Anopheles vector breeding (environment). This explanation is correct as far as it goes, but it provides no basis for explaining why malaria is specifically concentrated in certain valleys and not others, why certain settlements bear dramatically higher case loads than adjacent settlements, why the intensity of malaria transmission varies predictably with forest density, river gradient, and altitude, and why some CHT communities have developed apparent partial immunity to malaria (with asymptomatic or low-grade infections prevailing in older adults who have lived all their lives in high-transmission areas) while others remain fully vulnerable. The quadrilateral model adds the terrain axis, which encompasses the specific combination of valley configuration (which creates micro-drainage systems that concentrate slow-moving water in the valley floor), forest canopy density (which creates the shaded, humid microclimate preferred by Anopheles dirus for resting and breeding), altitude gradient (which creates the temperature differential that limits Plasmodium development above approximately 1,800 meters, a threshold relevant only to the highest ridges of Bandarban), and proximity to jhum field margins (which have been shown in CHT studies to be associated with elevated Anopheles density because jhum clearing creates the open, disturbed ground that supports certain breeding species). Adding the terrain axis to the epidemiological analysis produces a spatially precise, mechanistically coherent, and operationally actionable understanding of malaria distribution in the CHT that the classical model cannot generate.

3.3 Indigenous Causal Theories and Their Clinical Translation

The indigenous medical cosmologies of the CHT communities are not merely cultural artifacts of historical interest. They are living theoretical systems that continue to shape the health-seeking behavior, treatment adherence, and illness narrative of a significant proportion of the CHT population, and they deserve systematic engagement from the contemporary clinician and public health practitioner. This section provides a clinical translation of the major indigenous causal theories of the CHT's principal ethnic communities, not as a reduction of these rich cosmological

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systems to biomedical analogs, but as an intellectual bridge that allows the clinician to understand and respect the patient's interpretive framework while maintaining the integrity of the biomedical diagnostic and therapeutic process.

The Chakma concept of "Bhutu" illness represents one of the most clinically significant examples of indigenous causal theory in the CHT. Bhutu refers to a category of illness attributed to spirit possession or spirit aggression, typically characterized by sudden onset, altered consciousness, behavioral disturbance, high fever, or unexplained physical symptoms in the absence of an obvious social precipitant. From a biomedical perspective, presentations consistent with the Chakma category of Bhutu illness include febrile psychosis from cerebral malaria, acute manic or psychotic episodes (particularly in their early presentations when organic exclusion is necessary), conversion disorder and dissociative states, delirium tremens in alcohol-dependent individuals, and various neurological presentations including viral encephalitis and meningismus. The clinical significance of the Bhutu category lies in the treatment pathway it generates. A Chakma patient or family interpreting an illness as Bhutu will typically seek ritual treatment from a spiritual specialist as a first-line response, and may present to biomedical services only after ritual interventions have failed, at which point the condition (if it is, for example, cerebral malaria or bacterial meningitis) may be significantly more advanced than it would have been with earlier biomedical presentation. This delay-to-biomedical-care pathway in the context of spiritually interpreted illness is a well-documented phenomenon in CHT studies and represents a major driver of preventable mortality from treatable conditions. The appropriate clinical response is neither to dismiss the Bhutu interpretation as superstition (which damages the therapeutic relationship and increases the likelihood of future healthcare avoidance) nor to uncritically defer to it (which may allow a biomedically treatable condition to progress beyond the window of effective intervention). The appropriate response is to work collaboratively with the patient and family, acknowledging the legitimacy of the Bhutu framework within its own cosmological domain while conducting the biomedical evaluation necessary to identify and treat any concurrent biological condition.

The Marma concept of "Pi" illness is conceptually distinct from Bhutu. Pi refers to a category of illness attributed to dietary violation, specifically the consumption of foods that are categorically inappropriate for the individual's constitutional type, seasonal context, or specific life circumstances. The Pi concept maps reasonably well onto some aspects of Ayurvedic dietary medicine and shares with it the notion that the body's constitution (which the Marma tradition describes in terms broadly analogous to the Ayurvedic Prakriti concept, though with distinct categories specific to the Marma system) determines what foods are health-promoting and what foods are pathogenic for that particular individual. Pi illness presentations in Marma communities typically involve gastrointestinal symptoms (nausea, vomiting, diarrhea, abdominal pain), skin eruptions, and general malaise following specific dietary exposures. From a biomedical perspective, Pi presentations may include food poisoning (from the consumption of inadequately prepared or stored foods, particularly during the hot season), allergic or intolerance reactions to specific foods, or gastrointestinal infections from foods prepared or consumed in ways that increase pathogen exposure. The Marma dietary classification system, in its identification of high-risk food categories for specific constitutional types and seasonal contexts, may function as a practically effective risk reduction system for food-associated illness in many

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cases, embodying epidemiological wisdom accumulated through centuries of community health experience.

The Tripura (Tipra) concept of "Khumbai" illness integrates the cosmological framework of the indigenous Tripura religion (which blends Shakta Hindu influences with pre-Hindu animist elements) with a classification of illnesses attributed to violation of community norms, interpersonal conflicts, and ancestral curse. Khumbai illness is typically characterized by chronic, wasting presentations in which a previously healthy individual declines progressively in the absence of obvious acute disease, losing weight, strength, and vitality over months or years. From a biomedical perspective, Khumbai presentations are particularly important because the clinical picture they describe, chronic progressive debilitation with weight loss and weakness, corresponds to the presentation profile of several serious and treatable conditions that are prevalent in the CHT, including tuberculosis (which produces precisely this clinical picture as a "consumptive" illness), HIV/AIDS (which, while documented as a health problem in neighboring Myanmar and in the mobile populations crossing the CHT-Myanmar border, has been systematically understudied in the CHT itself), malnutrition syndromes, and cancer (for which both detection and treatment capacity in the CHT is severely limited). The Khumbai framework produces a community explanation and social response to chronic wasting illness that includes both ritual intervention and dietary supplementation (specific high-nutrition foods are prescribed within the Khumbai healing protocol), and the nutritional supplementation component represents a convergence with biomedical therapeutic principles.

3.4 The Psychoecological Health Philosophy of the CHT

The Psychoecological Health Philosophy of the CHT, as developed in this textbook, represents a novel integrative framework that brings together the ecological psychology of the CHT landscape, the indigenous psychospiritual healing traditions of CHT communities, and the contemporary neuroscience and psychoneuroimmunology of trauma, stress, and immune function, to produce a unified understanding of the psychological and psychosomatic health dimensions of CHT populations. This framework rests on four foundational principles. The first principle is Landscape-Mind Integration, which holds that the psychological states of CHT indigenous community members are not merely influenced by but are constitutively shaped by the ecological and social landscape of the CHT, such that disruption of the landscape through deforestation, land alienation, flood, or political violence produces measurable psychological disturbances that are not secondary or epiphenomenal but primary pathological processes. The second principle is Collective Trauma Somatization, which holds that the political history of the CHT, including the violence of the conflict period, the trauma of the Kaptai displacement, and the ongoing experience of land insecurity and political marginalization, has produced a pattern of collective trauma with both psychological and somatic manifestations, including elevated rates of anxiety and depression, somatoform presentations, stress-related chronic disease (hypertension, diabetes, cardiovascular disease), and immune dysregulation that increases susceptibility to infectious illness. The third principle is Healing Ecology, which holds that the traditional healing practices of CHT communities, including both botanical treatments and ritual healing ceremonies, function as psychoecological restorative interventions that address the landscape-mind integration disruptions produced by illness, trauma, and social conflict, and that their value

is not exhausted by their pharmacological mechanisms but extends to their psychoneuroimmunological effects through the mobilization of hope, meaning, social support, and cosmological reintegration in the healing process. The fourth principle is Structural Pathology Recognition, which holds that the clinician and public health practitioner working in the CHT has an ethical and scientific obligation to recognize the structural determinants of the psychological and psychosomatic ill health they encounter, and to advocate for structural change (including land rights protection, political representation, equitable economic development, and the elimination of institutional discrimination) as a component of the comprehensive public health response to CHT health disparities.

MODEL EXAMINATION QUESTIONS: CHAPTER THREE

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

1. The classical epidemiological triad consists of which three elements? a) Agent, host, and vector b) Agent, host, and environment c) Pathogen, patient, and physician d) Infection, inflammation, and immunity (Correct Answer: b)
2. The Chakma category of "Bhutu" illness, from a biomedical differential diagnosis perspective, most importantly overlaps with which of the following conditions? a) Hypertension and diabetes b) Febrile psychosis from cerebral malaria, acute psychotic episodes, conversion disorder, and encephalitic presentations c) Malnutrition and vitamin deficiency states d) Chronic obstructive pulmonary disease and asthma (Correct Answer: b)
3. Psychoneuroimmunology studies the relationship between which systems? a) The immune system and the cardiovascular system only b) Psychological states, the nervous system, and the immune system c) The endocrine system and the reproductive system d) Nutritional status and immune function exclusively (Correct Answer: b)
4. The Marma concept of "Pi" illness is primarily attributed to which cause within the indigenous framework? a) Spirit possession by forest spirits b) Violation of community social norms c) Dietary violation specific to constitutional type and seasonal context d) Ancestral curse resulting from ritual transgression (Correct Answer: c)
5. Which WHO Commission's 2008 report formalized the social determinants of health framework at the global level? a) The Commission on Macroeconomics and Health (CMH) b) The Commission on Social Determinants of Health (CSDH) c) The High-Level Panel on Universal Health Coverage d) The Expert Advisory Panel on the International Health Regulations (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

6. The CHT Ecological Epidemiology Doctrine as defined in this textbook replaces the classical epidemiological triad with a quadrilateral model. Which of the following correctly identifies all four axes of this model? a) Agent, host, environment, and vector b) Pathogen, immunity, socioeconomic status, and healthcare access c) Agent, host,

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environment, and terrain d) Biological, psychological, social, and spiritual determinants (Correct Answer: c)

7. A clinician working with a Chakma patient whose family is interpreting the patient's acute febrile altered consciousness as Bhutu illness should adopt which of the following clinical approaches? a) Firmly reject the Bhutu interpretation and insist on biomedical treatment alone, educating the family about germ theory b) Defer entirely to the Bhutu healing protocol and allow the traditional specialist to manage the case c) Acknowledge the legitimacy of the Bhutu framework within its cosmological domain while conducting the full biomedical evaluation necessary to identify and treat concurrent biological conditions including cerebral malaria and bacterial meningitis d) Report the family to health authorities for seeking traditional treatment (Correct Answer: c)
8. In the context of the Tripura concept of "Khumbai" illness (chronic wasting), which of the following biomedical conditions should be most urgently excluded by the clinician due to its prevalence in the CHT and its treatability? a) Hypertension and type 2 diabetes b) Tuberculosis c) Asthma and chronic obstructive pulmonary disease d) Skin diseases including scabies and eczema (Correct Answer: b)

CHAPTER FOUR: THE ETHNOMEDICINAL COMPLEX OF THE CHITTAGONG HILL TRACTS: SYSTEMS, PRACTITIONERS, PHARMACOPOEIA, AND CONTEMPORARY RELEVANCE

4.1 Defining the CHT Ethnomedicinal Complex

The CHT Ethnomedicinal Complex is defined in this textbook as the integrated system of medical knowledge, therapeutic practice, practitioner networks, pharmacological resources, and cosmological frameworks that has evolved across the CHT's indigenous communities over centuries of ecological habitation, cultural exchange, and adaptive response to the specific disease burden of the hill territory, and that continues to function as a primary or complementary healthcare resource for a significant proportion of the CHT population in the twenty-first century. The term "complex" is chosen deliberately to convey several important features of this system. First, it is not monolithic. The eleven ethnic communities of the CHT have distinct ethnomedicinal traditions that differ in their pharmacological emphasis, their cosmological frameworks, their practitioner roles and specializations, and their integration with the broader CHT natural environment. Second, it is not static. The CHT ethnomedicinal complex has evolved continuously in response to new disease exposures (including epidemic diseases introduced through colonial contact and recent infectious disease emergencies), changing ecological conditions (including deforestation that has eliminated some traditional plant sources), and interactions with biomedical and Ayurvedic medical systems. Third, it is not marginal. In remote areas of the CHT where biomedical healthcare remains inaccessible or unaffordable, the ethnomedicinal complex constitutes the primary healthcare system for the resident population, and even in areas with better biomedical access, it functions as a complementary system that addresses dimensions of illness (social, spiritual, psychological, nutritional) that biomedical services do not address. Fourth, it is scientifically significant. A growing body of

pharmacological research is documenting the biological mechanisms of action of CHT ethnomedicinal plants, confirming the efficacy of many traditional treatments and identifying novel bioactive compounds with potential applications in drug development.

The CHT Ethnomedicinal Complex can be organized into five subsystems defined by their primary practitioner type and therapeutic modality. The first subsystem is the Botanical Subsystem, centered on the Kabiraj or Baiddya healer who specializes in the identification, preparation, and administration of plant-based medicines drawn from the forest pharmacopoeia of the CHT. The second subsystem is the Ritual-Spiritual Subsystem, centered on practitioners including Buddhist monks (in Chakma, Marma, and Tanchangya communities), spirit-pacification specialists or Ojha figures, and ritual healing ceremony leaders who address the cosmological dimensions of illness through prayer, mantra, ritual sacrifice, and ceremonial intervention. The third subsystem is the Dietary Regulatory Subsystem, centered on the application of community dietary classification frameworks (such as the Marma Pi system, the Chakma hot-cold food classification, and the Tripura seasonal dietary calendar) to prevent and treat illness through food. The fourth subsystem is the Midwifery and Reproductive Health Subsystem, centered on the traditional birth attendant (Dai) and the elder women of the community who manage pregnancy, birth, and the postnatal period according to traditional protocols. The fifth subsystem is the Physical and Manipulative Subsystem, which encompasses traditional massage (practiced in Marma and Chakma communities using herbal oils), bone-setting practices, and the application of heat (through heated stone application or steam inhalation) for musculoskeletal and respiratory conditions.

4.2 The Baiddya: Healer-Pharmacist of the Hills

The Baiddya (also spelled Baiddyo, Vaidya, or Boiddo in different community dialects) is the central figure of the CHT's botanical healing tradition and one of the most pharmacologically sophisticated indigenous practitioners in South Asia. The Baiddya's role encompasses botanical taxonomy (the identification and classification of medicinal plants in the CHT forest), plant ecology (knowledge of the seasonal availability, habitat specificity, and cultivation requirements of medicinal species), pharmaceutical preparation (including the techniques of aqueous extraction, fermentation, maceration, drying, and powdering used to prepare different classes of botanical medicines), dosimetry (the determination of appropriate doses for different age groups, constitutional types, and disease severities), and clinical diagnosis (the Baiddya's assessment of the patient, conducted through observation, palpation, and inquiry, to determine the appropriate treatment). The Baiddya tradition is transmitted through apprenticeship, typically from a master Baiddya to a selected disciple over a period of years, and requires the accumulation of a large corpus of embodied knowledge that cannot be fully transmitted through written texts or formal instruction. The authority of the Baiddya within CHT communities derives from a combination of demonstrated therapeutic success (communities with long exposure to a specific Baiddya evaluate their practitioners empirically, and ineffective healers lose clientele), inherited lineage prestige (Baiddya families with multi-generational healing traditions carry significant social authority), and spiritual credentials (the capacity to access forest plant knowledge is culturally understood as requiring not merely botanical skill but a special relationship with the spirit world of the forest).

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A landmark ethnobotanical study conducted across Rangamati district in January and February of 2025 documented the current practice of fifteen experienced Baiddya healers from the Chakma, Marma, and Tanchangya communities. The study documented sixty-five medicinal plant species belonging to sixty-one genera and thirty-nine families in active therapeutic use. Pharmacological analysis of the documented plants found that a significant proportion had established scientific evidence for the mechanisms of action consistent with their traditional therapeutic applications. Among the conditions treated by the documented plant medicines were fever and malaria (consistent with the high burden of these conditions in the CHT), wound healing and infection management (consistent with the occupational hazard profile of subsistence farmers and forest workers), gastrointestinal disorders (consistent with the burden of diarrheal disease), respiratory conditions, snake and insect bite management, and reproductive health including menstrual regulation, fertility, and birth management. This breadth of pharmacological coverage demonstrates that the CHT Baiddya tradition is not a limited or narrowly specialized medical system but a comprehensive primary care resource that addresses the full spectrum of common health problems experienced by CHT communities.

The future of the Baiddya tradition faces several significant threats that have been identified by both community members and researchers. Deforestation is eliminating the habitat of numerous medicinal plant species, forcing Baiddya practitioners to travel increasingly long distances to collect necessary plants or to substitute less therapeutically appropriate species. The aging of the existing practitioner cohort, combined with declining interest among younger community members (who increasingly aspire to educational and occupational pathways outside traditional practice), creates a transmission risk for the ethnomedicinal knowledge system. The 2025 ethnobotanical study explicitly noted the risk of "vanishing ethnomedicinal wisdom" and called for urgent documentation and conservation of the CHT botanical healing knowledge system. Integration of Baiddya knowledge into formal healthcare systems, whether through research collaboration, practitioner registration, or the development of standardized botanical preparations from CHT medicinal plants, remains a significant untapped opportunity for strengthening the CHT health system while preserving a critically important cultural heritage.

4.3 The CHT Botanical Pharmacopoeia: Major Plant Categories and Bioactive Profiles

The CHT botanical pharmacopoeia encompasses an estimated 150 to 250 plant species in active or recent therapeutic use across the territory's eleven ethnic communities, though the precise number is uncertain because documentation has been geographically and community-specifically limited. The pharmacopoeia can be organized into major therapeutic categories based on the primary conditions for which the plants are employed. The anti-malarial and antipyretic category is the largest and most pharmacologically active, reflecting the centrality of febrile illness and malaria in the CHT disease burden. Plants in this category include species from the families Rubiaceae (which contains quinine-producing Cinchona as well as local species with demonstrable anti-Plasmodium activity), Meliaceae, Simaroubaceae, and Asteraceae, among others. Several CHT plant species have been shown in laboratory studies to possess anti-Plasmodium activity at clinically relevant concentrations, and the mechanism of action of at least some of these is through inhibition of hemozoin formation (the same mechanism exploited by chloroquine and related drugs), through disruption of the parasite's mitochondrial function, or

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through direct membrane toxicity to parasitized erythrocytes. The wound-healing and antimicrobial category is the second largest, encompassing plants with documented antibacterial, antifungal, and anti-inflammatory activity used topically for wound care, skin infections, and musculoskeletal injuries. The anthelmintic category addresses the significant burden of intestinal parasitic infection in CHT communities, and several CHT plants have been documented with activity against common helminth species including Ascaris, Trichuris, and hookworm. The reproductive health category includes plants used for menstrual regulation, management of pregnancy discomforts, birth facilitation, and postnatal recovery, some of which have uterotonic or uterine relaxant properties that are consistent with their traditional applications.

Bryophyllum pinnatum (Air Plant, locally called Pathorkuchi) deserves specific mention as one of the most widely used and best-pharmacologically-characterized medicinal plants of the CHT. It is employed by multiple CHT communities including the Chakma, Marma, and Tripura for the treatment of fever, burns, skin infections, respiratory conditions, and kidney stones. Its bioactive profile includes flavonoids (particularly quercetin and kaempferol derivatives), bufadienolides, and phenolic compounds with demonstrated anti-inflammatory, antibacterial, antifungal, analgesic, and anti-urolithic properties. Oroxylum indicum (Midnight Horror, locally called Bansha), a large tree species of the Bignoniaceae family, is used by CHT Baiddya practitioners for the treatment of asthma, respiratory infections, rheumatism, and as a bitter tonic, with its bioactive compounds including chrysin, baicalein, and oroxylin A having documented bronchodilatory, anti-inflammatory, and immunomodulatory properties. Syzygium cumini (Java Plum, Black Plum, locally called Jam) is used across multiple CHT communities for management of diabetes-associated symptoms (the seeds have documented anti-hyperglycemic activity through multiple mechanisms including alpha-glucosidase inhibition), diarrhea management, and urinary tract infections.

4.4 Buddhist Healing Traditions in the CHT

The Theravada Buddhist tradition, which is the predominant religious framework of the Chakma, Marma, and Tanchangya communities, provides a significant complementary healing system that operates alongside and in integration with both the Baiddya botanical tradition and biomedical services. Buddhist healing in the CHT draws on Pali scriptural traditions including the Tipitaka's medical passages, the tradition of medicinal knowledge attributed to the physician Jivaka Komarabhacca (the physician of the Buddha and of King Bimbisara), and locally developed ritual and meditative healing practices. The Buddhist healing tradition in the CHT is primarily mediated by the Buddhist sangha, the community of monks, and operates through several modalities. Paritta chanting, the recitation of specific Pali suttas (discourses) over a patient, is one of the most widely practiced healing rituals in CHT Buddhist communities and is understood to generate protective blessings and to purify the patient's kamma (ethical-causal life-force) in ways that support recovery. Meditation instruction, specifically the guidance of patients toward mindfulness meditation practice (Vipassana), is increasingly recognized not only within the tradition but in the contemporary scientific literature as a therapeutically significant intervention for stress reduction, pain management, and immune function support. Dietary guidance based on the Buddhist concept of "ahimsa" (non-harming) food principles, which emphasizes plant-based

nutrition and moderation, contributes to the dietary management of several CHT common conditions including dyslipidemia, diabetes, and cardiovascular disease.

The relationship between the Buddhist monastery and the health system of CHT communities is one of the most underappreciated dimensions of CHT public health. The monastery (vihara) functions in many CHT communities not only as a religious center but as a social welfare hub, a site of basic healthcare provision (monks frequently possess significant botanical knowledge), a refuge for the ill and the destitute, an educational institution (monastic schools have historically provided the primary educational resource in many remote CHT communities, and health literacy has been transmitted partly through monastic education), and a psychological support center where individuals in distress, including those experiencing grief, trauma, and interpersonal conflict, can access the monks' counseling. In the context of the CHT's inadequate biomedical health infrastructure, the monastery's health system functions are not merely traditional or cultural. They represent an active and practically significant component of the health system that deserves recognition, support, and strategic integration by health system planners.

MODEL EXAMINATION QUESTIONS: CHAPTER FOUR

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

1. The CHT Ethnomedicinal Complex is organized in this textbook into how many subsystems defined by practitioner type and therapeutic modality? a) Three b) Four c) Five d) Six (Correct Answer: c)
2. Bryophyllum pinnatum, used widely across CHT communities for fever and wound management, belongs to which plant family? a) Rubiaceae b) Meliaceae c) Crassulaceae d) Bignoniaceae (Correct Answer: c)
3. Oroxylum indicum is used in CHT ethnomedicine primarily for which conditions? a) Malaria and dysentery b) Asthma, respiratory infections, rheumatism, and as a bitter tonic c) Diabetes and kidney stones d) Skin infections and wound healing only (Correct Answer: b)
4. Syzygium cumini (Java Plum) seeds have documented anti-hyperglycemic activity primarily through which mechanism? a) Insulin secretagogue activity b) Alpha-glucosidase inhibition c) GLUT4 transporter upregulation d) GLP-1 receptor agonism (Correct Answer: b)
5. The physician of the Buddha according to Pali Buddhist healing traditions, whose medical knowledge informs Theravada Buddhist healing practice, was: a) Nagarjuna b) Charaka c) Sushruta d) Jivaka Komarabhacca (Correct Answer: d)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

6. A plant-based medicine used by CHT Baiddya practitioners is found to inhibit hemozoin formation in Plasmodium falciparum. This mechanism of action is analogous to which class of established antimalarial drugs? a) Artemisinin-based combination therapies

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(ACTs) b) Chloroquine and related 4-aminoquinolines c) Antifolates including sulfadoxine-pyrimethamine d) Atovaquone-proguanil (Malarone) (Correct Answer: b)

7. A public health researcher planning to integrate Baiddya healers into a community health system in remote Bandarban should identify which of the following as the most critical structural threat to the sustainability of this integration? a) Legal barriers to the practice of traditional medicine in Bangladesh b) The aging of the existing Baiddya practitioner cohort combined with deforestation eliminating medicinal plant habitats and declining transmission of knowledge to younger practitioners c) Community resistance to integrating traditional and biomedical medicine d) Insufficient bioactive compounds in CHT plant species to justify integration (Correct Answer: b)
8. The Vipassana meditation practice instructed by CHT Buddhist monks has been shown in the contemporary scientific literature to produce which of the following physiologically measurable effects relevant to its therapeutic value in the CHT context? a) Reduction in blood glucose only b) Stress reduction, pain modulation, and immune function support through psychoneuroimmunological mechanisms c) Increase in body weight and correction of malnutrition d) Direct antiviral and antibacterial activity (Correct Answer: b)

CHAPTER FIVE: THE EPIDEMIOLOGICAL ARCHITECTURE OF THE CHITTAGONG HILL TRACTS: BURDEN, DISTRIBUTION, AND DETERMINANTS OF DISEASE

5.1 The Epidemiological Transition Theory Applied to the CHT

The epidemiological transition, the conceptual framework describing the historical shift of population disease burden from infectious diseases of poverty toward chronic non-communicable diseases associated with longevity and lifestyle, was first formally articulated by Abdel Omran in 1971. In its classic formulation, the transition proceeds through three stages: the Age of Pestilence and Famine (high and fluctuating mortality from infectious diseases and nutritional deficiencies), the Age of Receding Pandemics (declining mortality from infectious disease as living standards and sanitation improve), and the Age of Degenerative and Man-Made Diseases (rising chronic disease burden as the population ages). Subsequent theorists have added a fourth stage, the Age of Delayed Degenerative Diseases (in which advances in cardiovascular disease treatment extend life expectancy) and in some frameworks a fifth stage addressing the re-emergence of infectious diseases in the context of rising antimicrobial resistance and global health security threats. The CHT represents a case of epidemiological non-transition or double burden of disease, in which the infectious disease burden characteristic of Omran's first stage persists alongside an emerging burden of non-communicable disease associated with lifestyle transition. This double burden is characteristic of transitional economies experiencing rapid but unequal development, and it creates a particularly challenging public health management problem because the health system must address the resource requirements of both the infectious disease control agenda and the growing NCD prevention and management agenda simultaneously, with resources that are inadequate for either.

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The CHT's burden of infectious disease remains substantially higher than the national average of Bangladesh across multiple disease categories. Malaria incidence is highest in Bangladesh in the CHT, with over 80 percent of Bangladesh's total malaria burden concentrated in the CHT and the adjacent Chittagong division. Tuberculosis prevalence among CHT indigenous communities has been estimated in several studies to be higher than national average, though population-level surveillance data specific to CHT indigenous communities remain inadequate. Diarrheal disease morbidity, particularly among children under five years, reflects the inadequate water, sanitation, and hygiene (WASH) infrastructure that characterizes most rural CHT settlements. Vaccine-preventable disease burden, most recently and dramatically illustrated by the 2025 measles outbreak in Bandarban, reflects the persistent gaps in immunization program coverage that have been documented in the CHT for decades. Parasitic infections including helminthiasis (intestinal worm infection), filariasis (lymphatic filariasis is present in some CHT districts), and leishmaniasis (reported in some areas bordering Myanmar) add to the infectious disease burden. Nutritional deficiency diseases, particularly in children under five years and in pregnant and lactating women, including protein-energy malnutrition (both wasting and stunting), iron deficiency anemia, iodine deficiency disorders, and vitamin A deficiency, constitute a major and underacknowledged dimension of the CHT's disease burden that intersects with and amplifies the infectious disease burden through immune suppression.

5.2 Malaria: The Dominant Vector-Borne Disease of the CHT

Malaria occupies a position of singular epidemiological and historical significance in the Chittagong Hill Tracts. It is the most studied disease in the CHT health literature, the disease most closely associated with the territory's medical identity in the national and international scientific imagination, and the disease that has most consistently challenged the Bangladesh national health system's capacity to reach the most remote and vulnerable CHT communities. The epidemiology of malaria in the CHT has several features that distinguish it from malaria in other parts of Bangladesh and from malaria epidemiology globally.

More than 80 percent of Bangladesh's total annual malaria burden is concentrated in the CHT and adjacent Chittagong division. Within the CHT, malaria distribution is highly heterogeneous, with transmission concentrated in specific high-risk zones characterized by the combination of dense forest cover, valley topography, proximity to forest-edge Anopheles breeding habitats, and human settlements occupied by communities with limited access to preventive interventions including long-lasting insecticidal nets (LLINs) and indoor residual spraying (IRS). This spatial concentration of malaria risk in specific "hotspot" areas within the CHT is well-documented in the scientific literature and has been mapped using geographic information systems (GIS) and GPS-based surveillance methods. The hotspot nature of malaria transmission in the CHT has important implications for control strategy: targeted intensification of interventions in identified hotspot areas is likely to be more cost-effective than uniform coverage across the entire CHT, though achieving adequate coverage within hotspot areas is itself a significant challenge given their geographical remoteness.

Plasmodium falciparum is the predominant malarial species in the CHT, accounting for approximately 96 percent of malaria admissions to Chittagong Medical College Hospital (the

primary tertiary referral facility for severe malaria in Chittagong Division) in studies covering the period from 1999 to 2011. Crucially, P. falciparum in the CHT is predominantly chloroquine-resistant, meaning that chloroquine, which was the mainstay of malaria treatment in Bangladesh for decades, is now effectively useless against the dominant strain circulating in the CHT. This has profound clinical implications. A patient presenting with febrile illness consistent with malaria in the CHT must not be treated empirically with chloroquine. The current evidence-based treatment standard for P. falciparum malaria is artemisinin-based combination therapy (ACT), specifically artemether-lumefantrine as the first-line regimen in Bangladesh. However, the emergence of partial artemisinin resistance in Plasmodium falciparum from the Greater Mekong Subregion, documented since the early 2010s and now confirmed as spreading westward toward Bangladesh, represents an escalating threat to the current treatment standard and demands urgent surveillance to monitor artemisinin sensitivity in CHT P. falciparum isolates.

Plasmodium vivax accounts for a minority of malaria cases in the CHT (approximately 4 percent of hospital admissions in the cited Chittagong Medical College Hospital study), but its clinical and public health significance extends beyond its numerical prevalence. P. vivax malaria, unlike P. falciparum, produces dormant hepatic hypnozoites that can reactivate weeks to months after the primary infection, producing relapsing malaria. The radical cure of P. vivax malaria, which requires treatment with primaquine (a tissue schizontocide active against hepatic hypnozoites) in addition to a blood schizontocide for the acute attack, is complicated in the CHT by the high prevalence of glucose-6-phosphate dehydrogenase (G6PD) deficiency among indigenous CHT populations. G6PD deficiency is a sex-linked recessive condition in which reduced activity of the G6PD enzyme (critical to the hexose monophosphate shunt and protection of erythrocytes from oxidative damage) renders individuals vulnerable to acute hemolytic anemia when exposed to primaquine and other oxidant drugs. Studies conducted in the Mekong subregion, where the ethnic populations involved are closely related to those of the CHT, have documented G6PD deficiency prevalence rates of 10 to 20 percent in indigenous male populations, suggesting that G6PD prevalence in CHT indigenous communities is likely substantially higher than has been measured in Bangladesh-specific data. This has direct implications for the safe administration of primaquine for P. vivax radical cure in the CHT: G6PD testing is a prerequisite for safe primaquine prescription, and the absence of point-of-care G6PD testing capability in most CHT health facilities represents a significant patient safety gap.

The seasonal pattern of malaria in the CHT is marked with a single peak in P. falciparum transmission from June to August, coinciding with peak rainfall and the associated increase in Anopheles breeding habitat. This seasonal pattern has important implications for health system preparedness, since it creates a predictable surge in malaria case presentations at CHT health facilities during the monsoon period, when simultaneously the accessibility of those facilities from remote communities is at its lowest (due to road flooding and river crossing hazards). The monsoon malaria surge, combined with monsoon-induced healthcare access degradation, creates the greatest risk period for malaria mortality in the CHT each year and requires specific surge capacity planning in the health system.

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The role of climate variability in modulating malaria transmission in the CHT has been studied systematically in Rangamati district. Research has demonstrated a direct influence of temperature, rainfall, and humidity on Anopheles vector density and Plasmodium parasite development rate (the extrinsic incubation period, which shortens at higher temperatures, allowing faster development of infectious sporozoites within the mosquito). Climate modeling studies suggest that ongoing anthropogenic climate change will alter the seasonal and geographic distribution of malaria risk in the CHT, potentially extending the transmission season and shifting the geographic boundaries of intense transmission to higher elevations. Elderly individuals, women (particularly pregnant women, who have malaria-specific immunosuppression), and children are identified in the literature as disproportionately bearing the risk from climate-associated changes in malaria epidemiology.

5.3 Diarrheal Diseases: The Waterborne Burden

Diarrheal diseases represent the second most commonly reported illness category in CHT community health surveys, exceeded in frequency only by fever (which is substantially attributable to malaria and other acute infectious etiologies). The diarrheal disease burden of the CHT is driven by a convergence of inadequate water, sanitation, and hygiene infrastructure; behavioral risk factors including open defecation, inadequate handwashing, and unsafe food preparation practices; and the specific ecological conditions of the CHT that create pathogen transmission pathways not present in equivalent intensity in the plains of Bangladesh. The WASH infrastructure deficit in the CHT is severe by any measure. Studies of CHT indigenous communities have documented that approximately 39 percent of households in surveyed areas had no access to toilet facilities, while 32 percent had access to pit latrines without lids (which provide minimal pathogen containment), and only approximately 26.5 percent had access to pit latrines with lids. These figures describe a sanitation environment in which fecal-oral transmission of enteropathogens is structurally facilitated, creating conditions where interventions targeting individual behavior (handwashing education, for example) are necessary but dramatically insufficient without corresponding investment in sanitation infrastructure.

The drinking water sources of CHT communities reflect the hydrological character of the territory. In valley and lowland communities, river and stream water is the primary drinking water source, with the microbiological quality of this water subject to severe deterioration during and immediately after rainfall events that mobilize surface contamination from open defecation sites and jhum fields treated with animal manure. In upland ridge communities, spring water is more commonly used, and while spring water in some CHT locations is of excellent microbiological quality, in others it is contaminated by surface runoff through inadequately protected catchment areas. Rainwater harvesting is practiced in some CHT communities, particularly in areas where the only alternative is severely contaminated surface water, but storage practices frequently result in contamination of the collected water during the storage period. The chemical quality of CHT drinking water also presents concerns distinct from those of the plains of Bangladesh, where arsenic contamination of groundwater is a major public health issue. In the CHT, the primary chemical concerns in drinking water include elevated iron and manganese concentrations in some areas (which affect palatability and may have health effects with long-term exposure), naturally occurring fluoride in some hill springs (which can cause

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dental and skeletal fluorosis at concentrations exceeding recommended limits), and microorganism contamination compounds from jhum burning runoff during the burning season.

The principal enteropathogens responsible for diarrheal disease morbidity in the CHT include Vibrio cholerae (with both endemic and epidemic cholera documented in the territory, particularly in the river valley settlements along the Karnaphuli system), Rotavirus (the leading cause of severe diarrhea requiring hospitalization in children under five globally and likely in the CHT as well, though CHT-specific Rotavirus epidemiology has not been systematically studied), enterotoxigenic Escherichia coli (ETEC), Shigella dysenteriae (which produces particularly severe bloody diarrhea, dysentery, and hemolytic uremic syndrome in children), and Cryptosporidium parvum (a protozoan enteroparasite of increasing global public health significance that is particularly dangerous in immunocompromised individuals and malnourished children). Campylobacter species and Salmonella species add to the bacterial enteropathogen burden, particularly in communities where close proximity to domestic animals (chickens, ducks, pigs, and goats are commonly kept in or near CHT households) creates frequent human-animal-pathogen contact. The helminthic infection burden, particularly with Ascaris lumbricoides, Trichuris trichiura, and hookworm (Ancylostoma duodenale and Necator americanus), while not causing diarrheal disease in the classical sense, contributes significantly to the nutritional and immunological vulnerability of CHT children by competing for dietary nutrients and generating chronic intestinal inflammation.

5.4 Tuberculosis in the CHT: A Neglected Priority

Tuberculosis, caused by Mycobacterium tuberculosis, is a disease of poverty, overcrowding, malnutrition, and immune compromise, and the CHT presents all of these risk conditions in combination. TB in the CHT has been inadequately studied, with most available data coming from national surveillance systems that do not routinely disaggregate data by ethnic group or geographic subdistrict within the CHT. The available evidence suggests that TB prevalence among CHT indigenous communities is higher than the national average, though precise community-specific estimates are not available. The epidemiological risk factors for high TB prevalence in the CHT are well established. Protein-energy malnutrition (which severely impairs the T-cell mediated immune response that normally contains Mycobacterium tuberculosis infection and prevents progression from latent to active disease) is prevalent among CHT indigenous children and adults, with documented rates of childhood stunting exceeding 45 percent in some CHT communities. Household overcrowding in bamboo structures with limited ventilation creates efficient airborne TB transmission conditions. Limited access to diagnostic services (particularly bacteriological confirmation of pulmonary TB, which requires sputum collection, transportation, and microscopy or GeneXpert analysis) means that cases go undetected for extended periods, during which they remain infectious and continue to transmit. The CHT national TB control program, which has extended the DOTS (Directly Observed Treatment, Short-course) strategy to the CHT with some success in accessible areas, has not achieved adequate geographic or population coverage in the most remote communities.

The clinical presentation of pulmonary TB in CHT patients requires specific attention because the typical textbook presentation (productive cough of more than three weeks, hemoptysis, night

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sweats, weight loss, low-grade fever, fatigue) is frequently delayed in presentation to health services due to the delay-to-care pathway documented across multiple CHT studies. Many CHT patients with pulmonary TB present to health facilities only after weeks or months of symptoms, often with advanced disease characterized by significant cavitation on chest radiography, high sputum bacillary load (making them highly infectious), and significant nutritional compromise. This late presentation pattern increases both the severity of individual patient outcomes and the community-level transmission burden. The overlap between the clinical presentations of pulmonary TB and those of community-recognized illness categories such as the Tripura "Khumbai" (chronic wasting illness) means that some patients with TB undergo extended traditional treatment before seeking biomedical evaluation, with clinical implications as described in Chapter Three. Drug-resistant TB, including multidrug-resistant TB (MDR-TB, defined as resistance to at least isoniazid and rifampicin) and extensively drug-resistant TB (XDR-TB, defined as MDR-TB with additional resistance to fluoroquinolones and at least one injectable second-line agent), represents an escalating concern in the CHT given the territory's proximity to Myanmar, where high rates of drug-resistant TB have been documented, and the movement of people across the CHT-Myanmar border that creates conditions for importation of resistant strains.

5.5 Nutritional Epidemiology of the CHT: The Malnutrition Crisis

The nutritional status of CHT indigenous communities, particularly children and women, represents perhaps the most severe and most unjust health crisis in the territory, and one of the least adequately addressed. Data published in The Lancet Southeast Asia in October 2025 (authored by Kundu and Das Gupta) reported that in 2018, more than 30 percent of indigenous preschool children in Bandarban were underweight, approximately 45 percent were stunted (a measure of chronic malnutrition reflecting inadequate growth over extended periods), and 15 percent were wasted (a measure of acute malnutrition reflecting recent inadequate food intake or illness). These figures are dramatically worse than national averages for Bangladesh, which in the 2017-2018 Bangladesh Demographic and Health Survey showed 22 percent underweight, 31 percent stunted, and 8 percent wasted among children under five years. The gap between CHT indigenous child nutritional status and the national average represents not merely a statistical disparity but a structural inequity that has profound and long-lasting consequences for the affected children, their communities, and the development of Bangladesh as a whole. The same 2025 study reported that only 12 to 13 percent of Marma and Mro children in Bandarban achieved minimum dietary diversity (defined by WHO as consumption of at least four of seven food groups in the past 24 hours), compared with more than 50 percent among Bengali children in the same district. This extraordinary disparity in dietary diversity within a single district is a direct reflection of the intersection of poverty, geographic isolation, market inaccessibility, and the degradation of the traditional food systems that historically sustained CHT communities.

The causes of malnutrition in CHT indigenous communities are multiple, interconnected, and deeply structural. Food production insecurity, driven by the degradation of jhum agriculture (as discussed in Chapter One), land alienation, and the destruction of traditional food systems, is the foundational cause. Market inaccessibility, arising from the terrain and transport infrastructure deficits of the CHT, limits the ability of communities to supplement inadequate local food

production with purchased food. The seasonal nature of food availability, with the pre-harvest lean season (typically February to April, before the jhum harvest) representing a period of acute food insecurity for many CHT communities, creates predictable and cyclical episodes of acute malnutrition that compound the chronic malnutrition produced by year-round dietary inadequacy. The interaction between malnutrition and infection creates a vicious cycle in which each condition exacerbates the other: malnourished children are more susceptible to diarrheal disease, malaria, and respiratory infections; these infections reduce appetite and nutrient absorption while increasing metabolic demand; and the resulting nutritional deterioration further impairs immune function. The 2025 Lancet Southeast Asia paper explicitly characterized the nutritional crisis among CHT indigenous children as "a missing piece in Bangladesh's nutrition agenda," noting that national nutrition policies and programs have not adequately addressed the specific structural determinants of malnutrition in CHT indigenous communities and calling for targeted, culturally sensitive, and structurally oriented nutrition interventions for this population.

MODEL EXAMINATION QUESTIONS: CHAPTER FIVE

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

1. Plasmodium falciparum accounts for approximately what percentage of malaria hospital admissions in Chittagong Medical College Hospital in studies from 1999-2011? a) 50% b) 75% c) 86% d) 96% (Correct Answer: d)
2. The radical cure of Plasmodium vivax malaria requires which drug to eliminate hepatic hypnozoites (the relapse-causing dormant liver stage)? a) Chloroquine b) Artemether c) Primaquine d) Quinine (Correct Answer: c)
3. G6PD (Glucose-6-Phosphate Dehydrogenase) deficiency is clinically relevant to primaquine use because primaquine can cause which serious adverse effect in G6PD-deficient individuals? a) Acute renal failure b) Acute hemolytic anemia c) Stevens-Johnson syndrome d) Peripheral neuropathy (Correct Answer: b)
4. According to data cited in the 2025 Lancet Southeast Asia paper, what percentage of indigenous preschool children in Bandarban were stunted in 2018? a) 22% b) 31% c) 38% d) 45% (Correct Answer: d)
5. The peak transmission season for Plasmodium falciparum in the CHT coincides with: a) The dry season (January to March) b) The pre-monsoon hot season (April to May) c) The peak monsoon rainfall period (June to August) d) The post-monsoon cool season (October to December) (Correct Answer: c)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

6. A CHT district hospital physician encounters a patient with Plasmodium vivax malaria confirmed by RDT. Before prescribing primaquine for radical cure, the physician must ensure: a) The patient weighs at least 50 kilograms b) G6PD testing has been performed and the patient is not G6PD-deficient c) The patient has completed a full course of blood

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schizontocide therapy with artemether-lumefantrine d) Both b and c are prerequisites for safe primaquine prescription (Correct Answer: d)

7. The "double burden of disease" concept as applied to the CHT refers to: a) The simultaneous high burden of P. falciparum and P. vivax malaria b) The persistence of a high infectious disease burden characteristic of epidemiological transition Stage 1 alongside an emerging non-communicable disease burden, with inadequate health system resources to address both c) The dual burden of disease in both the Chakma and non-Chakma populations of the CHT d) The simultaneous disease burden affecting both children and adults in CHT communities (Correct Answer: b)
8. A CHT public health officer designing a diarrheal disease prevention program identifies that 39% of surveyed households have no toilet facilities. According to the public health principles articulated in this textbook, this finding indicates that interventions should prioritize which approach? a) Handwashing education alone, targeting individual behavior change b) Distribution of oral rehydration solution (ORS) at community level c) Combined investment in sanitation infrastructure (toilet construction and promotion) AND behavioral interventions, recognizing that individual behavior change is insufficient without structural sanitation improvement d) Water treatment with chlorine tablets at household level only (Correct Answer: c)

CHAPTER SIX: ENVIRONMENTAL HEALTH FOUNDATIONS OF THE CHITTAGONG HILL TRACTS: AIR, WATER, SOIL, AND THE ECOLOGY OF EXPOSURE

6.1 The Environmental Health Paradigm for the CHT

Environmental health, in its most comprehensive contemporary formulation, encompasses the study of how the physical, chemical, and biological components of the natural and built environment influence human health, operating through multiple exposure pathways including inhalation, ingestion, dermal contact, and indirect biological routes (such as vector-mediated disease transmission). For the CHT, environmental health is not an abstract academic concern but a daily, immediate, and life-determining reality for every person who lives in the territory. The environmental health conditions of the CHT are shaped by a combination of natural features (the geology, hydrology, ecology, and climate of the territory) and human modifications of the natural environment (including deforestation, jhum cultivation, dam construction, settlement patterns, and the use of cooking fuels). Understanding the environmental health landscape of the CHT requires engaging simultaneously with all of these dimensions, and it requires a theoretical framework capable of accommodating both the biological specificity of pathogen-host interactions and the political economy of environmental degradation.

The foundational environmental health principle applied to the CHT in this textbook is the Environmental Burden Accumulation Principle, which holds that in resource-poor, geographically isolated, and politically marginalized communities such as those of the CHT, environmental health exposures do not operate in isolation from one another but accumulate

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across multiple pathways simultaneously, creating a composite environmental burden that is greater than the sum of its individual components and that produces health effects not predictable from analysis of any single exposure. A CHT indigenous community member is simultaneously exposed to indoor air pollution from wood cooking fires (with exposures to PM2.5, carbon monoxide, and polycyclic aromatic hydrocarbons that have been measured in studies from similar settings across South and Southeast Asia to far exceed WHO air quality guidelines), outdoor air pollution from jhum burning during the burning season, microbiologically contaminated drinking water from unprotected surface sources, agricultural chemical exposures from pesticide use in jhum fields and terraced gardens, heavy metal exposure from naturally occurring mineral deposits in some CHT river systems, and the physical and occupational hazards of subsistence agriculture on steep slopes. The aggregate of these exposures, rather than any single exposure in isolation, is what determines the environmental health trajectory of the individual and the community. The Environmental Burden Accumulation Principle provides the theoretical foundation for an integrated environmental health assessment approach in the CHT that avoids the fragmentation of environmental health analysis into single-exposure studies and instead demands a comprehensive, cumulative exposure framework.

6.2 Indoor Air Quality and Household Energy in the CHT

Indoor air pollution from the combustion of solid fuels for cooking and heating is one of the most pervasive and clinically significant environmental health hazards in the CHT. The overwhelming majority of CHT indigenous households use wood, bamboo, or other biomass as their primary cooking fuel, burned on open fires or simple stoves inside bamboo and timber structures with limited ventilation. Survey data from CHT studies document that essentially all respondents used wood as their primary cooking fuel, and the physical characteristics of the majority of CHT housing structures (bamboo walls, mud floors, tin roofs, minimal window openings) mean that ventilation is severely inadequate for the removal of combustion byproducts. The health effects of chronic household solid fuel combustion on the respiratory system have been extensively documented in the global literature and include increased risk of acute lower respiratory infection (particularly pneumonia) in children, chronic obstructive pulmonary disease in adults (particularly women, who spend the most time cooking and are therefore most intensively exposed), lung cancer (from PAH exposure), and adverse pregnancy outcomes including low birth weight and preterm birth. The global burden of disease attributable to household air pollution from solid fuel combustion was estimated by the Global Burden of Disease study at approximately 2.3 million deaths annually, making it one of the leading environmental risk factors for mortality globally. In the CHT, the combination of nearly universal solid fuel cooking exposure with the extreme population density of indoor living spaces in bamboo structures, the absence of household-level ventilation improvements, and the absence of clean cooking fuel alternatives (LPG and improved cookstoves remain rare in remote CHT communities), creates a household air pollution burden of severe magnitude that has not been systematically quantified in CHT-specific studies but is almost certainly among the highest in Bangladesh.

The respiratory health consequences of household air pollution in the CHT are amplified by several CHT-specific factors. First, the nutritional deficiency of the CHT population, particularly

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the high prevalence of stunting (chronic malnutrition), means that the respiratory reserve and immune defense capacity of CHT children are significantly compromised, making them more susceptible to serious respiratory outcomes from equivalent air pollution exposures compared with better-nourished children. Second, the jhum burning season creates a period of acute outdoor air quality degradation that is superimposed on the chronic indoor air quality burden, as described in Chapter One. Third, the physical characteristics of CHT bamboo housing, with its limited thermal mass and poor insulation, means that cooking fires must be maintained for longer periods to achieve and maintain cooking temperatures, increasing the duration of indoor pollutant generation. Fourth, the geographic isolation of CHT communities limits access to biomedical care for respiratory illness, increasing the likelihood that acute lower respiratory infections will progress to severe pneumonia before the patient receives appropriate antibiotic treatment.

6.3 Water Quality and the WASH Crisis

The water, sanitation, and hygiene (WASH) situation of the CHT, described in its quantitative dimensions in Chapter Five, requires deeper exploration of its causal structures and its ecological context in order to develop effective interventions. The water quality challenges of the CHT are fundamentally different from those of the Bangladesh plains in their physical, chemical, and microbiological character, and they demand solutions designed specifically for the CHT's ecological and social context rather than simple adaptations of plains-WASH program models. In the CHT, the primary water sources are rivers, streams, hill springs, and rainwater, in contrast to the groundwater sources (tube wells) that provide the primary drinking water supply across most of the Bangladesh plains. This difference has profound implications for both the nature of water quality threats and the appropriate technological responses. The arsenic contamination of groundwater that affects tens of millions of people in the plains of Bangladesh is essentially irrelevant in most of the CHT, where groundwater is rarely accessed because the hard rock geology of the hills makes shallow tube well sinking impossible in many areas and the population relies on surface and spring water instead. The water quality threats specific to CHT surface and spring sources include microbiological contamination from fecal pollution (particularly from open defecation in settlements without adequate sanitation), turbidity and associated pathogen co-transport during heavy rainfall events (which cause surface runoff that carries both suspended organic matter and enteropathogens from open defecation sites and agricultural areas into streams and rivers), and occasional natural chemical quality concerns from geologically derived trace elements in hill springs.

The monsoon season creates a particularly severe water quality challenge in the CHT. The high-intensity rainfall events that characterize the CHT monsoon (Bandarban district receives among the highest annual rainfall in Bangladesh, with some years exceeding 4,000 millimeters of annual precipitation) generate intense surface runoff that dramatically increases the turbidity of all surface water sources, elevates pathogen concentrations through fecal matter mobilization, and can overwhelm spring catchments with surface contamination. The post-monsoon period is often when diarrheal disease incidence peaks, as contaminated water consumed during and immediately after heavy rain events produces illness in the following days and weeks. The management of this monsoon-season water quality crisis requires a combination of household-

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level water treatment (such as boiling or solar disinfection for those communities that can consistently apply these practices), point-of-source protection and improvement (spring box construction, intake protection, and basic filtration for community springs), and community-level WASH education appropriately adapted to the cultural and linguistic contexts of CHT indigenous communities. The language barrier between Bangla-medium WASH education materials and indigenous community members who speak Chakma, Marma, Tripuri, or other indigenous languages as their primary means of communication represents a significant impediment to the effectiveness of WASH education programs in the CHT that has been consistently documented in the qualitative health research literature.

6.4 Deforestation, Land Degradation, and Health

The deforestation of the CHT, which has proceeded at an accelerating rate since the colonial period and most dramatically since the 1970s as a consequence of the resettlement program, intensified jhum cultivation, commercial timber extraction, rubber plantation establishment, and military clearance of forest in strategic areas during the conflict period, represents one of the most serious environmental health challenges facing the CHT. The relationship between deforestation and health in the CHT operates through multiple pathways. First, deforestation destroys the habitat of the medicinal plants that form the pharmacopoeia of the CHT ethnomedicinal complex, reducing the therapeutic resources available to Baiddya practitioners and increasing community dependence on biomedical pharmaceuticals that are frequently unavailable, unaffordable, or inappropriately supplied in remote areas. Second, deforestation degrades the water quality of CHT rivers and streams by eliminating the forest cover that regulates infiltration, retards surface runoff, and provides riparian buffer zones that filter agricultural and fecal pollutants from water coursing over the landscape before it reaches stream channels. Third, deforestation alters Anopheles vector habitat in complex ways: in some cases, it may reduce vector density by eliminating the shaded, forested streams preferred by Anopheles dirus, but in other cases, it creates new breeding habitats in the form of open, sun-exposed pools that support other Anopheles species, and the forest-edge interface created by partial deforestation is documented in the literature as a zone of particularly high Anopheles density and malaria transmission intensity. Fourth, deforestation reduces the availability of wild foods (fruits, vegetables, mushrooms, small game, insects) that have historically provided nutritional supplementation to CHT communities during the pre-harvest lean season, contributing to the nutritional insecurity documented in the recent literature.

A critical ethnographic study published in April 2025, examining the impacts of climate change and environmental degradation on indigenous communities in the CHT, documented the lived experiences of environmental change in CHT indigenous households. The study found that extreme heat, unpredictable rainfall patterns, and land degradation were the primary environmental stressors identified by indigenous community members, including Garo and Hajong communities in and around the CHT. The study highlighted the compounding effects of climate change (which alters rainfall timing and intensity, increases temperature, and shifts the seasonal calendar in ways that disrupt traditional agricultural calendars) and direct environmental degradation (through deforestation, soil erosion, and water source pollution) on the health and livelihoods of CHT indigenous communities. Climate change represents an emerging amplifier

of all pre-existing environmental health risks in the CHT: it intensifies the monsoon flooding that degrades water quality, increases the temperature conditions that accelerate Plasmodium development within Anopheles vectors and extend the malaria transmission season, exacerbates food insecurity by disrupting jhum harvest timing, and increases the frequency and severity of extreme weather events (including landslides, which are a recurring cause of injury, displacement, and infrastructure destruction in the CHT hill terrain) that have direct and immediate health consequences.

6.5 Occupational Health in the CHT

The occupational health of CHT indigenous communities has received essentially no systematic academic attention despite the presence of significant occupational health risks inherent in the primary occupational activities of the CHT population. Jhum agriculture involves a range of occupational hazards including exposure to venomous snakes and insects during field clearance and cultivation (snakebite is a significant cause of morbidity and mortality in the CHT, with inadequate antivenom availability at most CHT health facilities constituting a critical gap in clinical management capacity), physical injury from the manual labor of slope clearance and soil preparation on steep terrain (musculoskeletal injuries, particularly to the back and lower limbs, are prevalent among adult jhum farmers), exposure to agricultural pesticides (used increasingly in CHT jhum and garden cultivation, with evidence that misuse of organophosphate and pyrethroid compounds is occurring in some communities), and smoke inhalation during the burning phase. Forest work, including timber collection, bamboo harvesting, rattan collection, and forest product gathering, which provides supplementary income for many CHT households, involves risks of falls, cuts and puncture wounds, animal encounters, and exposure to forest-associated vector-borne diseases. River and lake fishing, the primary livelihood of many Kaptai Lake-adjacent communities, involves drowning risk (particularly during monsoon season when river currents are powerful and unpredictable), prolonged sun exposure (with implications for skin cancer risk, cataract development, and heat illness), and immersion in water of variable microbiological quality. Domestic labor, performed predominantly by women, involves the greatest household air pollution exposure and the physical hazards of cooking, water collection (which often requires carrying heavy loads over long distances in difficult terrain), and childcare in resource-poor conditions.

MODEL EXAMINATION QUESTIONS: CHAPTER SIX

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

1. The Environmental Burden Accumulation Principle holds that in resource-poor communities, environmental health exposures: a) Cancel each other out through biological antagonism b) Operate in isolation from each other and can be analyzed independently c) Accumulate across multiple simultaneous pathways, creating a composite burden greater than the sum of individual components d) Are less severe than in urban environments due to lower industrial pollution levels (Correct Answer: c)

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2. The primary water quality concern in CHT surface water sources is DIFFERENT from the primary concern in Bangladesh plains groundwater. The plains concern is arsenic. The primary CHT surface water concern is: a) Fluoride toxicity b) Heavy metal contamination from mining c) Microbiological contamination from fecal pollution, particularly elevated during monsoon season d) Industrial organic chemical contamination (Correct Answer: c)
3. Chronic exposure to smoke from wood cooking fires in CHT bamboo households is most strongly associated with increased risk of which condition in adult women? a) Osteoporosis and calcium deficiency b) Chronic obstructive pulmonary disease (COPD) and lung cancer c) Diabetes mellitus type 2 d) Iron deficiency anemia (Correct Answer: b)
4. Landslides in the CHT hill terrain represent which category of environmental health hazard? a) Chemical hazard b) Biological hazard c) Geophysical/Physical hazard d) Radiological hazard (Correct Answer: c)
5. The WHO-defined threshold for minimum dietary diversity in children is consumption of at least how many food groups in the preceding 24 hours? a) Two of five food groups b) Three of six food groups c) Four of seven food groups d) Five of eight food groups (Correct Answer: c)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

6. A CHT epidemiologist investigating a cluster of severe acute respiratory infections in children in a remote Bandarban community during the jhum burning season (February to April) should consider which combination of exposure pathways as the most likely contributing factors? a) Waterborne contamination and foodborne pathogens only b) Indoor air pollution from wood cooking fires (chronic baseline) superimposed with outdoor PM2.5 exposure from jhum burning smoke, in the context of nutritional compromise (stunting) that reduces respiratory reserve and immune defense c) Occupational chemical exposure from pesticides used in jhum fields d) Volcanic gas emissions from underground geothermal sources (Correct Answer: b)
7. The relationship between deforestation and Anopheles malaria vector density in the CHT is best described as: a) Always inversely related (more deforestation uniformly reduces vector density) b) Always directly related (more deforestation uniformly increases vector density) c) Complex and context-dependent: deforestation may reduce Anopheles dirus habitat while creating new breeding conditions for other species, and forest-edge interfaces are zones of particularly high transmission intensity d) Unrelated, because Anopheles breeding is determined by rainfall alone (Correct Answer: c)
8. A 35-year-old male jhum farmer in Khagrachhari presents with acute systemic illness following a snake bite sustained while clearing a jhum field. The clinician at the nearest upazila health complex finds no antivenom available in the facility. This situation reflects which domain of the Terrain-Conditioned Pathology framework? a) Topographic Pathology b) Psychoecological Pathology c) Pharmaceutical Access Pathology d) Hydrological Pathology (Correct Answer: c)

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CHAPTER SEVEN: DIAGNOSIS IN THE CHT: PRINCIPLES, BARRIERS, PROTOCOLS, AND CONTROVERSIES

7.1 The CHT Diagnostic Philosophy

Diagnosis, in the context of the CHT, cannot be reduced to the application of textbook algorithms to presenting symptoms in a well-equipped clinical setting, because the CHT is not a well-equipped clinical setting and its patients do not arrive with the pre-diagnostic histories, documented medication lists, and prior investigation results that textbook diagnostic algorithms presuppose. The CHT demands a diagnostic philosophy adapted to conditions of resource scarcity, geographic constraint, linguistic diversity, cultural specificity, and epidemiological particularity. This textbook articulates what it calls the CHT Contextual Diagnostic Doctrine, which holds that effective clinical diagnosis in the CHT requires the integration of four knowledge domains: the universal biomedical knowledge domain (the clinical science of disease that is applicable everywhere), the CHT epidemiological domain (the specific disease prevalence, risk factor distribution, and clinical presentation patterns that characterize the CHT as a distinct medical geography), the CHT sociocultural domain (the understanding of how CHT patients from different ethnic communities present, narrate, and contextualize illness, and how cultural and linguistic factors shape both the diagnostic encounter and the treatment relationship), and the CHT resource domain (the realistic assessment of what diagnostic tools, laboratory capabilities, imaging, and referral resources are actually available in the specific clinical context in which the diagnosis is being made).

The CHT Contextual Diagnostic Doctrine makes a specific claim that distinguishes it from generic resource-limited medicine frameworks: in the CHT, epidemiological knowledge is a diagnostic tool of equal or greater importance than laboratory investigation. When the pretest probability of a specific diagnosis is very high based on the epidemiological context (for example, a febrile patient from a forest valley community in Rangamati during June to August has a high pre-test probability of P. falciparum malaria), this probability must be integrated into the diagnostic process in a way that justifies empirical treatment even when confirmatory laboratory testing is unavailable or delayed. Conversely, when a condition with low prior probability in the CHT context produces a positive laboratory result, the clinician must consider the possibility of false positivity before committing to a potentially harmful treatment. This probabilistic, epidemiologically informed diagnostic approach is not a compromise of diagnostic rigor. It is the appropriate application of Bayesian reasoning to the clinical problem, and it produces better diagnostic outcomes than either reflexive empiricism (treating without investigation regardless of circumstances) or paralytic investigation-dependence (refusing to treat without laboratory confirmation regardless of clinical and epidemiological evidence).

7.2 The Diagnostic Cascade in CHT Clinical Practice

The diagnostic cascade in CHT clinical practice refers to the sequential series of investigative and inferential steps through which the clinician moves from the initial clinical presentation to a diagnosis that is sufficiently certain to guide treatment, adapted to the resource realities of the CHT setting. The CHT diagnostic cascade has five levels. The first level is History and Clinical

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Context, encompassing the collection of a comprehensive and culturally informed clinical history, including the patient's community of origin (which provides essential epidemiological context), occupation (which identifies occupational risk factors), residential area and household conditions (which inform environmental risk factor assessment), travel history (which identifies potential disease importation from neighboring Myanmar or other areas), illness chronology (which distinguishes acute from subacute and chronic presentations), and the patient's pre-existing health conditions and current medications. At this level, the awareness that many CHT patients may have previously sought treatment from traditional healers and may have received botanical preparations that could interact with biomedical medications (for example, some CHT ethnomedicinal plants have cytochrome P450 inhibitory activity that could affect the metabolism of artemether-lumefantrine) is clinically important and should prompt specific inquiry.

The second level of the cascade is the Physical Examination, which in the CHT context must be both comprehensive and systematically focused on the disease presentations most likely given the epidemiological context. For a febrile patient in the CHT, the physical examination must specifically assess for the signs of complicated P. falciparum malaria (reduced consciousness level, focal neurological signs, respiratory distress, jaundice, pallor of severe anemia, convulsions, abnormal bleeding, pulmonary edema signs), which indicate cerebral malaria, severe malarial anemia, or other end-organ complications that require immediate referral to a higher-level facility for intensive care management. The peripheral blood smear examination remains a core component of the physical examination in the CHT context, where the clinical skills of film preparation, staining, and microscopic examination of thick and thin blood films for malaria parasites should be regarded as mandatory competencies for all physicians practicing in malaria-endemic areas of the territory. The third level of the cascade is Point-of-Care Diagnostics, encompassing the rapid diagnostic tests (RDTs) and other point-of-care tests that are available at or near the point of clinical contact. For malaria, the malaria RDT (based on detection of HRP2 antigen for P. falciparum or aldolase/pLDH for pan-Plasmodium detection) is the primary diagnostic tool in most CHT clinical settings and has largely replaced peripheral blood smear microscopy as the primary diagnostic modality in community and primary care settings, though it should be supplemented by microscopy when available for treatment monitoring and species confirmation. For tuberculosis, the GeneXpert MTB/RIF assay (a molecular test capable of detecting M. tuberculosis DNA and rifampicin resistance simultaneously in approximately two hours) represents the diagnostic gold standard that should be available at district hospitals; sputum smear microscopy remains the primary screening tool in lower-level facilities.

The fourth level of the cascade is Laboratory Investigation, encompassing the hematological, biochemical, microbiological, and immunological investigations available at the district hospital level and above. Complete blood count (CBC) with differential is essential for the assessment of the hemolytic anemia of malaria, the lymphopenia of viral infections, the eosinophilia of helminthic infections, and the neutrophilia of bacterial infections. Blood glucose measurement (particularly in febrile unconscious patients where hypoglycemia must be excluded, both as a primary cause of altered consciousness and as a complication of malaria itself and of quinine treatment for severe malaria) is a critical investigation in the CHT context. Liver function tests are relevant in severe malaria patients with jaundice, in the assessment of patients on potentially

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hepatotoxic medications (including anti-tuberculosis drugs), and in the evaluation of patients with suspected leptospirosis (a disease documented in CHT animal-contact communities). Sputum culture and sensitivity for M. tuberculosis is available at district hospital level in some CHT facilities, though the long turnaround time of conventional culture (four to eight weeks) limits its clinical utility for treatment initiation decisions. The fifth level of the cascade is Specialist Referral and Advanced Investigation, encompassing the assessment and investigation available at Chittagong Medical College Hospital (the primary tertiary referral center for the CHT) and at national referral centers in Dhaka, including neuroimaging, echocardiography, endoscopy, histopathology, and specialized microbiological and immunological investigations.

7.3 The Malaria Rapid Diagnostic Test: Performance, Limitations, and Interpretation in the CHT

The malaria rapid diagnostic test (malaria RDT) has transformed the diagnosis and management of malaria in resource-limited settings globally and has been central to the substantial progress achieved in malaria control in the CHT. However, the CHT clinician must have a thorough understanding of the performance characteristics, limitations, and potential pitfalls of malaria RDT interpretation in order to use this tool effectively and safely. Malaria RDTs based on detection of the P. falciparum-specific antigen HRP2 (Histidine-Rich Protein 2) are the most widely used format in the CHT and have high sensitivity (greater than 95 percent) and specificity (greater than 90 percent) for the detection of P. falciparum at parasite densities above approximately 200 parasites per microliter when tested against reference standard microscopy. However, several important limitations apply. First, HRP2-based RDTs may remain positive for days to weeks after treatment of P. falciparum malaria due to the persistence of HRP2 antigen in the circulation even after parasites have been cleared, which can lead to false interpretation of treatment failure (the post-treatment RDT positive being attributed to persistent infection rather than antigen persistence). Second, deletions in the hrp2 gene have been documented in P. falciparum populations in several countries in South Asia and the Greater Mekong Subregion, producing HRP2-negative P. falciparum strains that are not detected by HRP2-based RDTs. The prevalence of hrp2 gene deletion in CHT P. falciparum isolates has not been systematically studied, but given the proximity of the CHT to the Mekong subregion where these deletions are documented, this represents a significant concern for diagnostic validity. Third, very high parasite densities (prozone effect) can occasionally produce false-negative HRP2-based RDT results. The combination of these limitations means that in a CHT patient with a clinical presentation strongly consistent with P. falciparum malaria but a negative HRP2-based RDT, alternative testing (pan-pLDH RDT or blood smear microscopy) is indicated rather than dismissal of the malaria diagnosis.

7.4 Barriers to Diagnostic Access in the CHT: Structural, Geographic, and Linguistic

The barriers to diagnostic access in the CHT represent a multilayered and mutually reinforcing system of constraint that produces the delayed and incomplete diagnosis profile documented in the CHT health literature. Geographic barriers are the most frequently cited and most visually dramatic. The combination of mountainous terrain, poor road quality (many CHT roads are unpaved or seasonally impassable), river crossings without bridge infrastructure, and the vast

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distances between remote settlements and health facilities creates a physical barrier to diagnostic access of immense clinical significance. The reported case of Ngangoi Mro walking four kilometers through difficult terrain and then taking a vehicle to reach the clinic with his sick two-year-old son during the 2025 measles outbreak, at a time when the child was already seriously ill, illustrates at the human level what the statistics describe at the population level. The financial barrier to diagnostic access is closely related to the geographic barrier, because seeking care at a health facility requires not only the user fee for the clinical consultation and investigations but also the transport cost (the council head of Kurukpata explicitly noted during the 2025 measles crisis that farmers in the area "cannot afford even boat or motorcycle fares to reach the hospital"), the opportunity cost of time away from agricultural labor during the planting or harvesting season when that labor is most critical, and the cost of accompanying family members who must take time from their own work. The linguistic barrier to diagnostic access operates at the point of clinical contact as well as at the level of public health communication. Most government health workers in the CHT are Bangla speakers with no training in indigenous languages, and most CHT indigenous patients from rural communities have limited or no Bangla proficiency. This linguistic mismatch makes the clinical history-taking process inaccurate and incomplete, complicates the physical examination process (particularly for history of pain, symptom character, and duration), and severely limits the communication of diagnostic findings and treatment instructions from clinician to patient. The cultural barrier to diagnostic access involves the indigenous communities' experience of institutional distrust (rooted in the political history of the CHT), the cosmological interpretation of illness that may lead patients to seek traditional healing as a first-line response, gender norms that restrict women's autonomous healthcare-seeking (particularly for reproductive health conditions), and the stigma associated with certain diagnoses (such as mental illness and sexually transmitted infections) that leads patients to avoid seeking diagnosis even when access would otherwise be possible.

7.5 Case Study: Diagnosis and Management of Severe Malaria in a Remote CHT Setting

A case study provides the clinical grounding for the diagnostic principles articulated in this chapter. A 24-year-old male Marma jhum farmer from a remote village in Alikadam upazila, Bandarban, is brought to the Alikadam Upazila Health Complex by family members on an early August morning. The patient is severely obtunded (GCS 8/15), febrile (axillary temperature 39.8 degrees Celsius), pale, and mildly jaundiced. According to the family, he had been unwell with fever for five days, initially treated with herbal preparations by the local Baiddya, but had deteriorated rapidly in the past 24 hours with increasing confusion and one witnessed convulsion. The family reports that several other men in the same village had had similar febrile illness in the past week, with most recovering after oral artemether-lumefantrine obtained from a BRAC shasthya shebika. Examination reveals a pulse of 112 beats per minute, blood pressure of 90/60 mmHg, respiratory rate of 24 breaths per minute, moderate conjunctival pallor, mild scleral icterus, and a fever. Neurological examination shows bilateral Babinski responses. Blood glucose on bedside glucometer is 2.8 mmol/L (hypoglycemia).

Applying the CHT Contextual Diagnostic Doctrine: the history provides strong epidemiological support for P. falciparum malaria (endemic area, August peak season, cluster of febrile illness in the community, prior malaria in the village), and the clinical presentation (febrile obtundation

with convulsion, anemia, jaundice, and hypoglycemia in a previously healthy young man) is classic for severe complicated P. falciparum malaria with cerebral manifestation. A malaria RDT (HRP2/pLDH combination) is performed, returning positive for P. falciparum. The clinician at the UHC correctly identifies this as a case of severe malaria requiring parenteral artesunate as the first-line treatment for severe malaria globally and in Bangladesh, correct immediate management of hypoglycemia with IV dextrose (50 mL of 50% dextrose IV immediately, followed by 10% dextrose infusion), anticonvulsant therapy for convulsion management (diazepam IV or rectal for immediate convulsion control, with phenobarbitone for continued seizure prophylaxis in cerebral malaria), careful fluid management (avoiding fluid overload in cerebral malaria where cerebral edema may be present), and urgent referral to Chittagong Medical College Hospital for intensive care management. The decision to initiate parenteral artesunate at the UHC rather than waiting for referral is correct and is supported by the WHO guidelines on severe malaria, which recommend initiating parenteral treatment immediately and continuing during transfer, since delay of artesunate treatment in cerebral malaria measurably increases mortality.

MODEL EXAMINATION QUESTIONS: CHAPTER SEVEN

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

1. The Glasgow Coma Scale (GCS) score of 8/15 in the case study patient indicates: a) Normal conscious level b) Mild impairment of consciousness c) Severe impairment of consciousness, below the threshold of 9 that defines severe altered consciousness d) Irreversible brain damage (Correct Answer: c)
2. In the case study patient with severe P. falciparum malaria, the blood glucose level of 2.8 mmol/L indicates: a) Normal blood glucose b) Hypoglycemia, requiring immediate IV dextrose administration c) Diabetic hyperglycemia requiring insulin d) Pseudo-hypoglycemia from sampling error (Correct Answer: b)
3. The first-line treatment for severe complicated P. falciparum malaria as per current WHO guidelines is: a) Oral artemether-lumefantrine b) Intramuscular quinine c) Parenteral artesunate (IV or IM) d) Intravenous chloroquine (Correct Answer: c)
4. HRP2-based malaria RDTs may remain positive after successful treatment of P. falciparum malaria due to: a) Reinfection with a new malaria strain b) Persistence of HRP2 antigen in circulation after parasitological clearance c) Development of drug resistance d) Cross-reactivity with P. vivax antigens (Correct Answer: b)
5. The five levels of the CHT diagnostic cascade in order are: a) Laboratory investigation, history, physical examination, RDT, referral b) History and clinical context, physical examination, point-of-care diagnostics, laboratory investigation, specialist referral and advanced investigation c) Symptom recognition, treatment initiation, dose adjustment, follow-up, referral d) RDT, microscopy, culture, imaging, biopsy (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

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6. A clinician at a CHT upazila health complex encounters a patient from a forest valley community in August with a clinical presentation highly consistent with complicated P. falciparum malaria, but the HRP2-based malaria RDT returns negative. The most appropriate next step is: a) Accept the RDT result as definitive, exclude malaria, and treat for alternative febrile illness b) Perform a pan-pLDH RDT or blood smear microscopy to investigate the possibility of HRP2-gene-deletion P. falciparum or an RDT false-negative result, given the high clinical pretest probability c) Initiate empirical antimalarial treatment without further investigation based on clinical judgment alone d) Refer immediately to district hospital without initiating any treatment (Correct Answer: b)
7. The bilateral Babinski (extensor plantar) response documented in the case study patient with cerebral malaria indicates: a) Normal finding in an obtunded patient b) Upper motor neuron involvement consistent with cerebral dysfunction in complicated malaria c) Peripheral neuropathy from malnutrition d) Drug toxicity from previous antimalarial treatment (Correct Answer: b)
8. Which of the following anticonvulsant drugs is recommended for immediate seizure control in a CHT UHC setting where IV access has been established, in a patient with cerebral malaria experiencing acute convulsion? a) Phenytoin IV loading dose b) Diazepam IV c) Sodium valproate IV d) Levetiracetam IV (Correct Answer: b)

CHAPTER EIGHT: MENTAL HEALTH, TRAUMA, AND PSYCHOSOCIAL WELLBEING IN THE CHT: THE INVISIBLE EPIDEMIC

8.1 The Mental Health Epidemiology of Political Violence and Displacement

The mental health consequences of the political history of the CHT represent one of the most profoundly underaddressed dimensions of health in the territory, and one that is insufficiently represented in both the academic literature and the public health policy discourse. The combination of the Kaptai Dam displacement (which affected an estimated 100,000 people and destroyed the ancestral homeland of the Chakma community in a single catastrophic event), the armed conflict period from 1975 to 1997 (during which an estimated 40,000 to 60,000 people were killed, according to various sources, with hundreds of thousands displaced and subjected to systematic violence), and the ongoing experience of land insecurity, political marginalization, and ethnic discrimination in the post-Accord period, has created conditions for the development of population-level mental health consequences of extraordinary severity. Post-traumatic stress disorder (PTSD), major depressive disorder, generalized anxiety disorder, complex trauma (characterized by pervasive dysregulation of emotion, identity, and interpersonal functioning arising from prolonged exposure to severe trauma in the context of interpersonal violence or captivity, a concept increasingly formalized in ICD-11 as Complex PTSD or CPTSD), and what the mental health literature increasingly recognizes as "moral injury" (the psychological damage produced by participation in or witnessing of acts that violate one's deeply held moral values) have all been theorized as consequences of the CHT conflict experience.

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Intergenerational trauma transmission, the process through which the psychological consequences of severe trauma are transmitted from directly traumatized individuals to their children and grandchildren through epigenetic mechanisms, attachment disruption, altered parenting behavior, and the transmission of narratives and schemas of threat and loss, is a key concept for understanding the contemporary mental health landscape of the CHT. The children of individuals directly traumatized by the Kaptai displacement (now adults in their fifties and sixties) and the children of conflict-period survivors (now adults in their twenties and thirties) carry within them the epigenetic and developmental consequences of their parents' and grandparents' experiences, manifesting as elevated rates of anxiety, emotional dysregulation, attenuated stress resilience, and heightened biological reactivity to perceived threat. This intergenerational transmission of trauma has direct clinical implications: the elevated baseline stress and anxiety of CHT indigenous community members, particularly those from communities most directly affected by political violence, influences their immune function, their pain perception, their treatment adherence, and their engagement with health services in ways that cannot be fully understood without awareness of this traumatic history. The clinician who treats a CHT indigenous patient without this awareness is working with an incomplete model of the patient's health determinants.

8.2 Substance Use Disorders and Mental Health in the CHT

Substance use disorders, particularly alcohol use disorder, represent a significant and underacknowledged mental health burden in several CHT ethnic communities. The traditional fermented rice beer (broadly called Zu or Jum in Chakma, Marma, and related communities) has been brewed and consumed in CHT communities for centuries as a component of cultural ceremonies, social gatherings, and agricultural festivals. Traditional Zu consumption was regulated within the community by social norms governing the contexts of consumption and the quantities consumed, and it served important social bonding and ritual functions. The disruption of traditional social regulation mechanisms (through displacement, cultural disruption, political violence, and the weakening of community governance structures), combined with the increased availability of commercial alcohol (particularly cheap distilled spirits) in CHT markets as border controls have relaxed, has contributed in some CHT communities to a pattern of heavy and problematic alcohol consumption that exceeds traditional cultural norms. Alcohol use disorder in the CHT is associated with liver disease (hepatocellular damage and cirrhosis from chronic heavy alcohol consumption), domestic violence (with particular consequences for the health of women and children in affected households), nutritional deficiency (heavy alcohol consumption displaces caloric intake from nutritionally adequate food), mental health comorbidity (depression and anxiety both increase alcohol use and are worsened by it), and impaired engagement with healthcare services (including treatment adherence for conditions like tuberculosis, malaria, and hypertension).

Tobacco use, through both smoked (cigarette and local tobacco pipe) and smokeless forms, is prevalent across CHT communities and represents a major risk factor for several of the significant morbidities of the territory, including chronic obstructive pulmonary disease, lung cancer, oral and oropharyngeal cancer, cardiovascular disease, and adverse pregnancy outcomes. The smokeless tobacco traditions of several CHT communities, including the chewing of betel

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nut (Areca catechu) with tobacco and betel leaf (Paan), are deeply embedded in social interaction practices and are associated with an elevated risk of oral submucous fibrosis (a premalignant condition that significantly restricts mouth opening and is strongly associated with oral cancer) and oral squamous cell carcinoma. The oral cancer burden of the CHT, though not systematically quantified, is almost certainly significant given the prevalence of betel nut-tobacco chewing practices, and the absence of oral cancer screening programs and the extreme delay in presentation to specialist oncological services (due to the geographic and financial barriers documented across this textbook) means that most CHT oral cancer patients present at advanced stages when curative treatment is no longer feasible.

8.3 The Concept of Structural Suffering and Its Clinical Expression

Paul Farmer's concept of "structural violence," which refers to the systematic harm caused to people by social structures and institutions characterized by poverty, racism, political exclusion, and gender inequality, provides an important theoretical lens for understanding the mental health and psychosocial dimensions of health in the CHT. In the CHT, structural violence operates through the mechanisms of land alienation (which strips communities of their most fundamental economic and cultural resource), political marginalization (which denies communities effective voice in decisions that determine their lives), institutional discrimination (which consistently provides inferior public services to indigenous communities compared with Bengali communities in the same geographic area), and the legacy of conflict violence (which has left a deep wound in the collective psyche of CHT indigenous communities that decades of inadequate post-conflict transitional justice have failed to address). The clinical expression of structural suffering in the CHT takes the form of elevated rates of depression, anxiety, substance use disorders, domestic violence, school drop-out (which has long-term health consequences through the pathway of low education and health literacy), and a pervasive sense of helplessness and hopelessness about the future that represents both a mental health condition in its own right and a barrier to effective engagement with preventive health behavior and healthcare services.

The Psychoecological Health Philosophy articulated in Chapter Three provides the framework for addressing structural suffering in clinical practice. The clinician who sees a depressed CHT indigenous adult is not seeing a patient with a purely biological condition treatable with antidepressants alone. The clinician is seeing a person whose depression is rooted in a specific historical, social, and ecological context of structural violence, and whose treatment must address the biological, psychological, and social dimensions of their suffering simultaneously. This does not mean that antidepressants are inappropriate (they may be an important component of treatment for many patients), but it does mean that antidepressants alone, without addressing the psychosocial context of the patient's suffering, are an inadequate and ethically incomplete response. The integration of psychological support (particularly narrative therapy and community-based therapeutic models that allow patients to situate their experiences within a coherent social and historical narrative), social support (strengthening family and community connections that have been disrupted by displacement and violence), livelihood support (addressing the economic insecurity that drives anxiety and hopelessness), and advocacy for structural change (land rights protection, political participation, non-discriminatory public

service delivery), within a comprehensive mental health response, represents the appropriate translation of the Psychoecological Health Philosophy into clinical practice.

MODEL EXAMINATION QUESTIONS: CHAPTER EIGHT

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

1. Complex PTSD (Complex Post-Traumatic Stress Disorder, CPTSD) is formalized in which diagnostic classification system? a) DSM-5 (Diagnostic and Statistical Manual of Mental Disorders, 5th edition) b) ICD-10 (International Classification of Diseases, 10th revision) c) ICD-11 (International Classification of Diseases, 11th revision) d) The Chinese Classification of Mental Disorders (CCMD-3) (Correct Answer: c)
2. Oral submucous fibrosis, a premalignant condition with high risk of oral cancer, is most strongly associated with which substance use practice prevalent in CHT communities? a) Heavy alcohol consumption b) Tobacco smoking only c) Betel nut (Areca catechu) chewing, particularly with tobacco d) Cannabis smoking (Correct Answer: c)
3. The concept of "moral injury" as a form of psychological harm refers to: a) Physical injury caused by morally reprehensible actors b) Psychological damage from participating in or witnessing acts that violate deeply held moral values c) Injury caused by unethical medical practitioners d) Legal liability arising from medical malpractice (Correct Answer: b)
4. The epigenetic transmission of trauma from parent to child refers to which mechanism? a) Genetic mutation caused by traumatic experience that is passed to offspring b) Chemical modifications of DNA or histone proteins that alter gene expression patterns in response to environmental stressors, and that can be transmitted to subsequent generations c) Direct psychological conditioning of children by traumatized parents d) Nutritional deficiencies caused by parental trauma that affect fetal development (Correct Answer: b)
5. Paul Farmer's concept of "structural violence" refers to: a) Physical violence committed by state military forces b) Systematic harm caused to people by social structures characterized by poverty, racism, political exclusion, and gender inequality c) Violence committed during natural disasters d) Psychological violence in intimate partner relationships (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

6. A CHT mental health program planner is designing a community-based intervention for depression among displaced Chakma community members in Rangamati. According to the Psychoecological Health Philosophy articulated in this textbook, the most comprehensive and ethically appropriate intervention should include which combination of components? a) Antidepressant medication distribution alone through mobile clinics b) Integration of antidepressant medication (where appropriate), narrative therapy and psychological support, community social support strengthening, livelihood support, and

advocacy for structural change including land rights protection c) Traditional healing ceremonies only, using indigenous Chakma ritual specialists d) Referral of all depressed patients to the Chittagong Medical College Hospital psychiatry department (Correct Answer: b)

7. Alcohol use disorder in CHT communities is most directly associated with which of the following health consequences? a) Increased susceptibility to malaria through alcohol-induced immune suppression, liver disease, domestic violence, nutritional deficiency, and impaired treatment adherence b) Improved social bonding and communal health through traditional ceremonial consumption c) Reduced anxiety and depression through alcohol's anxiolytic effects d) Cardiovascular protective effects similar to those reported for moderate alcohol consumption in Western populations (Correct Answer: a)
8. The narrative therapy approach to psychological support in CHT trauma populations is specifically appropriate because: a) It is the cheapest form of therapy available in resource-limited settings b) It allows patients to situate their individual experiences within a coherent social and historical narrative, which is particularly important for populations whose suffering has structural and collective dimensions c) It requires no trained therapist and can be self-administered d) It has the strongest evidence base for PTSD treatment compared with any other psychotherapy (Correct Answer: b)

CHAPTER NINE: REPRODUCTIVE HEALTH, MATERNAL MORTALITY, AND CHILD HEALTH IN THE CHT

9.1 The Maternal Health Crisis

Maternal health in the CHT represents a domain of both significant progress and persistent, deep inequality. The national maternal mortality ratio (MMR) of Bangladesh has declined dramatically over the past two decades, from an estimated 570 maternal deaths per 100,000 live births in 1990 to 163 per 100,000 live births in 2019 (World Bank data), one of the most rapid sustained declines in maternal mortality in global health history. However, this national progress has been unequally distributed, and the available evidence suggests that the MMR in CHT indigenous communities remains substantially higher than the national average, though precise CHT-specific MMR estimates are not available due to inadequate vital registration and cause-of-death data collection in the territory. The drivers of elevated maternal mortality in CHT indigenous communities include several factors that are specific to or particularly severe in the CHT context. The first is the extremely high proportion of births occurring without skilled attendance. In remote CHT communities, the majority of births are attended by traditional birth attendants (Dais) or by family members rather than by midwives, nurses, or physicians. While skilled Dais can provide competent management of normal deliveries, they are not equipped to manage obstetric emergencies (postpartum hemorrhage, eclampsia, obstructed labor, sepsis, and unsafe abortion complications), which together account for the overwhelming majority of maternal deaths globally and in Bangladesh.

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The management of obstetric emergencies in the CHT is further compromised by the terrain-driven access barriers that make emergency obstetric care (EmOC) facilities in district hospitals effectively unreachable from many remote communities. Postpartum hemorrhage, the leading single cause of maternal death globally, progresses from its onset to death within minutes to a few hours if untreated; if the patient is multiple hours away from the nearest facility capable of blood transfusion and surgical management, the window for life-saving intervention has typically closed before she arrives. Eclampsia (the neurological complication of preeclampsia, characterized by convulsions in association with hypertension and proteinuria in pregnancy or the immediate postpartum period) is a leading cause of maternal death in Bangladesh and carries particularly high mortality in the CHT because of the diagnostic challenge (blood pressure monitoring and urine dipstick testing for proteinuria are not available at the household level), the limited availability of magnesium sulfate (the first-line treatment for eclampsia prevention and treatment) in peripheral facilities, and the distance from definitive obstetric care. The CHT's high altitude areas add an additional risk factor for preeclampsia, since altitude-associated chronic hypoxia has been documented in the global literature to increase placental dysfunction and preeclampsia risk.

Malaria in pregnancy represents a CHT-specific obstetric risk of major significance. Pregnant women in malaria-endemic areas of the CHT are at elevated risk of P. falciparum malaria infection due to the pregnancy-associated expression of a unique placental chondroitin sulfate A (CSA) receptor that is preferentially parasitized by a CSA-binding variant of P. falciparum, a phenomenon known as placental malaria. Placental malaria produces placental dysfunction that causes intrauterine growth restriction (leading to low birth weight, the most significant predictor of neonatal and infant mortality), severe maternal anemia (as the placental malaria provokes an intense local inflammatory response that increases hemolytic destruction of erythrocytes), and elevated risk of preterm birth. The management of malaria in pregnancy in the CHT requires particular attention to drug safety: artemether-lumefantrine (the first-line treatment for uncomplicated P. falciparum malaria in non-pregnant adults and children in Bangladesh) has limited data on safety in the first trimester of pregnancy, and the alternative regimen (quinine plus clindamycin) is more complex, requires multiple daily doses, and is associated with more side effects, creating adherence challenges. Artesunate-based regimens are currently considered the preferred treatment for severe P. falciparum malaria in the second and third trimesters. Intermittent preventive treatment in pregnancy (IPTp) with sulfadoxine-pyrimethamine (SP), the WHO-recommended strategy for malaria prevention in pregnancy in sub-Saharan Africa, has not been widely implemented in Bangladesh, partly because SP resistance is common in Asian P. falciparum strains, and the optimal preventive strategy for malaria in pregnancy in the CHT context remains an area of clinical and research uncertainty.

9.2 Child Health, Vaccination, and the 2025 Measles Crisis

Child health in the CHT is shaped by the intersection of the nutritional deficiency, infectious disease burden, and healthcare access barriers documented throughout this textbook, and by the specific vulnerabilities of the pediatric age group to these compounded adversities. The under-five mortality rate (U5MR), the number of deaths occurring in children between birth and five years per 1,000 live births, is the internationally accepted summary measure of child health

status, and it is consistently higher in CHT indigenous communities than in the general Bangladesh population, though precise community-specific estimates remain unavailable. The leading causes of under-five mortality in the CHT include neonatal causes (prematurity and low birth weight, neonatal sepsis, birth asphyxia, and congenital abnormalities), pneumonia and acute lower respiratory infections, diarrheal diseases, malaria, and malnutrition (which contributes to mortality from all of the above as an underlying cause). Vaccine-preventable diseases, including measles, which were declining rapidly across Bangladesh as immunization coverage improved, represent a specific and newly urgent concern following the 2025 measles outbreak.

The 2025 measles outbreak in Bangladesh represents the most severe child health crisis in the CHT in the twenty-first century and provides a real-time case study of the structural failures that drive preventable child mortality in the territory. The outbreak, which began in mid-March 2025 and had produced nearly 35,000 suspected measles cases (primarily among children five years and younger) and 227 confirmed child deaths by early May 2025, was most severely concentrated in the Mro community of Kurukpata Union in Alikadam upazila, Bandarban. The epidemiological and public health analysis of this outbreak reveals a convergence of multiple systems failures operating simultaneously. The immunization coverage failure is the proximate cause: the children of Kurukpata and surrounding areas were largely unvaccinated against measles, leaving them fully susceptible to a highly transmissible virus (the basic reproduction number R0 of measles is among the highest of any known infectious pathogen, ranging from 12 to 18 in fully susceptible populations). The structural causes underlying this immunization coverage failure include geographic inaccessibility (Kurukpata is described by district health officials and community leaders as one of the most remote parts of Bangladesh, accessible only by foot or by boat at significant cost and difficulty), communication barriers (the Mro community communicates primarily in the Mro language, and health promotion and immunization outreach has been conducted in Bangla that most community members do not understand), vaccine hesitancy (documented among some Mro families due to distrust of government services and concern about adverse effects), and a chronic failure of the national immunization program to design and implement strategies specifically adapted to the needs of geographically and culturally distinct remote indigenous communities.

The clinical management of measles in CHT settings requires attention to the specific complications that account for the high case fatality ratio in malnourished populations. Measles itself is caused by the measles morbillivirus (Paramyxoviridae family) and causes a systemic viral illness characterized by the prodromal phase (fever, cough, coryza, and conjunctivitis), the appearance of Koplik spots (the pathognomonic enanthem appearing on the buccal mucosa two days before the rash), and the centrifugally spreading maculopapular erythematous rash beginning on the face and spreading to the trunk and extremities. In well-nourished, well-managed populations, measles has a low case fatality rate (less than 0.1 percent in high-income countries). In malnourished populations without access to supportive care, the case fatality rate rises dramatically, reaching 5 to 10 percent or more, because malnutrition impairs the immune response to the virus and increases the severity and frequency of measles complications, which include pneumonia (the most common cause of measles mortality), encephalitis (measles encephalitis occurs in approximately 1 in 1,000 cases and carries a mortality of 15 percent with survivors at high risk of permanent neurological sequelae), keratoconjunctivitis (which can

produce corneal scarring and blindness in vitamin A-deficient children, a particular concern in the CHT given the documented vitamin A deficiency prevalence in some communities), and cancrum oris (noma, a rapidly progressive gangrenous infection of the mouth associated with severe malnutrition and immune compromise).

Vitamin A supplementation is a cornerstone of measles management in resource-limited settings, recommended by WHO for all children with measles in countries where vitamin A deficiency is prevalent. A high dose of vitamin A (200,000 IU for children over one year, 100,000 IU for children six to twelve months, 50,000 IU for infants under six months) administered on two consecutive days at the time of measles diagnosis reduces measles mortality, the risk of ocular complications (particularly corneal ulceration and blindness), and the duration of illness. In the context of the 2025 CHT measles outbreak, ensuring universal vitamin A supplementation for all confirmed and suspected measles cases was a priority intervention, given the documented high prevalence of vitamin A deficiency among CHT indigenous children.

MODEL EXAMINATION QUESTIONS: CHAPTER NINE

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

1. Koplik spots, the pathognomonic enanthem of measles, appear: a) On the skin of the face, coinciding with rash onset b) On the buccal mucosa approximately two days before the rash appears c) On the palms and soles in the early prodromal phase d) On the soft palate in the late rash phase (Correct Answer: b)
2. The basic reproduction number (R0) of measles in a fully susceptible population is approximately: a) 1 to 2 b) 2 to 4 c) 5 to 7 d) 12 to 18 (Correct Answer: d)
3. The WHO-recommended vitamin A dose for a child over one year with measles in a setting where vitamin A deficiency is prevalent is: a) 50,000 IU on two consecutive days b) 100,000 IU as a single dose c) 200,000 IU on two consecutive days d) 500,000 IU as a single dose (Correct Answer: c)
4. Placental malaria preferentially involves parasitization of which receptor on placental syncytiotrophoblast cells? a) Duffy blood group antigen (DARC) b) Chondroitin sulfate A (CSA) c) CD36 d) ICAM-1 (Correct Answer: b)
5. Cancrum oris (noma), a rapidly progressive gangrenous infection of the mouth associated with severe malnutrition, is a recognized complication of which infectious disease in malnourished children? a) Malaria b) Tuberculosis c) Measles d) Typhoid fever (Correct Answer: c)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

6. A public health investigation of the 2025 measles outbreak in Kurukpata, Alikadam, identifies multiple simultaneous system failures. Rank the following contributing factors in order of their structural primacy as root causes (most fundamental to least fundamental): i. Geographic inaccessibility of Kurukpata preventing routine

immunization visits ii. Vaccine hesitancy among Mro families iii. Failure of the national immunization program to design strategies adapted to remote indigenous communities iv. Absence of a temporary immunization outreach camp in Kurukpata

Which ranking best represents the structural analysis articulated in this textbook? a) iv, ii, i, iii b) iii, i, ii, iv c) i, iv, iii, ii d) ii, iii, iv, i (Correct Answer: b)

7. The first-line regimen for treatment of uncomplicated P. falciparum malaria in a pregnant woman in the second trimester in Bangladesh is: a) Chloroquine (since it is the safest option in pregnancy) b) Sulfadoxine-pyrimethamine (IPTp standard) c) Quinine plus clindamycin (preferred over artemether-lumefantrine in the first trimester, but artesunate-based regimens are preferred for severe disease in second/third trimester; the national guideline should be consulted for current first-trimester guidance on uncomplicated malaria) d) Artemether-lumefantrine only (Correct Answer: c, noting the complexity and the need to consult current Bangladesh national malaria treatment guidelines)
8. A CHT neonatal health program identifies that 60% of births in a remote Bandarban community are occurring without skilled birth attendance. According to the evidence base for maternal and neonatal health in resource-limited settings, which single intervention would produce the greatest reduction in neonatal mortality in this community? a) Distribution of oxytocin for postpartum hemorrhage prevention to all Dais b) Establishment of antenatal care (ANC) with hypertension screening c) Training and continuous supportive supervision of traditional birth attendants (Dais) in essential newborn care (clean cord care, immediate drying and warming, early breastfeeding support) combined with clear protocols for emergency referral d) Vitamin A supplementation for all neonates (Correct Answer: c)

CHAPTER TEN: INFECTIOUS DISEASE EMERGENCIES, EPIDEMIC PREPAREDNESS, AND HEALTH SYSTEM RESILIENCE IN THE CHT

10.1 The Concept of CHT Health System Resilience

Health system resilience, defined in this textbook as the sustained capacity of the CHT health system to absorb, adapt, and recover from health shocks (including epidemic disease emergencies, natural disasters, and political crises) while maintaining the delivery of essential health services to all segments of the CHT population, is the organizing concept for this final chapter of Part One. The CHT health system, as characterized throughout this textbook, is a system under chronic and severe structural stress, operating with inadequate resources, fragmented governance, incomplete geographic coverage, linguistic and cultural misalignment with the populations it serves, and the historical legacies of political conflict and structural marginalization. In this context, health system resilience is not a technical attribute that can be built by purchasing equipment or training clinicians in isolation. It is a systemic property that emerges from the quality of the connections between all components of the health system, including formal government facilities, non-governmental health providers, traditional healers,

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community health workers, political governance structures, and the communities themselves. Strengthening CHT health system resilience requires simultaneous investment in the strengthening of each of these components and, most critically, in the quality of the connections between them.

The 2025 measles outbreak in the CHT provides a real-time case study for the analysis of health system resilience, and specifically for the analysis of how its failure in this context was both predictable and preventable. The outbreak revealed specific resilience failures in several domains. In the absorption domain (the system's capacity to continue functioning during the shock without complete breakdown), the revelation that the health system had no functioning immunization program in Kurukpata prior to the outbreak indicates a failure of routine health service delivery so fundamental that the system had no established capacity to absorb the shock of an introduced measles case. In the adaptation domain (the system's capacity to reconfigure its functioning in response to an emerging threat), the response to the outbreak included establishment of a temporary medical camp at Kurukpata primary school staffed with two medical officers, three senior nurses, one medical assistant, and one support staff with capacity for approximately thirty patients, which represented a reasonable adaptive response given available resources but was insufficient in scale for the magnitude of the outbreak and delayed by communication difficulties and administrative processes. In the transformation domain (the system's capacity to fundamentally redesign itself to perform better under future shocks), the long-term lessons of the 2025 outbreak, including the need for permanent health outreach strategies adapted to remote indigenous communities, linguistic and cultural competence in immunization program design, engagement of local leaders (karbaris and headmen) in health promotion, and recognition of specific communities as requiring special program targeting, must be translated into policy and program changes rather than being filed as emergency lessons and forgotten.

10.2 Epidemic Preparedness Principles for the CHT

Epidemic preparedness in the CHT context requires adaptation of the International Health Regulations (IHR 2005) framework and the WHO's Health Emergency and Disaster Risk Management (Health EDRM) framework to the specific ecological, geographical, cultural, and systemic characteristics of the CHT. Several CHT-specific epidemic preparedness principles apply. The Border Proximity Principle holds that the CHT's extensive borders with Myanmar and India create specific epidemic introduction risks that must be addressed through enhanced surveillance at the border areas, intelligence-sharing arrangements with health authorities in Chin State (Myanmar) and Mizoram (India), and specific protocols for the evaluation and management of patients presenting from border-crossing communities. Myanmar's health system has been severely compromised by the ongoing political crisis following the military coup of February 2021, and the displacement of large numbers of people from Chin State into CHT border areas creates conditions for the introduction of infectious diseases (including drug-resistant tuberculosis, cholera, and potentially other epidemic-prone pathogens) that require proactive surveillance and response capacity.

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The Community Engagement Imperative holds that in the CHT, where institutional trust among indigenous communities is compromised by the political history of the territory, epidemic preparedness and response activities that are conducted without meaningful community engagement are likely to fail. The 2025 measles outbreak response was impeded by vaccine hesitancy that arose partly from community distrust of government health programs, and the local response leadership correctly identified that awareness programs involving local public representatives, village chiefs (karbaris), and headmen should precede or accompany vaccine delivery. This lesson is not new: it has been documented in CHT health research over multiple decades and it applies to the management of all epidemic-prone conditions, from cholera to influenza to COVID-19. The effective engagement of traditional community leaders, religious figures (including Buddhist monks in Chakma, Marma, and Tanchangya communities), and trusted community health workers as health promotion partners is not an optional complement to epidemic response in the CHT. It is an operational prerequisite for the effectiveness of the response.

The Surge Capacity Asymmetry Principle holds that the CHT health system's surge capacity (the ability to expand service delivery beyond normal operating capacity to meet the demands of an epidemic or disaster) is most severely compromised precisely in the communities that face the highest epidemic risk. Kurukpata, the most remote and most immunization-coverage-deficient community in the CHT, where the 2025 measles outbreak was most concentrated, is also the community to which it is most logistically difficult to deploy additional medical personnel, supplies, and equipment at short notice. This asymmetry between epidemic risk and surge capacity must be addressed through pre-positioned health resources (stockpiles of essential medicines, vaccines, and supplies at locations accessible to remote communities), pre-established community health worker networks trained in epidemic recognition and response in the highest-risk communities, and standing rapid response protocols that can be activated without the delays of ad hoc administrative authorization.

10.3 COVID-19 and the CHT: Lessons from a Partially Documented Emergency

The COVID-19 pandemic of 2020-2022 reached the CHT with uncertain but likely significant impact on the indigenous communities of the territory. The CHT-specific data on COVID-19 incidence, severity, and mortality among indigenous communities are extremely limited, largely because the testing and surveillance infrastructure that would be required to generate these data was not established in the remote parts of the CHT during the pandemic period. However, several indirect effects of the COVID-19 pandemic on CHT health have been documented or can be inferred from the broader literature on COVID-19's health system impacts in resource-limited settings. The disruption of routine health services (including immunization programs, tuberculosis treatment services, malaria control activities, and antenatal care) during the pandemic period almost certainly created gaps in coverage that have had lasting consequences. The compression of routine immunization coverage that occurred during the COVID-19 pandemic period in Bangladesh (with EPI outreach activities suspended or reduced during lockdown periods) is one of the factors that has been cited as contributing to the immunization coverage gaps that left CHT children susceptible to the 2025 measles outbreak. Supply chain disruptions during the pandemic affected the availability of artemisinin-based combination

therapies, long-lasting insecticidal nets, and other essential malaria control commodities in the CHT. Economic disruptions reduced household income and food access, exacerbating the pre-existing nutritional vulnerability of CHT indigenous communities.

10.4 Emerging Infectious Disease Risks in the CHT

The CHT's geographic position at the interface of South Asia, Southeast Asia, and the eastern Himalayan foothills, its extensive border with Myanmar, its large and ecologically diverse forest zone, its complex network of human-animal-ecosystem interactions (including domestic animal keeping, hunting, and forest product collection), and its proximity to several of the world's most active emerging infectious disease hotspots creates a constellation of emerging infectious disease risks that demand proactive surveillance and preparedness attention. The Greater Mekong Subregion, which abuts the CHT's eastern border zone through Myanmar, is one of the global epicenters of emerging infectious disease emergence and of drug-resistant pathogen development, including the emerging artemisinin resistance in P. falciparum that represents the most urgent current threat to malaria treatment globally. The CHT forest zone, with its rich biodiversity of mammalian and avian reservoir hosts, is a potential site for zoonotic disease spillover events. Nipah virus, a paramyxovirus transmitted from fruit bats (Pteropus species) to humans through consumption of contaminated date palm sap or through direct contact with infected bats, has caused repeated outbreaks in Bangladesh, primarily in the northwestern districts, and has a bat reservoir that is also present in the CHT forest zone. Highly Pathogenic Avian Influenza (HPAI, particularly H5N1), which has caused sporadic human infections across South and Southeast Asia through contact with infected poultry or wild birds, represents a risk in CHT communities where domestic poultry keeping is ubiquitous and contact between domestic and wild birds occurs in the forest-edge environment. The systematic surveillance for novel emerging infectious diseases in the CHT, through enhanced sentinel surveillance in forest-edge communities, zoonotic disease monitoring in domestic and wild animal populations, and strengthened One Health connectivity between human health, animal health, and environmental health monitoring systems, represents a priority investment for the long-term health security of the CHT.

MODEL EXAMINATION QUESTIONS: CHAPTER TEN

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

1. The International Health Regulations (IHR 2005) were adopted in which year? a) 1969 b) 1990 c) 2005 d) 2010 (Correct Answer: c)
2. Nipah virus is transmitted to humans from its primary reservoir host, which belongs to which genus of bats? a) Rhinolophus (horseshoe bats) b) Pteropus (flying foxes/fruit bats) c) Myotis (mouse-eared bats) d) Tadarida (free-tailed bats) (Correct Answer: b)
3. The Surge Capacity Asymmetry Principle as defined in this textbook states that in the CHT, health system surge capacity is: a) Highest in the communities with the greatest epidemic risk b) Proportional to the population size of each community c) Most severely

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compromised precisely in the communities that face the highest epidemic risk d) Adequate everywhere due to NGO support (Correct Answer: c)

4. Drug-resistant tuberculosis, specifically MDR-TB, is defined as resistance to at minimum which drugs? a) Isoniazid and ethambutol b) Isoniazid and rifampicin c) Rifampicin and pyrazinamide d) Streptomycin and para-aminosalicylic acid (Correct Answer: b)
5. Highly Pathogenic Avian Influenza (HPAI) in the CHT context is primarily associated with which exposure route in humans? a) Mosquito biting b) Contaminated drinking water c) Contact with infected poultry or wild birds d) Person-to-person transmission through respiratory droplets (Correct Answer: c)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

6. A One Health approach to emerging infectious disease surveillance in the CHT would require integration of which monitoring systems? a) Human health surveillance only through hospital-based sentinel sites b) Human health surveillance, animal health surveillance (both domestic and wild), and environmental monitoring, connected through information-sharing protocols and joint response mechanisms c) Environmental monitoring and climate modeling only d) National and international border health screening programs only (Correct Answer: b)
7. The COVID-19 pandemic's most significant indirect health impact on CHT indigenous communities is best described as: a) Directly killing large numbers of CHT indigenous community members from COVID-19 itself b) Disruption of routine health services (including immunization, TB treatment, and malaria control), supply chain degradation, and economic disruption that amplified pre-existing vulnerabilities, with immunization gaps contributing to subsequent vaccine-preventable disease outbreaks including the 2025 measles crisis c) Improving health literacy and engagement with government health services through COVID-19 awareness campaigns d) Temporary reduction in malaria transmission due to COVID-19 lockdown-related reduction in movement between communities (Correct Answer: b)
8. The Community Engagement Imperative as articulated in this textbook holds that in epidemic response activities in the CHT: a) Community engagement is optional but helpful for improving public relations b) Community engagement is a technical supplement that can be added to standard epidemic response protocols if resources permit c) Meaningful community engagement, including activation of traditional community leaders, religious figures, and trusted community health workers as health promotion partners, is an operational prerequisite for the effectiveness of epidemic response in the CHT, not an optional complement d) Community engagement is inappropriate during acute epidemic emergencies where speed of response takes priority over consultation (Correct Answer: c)

EPILOGUE TO PART ONE: TOWARD A JUST AND EFFECTIVE HEALTH SYSTEM FOR THE CHITTAGONG HILL TRACTS

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The ten chapters of Part One of this textbook have established the foundational knowledge required to understand the health of the Chittagong Hill Tracts as a complex, historically determined, ecologically embedded, and politically conditioned reality. The territory's geomedicinal identity, its profound ethnomedicinal heritage, its extraordinary burden of infectious disease and malnutrition, its environmental health challenges, its diagnostic barriers, its mental health crisis rooted in political violence and structural suffering, its maternal and child health emergency, and its urgent need for epidemic preparedness and health system resilience have been explored through the integrated lens of the Terrain-Conditioned Pathology framework, the CHT Ecological Epidemiology Doctrine, the Psychoecological Health Philosophy, and the CHT Contextual Diagnostic Doctrine that constitute the original theoretical contributions of this textbook.

Several foundational principles emerge from Part One that will animate the remaining nine parts of this textbook. First, the CHT cannot be understood through a single discipline or a single theoretical lens. The health of its people is simultaneously a biological, ecological, social, political, psychological, and historical phenomenon, and the practitioner who approaches it with a single-discipline toolkit will always be missing something crucial. Second, indigenous knowledge, including the ethnomedicinal traditions of the CHT's eleven communities, is not a supplement to or a substitute for biomedical medicine. It is a co-equal knowledge system with distinct strengths and limitations, and the most effective and most ethical healthcare for CHT communities is healthcare that integrates the best of both traditions rather than privileging either at the expense of the other. Third, the health disparities experienced by CHT indigenous communities are not natural, inevitable, or acceptable. They are the products of specific historical decisions, ongoing policy failures, and structural inequalities that could be changed, and the clinician and public health practitioner who works in the CHT has both a professional and a moral obligation to understand the structural roots of the health disparities they encounter and to advocate for the structural changes required to address them. Fourth, the communities of the CHT are not passive victims of their circumstances. They are active agents who have developed sophisticated adaptive strategies for managing their health in conditions of extreme adversity, and who possess knowledge, resilience, and social capital that are powerful resources for health system strengthening when they are recognized, respected, and engaged rather than ignored or overridden.

Parts Two through Ten of this textbook will build on the foundations established here to develop in depth the clinical science, diagnostic protocols, public health strategies, policy analysis, and case study literature required for the comprehensive education of clinicians and public health practitioners who are committed to working for the health of the Chittagong Hill Tracts and its people. The work that lies ahead is large, the challenges are real, and the stakes, measured in the lives of children like Rengle Mro, carried four kilometers by his father to reach a clinic that was barely equipped to help him, are incalculable. This textbook is written in the conviction that better education produces better practitioners, and better practitioners save more lives, and that even in the most remote valley of the Chittagong Hill Tracts, every life is worth the full measure of the medical and public health knowledge that the world has accumulated, applied with the cultural sensitivity, the intellectual humility, and the moral courage that this extraordinary territory demands.

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PART ONE COMPREHENSIVE ASSESSMENT: INTEGRATIVE EXAMINATION QUESTIONS

Short Essay Questions for MBBS/BAMS/BUMS/BHMS Final Examinations:

1. Describe the concept of Terrain-Conditioned Pathology (TCP) and its five domains. Using the example of malaria in the Chittagong Hill Tracts, illustrate how the quadrilateral model of the CHT Ecological Epidemiology Doctrine extends beyond the classical epidemiological triad to produce a more comprehensive and operationally actionable understanding of disease distribution. (25 marks)
2. A 30-year-old Chakma woman presents to an upazila health complex in Rangamati at 28 weeks of pregnancy with fever, pallor, and reduced fetal movement. She reports having been unwell for three days with progressively worsening symptoms. She initially sought treatment from a local Baiddya healer and took a herbal preparation before attending the clinic. Describe your approach to this patient using the CHT diagnostic cascade, identifying the most important differential diagnoses in the CHT context, the diagnostic investigations you would prioritize, and the management principles you would apply. (25 marks)
3. Analyze the 2025 measles outbreak in Kurukpata, Alikadam, Bandarban, as a case study in health system failure. Identify the multiple system failures that contributed to the outbreak using the framework of health system resilience (absorption, adaptation, and transformation domains). What specific interventions at the health system, community, and policy levels would you recommend to prevent a similar outbreak in this community in the future? (25 marks)

Long Essay Questions for FCPS/MD/MPH Examinations:

4. The CHT's indigenous communities bear a disproportionate burden of malnutrition compared with the general population of Bangladesh. Drawing on data from the most recent published literature (2025), describe the epidemiological evidence for this disparity, analyze the multiple causative pathways operating through the domains of food production, market access, dietary diversity, and nutritional education, and develop a comprehensive evidence-based nutritional intervention program for a remote Bandarban community with high rates of childhood stunting and wasting. Your program should be adapted to the cultural, linguistic, and ecological context of the community and should address the structural determinants of malnutrition as well as the immediate nutritional deficiencies. (50 marks)
5. Construct a comprehensive environmental health assessment for a hypothetical remote valley community of 500 people in Khagrachhari district, consisting primarily of Tripura jhum farming households using wood for cooking, relying on a river stream for drinking water, with no sanitation facilities and living in bamboo housing structures with limited ventilation. Your assessment should apply the Environmental Burden Accumulation Principle to identify and characterize the composite environmental health risk profile of

this community, prioritize the environmental health risks by their contribution to the measurable disease burden, and propose an integrated environmental health intervention program addressing the highest-priority risks within the resource constraints typical of a remote CHT setting. (50 marks)

BIBLIOGRAPHY AND FURTHER READING FOR PART ONE

Note: The following represent key sources that have informed Part One. Students are encouraged to access original publications for detailed primary data and methodological details.

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PART TWO: CLINICAL DISEASE MANAGEMENT, DIAGNOSTIC PROTOCOLS, ADVANCED EPIDEMIOLOGY, AND THE PATHOLOGY OF COMMON CONDITIONS IN THE CHT

Foreword to Part Two

Part One established the conceptual, historical, ecological, and theoretical foundations necessary for medical and public health practice in the Chittagong Hill Tracts. It introduced the Terrain-Conditioned Pathology framework, the CHT Ecological Epidemiology Doctrine, the Psychoecological Health Philosophy, and the CHT Contextual Diagnostic Doctrine as original organizing principles for understanding health and disease in this extraordinary territory. It traced the arc of CHT clinical and public health history from the pre-colonial medical cosmos through colonial disruption, post-independence structural crisis, armed conflict, the 1997 Peace Accord, and the contemporary health system's persistent inequities. It established the epidemiological architecture of the territory's dominant disease burdens, introduced the ethnomedicinal complex of its indigenous communities, and concluded with the urgent lessons of the 2025 measles outbreak in Bandarban. Part Two now enters the clinical and biomedical engine room. Its purpose is to develop, with the rigor and depth that medicine demands, the clinical science of the diseases that kill and disable the people of the Chittagong Hill Tracts, to advance the diagnostic and therapeutic protocols appropriate to the CHT's specific ecological, geographical, and resource context, and to build the clinical reasoning architecture that allows the CHT practitioner to translate the theoretical insights of Part One into therapeutic action at the bedside. Part Two does not retreat from the structural, historical, and philosophical dimensions that Part One foregrounded. Clinical medicine in the CHT is never separable from those dimensions, and this textbook refuses the convenient but false separation between the science of disease mechanisms and the science of disease distribution and determinants. Every chapter of Part Two will integrate the clinical and the structural, the pharmacological and the epidemiological, the therapeutic and the preventive, because the patients who present to CHT clinicians exist simultaneously in all of these dimensions and they deserve a practitioner who can think and act across all of them.

CHAPTER ONE: ADVANCED MALARIA CLINICAL SCIENCE, DRUG RESISTANCE INTELLIGENCE, AND TREATMENT PROTOCOLS FOR THE CHT

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1.1 The Plasmodium Biology as a Clinical Foundation

The clinician who treats malaria in the Chittagong Hill Tracts must possess a more detailed understanding of Plasmodium biology than is routinely required in medical settings where malaria is merely one of many uncommon tropical diseases. In the CHT, malaria is the signature disease of the territory, the leading cause of hospital admission in the monsoon season, and the condition most likely to kill a patient if it is mismanaged, under-treated, or under-investigated. The clinical science of malaria management in the CHT begins with a precise and comprehensive understanding of the parasite's life cycle as it operates in the specific ecological conditions of the CHT forest valleys and river basins, because this life cycle determines every aspect of the clinical presentation, the diagnostic approach, the treatment protocol, and the prevention strategy that must be applied. Plasmodium falciparum, which accounts for approximately 80 to 90 percent of malaria infections in the CHT, completes its sexual cycle within the Anopheles mosquito (the sporogonic cycle) and its asexual replication cycle within the human host (the erythrocytic cycle). The parasite injected into the human host as sporozoites during the infective mosquito bite travels within minutes to the hepatocytes of the liver, where it undergoes the exoerythrocytic or pre-erythrocytic stage of development, replicating asymptomatically within liver cells over a period of approximately seven to fourteen days before releasing merozoites into the bloodstream. The invasion of red blood cells (erythrocytes) by these merozoites initiates the erythrocytic cycle, which is entirely responsible for the clinical manifestations of malaria, since it is the rupture of parasitized red cells that releases pyrogenic substances (including glycosylphosphatidylinositol toxins) that cause fever, the immune activation that causes the systemic inflammatory response, and the sequestration of infected erythrocytes in the microvasculature of the brain, kidney, lung, and placenta that causes the life-threatening complications of severe P. falciparum malaria. Understanding this biology at a mechanistic level transforms the clinical approach to malaria from a protocol-following exercise to a genuinely reasoned therapeutic interaction with the pathophysiology of the patient's illness, and this transformation is particularly important in the CHT where clinical decision-making must frequently proceed without the laboratory support that textbook protocols assume. The pre-erythrocytic stage of P. falciparum is clinically silent, which is why the incubation period of falciparum malaria (typically seven to fourteen days after infective mosquito bite, though it can extend to three months or more under some circumstances) is a period during which the patient feels entirely well despite active parasite replication in the liver. The erythrocytic cycle of P. falciparum has a period of approximately 48 hours, meaning that fever peaks (if the classic tertian pattern is present, which it frequently is not in hyperparasitemic infections where multiple cohorts of parasites are replicating asynchronously) occur every 48 hours, corresponding to the synchronous rupture of parasitized erythrocytes at the completion of each erythrocytic cycle. The CHT clinician must know that the classic tertian fever pattern of malaria is not a reliable distinguishing feature in practice, because many patients with confirmed P. falciparum malaria present with continuous or irregular fever rather than the 48-hour cycle, and the absence of the textbook pattern should not reduce the index of clinical suspicion for malaria in an appropriate epidemiological context. The gametocyte stage of P. falciparum, in which the sexual forms of the parasite develop within the human bloodstream before being taken up by the next feeding Anopheles mosquito, is clinically silent in the individual patient but epidemiologically critical for transmission, because gametocytes are not targeted by artemisinin-based combination

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therapies (which clear asexual erythrocytic forms) and can persist in the circulation for days to weeks after clinical cure, maintaining the patient's capacity to infect Anopheles mosquitoes during that period. This has direct public health relevance in the CHT: the single-dose primaquine (0.25 mg/kg) now recommended by WHO as a gametocytocidal addition to ACT for P. falciparum treatment (to accelerate gametocyte clearance and reduce onward transmission) should be considered as part of the CHT treatment protocol, with the caveat that G6PD testing at the available rapid quantitative level should be performed when feasible given the documented G6PD deficiency prevalence in CHT ethnic communities. The sequestration of P. falciparum-parasitized erythrocytes in the deep microvasculature, which is the central pathophysiological mechanism of severe falciparum malaria, occurs because P. falciparum-infected red cells express the adhesin molecule PfEMP1 (Plasmodium falciparum erythrocyte membrane protein 1) on their surface, which mediates cytoadherence to endothelial receptors including CD36, ICAM-1, thrombospondin, and in the placenta, chondroitin sulfate A. This sequestration removes parasitized cells from the peripheral circulation (producing the diagnostic phenomenon that peripheral blood parasitemia, as measured by blood smear or RDT, may underestimate total body parasite burden in severe malaria), creates local hypoxia and metabolic acidosis in sequestered microvascular beds, and triggers endothelial activation and the blood-brain barrier disruption that underlies cerebral malaria. Every one of these mechanisms has a clinical implication that must be understood and acted upon in the CHT clinical setting.

1.2 Redefining Uncomplicated and Severe Malaria in the CHT Context

The WHO classification of malaria as uncomplicated or severe is a foundational clinical tool, but in the CHT context it requires augmentation with CHT-specific risk stratification criteria that go beyond the standard WHO criteria to account for the access barriers, nutritional vulnerabilities, and clinical resource constraints that characterize the CHT health landscape. Uncomplicated malaria, defined in the WHO classification as symptomatic malaria without the features of organ dysfunction or severe parasite burden that define severe disease, is managed in the CHT overwhelmingly at the community level through oral artemether-lumefantrine administered by BRAC Shasthya Shebika community health workers following positive malaria RDT. This community-level treatment model has been the cornerstone of the dramatic malaria case reduction achieved in Bangladesh between 2008 and 2022, and the evidence base for its effectiveness is robust. The CHT-Augmented Severity Classification System proposed in this textbook adds two risk stratification categories to the WHO framework: the High-Risk Uncomplicated category, which encompasses patients with uncomplicated malaria by standard WHO criteria but who have one or more CHT-specific high-risk features (severe malnutrition, age under two years or over sixty years, confirmed or suspected pregnancy, hyperparasitemia above 2 percent without other WHO severe criteria, or residence more than two hours from a facility capable of parenteral treatment), and the Borderline Complicated category, which encompasses patients with a single WHO feature of severe malaria who are alert, cooperative, and able to swallow oral medication, and whose clinical trajectory over the first four hours of observation is stable or improving. The clinical rationale for the High-Risk Uncomplicated category is that these patients are at substantially elevated risk of rapid clinical deterioration to frank severe malaria, and they should be managed at or immediately referred to a facility capable of parenteral treatment even while oral ACT is initiated, rather than being sent home with oral

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medication alone as would be appropriate for standard uncomplicated malaria. The CHT experience confirms that patients in remote valley communities who develop severe malaria at home after being discharged with oral treatment for "uncomplicated" malaria frequently die during the transfer to a facility capable of parenteral therapy, because the transfer time in the CHT's terrain often exceeds the window for life-saving intervention. The definition of severe malaria in this textbook integrates the 2023 updated WHO criteria with CHT-specific clinical intelligence. The standard WHO severe malaria criteria include impaired consciousness or coma (any GCS below 15 with onset related to the malarial illness), prostration (inability to sit or stand without support), multiple convulsions (more than two in 24 hours), respiratory distress (deep breathing with acidotic pattern), acute pulmonary edema (radiological or clinical), hypoglycemia (blood glucose below 2.2 mmol/L), circulatory collapse (systolic BP below 70 mmHg in adults, with cold clammy skin), severe anemia (hemoglobin below 5 g/dL with parasitemia), jaundice (serum bilirubin above 50 micromol/L with parasitemia), hemoglobinuria (not from G6PD-related hemolysis), active bleeding, and hyperparasitemia (P. falciparum parasitemia above 10 percent in blood smear, or above 5 percent in non-immune patients). In the CHT context, severe anemia is of particular clinical significance because the baseline hemoglobin of many CHT indigenous community members is already below normal due to chronic nutritional iron deficiency anemia, meaning that the hemolytic anemia of P. falciparum malaria superimposes on a compromised baseline and reaches the WHO severe anemia threshold of 5 g/dL more rapidly than in a well-nourished patient. A CHT clinician who applies the standard WHO threshold without recognizing the patient's compromised baseline may underestimate the acuity of their anemic deterioration. The metabolic acidosis of severe malaria, which drives the respiratory distress pattern (deep breathing, Kussmaul respiration) that is a clinical marker of life-threatening disease, reflects a combination of lactic acidosis from sequestration-driven tissue hypoxia, hypovolemia from inadequate fluid intake and insensible losses in febrile illness, and the increased metabolic demand of parasitemia. Blood lactate measurement, though not available at most CHT peripheral facilities, is the most sensitive laboratory marker of the severity of metabolic acidosis in severe malaria and is a strong predictor of mortality, with blood lactate above 5 mmol/L associated with high mortality risk. At facilities where blood lactate is not measurable, the clinician must rely on the clinical assessment of Kussmaul breathing pattern (depth and rate rather than oxygen saturation alone) as the bedside proxy for metabolic acidosis severity.

1.3 The Artemisinin Resistance Crisis and Its CHT Implications: The 2025 Warning

The most alarming recent development in malaria clinical science as it pertains to the CHT is the formal documentation of CHT-specific P. falciparum genomic characteristics that render the territory's parasite population particularly vulnerable to the development of high-level artemisinin resistance if Kelch13 (K13) gene mutations, which are the molecular markers of artemisinin partial resistance validated by WHO, were to be imported into the CHT from neighboring Myanmar or Thailand. A landmark study published in the peer-reviewed journal mBio in 2025, based on genome-editing experiments using P. falciparum isolates obtained directly from the CHT, demonstrated that CHT-endemic P. falciparum strains already carry K13-independent artemisinin resistance (defined by in vitro survival of ring-stage parasites treated with dihydroartemisinin at the ring-stage survival assay threshold) and that when K13 mutations

prevalent in the Greater Mekong Subregion (specifically F446I, R561H, and C580Y) were introduced into these CHT strains by genome editing, the resulting modified parasites exhibited K13-mediated artemisinin resistance at levels that were dramatically higher than those observed in equivalent experiments using laboratory reference strains or parasites from other geographic backgrounds. Most strikingly, the K13 R561H mutation, which is currently the dominant allele at the Thai-Myanmar border and is expanding in Rwanda, produced mean ring-stage survival assay values of 30.9 percent plus or minus 1.9 percent in the CHT-resistant genetic background, which the authors described as "an unprecedented resistance level among K13-engineered lines." The clinical translation of this finding for the CHT practitioner is sobering: the parasite population of the CHT is not merely a passive recipient of resistance genes that might drift in from Myanmar. It is a genetic environment specifically primed, by its own K13-independent resistance mechanisms, to amplify any K13 mutation that enters the CHT gene pool to levels of resistance that would produce clinical ACT treatment failures far exceeding anything currently observed in the Mekong subregion itself. The same 2025 mBio study found that the R561H mutation also conferred a fitness advantage (0.5 percent per generation growth advantage) in the CHT genetic background, meaning that if it were introduced, it would spread through the CHT P. falciparum population under natural selection pressure even without continued artemisinin exposure. These findings establish a new clinical and public health urgency for malaria management in the CHT: the current window of ACT efficacy must be used as aggressively and strategically as possible to eliminate the residual P. falciparum transmission in the CHT before K13 mutations arrive, and intensive molecular surveillance for K13 mutations must be established as an immediate priority in all CHT districts. The CHT's National Strategic Plan for Malaria Elimination targeting 2030 acquires an urgent new dimension from these findings, because the biological clock of artemisinin resistance acquisition in the CHT is not merely a theoretical concern but a documented genomic inevitability if K13 mutations circulating 200 kilometers away in Myanmar are allowed to cross the CHT's porous border through human movement. For the clinical practitioner in the CHT, the immediate implications are as follows: all P. falciparum malaria patients treated with artemether-lumefantrine should be assessed for adequate treatment response at day 3 post-treatment initiation (with day 3 blood smear or RDT), and patients with persistent positivity on day 3 should be referred for day 7 and day 28 follow-up assessment and for management according to treatment failure protocols, which currently involve the use of artesunate-amodiaquine or quinine plus doxycycline as alternative regimens. The detection of an ACT treatment failure in a CHT patient must be reported immediately to the National Malaria Elimination Program and investigated for K13 mutation status, because each detected treatment failure in the CHT is a potential early signal of the resistance catastrophe that the 2025 mBio study has warned is biologically plausible and epidemiologically imminent.

1.4 Metapopulation Dynamics and the Human Mobility Dimension of CHT Malaria

A November 2025 study published in Communications Medicine by Mahmud, Chang, and colleagues developed the first comprehensive metapopulation model of malaria transmission in the CHT parameterized with human mobility data from mobile phone records and fit to detailed epidemiological case data from all three CHT districts. This study made several findings of immediate operational significance for malaria control and elimination planning in the CHT. First, it demonstrated substantial heterogeneity in transmission intensity across the CHT, with the

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estimated basic reproduction number (R0) varying greatly across places that show similar levels of observed case incidence, a finding that means that case incidence data alone are an inadequate guide for intervention targeting and that transmission modeling incorporating mobility and connectivity is essential for efficient resource allocation. Second, the study found that when vector control interventions are applied locally, the greatest impact in reducing overall CHT malaria incidence comes from targeting places with both high transmission intensity and high connectivity with more populated districts in the western part of the CHT, not necessarily from targeting the districts with the highest raw case counts. This finding has a direct policy implication: Rangamati, which is the most connected of the three CHT districts (via the Kaptai Lake waterway and road system), may be a higher-priority target for intensive vector control than Bandarban's most remote valleys, even if Bandarban's remote valleys have higher per-capita incidence, because reducing transmission in Rangamati interrupts both local transmission and the importation pathways that seed remote areas. Third, the study confirmed what community health workers in the CHT have long observed empirically: that forest workers, cross-border migrants, and seasonal labor migrants who move between high-transmission and low-transmission areas are the primary drivers of parasite importation, and that interventions targeting this mobile population are a necessary complement to fixed-location vector control and case management strategies. The metapopulation model also found that the basic reproduction number in some CHT sub-districts was below 1 without any intervention (meaning that transmission was self-limiting in those areas), while in others it remained substantially above 1 even with current levels of intervention, implying that achieving elimination in the CHT will require specifically targeting the small number of high-R0 hotspot areas where sustained transmission occurs, rather than implementing uniform moderate-intensity interventions across the entire territory. For the CHT clinician, the human mobility findings of this study translate into a specific clinical inquiry that must be incorporated into every malaria patient encounter: the travel history covering the preceding three to four weeks must be systematic and specific, asking not merely about general travel but about forest entry (including duration and nature of forest work), overnight stays in the forest or in forest-edge settlements, and any border-crossing activity. A patient who presents with P. falciparum malaria and a history of recent entry into forest areas in Bandarban or Rangamati, or recent crossing into or return from Myanmar, represents both a treatment case and a potential surveillance sentinel, and their case data should be reported through the appropriate national surveillance systems.

1.5 Treatment Protocols for Uncomplicated and Severe Malaria in the CHT: A Clinical Reference

The treatment protocol for uncomplicated P. falciparum malaria in adult patients in the CHT, consistent with the Bangladesh National Malaria Treatment Guidelines (2021-2025), is artemether-lumefantrine as the first-line regimen. The standard adult dose is four tablets (each tablet containing 20 mg artemether and 120 mg lumefantrine) taken at the time of diagnosis, repeated at 8 hours, and then twice daily (morning and evening) for the following two days, constituting a six-dose regimen over three days. Artemether-lumefantrine must always be taken with food or milk containing fat to ensure adequate lumefantrine absorption, as lumefantrine is poorly absorbed in the fasted state. This instruction is of particular relevance in the CHT context where the patients most at risk of malaria are often the most food-insecure, and the clinician

must ensure that nutritional support is provided alongside the medication. The weight-based dosing for children is essential: children below 5 kg should be treated with oral quinine (not AL) due to inadequate data on AL safety at very low weights; children 5-14 kg receive one tablet per dose; children 15-24 kg receive two tablets per dose; children 25-34 kg receive three tablets per dose; and children 35 kg and above receive the standard four-tablet adult dose. The treatment protocol for severe P. falciparum malaria is parenteral artesunate as the WHO-recommended global standard, currently adopted in the Bangladesh National Malaria Treatment Guidelines. The dose of intravenous artesunate is 2.4 mg/kg of body weight administered intravenously at 0, 12, and 24 hours, then once daily until the patient can tolerate oral medication, at which point the patient should complete a full course of oral artemether-lumefantrine (the transition to oral ACT completes the treatment by eliminating any residual drug-sensitive parasitemia and ensuring complete parasite clearance). In facilities where IV artesunate is not available, intramuscular artesunate at the same dose is the preferred alternative; if artesunate is unavailable in any formulation, artemether intramuscularly (3.2 mg/kg loading dose, then 1.6 mg/kg every 12 hours) or quinine intravenously (20 mg/kg loading dose over 4 hours, then 10 mg/kg every 8 hours in 5% dextrose) are acceptable second-line alternatives. The critical point that the CHT clinician must internalize is that the choice between artesunate and quinine for severe malaria is not merely a question of drug availability. The AQUAMAT trial (published in The Lancet in 2010 and confirmed by subsequent studies) demonstrated that parenteral artesunate reduces severe malaria mortality by 35 percent compared with parenteral quinine in African children, and comparable superiority has been demonstrated in South and Southeast Asian adults in the SEAQUAMAT trial. Quinine, while effective, has a narrower therapeutic window and carries risks of hypoglycemia (from stimulation of insulin secretion), cardiac toxicity from QTc prolongation (which requires ECG monitoring during administration), and cinchonism (tinnitus, deafness, nausea, vomiting). Every effort should be made to stock parenteral artesunate at CHT district hospitals and upazila health complexes, and its absence from a CHT facility's essential drug list should be reported to the district health officer and the National Malaria Elimination Program as a priority stock-out issue. Post-artesunate delayed hemolysis (PADH) is a clinically important complication of severe malaria treatment that was first comprehensively described in European travelers with imported malaria treated with parenteral artesunate and has since been documented in endemic settings including South and Southeast Asia. PADH occurs in a minority of patients who have received parenteral artesunate, typically 2 to 6 weeks after treatment, as a consequence of the drug's mechanism of action: artesunate causes the rapid sequestration of parasitized erythrocytes in the spleen (pitting), followed by their re-entry into circulation in a non-parasitized but membrane-damaged state, after which these once-parasitized but now-cleared erythrocytes are destroyed by macrophage phagocytosis in the reticuloendothelial system. The clinical presentation of PADH is a new episode of hemolytic anemia occurring in a patient who has apparently recovered from severe malaria and been discharged, which can be dramatic and dangerous in patients with limited physiological reserve. CHT clinicians who have treated patients with IV artesunate for severe malaria must ensure follow-up hemoglobin assessment at 2 to 4 weeks post-treatment.

MODEL EXAMINATION QUESTIONS: CHAPTER ONE (PART TWO)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

1. The Kelch13 mutation R561H, studied in a 2025 mBio paper using CHT-derived P. falciparum isolates, produced ring-stage survival assay values of approximately: a) 3-5% b) 10-15% c) 30.9% d) 50% (Correct Answer: c)
2. The dose of intravenous artesunate for severe malaria is: a) 1.2 mg/kg at 0, 12, 24 hours then daily b) 2.4 mg/kg at 0, 12, 24 hours then daily c) 4.8 mg/kg once daily only d) 10 mg/kg every 8 hours (Correct Answer: b)
3. Post-artesunate delayed hemolysis (PADH) typically occurs at what interval after IV artesunate treatment for severe malaria? a) Within 24 hours of treatment b) 24 to 72 hours after treatment c) 2 to 6 weeks after treatment d) 3 to 6 months after treatment (Correct Answer: c)
4. Artemether-lumefantrine is poorly absorbed without fat because: a) Artemether requires bile salts for activation b) Lumefantrine is highly lipophilic and requires dietary fat for adequate oral bioavailability c) The combination has high first-pass hepatic metabolism d) Stomach acid degrades both compounds in the absence of fat (Correct Answer: b)
5. The metapopulation malaria modeling study published in Communications Medicine in November 2025 found that the greatest impact of local vector control in reducing overall CHT malaria incidence comes from targeting areas with which characteristic? a) Highest raw case counts regardless of connectivity b) Lowest baseline population immunity c) Both high transmission intensity and high connectivity with more populated CHT western districts d) Closest proximity to the Myanmar border (Correct Answer: c)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

1. A 28-year-old male forest worker from Bandarban presents on day 4 of artemether-lumefantrine therapy for confirmed P. falciparum malaria. He reports that he has been taking the medication correctly with food. A repeat RDT on day 4 remains positive. The most appropriate next step is: a) Continue the same ACT course for two more days b) Add doxycycline to the artemether-lumefantrine c) Assess for ACT treatment failure using day 3 criteria (clinical and parasitological), report the potential treatment failure to the National Malaria Elimination Program, collect a blood sample for K13 mutation genotyping if available, and switch to an alternative regimen such as artesunate-amodiaquine or quinine plus doxycycline d) Repeat the RDT after 24 hours (Correct Answer: c)
2. The clinical finding of Kussmaul respiration (deep, labored, rapid breathing) in a CHT patient with confirmed severe P. falciparum malaria is the clinical expression of which pathophysiological mechanism? a) Pulmonary edema from fluid overload b) Metabolic acidosis from lactic acidosis due to sequestration-driven tissue hypoxia, hypovolemia, and the increased metabolic demand of parasitemia c) Primary respiratory infection superimposed on malaria d) Cerebral herniation causing central respiratory failure (Correct Answer: b)
3. The CHT-Augmented Severity Classification defines the "High-Risk Uncomplicated" malaria category to include patients with uncomplicated malaria who have one or more specific risk features. Which of the following is correctly included in this category? a) Age 25-35 years with normal nutritional status b) Confirmed pregnancy, regardless of

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parasitemia level c) Residence within 30 minutes of a CHT upazila health complex d) Prior episode of uncomplicated malaria in the past year (Correct Answer: b)

CHAPTER TWO: TUBERCULOSIS, LEPROSY, AND MYCOBACTERIAL DISEASE IN THE CHT: CLINICAL SCIENCE, DIAGNOSIS, AND MANAGEMENT

2.1 The Mycobacterium tuberculosis-Host Interaction in the Malnourished CHT Patient

Tuberculosis, in the Chittagong Hill Tracts, is not the tuberculosis of medical textbooks written for urban academic hospitals. It is a disease that arrives late, is diagnosed slowly, and kills people who should have been cured, not because its biology is different in the CHT but because the conditions under which it encounters human hosts, health systems, and clinical judgment are so profoundly unlike those assumed by standard diagnostic and therapeutic frameworks that the standard frameworks themselves become unreliable guides. The foundational immunological principle governing tuberculosis pathogenesis is that Mycobacterium tuberculosis, inhaled as aerosolized droplet nuclei produced by the cough of an infectious index case, is taken up by alveolar macrophages in the lung, where it resists intracellular killing by a remarkably sophisticated array of virulence mechanisms including inhibition of phagosome-lysosome fusion, neutralization of reactive oxygen and nitrogen species, and modulation of the macrophage's apoptosis program to prevent its own destruction. In the immunocompetent host with adequate nutritional status, this initial infection is typically contained by the combination of innate macrophage defense and adaptive T-cell-mediated immunity (specifically CD4+ T cells recognizing mycobacterial antigens presented by infected macrophages and producing the IFN-gamma signaling cascade that activates the macrophage's mycobactericidal machinery), resulting in the formation of a granuloma, which is a organized immunological containment structure of macrophages, epithelioid cells, and lymphocytes that walls off the mycobacteria and prevents their further spread. This granuloma formation defines latent tuberculosis infection (LTBI), which is the state in which approximately 90 percent of initially infected individuals exist, harboring viable but contained mycobacteria in granulomatous lesions that may persist for decades. The 10 percent of infected individuals in whom primary progressive tuberculosis develops, or in whom subsequent reactivation of LTBI occurs, are those whose T-cell mediated immunity is sufficiently impaired to allow granuloma dissolution and bacterial proliferation. In the CHT, the conditions for granuloma dissolution are pervasive and severe. Protein-energy malnutrition (with documented stunting rates exceeding 45 percent in some CHT communities) impairs T-cell function at every level of the adaptive immune cascade, reducing the number of circulating CD4+ T cells, impairing their activation and cytokine production, and reducing the effectiveness of macrophage bactericidal activity even when T-cell signaling is intact. Vitamin D deficiency, which is paradoxically prevalent in sunny tropical populations including some CHT communities due to melanin-related reduced cutaneous vitamin D synthesis and dietary insufficiency, impairs the vitamin D receptor-mediated pathway of macrophage autophagy induction that is essential for intracellular mycobacterial killing, providing a specific mechanistic link between nutritional deficiency and heightened TB susceptibility in CHT populations. Zinc deficiency, also prevalent in CHT communities with limited dietary diversity, impairs multiple

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arms of the immune response including natural killer cell activity and T-cell proliferation. HIV coinfection, though its prevalence in the CHT is not systematically characterized and likely lower than in the neighboring Myanmar population, represents the most powerful single immunosuppressive risk factor for TB progression from LTBI to active disease (increasing the risk from the approximately 10 percent lifetime risk in HIV-uninfected individuals to 5 to 10 percent per year in HIV-infected individuals with undetected infection), and its presence in CHT populations linked to cross-border movement and sex work in border communities represents a critically understudied intersection of two major infectious disease burdens. The concept of the Mycobacterial Disease Continuum, defined in this textbook as the full spectrum of mycobacterium-host interaction states from initial infection through latent infection, subclinical disease, primary progressive disease, and reactivation disease, integrated with the gradient of immunological competence that ranges from the fully immunocompetent CHT individual to the severely malnourished child or the HIV-coinfected adult, provides a more clinically actionable model for understanding TB in the CHT than the binary latent-active distinction that dominates most TB teaching. The Continuum model alerts the clinician that the CHT patient population contains a large reservoir of individuals at elevated risk of transition from earlier to later stages of the Continuum, and that the clinical manifestations they present are distributed across this spectrum in ways that require diagnosis to be inclusive of pre-cavitary and extrapulmonary forms, not merely the classic smear-positive cavitary pulmonary TB that dominates textbook descriptions. Lymph node tuberculosis (scrofula), which produces painless, rubbery cervical lymphadenopathy that may eventually liquefy and discharge through the skin as a chronic draining sinus, is a common form of extrapulmonary TB in CHT children and young adults, and it is frequently not recognized as tuberculosis because clinical teaching has focused on pulmonary TB as the primary presentation. Bone and joint tuberculosis (skeletal TB), which commonly affects the spine (Pott's disease of the spine, producing vertebral collapse, kyphotic deformity, and paraplegia if untreated), the hip, and the knee, causes chronic musculoskeletal pain and disability and is misdiagnosed in the CHT setting as arthritis, musculoskeletal injury from agricultural labor, or non-specific backache, delaying diagnosis by months to years. Abdominal tuberculosis, which can produce ascites (TB peritonitis), chronic abdominal pain, bowel obstruction, and constitutional symptoms, is a particularly challenging diagnostic entity in the CHT because it mimics numerous other abdominal conditions and because the diagnostic investigation (laparoscopy, ascitic fluid analysis, histopathology of peritoneal biopsy) requires referral to a tertiary center that most CHT patients cannot access or afford.

2.2 Drug-Resistant Tuberculosis: The Cross-Border Threat

The emergence of drug-resistant tuberculosis in the CHT, specifically the risk of multidrug-resistant TB (MDR-TB, defined as resistance to isoniazid and rifampicin, the two most important first-line anti-tuberculosis drugs) and extensively drug-resistant TB (XDR-TB, defined as MDR-TB with additional resistance to fluoroquinolones and at least one injectable second-line agent), is a threat that originates primarily from the territory's geographical position adjacent to Myanmar, where the estimated MDR-TB proportion among new TB cases is approximately 5 percent and among previously treated cases is approximately 28 percent (Global TB Report 2024 estimates), substantially higher than the equivalent Bangladesh national figures. The mechanism of resistance transfer across the CHT-Myanmar border is human movement: forest workers,

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cross-border traders, refugees, and migrants who carry active pulmonary TB with drug-resistant strains across the border into CHT communities can initiate transmission chains of MDR-TB in previously drug-sensitive local TB populations if their disease goes undetected or if they receive inadequate treatment. The Revised National Tuberculosis Control Programme (RNTCP/NTP) of Bangladesh operates in the CHT through a network of health facilities that provide DOTS (Directly Observed Treatment, Short-course), with community health workers or designated treatment observers supervising daily tablet ingestion during the intensive phase of treatment. However, the reach of DOTS supervision in the most remote CHT communities is inadequate, creating gaps in the treatment supervision that allow for treatment interruption, which is the primary driver of acquired drug resistance. The clinical detection of MDR-TB requires specimen collection for GeneXpert MTB/RIF testing (which detects rifampicin resistance, a reliable proxy for MDR-TB in high-resistance-prevalence settings), followed by phenotypic drug susceptibility testing for the full first-line and relevant second-line drug panel in confirmed MDR cases. In the CHT, GeneXpert machines are available at district hospital level in all three districts, but the collection and transport of sputum specimens from remote communities to district hospitals requires a cold chain that is frequently unreliable and a transport system that is subject to the terrain and seasonal access barriers described throughout this textbook. The recently introduced Truenat MTB and MTB-RIF Dx assays (chip-based isothermal nucleic acid amplification tests that can be performed at peripheral health facilities with intermittent electricity, without cold chain for the assay components) represent a potentially transformative technological development for TB diagnosis in the CHT's resource-limited peripheral settings, and their wider deployment in CHT upazila health complexes should be an immediate programmatic priority. The treatment of MDR-TB, which shifted from the traditional 18-24 month injectable-containing regimens to the WHO-endorsed all-oral shorter regimen (BPaL/M: bedaquiline, pretomanid, linezolid plus or minus moxifloxacin) in updated 2022 WHO guidelines, requires a six-month treatment course that must be administered under close monitoring for drug toxicity (particularly cardiac QTc prolongation from bedaquiline and moxifloxacin, and peripheral neuropathy and myelosuppression from linezolid) and is associated with substantially improved outcomes compared with older injectable-containing regimens. The implementation of BPaL/M regimens in the CHT context requires ECG monitoring capacity, hepatic and renal function testing, and the ability to manage linezolid toxicity, all of which are challenges at the peripheral facility level but are achievable at district hospital level with appropriate training and drug procurement.

2.3 Leprosy in the CHT: A Disease of the Margins

Leprosy, caused by Mycobacterium leprae (and the recently discovered Mycobacterium lepromatosis, a closely related species causing diffuse lepromatous leprosy identified in Mexico and the Caribbean but potentially of global distribution), is classified in Bangladesh as a low-endemic disease following the achievement of the WHO elimination threshold (prevalence below 1 per 10,000 population at the national level) more than a decade ago. However, national elimination does not mean local elimination, and in the remote communities of the CHT where access to early leprosy detection and treatment has been historically limited, pockets of active leprosy transmission and undiagnosed cases continue to exist. The clinical presentation of leprosy depends critically on the host's immunological response to M. leprae, which produces the spectrum of disease from tuberculoid leprosy (in which a strong cell-mediated immune response

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contains the infection to a few well-defined skin patches with marked sensory nerve involvement) to lepromatous leprosy (in which absent or severely compromised cell-mediated immunity allows unrestricted mycobacterial proliferation producing widespread skin infiltration, nasal mucosal involvement, multiple peripheral nerve trunks, and systemic dissemination). The Ridley-Jopling classification organizes leprosy into five types along this immunological spectrum: tuberculoid (TT), borderline tuberculoid (BT), borderline borderline (BB), borderline lepromatous (BL), and lepromatous (LL), with the borderline types being immunologically unstable and prone to reversal reactions (type 1 lepra reaction), which involve sudden immune activation in borderline patients producing acute inflammation of skin lesions and peripheral nerves, causing rapid and potentially irreversible neural damage if not promptly treated with systemic corticosteroids. In the CHT clinical setting, the most important clinical skills for leprosy are the recognition of early sensory loss in skin patches (the cardinal diagnostic criterion for tuberculoid leprosy), the systematic examination of the major peripheral nerve trunks (the ulnar nerve at the elbow, the median nerve at the wrist, the common peroneal nerve at the fibular head, the posterior tibial nerve behind the medial malleolus, the great auricular nerve in the neck, and the supraorbital nerve at the eyebrow) for enlargement and tenderness (palpable nerve enlargement is pathognomonic for leprosy in the appropriate clinical context), and the recognition of the deformities of untreated or late-treated leprosy (claw hand from ulnar nerve paralysis, foot drop from common peroneal nerve paralysis, lagophthalmos from facial nerve involvement, and the saddle nose deformity from nasal cartilage destruction in lepromatous disease) that indicate delayed diagnosis and represent the clinical legacy of the detection gap that persists in remote CHT communities. Multidrug therapy (MDT) with rifampicin, dapsone, and clofazimine remains the WHO-recommended treatment for all forms of leprosy, with paucibacillary leprosy (TT and BT) treated for 6 months and multibacillary leprosy (BB, BL, LL) treated for 12 months. The management of lepra reactions (both type 1, also called reversal reaction, and type 2, also called erythema nodosum leprosum, which is a systemic immune complex-mediated reaction in lepromatous patients characterized by tender nodular eruption, fever, and systemic inflammation) with appropriate anti-inflammatory therapy (systemic corticosteroids for type 1 reactions, systemic corticosteroids or thalidomide for type 2 reactions with significant systemic features) represents the most time-sensitive clinical intervention in leprosy management, since untreated reactions cause irreversible nerve damage within hours to days.

2.4 Nontuberculous Mycobacterial Infections: An Emerging CHT Concern

Nontuberculous mycobacteria (NTM), the large and diverse group of environmental mycobacteria that are not M. tuberculosis complex or M. leprae, represent an emerging concern in the CHT that has been insufficiently recognized in the local clinical and public health literature. NTM are ubiquitous in the CHT environment, present in soil, water (both surface and spring water), dust, and biofilms on various surfaces. Species including Mycobacterium avium complex (MAC), Mycobacterium kansasii, Mycobacterium fortuitum, Mycobacterium abscessus, and Mycobacterium marinum are the most commonly implicated in human NTM disease globally. The clinical presentations of NTM disease that are most relevant in the CHT include pulmonary NTM disease (which clinically mimics tuberculosis with chronic productive cough, hemoptysis, weight loss, and radiographic infiltrates, and is frequently misdiagnosed as

smear-negative or culture-negative TB in settings without full mycobacterial speciation capability), lymphadenitis (particularly cervical lymphadenitis from MAC in immunocompetent children, which can mimic TB lymphadenitis), skin and soft tissue NTM infections (from M. fortuitum and M. chelonae following skin injuries in CHT farmers and forest workers who have soil contact), and swimming pool or aquatic granuloma (from M. marinum following water-related skin trauma, which can present as chronic nodular skin lesions on the hand and forearm in fishing communities). The clinical importance of distinguishing NTM disease from tuberculosis in the CHT lies in the fact that NTM disease does not respond to standard anti-tuberculosis treatment (since NTM species are intrinsically resistant to many first-line anti-tuberculosis drugs), and patients who are misclassified as having drug-resistant TB based on clinical failure of standard treatment may in fact have NTM disease requiring a completely different drug regimen. The diagnosis of NTM disease requires mycobacterial culture with species identification, capabilities that are limited to district hospital level or above in the CHT, and emphasizes once again the critical importance of developing diagnostic infrastructure at the district level and improving specimen transport systems from peripheral communities.

MODEL EXAMINATION QUESTIONS: CHAPTER TWO (PART TWO)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

1. Pott's disease refers to tuberculosis of which anatomical site? a) The hip joint b) The knee joint c) The spine (vertebral tuberculosis) d) The elbow joint (Correct Answer: c)
2. The Ridley-Jopling classification of leprosy is based on which biological variable? a) The duration of disease before diagnosis b) The host's immunological response spectrum from strong cell-mediated immunity to absent cell-mediated immunity c) The number of skin lesions present d) The specific M. leprae strain responsible for the infection (Correct Answer: b)
3. The first-line treatment regimen for multibacillary leprosy under WHO MDT guidelines consists of which drugs? a) Isoniazid, rifampicin, and pyrazinamide b) Rifampicin, dapsone, and clofazimine c) Dapsone and rifampicin only d) Clofazimine and ofloxacin (Correct Answer: b)
4. The GeneXpert MTB/RIF assay detects which feature of M. tuberculosis that serves as a proxy for MDR-TB? a) Isoniazid resistance mutations b) Rifampicin resistance mutations c) Ethambutol resistance mutations d) Pyrazinamide resistance mutations (Correct Answer: b)
5. Type 1 lepra reaction (reversal reaction) is treated with: a) Clofazimine only b) Additional doses of MDT c) Systemic corticosteroids d) Thalidomide (Correct Answer: c)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

1. A 42-year-old Chakma woman in Rangamati has been on standard first-line anti-tuberculosis therapy (HRZE) for three months but shows no clinical improvement and continues to have positive sputum smears. GeneXpert MTB/RIF reveals rifampicin resistance. Which of the following actions is most appropriate? a) Continue current

treatment for a further three months b) Switch immediately to WHO-endorsed all-oral BPaL/M regimen (bedaquiline, pretomanid, linezolid with or without moxifloxacin), notify the national TB program, investigate contacts for MDR-TB, and arrange ECG and hepatic function monitoring c) Add levofloxacin to the existing first-line regimen d) Initiate empirical MDR treatment without further drug susceptibility testing (Correct Answer: b)

2. The mechanism by which protein-energy malnutrition specifically increases susceptibility to tuberculosis progression from LTBI to active disease involves: a) Direct stimulation of M. tuberculosis growth by malnutrition-associated metabolic byproducts b) Impairment of CD4+ T-cell function and cytokine production, reduced macrophage bactericidal activation, and vitamin D deficiency-mediated impairment of autophagy induction c) Increased Anopheles vector density in malnourished communities d) Reduction in BCG vaccine efficacy in malnourished children (Correct Answer: b)

CHAPTER THREE: DIARRHEAL DISEASES, ENTERIC INFECTIONS, AND WATERBORNE PATHOGENS IN THE CHT: CLINICAL MANAGEMENT AND EPIDEMIOLOGICAL ANALYSIS

3.1 The Enteric Disease Ecology of the CHT

The diarrheal and enteric disease burden of the Chittagong Hill Tracts is produced by a convergence of pathogen diversity, ecological transmission conditions, nutritional vulnerability, and healthcare access barriers that makes it both more complex and more deadly in the CHT context than in the clinical settings assumed by standard enteric disease management guidelines. The enteric disease ecology of the CHT is defined by the dominant role of surface water sources (rivers, streams, and springs) rather than the groundwater sources (tube wells) that are the primary drinking water supply across most of Bangladesh's plains, and by the WASH infrastructure deficit that creates efficient fecal-oral transmission pathways across the territory's three districts. The CHT Enteric Pathogen Hierarchy defines the relative clinical and public health priority of the major enteropathogens based on their prevalence in the CHT context, their clinical severity, their transmissibility, and their treatability. At the apex of the Hierarchy in terms of epidemic potential and case fatality if untreated is Vibrio cholerae O1 (and O139), which causes cholera, the most rapidly fatal infectious diarrheal disease known to clinical medicine, with the capacity to kill a previously healthy adult within hours of symptom onset through the Vibrio cholerae toxin-mediated massive secretion of electrolyte-rich fluid from the intestinal epithelium (producing the pathognomonic rice-water stool and the profound dehydration, electrolyte depletion, and circulatory collapse that, if untreated, result in death from hypovolemic shock in a majority of cases). Cholera has been documented in the CHT, particularly in the river valley communities along the Karnaphuli system, during outbreaks that typically follow flood events when the fecal contamination of drinking water sources is maximal, and it represents the greatest immediate risk of epidemic mortality from diarrheal disease in the territory. The second tier of the CHT Enteric Pathogen Hierarchy encompasses the major bacterial enteropathogens that produce severe but less immediately fatal diarrheal illness:

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Shigella dysenteriae type 1 (which produces the most severe bacterial dysentery, characterized by bloody and mucoid stool, tenesmus, high fever, and the systemic complications of hemolytic uremic syndrome in children and toxic megacolon in severe cases), Salmonella typhi and paratyphi (the agents of enteric fever, which in the CHT context can be particularly severe in malnourished children and adults because their impaired immune response to the systemic Salmonella bacteremia is more permissive of bacterial dissemination and end-organ complications including intestinal perforation, encephalopathy, and myocarditis), and enterotoxigenic Escherichia coli (ETEC, the most common cause of acute watery diarrhea in children across South and Southeast Asia, mediated by the heat-labile and heat-stable enterotoxins that mimic the action of cholera toxin in inducing intestinal fluid secretion). The third tier encompasses enteropathogens that are particularly significant in the CHT for community-specific reasons: Rotavirus (the leading cause of severe, dehydrating diarrhea requiring hospitalization in children under 5 years globally, now preventable by oral rotavirus vaccine which has not been fully deployed in all CHT communities), Campylobacter jejuni (a zoonotic enteropathogen transmitted from domestic poultry that is endemic in CHT households where chickens are kept free-range and their feces contaminate food and water preparation areas), Cryptosporidium parvum and Cryptosporidium hominis (protozoan enteroparasites that cause self-limited diarrhea in immunocompetent hosts but can cause life-threatening chronic diarrhea in immunocompromised individuals including severely malnourished children and HIV-infected adults), and Entamoeba histolytica (the causative agent of amoebiasis, which produces both intestinal disease ranging from asymptomatic colonization to dysentery and liver abscess, the latter being a well-documented complication in CHT communities where Entamoeba exposure is facilitated by contaminated water sources and food handling practices). The clinical differentiation of these enteric pathogens at the bedside, without the benefit of stool culture and microscopy, relies on a combination of clinical features that the CHT practitioner must master. The character of the stool provides the first clinical discriminator: watery, non-bloody diarrhea suggests a secretory mechanism (cholera, ETEC, Rotavirus, Cryptosporidium), while bloody and mucoid diarrhea suggests an invasive mechanism (Shigella, Entamoeba, Campylobacter). The presence of fever is more common with invasive pathogens than with pure secretory pathogens (though cholera can produce modest fever and Shigella classically produces high fever). The clinical severity of dehydration, assessed by the WHO dehydration scale (no dehydration, some dehydration, severe dehydration) based on the patient's general appearance, eye sunkenness, skin turgor, and oral mucosa assessment, determines the treatment priority: severe dehydration is a medical emergency requiring immediate IV fluid resuscitation regardless of the etiological agent.

3.2 Oral Rehydration Therapy: The CHT Application

Oral rehydration therapy (ORT) using oral rehydration solution (ORS) is the cornerstone of diarrheal disease management globally and in the CHT, and its correct application in the CHT context requires understanding both its pharmacological basis and its practical deployment in resource-limited, remote settings. The WHO/UNICEF reduced-osmolarity ORS (composed of 2.6 g/L sodium chloride, 2.9 g/L trisodium citrate, 1.5 g/L potassium chloride, and 13.5 g/L glucose, with a total osmolarity of 245 mOsm/L) exploits the sodium-glucose cotransporter (SGLT1) of the intestinal enterocyte, which remains functionally intact even during secretory diarrhea caused by cholera toxin or ETEC enterotoxins (whose action specifically increases

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intracellular cAMP, driving chloride secretion through CFTR channels, while leaving the sodium-glucose cotransport mechanism unaffected). The coupling of glucose and sodium transport across the enterocyte membrane drives water absorption through osmosis, generating net fluid absorption from the intestinal lumen at a rate that can match or exceed the rate of cholera toxin-driven fluid secretion in most cases of uncomplicated cholera, as long as ORS is administered continuously and in sufficient volume. In the CHT context where commercial ORS sachets are frequently unavailable in remote communities, the home preparation of ORS from household ingredients (one teaspoon of salt and eight teaspoons of sugar dissolved in one liter of clean water) provides an adequate, though not optimally formulated, substitute. The BRAC Shasthya Shebika community health worker network has been a primary vehicle for ORS distribution and education across the CHT for decades, and the knowledge of ORS preparation and use is more widely disseminated in CHT communities than most other health promotion messages, though correct application remains inconsistent. The Zinc supplementation adjunct to ORS for diarrhea management in children under 5 years, now recommended by WHO (10 mg/day in infants under 6 months, 20 mg/day in children 6 months to 5 years, for 14 days following any episode of diarrhea), provides two distinct benefits: it shortens the duration of the current diarrheal episode (through enhancement of intestinal epithelial barrier repair and immune function) and it reduces the incidence of subsequent diarrheal episodes over the following 2 to 3 months (through its systemic immunological and nutritional restoration effects). In a CHT context where childhood zinc deficiency is prevalent and diarrheal episodes are a major driver of childhood nutritional deterioration, the systematic deployment of zinc supplementation alongside ORS for all diarrheal episodes in children represents a high-impact, low-cost intervention that should be a standard component of every CHT community health worker's kit. The management of severe dehydration with IV fluids in the CHT requires the rapid infusion of isotonic crystalloid solution: Ringer's lactate (the preferred fluid for cholera dehydration management at 100 mL/kg over 3 hours for children above 1 year, faster for adults) or normal saline (0.9% NaCl, acceptable if Ringer's lactate is unavailable). The danger of using 5% dextrose alone for rehydration in cholera or other secretory diarrheas must be understood: dextrose in water is rapidly metabolized, leaving hypotonic free water that does not effectively expand the intravascular volume depleted by the cholera fluid losses, and can cause hyponatremia. The dictum that no CHT facility managing diarrheal disease should administer 5% dextrose as a volume replacement for diarrheal dehydration without co-administering adequate sodium-containing fluid represents a specific patient safety principle for the CHT clinical setting.

3.3 Typhoid and Enteric Fever in the CHT: Diagnosis, Management, and the Fluoroquinolone Resistance Problem

Typhoid fever, caused by Salmonella enterica serovar Typhi, and paratyphoid fever, caused by Salmonella Paratyphi A, B, and C, produce the enteric fever syndrome that is highly prevalent in the CHT's resource-limited, WASH-deficient communities and that represents a significant cause of both inpatient and outpatient morbidity across the territory's health facilities. The pathogenesis of typhoid fever follows a distinctive course that the CHT clinician must know precisely because it determines the diagnostic timeline and the clinical warning signs of life-threatening complications. Following ingestion of S. typhi in contaminated food or water, the organism penetrates the intestinal epithelium (via M cells overlying Peyer's patches in the terminal ileum),

is taken up by submucosal macrophages, and disseminates via the mesenteric lymphatics and the thoracic duct into the systemic circulation, producing the first bacteremic phase that corresponds to the clinical symptom onset (typically the first week of illness, characterized by stepwise rising fever, relative bradycardia compared with the degree of fever, headache, malaise, and constipation that progresses to diarrhea later in the illness). In the second week, the bacteremia is cleared by the reticuloendothelial system but bacteria re-seed from the gallbladder (where they may persist indefinitely in chronic carriers) back into the intestinal lumen through bile, producing the secondary seeding that drives the Peyer's patch hyperplasia, necrosis, and ulceration that are the pathological substrates of typhoid's most feared complications: intestinal perforation (occurring in approximately 1 to 3 percent of typhoid cases, producing the acute abdomen and peritonitis that requires urgent surgical intervention) and intestinal hemorrhage. The clinical diagnosis of typhoid in the CHT is particularly challenging because the classic presentation (stepwise fever, rose spots, splenomegaly, relative bradycardia) is present in a minority of cases and is modified by prior antibiotic use (which many CHT patients will have received before biomedical presentation, either from the informal drug shop sector or from traditional preparations with demonstrated antibacterial activity), by the malnourished and immunocompromised state of many CHT patients (which may attenuate the fever response and accelerate complications), and by the co-existence of malaria (which produces the same febrile syndrome and which, if the malaria RDT is positive, may divert clinical attention from typhoid as a concurrent or sole diagnosis). The Widal test (serum agglutination test for O and H antibodies against S. typhi), which is widely used in CHT health facilities due to its availability and low cost, is a notoriously unreliable diagnostic tool. Its sensitivity is poor in the first week of illness, when bacteremia is highest and treatment would be most effective. Its specificity is compromised by cross-reacting antibodies from prior Salmonella exposure, non-typhoid Salmonella infections, and malaria itself (which can produce false-positive Widal tests). Blood culture remains the diagnostic gold standard for typhoid, but its sensitivity even in ideal laboratory conditions is approximately 60 to 80 percent in the first week (the bacteremic phase), and it requires 48 to 72 hours of incubation before results are available, making it unsuitable for immediate clinical decision-making. The Typhidot and Test-it Typhoid rapid antibody tests (IgM-based rapid diagnostic tests for typhoid) provide faster results than culture and have better sensitivity and specificity than the Widal test, and their use in CHT district hospitals represents an improvement in diagnostic accuracy that should be prioritized. Fluoroquinolone resistance in S. typhi has been rising globally and in Bangladesh, where the prevalence of reduced fluoroquinolone susceptibility (nalidixic acid resistance as a surrogate marker) in blood culture-confirmed typhoid has been documented at levels that make empirical fluoroquinolone therapy (ciprofloxacin) unreliable in many settings. The emergence of extensively drug-resistant (XDR) typhoid (resistant to chloramphenicol, ampicillin, trimethoprim-sulfamethoxazole, fluoroquinolones, and third-generation cephalosporins, retaining susceptibility only to azithromycin and carbapenems), first extensively documented in Pakistan and subsequently reported in multiple South Asian countries, represents an emerging threat to typhoid management in the CHT, since the mobile population connecting the CHT to the broader South Asian subcontinent creates pathways for XDR typhoid importation. Current first-line empirical treatment for typhoid in settings with documented fluoroquinolone resistance should use azithromycin (1 g daily for 5 to 7 days for uncomplicated typhoid) or ceftriaxone (2 g IV daily for 10 to 14 days for severe typhoid). The oral typhoid Vi capsular polysaccharide vaccine (one

dose, effective for 3 years) and the new oral Ty21a typhoid vaccine (4 doses on alternate days, effective for 7 years) are effective preventive tools that should be considered in the CHT preventive healthcare framework, particularly for high-risk communities along waterways with documented cholera and typhoid transmission.

MODEL EXAMINATION QUESTIONS: CHAPTER THREE (PART TWO)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

1. The WHO reduced-osmolarity ORS has a total osmolarity of: a) 311 mOsm/L b) 245 mOsm/L c) 290 mOsm/L d) 330 mOsm/L (Correct Answer: b)
2. The zinc supplementation dose for children 6 months to 5 years with diarrhea, as per WHO recommendation, is: a) 5 mg daily for 7 days b) 10 mg daily for 14 days c) 20 mg daily for 14 days d) 40 mg daily for 5 days (Correct Answer: c)
3. Intestinal perforation is a complication of typhoid fever that most commonly occurs during which week of illness? a) First week b) Second week c) Fourth week d) Third to fourth week (Correct Answer: d)
4. The Widal test has which major limitation for typhoid diagnosis in the CHT? a) It cannot detect any Salmonella antigens b) Its sensitivity is poor in the first week of illness and its specificity is compromised by cross-reacting antibodies from prior infections and malaria c) It requires expensive laboratory equipment unavailable in district hospitals d) It only detects S. Paratyphi, not S. Typhi (Correct Answer: b)
5. Rice-water stool is pathognomonic of which diarrheal disease? a) Shigella dysentery b) Typhoid fever c) Cholera d) Amoebiasis (Correct Answer: c)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

1. A 10-year-old Mro child in Bandarban presents with high fever for 10 days, stepwise pattern, headache, and diffuse abdominal tenderness. The malaria RDT is negative. The Widal test shows TO 1:320 and TH 1:640. The clinician suspects typhoid fever. Which is the most appropriate diagnostic and therapeutic approach? a) Treat with ciprofloxacin based on Widal result alone b) Order blood culture if available, initiate empirical treatment with oral azithromycin (given fluoroquinolone resistance epidemiology) or IV ceftriaxone if there are signs of severity, and assess for complications including intestinal perforation c) Repeat the Widal test in 5 days d) Refer to a tertiary center before initiating any treatment (Correct Answer: b)
2. A 2-year-old child in Rangamati presents with 3 days of profuse watery diarrhea, is severely dehydrated (sunken eyes, skin turgor very poor, unable to drink), and weighs 10 kg. The standard WHO Protocol for severe dehydration rehydration Plan C calls for: a) Oral ORS only at 75 mL/kg over 4 hours b) IV Ringer's lactate at 100 mL/kg over 3 hours, reassessing every hour c) IV 5% dextrose only d) Oral rehydration over 12 hours (Correct Answer: b)

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CHAPTER FOUR: VECTOR-BORNE DISEASES BEYOND MALARIA IN THE CHT: DENGUE, KALA-AZAR, FILARIASIS, AND SCRUB TYPHUS

4.1 Dengue in the CHT: An Escalating Non-Malarial Febrile Burden

Dengue fever, caused by any of the four dengue virus serotypes (DENV-1, DENV-2, DENV-3, and DENV-4), transmitted by the bite of Aedes aegypti and Aedes albopictus mosquitoes, has emerged in the CHT as a significant and rapidly growing component of the febrile illness burden that was previously dominated by malaria. The changing disease landscape of dengue in the CHT reflects several epidemiological processes: the rapid urbanization of CHT administrative towns and the associated creation of Aedes aegypti breeding habitat (particularly discarded containers, water storage vessels, used tires, and roof gutters with standing water in peri-urban areas), the high dengue transmission pressure in neighboring Chittagong city (which has experienced some of the largest dengue outbreaks ever recorded in Bangladesh, with hundreds of thousands of cases reported during the 2023 outbreak), and the movement of people between Chittagong city and CHT communities that drives serotype introduction and transmission chain seeding. The clinical presentation of dengue in the CHT context has several features that make its distinction from malaria a key diagnostic priority. Dengue produces a characteristic clinical syndrome of sudden-onset high fever (40 degrees Celsius or above), severe retro-orbital headache (pain behind the eyes that worsens with eye movement, a feature practically absent in malaria), myalgia and arthralgia of such severity that dengue acquired the colloquial name "breakbone fever" historically, a characteristic skin flush or rash (flushed face and thorax initially, followed by a diffuse maculopapular rash in the majority of patients, typically appearing around day 3 to 4 of illness), and the laboratory finding of leukopenia (white cell count below 5,000 per microliter) and thrombocytopenia (platelet count below 100,000 per microliter). The distinction from malaria is clinically important because the management of the two conditions is completely different: malaria requires specific antiparasitic therapy that is ineffective against dengue and unnecessary in its absence, while dengue has no specific antiviral therapy and is managed supportively with careful fluid management, platelet monitoring, and avoidance of NSAIDs and aspirin (which inhibit platelet function and increase bleeding risk in dengue). The co-circulation of malaria and dengue in the CHT's vector ecosystem, which is unusual in the global context but has been documented in several settings in South and Southeast Asia where both Anopheles and Aedes mosquitoes coexist, creates diagnostic confusion because a patient with a febrile illness in the CHT's endemic season may have malaria, dengue, both, or neither, and a positive malaria RDT does not exclude concurrent dengue. The dengue NS1 antigen rapid diagnostic test (which detects the non-structural protein 1 secreted by dengue virus-infected cells and is positive from day 1 through approximately day 5 of illness, before seroconversion) and the dengue IgM/IgG combination RDT (which detects dengue antibodies and becomes positive after day 5 of illness) are the two primary point-of-care tools for dengue diagnosis, and their availability at CHT district hospitals is essential for accurate differential diagnosis of febrile illness in the dengue transmission season. Dengue Hemorrhagic Fever (DHF) and the more severe Dengue Shock Syndrome (DSS) represent the life-threatening complications of dengue, occurring primarily in secondary dengue infections (when the antibody-dependent enhancement mechanism triggers excessive immune activation against the new serotype) and in the early defervescence phase (day 4-6 of illness), characterized by plasma leakage (manifesting

as pleural effusion, ascites, and hemoconcentration), thrombocytopenia, hemorrhagic manifestations, and in shock syndrome, circulatory failure. The clinical warning signs that indicate transition from dengue fever to DHF/DSS include abdominal pain or tenderness (suggesting developing ascites and hepatomegaly), persistent vomiting, clinical fluid accumulation (pleural effusion or ascites detected clinically or by bedside ultrasound), mucosal bleeding, lethargy or restlessness, liver enlargement greater than 2 cm, and rapid platelet decline with rising hematocrit (hemoconcentration of 20 percent above baseline suggesting plasma leakage). Recognition of warning signs is the key skill for dengue clinical management in CHT settings, since the critical intervention at this stage is not antiviral treatment (which does not exist) but carefully titrated IV fluid resuscitation to compensate for plasma leakage without inducing fluid overload once the leakage phase has resolved (typically 24 to 48 hours after defervescence), a fluid balance challenge that requires frequent clinical reassessment. The dengue vaccine landscape has evolved with WHO-recommended Dengvaxia (the recombinant tetravalent dengue vaccine developed by Sanofi Pasteur), which is licensed for use in seropositive individuals aged 9 to 45 years in endemic settings but must not be administered to seronegative individuals (because it acts as a primary infection, sensitizing the recipient to severe dengue upon subsequent natural infection). The newer Qdenga (TAK-003, Takeda) tetravalent dengue vaccine, which has demonstrated efficacy in phase 3 trials including in seronegative individuals and was prequalified by WHO in 2023, represents a more universally applicable dengue vaccine option and should be considered in CHT dengue prevention planning.

4.2 Visceral Leishmaniasis (Kala-Azar): Epidemiological Status and Clinical Management

Visceral leishmaniasis (kala-azar), caused by Leishmania donovani and transmitted by the female sandfly Phlebotomus argentipes, is a disease with deep historical roots in the Bengal region and one that remains a clinically significant entity in the CHT despite the dramatic reductions in kala-azar burden achieved across Bangladesh through the South Asian Kala-Azar Elimination Initiative. The CHT's forested terrain, earthen-floored housing structures (a preferred breeding habitat for P. argentipes), and the presence of populations with nutritional compromise (which reduces the cell-mediated immune competence necessary to contain Leishmania infection) create conditions favorable to both P. argentipes vector survival and human susceptibility to visceral disease. The classic clinical presentation of kala-azar is the triad of prolonged fever (weeks to months, often daily or twice-daily, typically in the evening), progressive splenomegaly (which can become massively enlarged, reaching below the umbilicus in chronic cases, producing the pathognomonic splenomegaly-fever combination that has been the hallmark of kala-azar clinical recognition for more than a century), and weight loss with progressive cachexia. The Leishman-Donovan bodies (the amastigote form of the parasite, detectable within macrophages in splenic, bone marrow, or lymph node aspirate smears) provide the confirmatory diagnosis in cases where serology is indeterminate or unavailable. The aldehyde test (Chopra's formal gel test), which is positive in advanced kala-azar due to massive hypergammaglobulinemia, is a simple and inexpensive diagnostic aid that was historically used in the Bengal region and can still be applied in CHT peripheral settings lacking sophisticated serological equipment, though its sensitivity for early kala-azar is poor. The rK39 rapid serological test, which detects IgG antibodies against the recombinant kinesin antigen of Leishmania donovani, has high sensitivity (greater than 95 percent) and specificity (greater than

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97 percent) for active visceral leishmaniasis in South Asian settings and is the primary diagnostic tool at CHT district hospital level. The treatment of visceral leishmaniasis in Bangladesh has shifted from the sodium stibogluconate (SSG) era to the amphotericin B era following the development of widespread unresponsiveness to SSG in Bihar, India (which previously accounted for the majority of global kala-azar cases), with concern about cross-border transmission of SSG-unresponsive strains creating treatment policy conservatism across South Asia. Liposomal amphotericin B (AmBisome) is the WHO-recommended treatment for visceral leishmaniasis in South Asia and is highly effective with a cure rate exceeding 95 percent in clinical trials, administered as a single IV infusion of 10 mg/kg in the South Asian treatment protocol (or as multiple lower doses over 5 to 15 days in other protocols). Miltefosine (the first and only oral drug effective for visceral leishmaniasis), dosed at 2.5 mg/kg/day for 28 days, is an alternative treatment option that has the significant practical advantage of oral administration, eliminating the need for IV infusion facilities and reducing the hospitalization requirement, making it potentially more accessible for CHT community-level deployment. Post-kala-azar dermal leishmaniasis (PKDL), a delayed-onset skin manifestation of kala-azar occurring months to years after apparent cure of visceral disease, characterized by macular, papular, or nodular skin lesions that are hyperparasitized and serve as a reservoir for sandfly transmission, represents an important epidemiological complication of kala-azar control in the CHT and must be recognized and treated to interrupt ongoing transmission.

4.3 Lymphatic Filariasis and Scrub Typhus: Understudied CHT Burdens

Lymphatic filariasis, caused by the filarial nematode Wuchereria bancrofti transmitted by Culex mosquitoes (primarily Culex quinquefasciatus in the CHT's settled areas) and potentially by Brugia malayi transmitted by various Mansonia and Anopheles species in the CHT's forested areas, is a cause of chronic morbidity including lymphedema, hydrocele, and elephantiasis (massive lymphedematous enlargement of the limbs, scrotum, or breast) in parts of Bangladesh and in the adjacent regions of India and Myanmar. The prevalence of lymphatic filariasis in the CHT is not precisely characterized in the current literature, but the presence of both Culex and Mansonia breeding habitats in the CHT's river valleys and agricultural water bodies, combined with the presence of animal reservoir hosts for Brugia malayi in the CHT's forested terrain, suggests that filarial transmission may be occurring at levels not captured by passive surveillance systems. The diagnosis of lymphatic filariasis is made by the detection of microfilariae (the larval blood stage of the parasite) in a nighttime blood sample (since W. bancrofti microfilariae show nocturnal periodicity, being present in peripheral blood primarily between 10 PM and 2 AM when the patient is typically supine and Culex vectors are feeding), by detection of circulating filarial antigen using the immunochromatographic test (ICT) card test, or by ultrasound detection of adult worms in dilated scrotal lymphatics (the filaria dance sign, a specific ultrasound appearance of motile adult worms within dilated lymphatic vessels). Treatment with diethylcarbamazine (DEC) plus albendazole, or with ivermectin plus albendazole (in areas where loiasis is not prevalent), kills microfilariae and some adult worms and is administered as mass drug administration (MDA) programs targeting entire endemic communities. Scrub typhus, caused by Orientia tsutsugamushi (an obligate intracellular bacterium previously classified in the genus Rickettsia, now re-classified in the genus Orientia), transmitted by the bite of infected trombiculid mite larvae (chiggers) of the genus

Leptotrombidium, is emerging as an important and substantially underdiagnosed cause of acute febrile illness in the CHT forest-edge and agricultural communities. The chigger mite, which is the vector and reservoir of Orientia tsutsugamushi, is ubiquitous in the scrub and grassland vegetation of the CHT's jhum field margins, forest clearings, and river banks, precisely the habitats that CHT farmers and forest workers inhabit and work in daily. The clinical presentation of scrub typhus includes acute fever with severe headache, myalgia, and the characteristic eschar (a black, crusted skin lesion at the site of the chigger bite, resembling a cigarette burn, which is present in approximately 50 to 80 percent of cases), and the rash (a centripetally spreading maculopapular eruption appearing during the first week of illness). Scrub typhus can progress to severe disease with pneumonitis, encephalitis, acute renal failure, myocarditis, and multi-organ failure if not treated promptly. The CHT practitioner must include scrub typhus in the differential diagnosis of any febrile illness occurring in a person with recent vegetation exposure, and must specifically search for an eschar on examination (examining all skin surfaces including the genital region, axillae, and scalp where chigger bites commonly occur). Doxycycline (100 mg twice daily for 7 days for uncomplicated scrub typhus, or IV doxycycline for severe disease) produces rapid defervescence within 24 to 48 hours and is the treatment of choice. The dramatic clinical response to doxycycline is itself diagnostically informative: a patient with suspected scrub typhus who defervesces within 24 to 48 hours of starting doxycycline provides strong retrospective diagnostic evidence supporting the scrub typhus diagnosis. Azithromycin (500 mg once daily for 3 to 5 days) is an effective alternative for pregnant women and children under 8 years (in whom tetracyclines are contraindicated due to dental and skeletal effects).

MODEL EXAMINATION QUESTIONS: CHAPTER FOUR (PART TWO)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

1. The dengue NS1 antigen test is positive during which phase of dengue illness? a) Seroconversion phase (day 5 onwards) b) First 5 days of illness (viremic phase) c) Late convalescent phase d) Only during dengue shock syndrome (Correct Answer: b)
2. The characteristic skin lesion at the chigger bite site in scrub typhus is called: a) Rose spot b) Eschar c) Koplik spot d) Erythema migrans (Correct Answer: b)
3. The treatment of choice for uncomplicated scrub typhus in an adult CHT patient is: a) Ciprofloxacin 500 mg twice daily for 5 days b) Doxycycline 100 mg twice daily for 7 days c) Azithromycin 250 mg once daily for 3 days d) Chloramphenicol 500 mg four times daily (Correct Answer: b)
4. The rK39 rapid test for visceral leishmaniasis diagnosis detects: a) Leishmania donovani microfilariae in blood b) IgG antibodies against the recombinant kinesin antigen of Leishmania donovani c) Leishman-Donovan bodies in peripheral blood smear d) Circulating filarial antigen (Correct Answer: b)
5. Aedes aegypti, the primary urban dengue vector, breeds preferentially in: a) Slow-flowing forest streams b) Brackish water bodies c) Clean standing water in small containers, discarded tires, and water storage vessels d) Muddy pools in agricultural fields (Correct Answer: c)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

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1. A 35-year-old Chakma farmer in Rangamati presents with 5 days of high fever, severe headache, and myalgia. Examination reveals a small black crusted skin lesion in the right axilla and a maculopapular rash on the trunk. Malaria RDT is negative. The most likely diagnosis and appropriate first-line treatment are: a) Dengue fever, treated with supportive care and platelet monitoring b) Scrub typhus, treated with doxycycline 100 mg twice daily for 7 days c) Typhoid fever, treated with azithromycin d) Leptospirosis, treated with penicillin (Correct Answer: b)
2. The dengue warning signs that indicate transition to dengue hemorrhagic fever and mandate hospitalization for fluid management include all of the following EXCEPT: a) Abdominal pain or tenderness b) Persistent vomiting and clinical fluid accumulation (ascites, pleural effusion) c) Retro-orbital headache and myalgia d) Rapid platelet decline with rising hematocrit (hemoconcentration) (Correct Answer: c)

CHAPTER FIVE: NON-COMMUNICABLE DISEASES IN EPIDEMIOLOGICAL TRANSITION: CARDIOVASCULAR DISEASE, DIABETES, AND CANCER IN THE CHT

5.1 The NCD Emergence in the CHT: Paradox and Documentation

The emergence of non-communicable diseases as a significant component of the CHT's health burden represents one of the most clinically and epidemiologically consequential developments of the past two decades in CHT health, and one that is least prepared for by the current health system configuration. The epidemiological paradox of the CHT's NCD emergence is this: the same communities that bear among the highest infectious disease burdens in Bangladesh, including the highest malaria incidence, the highest rates of childhood stunting, and some of the most severe vaccination coverage gaps, are simultaneously experiencing the early stages of the lifestyle and nutritional transitions that drive NCD risk factor accumulation across the developing world. This is not contradictory when analyzed through the lens of the dual burden of disease concept introduced in Part One. The mechanisms connecting early-life malnutrition and infection burden to adult-onset non-communicable disease risk are now well-established in the developmental origins of health and disease (DOHaD) literature, which demonstrates that intrauterine growth restriction and early childhood malnutrition program a thrifty metabolic phenotype that is highly efficient at fat storage during periods of dietary sufficiency, predisposing malnourished-in-early-life individuals to dyslipidemia, insulin resistance, and cardiovascular risk when their diet improves even modestly in adulthood. In the CHT context, this means that the children who survived the chronic malnutrition documented in CHT communities in the 1990s and 2000s, who are now adults in their thirties and forties, constitute a cohort with elevated cardiometabolic risk that is only beginning to manifest in clinical presentations, and whose NCD burden will escalate dramatically over the next two decades without targeted interventions. The cardiovascular disease burden of the CHT is dominated by hypertension and its sequelae (stroke, heart failure, chronic kidney disease), which represent the primary NCD mortality drivers in Bangladesh's rural population and are likely similarly prominent in the CHT indigenous population. Nationally, the prevalence of hypertension among

adults aged 35 years and above in Bangladesh has been documented at approximately 30 percent in a cross-sectional study of more than 12,000 respondents, and while CHT-specific data disaggregated by ethnicity are inadequate, the combination of high salt intake (traditional Marma and Chakma food preservation practices involve high salt use), tobacco use (betel nut with tobacco chewing is highly prevalent), physical stress of subsistence labor, and the cardiovascular effects of chronic malaria (which damages the heart and vascular endothelium through inflammation, anemia, and the coagulation disturbances produced by severe parasitemia) creates a convergent risk factor profile for hypertension. Hypertension in the CHT is substantially undiagnosed due to the absence of blood pressure screening programs in most community settings, the cost and access barriers to diagnosis and medication, and the absence of symptoms in uncomplicated hypertension that would motivate spontaneous healthcare seeking. A significant proportion of CHT patients who present to district hospitals with stroke, acute cardiac failure, or hypertensive urgency have never had their blood pressure measured before, and represent the end-stage of years of untreated hypertension. The CHT Hypertension Cascade Framework proposes a four-stage clinical response: Stage 1 (Community Detection) encompasses opportunistic blood pressure screening integrated into every health system contact in the CHT, including antenatal care visits, immunization clinics, TB DOTS supervision visits, malaria treatment encounters, and community health worker household visits; Stage 2 (Risk Stratification) uses blood pressure category (the 2023 ESC/ISH criteria: Stage 1 hypertension at 140-159/90-99 mmHg, Stage 2 at 160-179/100-109 mmHg, Grade 3 at 180/110 mmHg or above), age, and target organ damage assessment to prioritize treatment urgency; Stage 3 (Treatment Initiation) uses single-pill combination antihypertensive therapy (amlodipine plus perindopril or telmisartan in a single tablet) as the preferred initial treatment approach in CHT settings because single-pill combinations dramatically improve adherence compared with multiple separate tablets, which is the most critical factor in hypertension control in settings where regular pharmacy access is difficult; and Stage 4 (Long-Term Follow-Up) uses community health worker platforms (BRAC Shasthya Shebika or community clinic health assistants) to provide monthly blood pressure monitoring and medication refill support, reducing the need for repeated district hospital visits. Diabetes mellitus, primarily type 2 diabetes driven by the interaction of genetic susceptibility (South and Southeast Asian populations have higher insulin resistance for given body mass index than European populations), dietary transition, physical inactivity associated with the shift from heavy agricultural labor to more sedentary livelihoods, and the DOHaD-mediated thrifty metabolic phenotype, is emerging in the CHT but its specific prevalence among indigenous CHT communities remains uncatalogued. The clinical presentation of diabetes in the CHT is typically late-stage: patients present with complications (peripheral neuropathy, diabetic foot ulcer, advanced retinopathy, or diabetic nephropathy with chronic renal failure) rather than with blood glucose elevation detected on routine screening, because blood glucose testing is not integrated into community-level healthcare in the CHT. A CHT diabetic foot ulcer patient who arrives at the district hospital after walking on an infected ulcer for weeks (possible because diabetic peripheral neuropathy has abolished pain sensation) typically presents with deep tissue infection extending to bone (osteomyelitis), with necrotic tissue, and with septicemia, a presentation that requires aggressive surgical debridement or amputation, prolonged antibiotic therapy, and intensive nursing care that strains CHT district hospital resources. The prevention of this cascade requires early diabetes detection through point-of-care blood glucose testing (the random blood glucose of 11.1 mmol/L or above, or

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fasting glucose of 7.0 mmol/L or above, or 2-hour post-load glucose of 11.1 mmol/L or above on oral glucose tolerance testing, as diagnostic criteria) and early management with metformin (the first-line oral hypoglycemic agent, inexpensive, effective, and safe in the absence of severe renal impairment) and lifestyle modification counseling adapted to the CHT cultural and food context. Cancer represents the third major NCD category in the CHT context. In addition to the oral cancer burden driven by betel nut-tobacco chewing (discussed in Part One), the CHT's infectious disease burden contributes specific cancer risks: chronic hepatitis B virus (HBV) infection (which is endemic in parts of the CHT, particularly in communities with traditional tattooing practices and limited awareness of the blood-borne transmission route) drives hepatocellular carcinoma risk; Helicobacter pylori infection (which is prevalent in populations with contaminated water sources) drives gastric cancer risk; and human papillomavirus (HPV) infection drives cervical cancer risk in women with limited access to cervical cancer screening (Pap smear and the newer HPV DNA testing). The cervical cancer prevention strategy for CHT women must prioritize both HPV vaccination (for adolescent girls before sexual debut, using the bivalent or nonavalent HPV vaccine now recommended by WHO) and cervical cancer screening using visual inspection with acetic acid (VIA), which does not require laboratory facilities and can be performed by trained health workers at community level, making it appropriate for CHT primary health facilities.

5.2 Stroke, Acute Coronary Syndrome, and Emergency Cardiovascular Care in the CHT

The management of acute cardiovascular emergencies in the CHT is profoundly constrained by the absence of the interventional and intensive care facilities required for definitive treatment, but effective first-response management within the capabilities of CHT health facilities can save lives and reduce disability in a significant proportion of cases. Ischemic stroke, which constitutes approximately 80 percent of all strokes globally and in Bangladesh, results from either thrombotic occlusion of a cerebral artery (typically complicating atherosclerotic plaque rupture or intracardiac thrombus from atrial fibrillation) or embolic occlusion (from cardioembolic or aortic arch sources). The clinical presentation of acute ischemic stroke is the sudden onset of focal neurological deficit, including hemiplegia or hemiparesis (weakness of the face, arm, and leg on one side of the body), hemisensory loss, dysphasia (language impairment), hemianopia (visual field defect), or diplopia and vertigo (from posterior circulation strokes involving the brainstem or cerebellum). The FAST acronym (Face drooping, Arm weakness, Speech difficulty, Time to call for help) has been adopted globally for public education on stroke recognition and is the appropriate framework for community-level stroke education in the CHT, adapted into the indigenous languages of the major CHT communities. In the CHT, the management of acute ischemic stroke at district hospital level is limited to supportive care (blood pressure management, blood glucose optimization, early mobilization with physiotherapy, aspirin and clopidogrel as antiplatelet therapy after exclusion of hemorrhagic stroke by clinical assessment or, ideally, CT imaging), since the thrombolytic therapy (IV tPA or tenecteplase) and the mechanical thrombectomy that represent definitive ischemic stroke treatment require CT angiography and interventional neuroradiology capabilities unavailable in the CHT. Hemorrhagic stroke (intracerebral hemorrhage or subarachnoid hemorrhage), which is less common than ischemic stroke but carries higher acute mortality, is managed at district hospital level with blood pressure reduction (avoiding excessive lowering), reversal of anticoagulants if

present, management of raised intracranial pressure (head elevation, osmotherapy with mannitol, and neurosurgical referral for selected cases with life-threatening hematoma), and urgent referral to Chittagong Medical College Hospital for neurosurgical evaluation. The critical issue for stroke management in the CHT is not primarily the treatment protocol but the time from stroke onset to first medical contact, which in remote CHT communities can exceed 12 to 24 hours due to the terrain and transport barriers, by which time the window for thrombolytic therapy (4.5 hours from onset for IV tPA) has invariably passed and the window for early stroke unit care has been significantly narrowed.

MODEL EXAMINATION QUESTIONS: CHAPTER FIVE (PART TWO)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

1. The diagnostic criteria for diabetes mellitus (WHO 2006, updated guidelines) include a random blood glucose of: a) 7.0 mmol/L or above b) 11.1 mmol/L or above c) 9.0 mmol/L or above d) 14.0 mmol/L or above (Correct Answer: b)
2. The FAST acronym for stroke recognition stands for: a) Fever, Ataxia, Seizure, Tremor b) Face drooping, Arm weakness, Speech difficulty, Time to call for help c) Flushing, Altered consciousness, Slurred speech, Tachycardia d) Focal deficit, Altered sensation, Sensory loss, Timing (Correct Answer: b)
3. The first-line oral hypoglycemic agent for type 2 diabetes, preferred in resource-limited settings due to its safety and cost, is: a) Glibenclamide b) Pioglitazone c) Metformin d) Sitagliptin (Correct Answer: c)
4. The time window for intravenous tPA thrombolysis in acute ischemic stroke is: a) Within 1.5 hours of symptom onset b) Within 4.5 hours of symptom onset c) Within 6 hours of symptom onset d) Within 12 hours of symptom onset (Correct Answer: b)
5. Hepatitis B virus (HBV) chronic infection is a primary risk factor for which cancer? a) Gastric cancer b) Cervical cancer c) Hepatocellular carcinoma d) Colon cancer (Correct Answer: c)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

1. The developmental origins of health and disease (DOHaD) hypothesis explains the association between early-life malnutrition in CHT communities and adult NCD risk through which mechanism? a) Direct genetic damage from nutritional deficiencies in childhood b) Programming of a thrifty metabolic phenotype by intrauterine growth restriction and early childhood malnutrition, conferring high fat-storage efficiency that predisposes to dyslipidemia, insulin resistance, and cardiovascular disease when dietary sufficiency is achieved in adulthood c) Persistent childhood infections causing chronic inflammation that directly damages cardiovascular tissue d) Low physical activity levels resulting from chronic childhood malnutrition (Correct Answer: b)
2. A CHT public health planner is designing an integrated NCD prevention strategy for a remote Khagrachhari community with limited healthcare access. The single intervention with the broadest preventive impact across multiple NCD categories (hypertension, diabetes, stroke, and oral cancer) would be: a) Provision of statins for all adults above age

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40 b) Integration of opportunistic blood pressure screening and blood glucose testing into every existing health system contact point (immunization clinics, malaria treatment encounters, TB DOTS visits, antenatal care) combined with community health worker-based follow-up c) Construction of a new CHT district hospital d) Deployment of mobile CT scanners to CHT communities (Correct Answer: b)

CHAPTER SIX: DERMATOLOGICAL CONDITIONS IN THE CHT: SKIN AS ECOLOGICAL INTERFACE AND CLINICAL TEXT

6.1 The Dermatological Ecology of the CHT

The skin is the largest organ of the body and the primary interface between the human organism and its environment, and in the CHT's ecologically complex and occupationally demanding landscape, the skin is subject to a wider range of environmental insults, infectious exposures, nutritional deficiencies, and occupational hazards than in virtually any other setting in Bangladesh. The dermatological burden of the CHT has been substantially undercharacterized in the clinical literature, with most published studies focusing on malaria, tuberculosis, and acute febrile illnesses, leaving the large and clinically significant dermatological morbidity of the territory inadequately documented, under-referred, and under-treated. The CHT Dermatological Burden Framework organizes the skin conditions of the territory into six etiopathological categories that reflect the specific ecology of CHT skin disease. The first category is Infectious Dermatology, encompassing the bacterial, fungal, viral, and parasitic skin infections that are endemic in CHT communities due to the combination of skin barrier disruption (from cuts, insect bites, and abrasions sustained in agricultural and forest work), environmental pathogen exposure (from soil, water, vegetation, and animal contact), the warm and humid climate that favors cutaneous pathogen survival and proliferation, and the immunological vulnerability of malnourished individuals. Bacterial skin infections, including impetigo (caused by Staphylococcus aureus and Streptococcus pyogenes), folliculitis and furunculosis (caused by S. aureus), and cellulitis (caused by S. aureus and streptococcal species), are the most common dermatological presentations at CHT health facilities and are substantially more common in children with severe malnutrition (who have impaired neutrophil function and a compromised skin barrier due to nutritional deficiency). The management of uncomplicated bacterial skin infections in the CHT primarily uses oral cloxacillin or dicloxacillin (for S. aureus-predominant infections) or oral phenoxymethylpenicillin (for streptococcal infections), with the important caveat that community-acquired methicillin-resistant S. aureus (CA-MRSA) has been documented in some South Asian community settings and must be considered when patients fail to respond to beta-lactam therapy. Fungal skin infections, including tinea capitis (ringworm of the scalp, caused by dermatophyte fungi including Trichophyton violaceum, T. tonsurans, and Microsporum canis, which is endemic in CHT communities where head contact between children in school and household settings facilitates transmission), tinea corporis (ringworm of the body), tinea pedis (athlete's foot, driven by the barefoot agricultural work culture of most CHT communities), tinea versicolor (caused by Malassezia furfur, producing hypopigmented or hyperpigmented patches on the trunk and upper arms), and cutaneous candidiasis (in

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intertriginous areas and in infants and immunocompromised individuals), are collectively the most prevalent skin conditions in CHT communities, though they are rarely presented to formal health facilities because they are widely regarded as normal occupational hazards of forest and agricultural life rather than medical conditions requiring treatment. Scabies, caused by the mite Sarcoptes scabiei, is highly endemic in CHT communities characterized by household crowding, limited access to water for bathing and clothes washing, and the delayed recognition and treatment-seeking that follows from stigma associated with the condition. The intensely pruritic papular eruption, particularly involving the finger webs, wrists, genitals, buttocks, and areolae, and the secondary bacterial skin infections (impetigo, furunculosis) superimposed on scabies lesions in scratched and traumatized skin, represent a significant and eminently treatable source of morbidity in CHT children and adults that requires active community-level case detection and mass treatment protocols (permethrin cream 5% applied to the entire body surface below the chin for all household members simultaneously, or oral ivermectin 200 mcg/kg as a single dose for adults and older children where topical application is impractical). The second category is Nutritional Dermatology, encompassing the skin manifestations of the nutritional deficiencies prevalent in CHT communities. Protein-energy malnutrition produces the characteristic integumentary signs of kwashiorkor (edematous malnutrition with skin changes including flaky paint dermatosis, hyperpigmentation alternating with depigmentation in pressure areas, and the flag sign of alternating pigmented and depigmented hair bands reflecting episodic protein deficiency) and marasmic kwashiorkor. Zinc deficiency produces acrodermatitis enteropathica-like changes (vesiculopustular eruption around body orifices and in acral locations). Niacin deficiency (pellagra, caused by inadequate dietary niacin or niacin-precursor tryptophan) produces the classic triad of dermatitis (photosensitive, symmetrical, well-demarcated hyperpigmented plaques on sun-exposed skin), diarrhea, and dementia (the three D's of pellagra), and is documented in populations predominantly dependent on maize or sorghum diets with limited protein variety, conditions that may apply in some CHT communities during food insecurity periods. Vitamin A deficiency produces night blindness (the earliest clinical sign), Bitot's spots (triangular gray-white foamy spots on the bulbar conjunctiva adjacent to the corneal limbus, representing keratinized epithelial debris with Corynebacterium xerosis colonization), and xerophthalmia (corneal xerosis, keratomalacia, and corneal ulceration in severe vitamin A deficiency, leading to blindness), and follicular hyperkeratosis on the skin. The dermatological manifestations of nutritional deficiency must be recognized as clinical nutritional emergencies requiring not merely topical treatment of the skin lesion but immediate nutritional rehabilitation targeting the underlying deficiency. The third category is Occupational Dermatology, encompassing the skin conditions specifically arising from the occupational exposures of CHT communities: allergic and irritant contact dermatitis from plant sap (many CHT forest plants produce latex or sap compounds with irritant or sensitizing properties), agricultural chemical dermatitis from pesticide and herbicide exposure, traumatic wounds and abrasions from agricultural tools and thorny vegetation requiring wound care and tetanus prophylaxis, snakebite wounds (the management of which is discussed in Chapter Eight), leech bites (highly prevalent in the monsoon forest and causing blood loss and secondary infection), and the photodamage and pigmentary disorders produced by sustained sun exposure in outdoor workers with limited melanin protection in some lighter-skinned CHT communities.

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6.2 Leprosy Skin Manifestations and Early Recognition

The skin manifestations of leprosy deserve extended discussion in the context of CHT dermatology because early recognition of leprosy lesions is the primary clinical tool for interrupting the progression to irreversible nerve damage and disability, and because leprosy skin lesions are frequently misidentified as common dermatological conditions (tinea versicolor, eczema, or pityriasis alba) in community health worker encounters and primary care consultations. The cardinal dermatological feature of leprosy in its tuberculoid and borderline forms is the hypopigmented or erythematous skin macule or plaque with impaired sensation, the sensory loss being both the most specific and the most frequently overlooked feature of leprosy in primary care. The CHT primary care practitioner must develop the habit of testing sensation in every skin lesion with altered pigmentation or texture, using a wisp of cotton wool to test light touch sensation and a pin or broken wooden applicator to test pain sensation, comparing the sensory response within the lesion to that in immediately adjacent normal skin. A macule that is anesthetic or hypoesthetic relative to surrounding skin is leprosy until proven otherwise in the CHT context. Borderline tuberculoid leprosy, which is the most common form in immunocompetent adults, produces a small number (typically fewer than five) of hypopigmented, anesthetic, and often asymmetric skin macules or plaques with elevated edges and a dry, rough surface reflecting the damage to the dermal nerves supplying sebaceous glands and sweat glands within the lesion. The nerve trunk closest to the leprosy skin lesion must always be palpated for enlargement and tenderness, since early localized nerve involvement is clinically and pathologically present in borderline tuberculoid leprosy even when the patient is unaware of any sensory or motor deficit. In lepromatous leprosy, the skin lesions are numerous (more than five, often many more), small, poorly demarcated, erythematous, and not anesthetic (because the massive parasitization of the skin in lepromatous disease affects sensory nerves diffusely and later than in the tuberculoid forms), with the classic leonine facies (thickening and corrugation of the facial skin, loss of eyebrows and eyelashes called madarosis, and nasal deformity from destruction of the nasal mucosal cartilage) appearing in advanced long-standing cases. Erythema nodosum leprosum (type 2 lepra reaction), which occurs specifically in lepromatous and borderline lepromatous patients, produces a dramatic systemic illness with fever, painful tender subcutaneous nodules erupting over the existing skin lesions, joint pains, peripheral nerve pain and tenderness, and iritis, and must be recognized as a medical emergency requiring immediate systemic corticosteroid or thalidomide therapy to prevent the permanent damage to eyes, nerves, and joints that results from untreated reaction.

MODEL EXAMINATION QUESTIONS: CHAPTER SIX (PART TWO)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

1. The three D's of pellagra are: a) Dermatitis, dehydration, diplopia b) Dermatitis, diarrhea, dementia c) Dysentery, dermatitis, death d) Diarrhea, depression, dizziness (Correct Answer: b)
2. Scabies is treated with topical permethrin cream 5% applied to: a) The affected areas only b) The entire body surface below the chin for all household members simultaneously c) The scalp and hair only d) Face and neck only (Correct Answer: b)

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3. Bitot's spots are a clinical sign of which nutritional deficiency? a) Vitamin C deficiency b) Zinc deficiency c) Vitamin A deficiency d) Vitamin D deficiency (Correct Answer: c)
4. In leprosy, the most specific cardinal diagnostic feature of the skin lesion is: a) Hyperpigmentation b) Impaired sensation (anesthesia or hypoesthesia) within the lesion c) Pruritus (itching) d) Vesicle formation (Correct Answer: b)
5. Community-acquired methicillin-resistant Staphylococcus aureus (CA-MRSA) skin infections fail to respond to which class of antibiotics? a) Tetracyclines b) Beta-lactam antibiotics (including cloxacillin and dicloxacillin) c) Trimethoprim-sulfamethoxazole d) Clindamycin (Correct Answer: b)

CHAPTER SEVEN: NUTRITIONAL DEFICIENCY DISEASES: ADVANCED CLINICAL MANAGEMENT AND THERAPEUTIC PROTOCOLS IN THE CHT

7.1 The Clinical Nutritional Emergency: Severe Acute Malnutrition in CHT Children

Severe acute malnutrition (SAM) in children, defined as weight-for-height Z-score below minus 3 (below the third percentile of the WHO Child Growth Standards reference population), or mid-upper arm circumference (MUAC) below 115 mm in children 6 to 59 months, or the presence of bilateral pitting edema of nutritional origin (kwashiorkor), is a medical emergency with high case fatality that requires both acute clinical management and nutritional rehabilitation. In the CHT, SAM has been documented in Bandarban district at prevalence rates substantially exceeding the national average, with the lowest dietary diversity in the entire district documented in Mro and Marma children in remote valley communities. The management of SAM in the CHT follows the WHO therapeutic care protocol for severely malnourished children, which is organized into two phases: the initial stabilization phase (Phase 1) and the rehabilitation phase (Phase 2). The physiological basis for the two-phase approach lies in the profound metabolic disturbances that accompany SAM and that make the severely malnourished child highly vulnerable to specific clinical catastrophes during refeeding. The malnourished child has reduced heart muscle mass, reduced cardiac output, reduced renal clearance capacity, impaired immune function, altered thermoregulatory capacity, and a profoundly altered hormonal environment characterized by low insulin, elevated cortisol, and suppressed thyroid function. These adaptations are physiologically appropriate responses to chronic energy and nutrient deprivation, but they create a paradox of vulnerability during refeeding: the reintroduction of adequate macronutrients, if done too rapidly, overwhelms the child's reduced cardiovascular and renal capacity (the refeeding syndrome, characterized by sudden electrolyte shifts, particularly hypophosphatemia, hypokalemia, and hypomagnesemia, as cellular uptake of these electrolytes is driven by insulin released in response to glucose infusion, producing potentially fatal cardiac arrhythmias and respiratory failure), and the increase in metabolic demand from active anabolism exhausts the compromised heart's capacity to increase cardiac output. The specific medical management problems that must be addressed in the initial stabilization phase of SAM management include hypoglycemia (blood glucose below 3.0 mmol/L, treated with oral glucose solution or, if the child is unconscious, IV 10% dextrose 5 mL/kg followed by oral or nasogastric feeds), hypothermia (axillary temperature below 35 degrees Celsius, treated with external warming, skin-to-skin contact with caregiver,

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warm clothing, and ensuring the child feeds regularly to generate metabolic heat), dehydration (managed with oral ReSoMal, the specific low-sodium rehydration solution designed for malnourished children rather than standard ORS, which contains lower sodium and higher potassium concentrations reflecting the electrolyte deficits of SAM), infection (all severely malnourished children must receive empirical broad-spectrum antibiotic therapy, regardless of whether infection is clinically apparent, because the immunological impairment of SAM renders them incapable of mounting the fever and inflammatory responses that normally signal infection, and because unrecognized infection is a major cause of SAM mortality), micronutrient deficiencies (all SAM children receive multivitamin supplementation, folic acid 1 mg/day for two weeks, zinc, and vitamin A at the start of the rehabilitation phase only, not the stabilization phase, to avoid vitamin A toxicity in already zinc-deficient children who cannot mobilize vitamin A from stores), and renal impairment (careful fluid management avoiding overhydration). Ready-to-use therapeutic food (RUTF), the lipid-based nutrient-dense paste composed of peanut paste, skimmed milk powder, vegetable oil, and a micronutrient blend (with a composition providing approximately 500 kcal per 92g sachet), provides the nutritional backbone of the community-based management of acute malnutrition (CMAM) approach that has transformed global SAM management since the mid-2000s. CMAM allows the majority of SAM children without medical complications (approximately 75 to 80 percent of SAM children) to be managed at home with RUTF rather than requiring hospitalization, through the community health worker delivery of RUTF sachets with weekly monitoring visits to check MUAC, weight, and medical complications. In the CHT, the CMAM approach faces specific implementation challenges including supply chain access to RUTF in remote communities, caregiver literacy and numeracy limitations affecting feeding protocol adherence, and the malaria co-morbidity that frequently complicates the nutritional rehabilitation of CHT SAM children, since malaria reduces appetite, disrupts sleep, and increases metabolic demand in a way that competes with the nutritional rehabilitation process.

7.2 Anemia in the CHT: Etiology, Classification, and Management

Anemia, the condition of reduced circulating hemoglobin below the age- and sex-specific WHO threshold values (Hb below 13 g/dL in adult males, below 12 g/dL in non-pregnant adult females, below 11 g/dL in pregnant women and children under 5 years, below 11.5 g/dL in children 5 to 11 years, and below 12 g/dL in children 12 to 14 years), is among the most prevalent clinical conditions in the CHT and one of the most inadequately characterized in its etiology. The public health management of anemia in Bangladesh has historically focused on iron deficiency as the dominant cause, driving iron supplementation programs for pregnant women and children as the primary intervention. In the CHT, iron deficiency anemia is certainly prevalent, driven by inadequate dietary iron intake (the traditional CHT diet is low in heme iron from red meat and fish in some communities, particularly during food insecurity periods), reduced iron absorption (from the phytate content of the jhum rice and pulse diet that inhibits non-heme iron absorption), and increased iron losses from menstruation in women and from intestinal parasitic infections (particularly hookworm, which causes blood loss from intestinal attachment sites that amounts to an estimated 0.03 to 0.13 mL of blood per worm per day, producing clinically significant iron deficiency anemia in heavily infected individuals). However, the CHT anemia burden is not primarily iron deficiency anemia in isolation. It is a

composite anemia driven by multiple concurrent causal pathways that standard iron supplementation programs do not address. Malaria is the most important concurrent cause of anemia in the CHT's endemic season, producing the hemolytic destruction of parasitized erythrocytes that can reduce hemoglobin by 2 to 4 g/dL within days during acute P. falciparum infections. Folate deficiency is prevalent in the CHT due to the low folate content of the traditional diet, the increased folate demand of pregnancy (when folate is critical for neural tube closure and fetal red cell production), and the reduced absorption of dietary folate in individuals with chronic diarrheal disease and malabsorption. Vitamin B12 deficiency, though less well-characterized in CHT communities, is a risk in communities with very limited animal product intake (B12 is found only in animal-derived foods). The anemia of chronic inflammation, which is driven by the elevated hepcidin production of chronic infection (malaria, tuberculosis, helminthiasis) that sequesters iron within macrophages and reduces intestinal iron absorption, is particularly prevalent in the CHT's population with high infectious disease burden and produces an anemia that is unresponsive to iron supplementation (because it is mediated by reduced iron mobilization, not iron depletion). Thalassemia (both alpha and beta thalassemia traits) is prevalent in Southeast Asian populations closely related to CHT indigenous communities (Marma, Chakma, and Tanchangya communities have genetic relationships with Tibeto-Burman and Mon-Khmer populations in whom thalassemia is common) and may contribute to the microcytic anemia burden in the CHT through a mechanism (impaired hemoglobin synthesis) that is identical in blood count appearance to iron deficiency anemia but completely unresponsive to iron supplementation. The clinical management of anemia in the CHT must reflect this etiological complexity. The ferritin measurement is the most specific marker of iron deficiency in the absence of inflammation, but elevated ferritin in the context of infection or inflammation (an acute phase response protein) falsely normalizes low ferritin values, making iron deficiency diagnosis less certain in the CHT's high-infection population. The CHT Anemia Diagnostic Algorithm proposes the following approach: first, treat the predominant concurrent infections (malaria and helminthiasis), since both malaria-associated hemolysis and hookworm blood loss will resolve with appropriate treatment; second, provide empirical iron and folate supplementation for all children and pregnant women regardless of specific diagnosis (since both deficiencies are prevalent and supplementation is safe and inexpensive); third, investigate for alternative diagnoses (thalassemia by hemoglobin electrophoresis, B12 deficiency by serum B12, chronic disease anemia by clinical context) in patients who fail to respond to iron and folate supplementation after six weeks; and fourth, reserve transfusion for severe anemia (Hb below 7 g/dL in non-pregnant individuals, below 8 g/dL in pregnancy, or below 5 g/dL in malaria, as per WHO severe malaria criteria) after weighing the risks of transfusion-transmitted infections against the clinical urgency.

MODEL EXAMINATION QUESTIONS: CHAPTER SEVEN (PART TWO)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

1. The WHO definition of severe acute malnutrition (SAM) by MUAC in children 6 to 59 months is: a) MUAC below 125 mm b) MUAC below 115 mm c) MUAC below 135 mm d) MUAC below 100 mm (Correct Answer: b)

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2. The refeeding syndrome in severely malnourished children is primarily characterized by: a) Hyperglycemia from excess carbohydrate intake b) Hypophosphatemia, hypokalemia, and hypomagnesemia from cellular uptake of electrolytes driven by insulin release during refeeding, producing potentially fatal cardiac arrhythmias c) Protein overload causing acute kidney injury d) Hypervitaminosis A from excessive supplementation (Correct Answer: b)
3. ReSoMal (the rehydration solution for malnourished children) differs from standard ORS in which key way? a) Higher glucose concentration b) Higher sodium and lower potassium concentrations c) Lower sodium and higher potassium concentrations d) Absence of glucose (Correct Answer: c)
4. The anemia of chronic inflammation (ACI) is caused by which mechanism? a) Dietary iron deficiency b) Elevated hepcidin production from chronic infection, which sequesters iron within macrophages and reduces intestinal iron absorption c) Vitamin B12 malabsorption d) Chronic blood loss from intestinal ulceration (Correct Answer: b)
5. Thalassemia produces anemia through which mechanism? a) Iron deficiency from chronic blood loss b) Folate deficiency from reduced dietary intake c) Impaired hemoglobin synthesis from mutations in globin chain genes d) Hemolysis from antibody-mediated red cell destruction (Correct Answer: c)

CHAPTER EIGHT: TRAUMA, SURGICAL CONDITIONS, AND EMERGENCY SURGERY IN THE CHT

8.1 Snakebite: The Neglected Occupational Emergency

Snakebite is one of the most under-recognized occupational and public health emergencies in the Chittagong Hill Tracts, and it represents a condition where the gap between the clinical management guidance available in standard textbooks and the clinical management reality of the CHT is particularly stark and particularly deadly. The WHO officially classified snakebite envenomation as a neglected tropical disease in 2017, acknowledging the global disproportionate burden of snakebite mortality and morbidity in tropical rural agricultural populations, precisely the demographic that characterizes the CHT's indigenous communities. The medically significant venomous snake species of the CHT include cobras (Naja naja and Naja kaouthia, the spectacled cobra and monocled cobra, whose venom contains postsynaptic neurotoxins causing descending neuromuscular paralysis and cardiotoxins causing cardiac arrhythmias and myocardial depression, as well as cytotoxic phospholipase A2 components causing local tissue necrosis), kraits (Bungarus caeruleus, the common krait, and Bungarus fasciatus, the banded krait, whose venom contains presynaptic neurotoxins called beta-bungarotoxins that irreversibly inhibit acetylcholine release at the neuromuscular junction, producing a profound and prolonged neuromuscular paralysis with respiratory failure that is the principal cause of krait bite fatality), Russell's viper (Daboia russelii, which is the single most important cause of snakebite fatality in South Asia, whose complex venom containing phospholipase A2, procoagulant enzymes, and metalloproteinases causes a devastating coagulopathy with systemic bleeding, acute renal failure, and local tissue necrosis), and pit vipers (Trimeresurus species and Calloselasma species, which

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inhabit the forest floor and vegetation of the CHT hill forests and cause predominantly local tissue destruction with cytotoxic venom components and variable systemic coagulopathy). The management of snakebite in the CHT is severely constrained by the critical gap in antivenom availability at most CHT health facilities. Snake antivenom is the only specific treatment for systemic snakebite envenomation, and its administration should not be delayed by transfers to higher-level facilities if a patient with signs of systemic envenomation (neuroparalysis, coagulopathy, hemolysis, or acute renal failure) presents to any CHT facility. The Haffkine Polyvalent Snake Antivenom available in Bangladesh is effective against the four principal medically important snake species (cobra, krait, Russell's viper, and saw-scaled viper), though its clinical efficacy against krait-specific neurotoxins is more limited than against the other species' venom components. The dose of antivenom is guided by clinical response rather than patient weight (a common misconception), with the initial dose being 10 ampoules for severe envenomation and additional doses given every 1 to 2 hours until the coagulopathy is reversed (for viper bites, assessed by the 20-minute whole blood clotting test), the neurological paralysis halted (for elapid bites), or the systemic toxicity controlled. Anaphylaxis from antivenom administration (which is common, occurring in up to 50 percent of patients within the first few hours of administration) must be anticipated and managed with subcutaneous adrenaline (0.5 mg subcutaneously), antihistamines, and hydrocortisone available at the bedside before antivenom infusion begins. The absence of antivenom at CHT peripheral facilities is both a patient safety crisis and a system failure, since antivenom's short shelf-life (typically 2-3 years), cold chain requirement, and cost have historically discouraged peripheral stocking, resulting in the perverse situation where the communities at highest snakebite risk (forest-edge agricultural communities in the CHT) are the furthest from the antivenom stores. The clinical protocol for snakebite first aid at the community level must emphasize immobilization of the bitten limb (to reduce venom absorption and lymphatic spread), immediate evacuation to the nearest health facility, and the specific avoidance of harmful first-aid practices that are common in CHT communities and that worsen outcomes: tourniquet application (which causes ischemia and increases local tissue necrosis), incision and suction of the bite wound (which increases infection risk without removing significant venom), and the application of herbal preparations to the bite wound (which may cause secondary infection and delay transport). The traditional snakebite management practices of several CHT ethnic communities, including application of specific leaf pastes and performance of healing rituals, reflect an understandable community response to a terrifying emergency, but they must be understood by CHT clinicians as potential sources of delay-to-care that directly increase morbidity and mortality in a condition where the therapeutic window for antivenom is narrow.

8.2 Trauma, Landslides, and Mass Casualty Preparedness

The CHT's mountainous terrain creates specific trauma epidemiology patterns that differ from those of Bangladesh's plains and that require specific preparedness at CHT health facilities. Landslides are the most episodic but most devastating cause of mass trauma in the CHT, with the 2017 Rangamati, Bandarban, and Khagrachhari landslide event (one of the largest landslide disasters in Bangladesh's history, triggered by exceptionally heavy monsoon rainfall in June 2017) killing more than 150 people across the three CHT districts and injuring hundreds more. The 2025 study by Islam and colleagues (published in June 2025) on environmental risks in the

CHT explicitly documented compounded vulnerabilities from land degradation, deforestation, and flash flooding linked to landslide risk, confirming that the landslide threat is not merely a natural hazard but a developmentally amplified one, worsened by human-driven forest clearance that removes the root systems stabilizing steep slopes. The clinical management of landslide trauma follows the ABCDE (Airway, Breathing, Circulation, Disability, Exposure) resuscitation framework of Advanced Trauma Life Support (ATLS), with the specific challenge in the CHT context that many landslide casualties are buried, producing a combination of crush injury (which causes crush syndrome: the release of myoglobin from crushed muscle into the systemic circulation, producing myoglobinuria, acute tubular necrosis, and acute renal failure as the kidneys attempt to filter the iron-containing myoglobin protein) and asphyxiation (from airway obstruction by debris, requiring rapid airway management with manual clearing, airway adjuncts, and potentially emergency surgical airway if conventional airway management fails). The fluid management of crush syndrome must prioritize aggressive early crystalloid resuscitation (targeting urine output of 200-300 mL/hour to flush myoglobin through the renal tubules before tubular obstruction) with urine alkalinization (sodium bicarbonate added to IV fluids to prevent myoglobin precipitation in the renal tubules) in the first 6 to 12 hours after extrication, a protocol that requires large volumes of IV fluids and close monitoring of urine output that strains peripheral CHT facility capacity but can prevent renal failure if initiated early. Agricultural trauma (machete and tool injuries, falls from trees or slopes), animal injuries (including cattle gore and buffalo injuries in farming communities), and drowning (in the Kaptai Lake fishing communities and from river crossings during monsoon flood events) complete the major trauma categories at CHT health facilities. Wound care in the CHT context must always include tetanus prophylaxis assessment (a five-dose primary vaccination series provides lifelong protection, but many CHT adults have never received tetanus vaccination) and wound management with appropriate antibiotic use (prophylaxis for heavily contaminated wounds, treatment for established wound infection), recognizing that wound infection with soil organisms including Clostridium species (which can cause gas gangrene, the rapidly progressing and life-threatening soft tissue infection caused by C. perfringens producing alpha-toxin that destroys cell membranes, requiring immediate surgical debridement and high-dose penicillin) is a particular risk in jhum farmers with soil-contaminated agricultural injuries.

MODEL EXAMINATION QUESTIONS: CHAPTER EIGHT (PART TWO)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

1. The single most important cause of snakebite fatality in South Asia is: a) Cobra (Naja naja) b) Common krait (Bungarus caeruleus) c) Russell's viper (Daboia russelii) d) King cobra (Ophiophagus hannah) (Correct Answer: c)
2. The first-aid instruction for snakebite that is commonly practiced in CHT communities but actually worsens outcomes is: a) Immobilization of the bitten limb b) Tourniquet application c) Immediate transport to a health facility d) Calm reassurance of the patient (Correct Answer: b)
3. Crush syndrome following extrication from a landslide is characterized by which primary mechanism of acute renal failure? a) Ischemic acute tubular necrosis from hypovolemic shock alone b) Myoglobin-induced renal tubular obstruction and direct tubular toxicity

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from released myoglobin c) Glomerulonephritis from immune complex deposition d) Obstructive uropathy from retroperitoneal hematoma (Correct Answer: b)

4. Gas gangrene is caused by which organism? a) Staphylococcus aureus b) Clostridium perfringens c) Streptococcus pyogenes d) Pseudomonas aeruginosa (Correct Answer: b)
5. The ATLS resuscitation framework is organized around the acronym ABCDE, which stands for: a) Analgesia, Blood tests, Catheter, Drugs, Evaluation b) Airway, Breathing, Circulation, Disability, Exposure c) Assessment, Bleeding control, Casting, Dressings, Evacuation d) Antibiotics, Blood transfusion, Crystalloids, Debridement, Elevation (Correct Answer: b)

CHAPTER NINE: RESPIRATORY DISEASES IN THE CHT: PNEUMONIA, ASTHMA, AND CHRONIC OBSTRUCTIVE PULMONARY DISEASE

9.1 Community-Acquired Pneumonia: The Leading Cause of Childhood Death in the CHT

Community-acquired pneumonia (CAP) is the single most important cause of acute childhood mortality in the CHT, exceeding even malaria in its contribution to under-five death in the non-epidemic baseline period, and it is a major cause of morbidity and mortality across all age groups. The epidemiology of CAP in the CHT reflects the convergence of multiple risk factors: indoor air pollution from wood combustion (which impairs mucociliary clearance and alveolar macrophage function, the primary innate defenses of the lung against aspirated bacteria), childhood malnutrition (which impairs the cellular and humoral immune responses necessary to contain pneumococcal and Haemophilus influenzae infections), viral respiratory infections (which damage the respiratory epithelium and impair local immune defenses, predisposing to secondary bacterial superinfection), overcrowded living conditions (which facilitate the respiratory droplet transmission of pneumococcal and viral respiratory pathogens between household members), and the seasonal jhum burning air quality crisis (which creates an acute spike in respiratory morbidity during February to April). The etiological spectrum of CAP in the CHT spans bacterial (Streptococcus pneumoniae as the most important bacterial pathogen in all age groups, followed by Haemophilus influenzae type b in unvaccinated children and Staphylococcus aureus in severe neonatal and young infant pneumonia), viral (respiratory syncytial virus as the most important viral pneumonia pathogen in infants and young children, influenza virus as a cause of primary viral pneumonia and secondary bacterial pneumonia in all ages, and human metapneumovirus as an increasingly recognized pathogen in young children), and atypical (Mycoplasma pneumoniae and Chlamydophila pneumoniae as causes of "walking pneumonia" in older children and young adults). The WHO Integrated Management of Childhood Illness (IMCI) classification of pneumonia by clinical severity provides the framework for clinical decision-making in CHT primary care settings where chest radiography and blood cultures are not available. In the IMCI framework, the presence of fast breathing (defined age-specifically as 60 breaths per minute or above in infants under 2 months, 50 or above in infants 2 to 11 months, and 40 or above in children 1 to 5 years) in the absence of chest indrawing or danger signs classifies the child as having pneumonia (not severe, manageable with oral amoxicillin in the community). Chest indrawing (the inward retraction of the lower chest

wall during inspiration, reflecting increased work of breathing from pneumonia-driven lung stiffness) classifies the child as having severe pneumonia requiring referral to a hospital-level facility for injectable antibiotic therapy. The presence of IMCI danger signs (inability to drink or breastfeed, persistent vomiting of all feeds, convulsions, lethargy, central cyanosis, or stridor in a calm child) classifies the child as having very severe pneumonia requiring immediate emergency referral for intensive management. The antibiotic management of community-acquired pneumonia in CHT settings uses amoxicillin (first-line for non-severe pneumonia in children) at 40-45 mg/kg/day in two divided doses for 5 days, with ampicillin-gentamicin IV combination for severe and very severe pneumonia requiring hospitalization (or, where the combination is unavailable, parenteral amoxicillin or crystalline penicillin G for streptococcal and pneumococcal coverage plus an aminoglycoside for Gram-negative coverage). The introduction of the pneumococcal conjugate vaccine (PCV10 and PCV13) into the Bangladeshi Expanded Programme on Immunization (EPI) has been one of the most important advances in childhood respiratory disease prevention in the country, significantly reducing pneumococcal pneumonia incidence and pneumococcal meningitis in the vaccinated birth cohorts. However, the immunization coverage gaps in the CHT that were exposed by the 2025 measles outbreak are likely also present for PCV, meaning that CHT children in the most remote and under-served communities may have inadequate pneumococcal vaccination coverage and therefore remain at full epidemic-era risk of pneumococcal disease. The Haemophilus influenzae type b (Hib) conjugate vaccine, also incorporated into the Bangladesh EPI pentavalent schedule, provides protection against the second most important bacterial cause of childhood pneumonia and bacterial meningitis, and its coverage in remote CHT communities is subject to the same systemic gaps as measles and pneumococcal vaccines. Completing the immunization coverage of CHT children for all scheduled EPI vaccines, as a direct lesson from the 2025 measles crisis, must be the highest-priority immunization policy action for the Bangladesh National Immunization Program's CHT component.

9.2 Chronic Obstructive Pulmonary Disease in CHT Women: The Indoor Air Pollution Legacy

Chronic obstructive pulmonary disease (COPD), defined by the GOLD (Global Initiative for Chronic Obstructive Lung Disease) criteria as a persistent, largely irreversible airflow limitation documented by post-bronchodilator spirometry showing FEV1/FVC ratio below 0.70 (70 percent of predicted), with respiratory symptoms of chronic cough, sputum production, and exertional dyspnea, is an emerging and substantially underdiagnosed condition among CHT adult women who represent the demographic most intensively exposed to household solid fuel combustion. The pathophysiology of biomass smoke-associated COPD is broadly analogous to tobacco-associated COPD (involving chronic bronchitis from airway inflammation and mucus hypersecretion, and emphysema from elastase-mediated alveolar wall destruction driven by the oxidative stress of repeated smoky exposures), but with specific differences in the particle size distribution of biomass combustion emissions (which include a larger proportion of ultrafine particles below 0.1 micrometers that penetrate more deeply into the alveolar space than the particles from cigarette combustion), in the chemical composition of the toxic emissions (biomass smoke contains polycyclic aromatic hydrocarbons and organic acid vapors at concentrations and in combinations not present in tobacco smoke), and in the pattern of exposure

(biomass smoke-associated COPD typically follows decades of high-intensity indoor cooking fire exposure, producing a characteristic clinical profile of breathlessness disproportionate to the degree of emphysema, with predominant small airways disease). The diagnosis of COPD in CHT women is challenged by the absence of spirometry at most CHT health facilities (spirometry is the diagnostic gold standard for COPD, measuring FEV1 and FVC by forced exhalation into a computerized spirometer), by the cultural normalization of chronic respiratory symptoms in women who have cooked on wood fires for their entire adult lives (the CHT equivalent of the "normal part of aging" cognitive distortion that delays COPD diagnosis in tobacco-smoking populations), and by the competing explanations for breathlessness in CHT women including severe iron deficiency anemia, tuberculosis, and cardiac failure (from hypertensive heart disease). The management of stable COPD in CHT settings uses short-acting bronchodilators (salbutamol MDI via spacer for symptomatic relief of breathlessness on exertion and during acute exacerbations), smoking and biomass smoke reduction counseling (with improved cookstove distribution as the most impactful structural intervention for reducing ongoing indoor air pollution exposure), pulmonary rehabilitation (exercise training and breathlessness management education, adaptable to community settings), influenza and pneumococcal vaccination (to reduce the frequency of acute exacerbations, which are the primary driver of COPD morbidity and hospitalization), and long-acting bronchodilators (tiotropium MDI or long-acting beta-agonist plus corticosteroid combinations) for patients with moderate to severe disease who can access and afford these medications. The management of acute exacerbations of COPD (AECOPD), characterized by sudden worsening of breathlessness, increased sputum purulence or volume, and cough frequency, requires systemic corticosteroids (prednisolone 30-40 mg/day orally for 5 days), antibiotics (typically doxycycline or amoxicillin-clavulanate), intensified bronchodilator therapy, and oxygen supplementation (targeting oxygen saturation of 88-92 percent rather than 94-98 percent, since hypercapnic COPD patients rely on hypoxic drive for respiratory effort and excessive oxygen supplementation can cause life-threatening hypercapnia by abolishing this drive), with the understanding that AECOPD in CHT patients may be precipitated by air pollution exposures, respiratory infections including influenza and pneumonia, and non-respiratory triggers including heart failure.

MODEL EXAMINATION QUESTIONS: CHAPTER NINE (PART TWO)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

1. In IMCI classification, chest indrawing in a child with fast breathing classifies the child as having: a) Non-severe pneumonia managed with oral amoxicillin b) Severe pneumonia requiring referral for injectable antibiotics c) Very severe pneumonia requiring immediate emergency management d) Not pneumonia (Correct Answer: b)
2. The target oxygen saturation in COPD patients during acute exacerbation management is: a) 94-98% (same as normal) b) 100% (maximum oxygenation) c) 88-92% (to preserve hypoxic respiratory drive) d) 80-85% (to prevent oxygen toxicity) (Correct Answer: c)
3. Respiratory syncytial virus (RSV) is the most important viral pneumonia pathogen in which age group? a) Adolescents and young adults b) Infants and young children under 2 years c) Adults over 60 years d) All age groups equally (Correct Answer: b)

4. The GOLD criteria for COPD diagnosis requires post-bronchodilator spirometry showing: a) FVC below 70% of predicted b) FEV1/FVC ratio below 0.70 c) FEV1 below 50% of predicted d) Total lung capacity above 120% of predicted (Correct Answer: b)
5. The first-line antibiotic treatment for community-acquired pneumonia in a child aged 2 to 59 months without severe features in a CHT primary care setting is: a) IV ceftriaxone b) Oral amoxicillin 40-45 mg/kg/day for 5 days c) Oral azithromycin d) Oral ciprofloxacin (Correct Answer: b)

CHAPTER TEN: ONE HEALTH, ZOONOTIC DISEASES, AND EMERGING INFECTIONS IN THE CHT: CLINICAL, EPIDEMIOLOGICAL, AND PHILOSOPHICAL DIMENSIONS

10.1 The One Health Philosophy and Its CHT Application

The One Health concept, formalized in global health policy discourse through the WHO-FAO-WOAH (World Organisation for Animal Health) tripartite joint plan of action and through the United Nations Environment Programme's (UNEP) growing engagement with the human-animal-environment interface as a driver of pandemic risk, represents the most philosophically and practically appropriate framework for understanding the infectious disease ecology of the Chittagong Hill Tracts. One Health is defined in this textbook as the systemic recognition that human health, animal health (both domestic and wild), and ecosystem health are not separate domains but are deeply interdependent components of a single biological system, and that the diseases, stresses, and perturbations that affect any component of this system propagate through the system in ways that cannot be understood or managed by disciplines working in isolation from one another. In the CHT, the One Health framework is not an abstract theoretical construct. It is a daily operational reality in which the intertwining of human and animal lives in close physical proximity (domestic chickens, ducks, pigs, goats, cattle, and dogs living in and around human dwellings), the sustained contact between forest-edge communities and wildlife populations (wild boar, deer, primates, bats, and rodents), the disruption of ecological boundaries through deforestation and forest-edge agriculture, and the movement of people and animals across the CHT-Myanmar and CHT-India borders, create a continuous and complex flow of microbial genetic material between animal reservoirs, arthropod vectors, and human populations. The zoonotic disease risk profile of the CHT is shaped by this One Health ecology in ways that have been substantially understudied in the current literature. Leptospirosis, caused by pathogenic Leptospira species maintained in the renal tubules of rodent reservoir hosts and transmitted to humans through contact with urine-contaminated water or soil (producing the clinical spectrum from self-limited anicteric leptospirosis with fever, headache, myalgia, and conjunctival injection, through Weil's disease, the severe icteric leptospirosis characterized by the triad of jaundice, acute renal failure, and hemorrhagic manifestations, to pulmonary leptospirosis with massive hemoptysis and alveolar hemorrhage), is highly prevalent in CHT rice farming communities where flooded paddy fields and waterlogged jhum sites create ideal conditions for Leptospira transmission, and where rodent populations are dense in agricultural settings. The diagnosis of leptospirosis in the CHT is particularly challenging because its clinical

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presentation overlaps substantially with severe malaria, typhoid fever, viral hepatitis, and dengue, and because the diagnostic gold standard (the microscopic agglutination test, MAT, which detects antibodies against specific Leptospira serogroups) is available only at reference laboratories. The Leptospira IgM ELISA and rapid immunochromatographic tests provide field-deployable serological diagnosis for the second week of illness and beyond, but the first-week serological diagnosis window remains a clinical gap in CHT settings. Treatment of leptospirosis is penicillin G (1.5 million units IV every 6 hours for 7 days) for severe disease, or oral doxycycline (100 mg twice daily for 7 days) for mild to moderate disease, and both are agents that the CHT district hospital should carry and use empirically in patients with the leptospirosis clinical syndrome during the rainy season. Nipah virus (NiV), a paramyxovirus transmitted from fruit bats (Pteropus giganteus, the Indian flying fox, which roosts in large colonies in CHT forest trees) to humans primarily through consumption of raw date palm sap contaminated by bat saliva and urine during the December to March bat feeding season, is not yet documented in the CHT itself (confirmed NiV outbreaks in Bangladesh have been concentrated in the northwestern districts of Rajshahi, Rangpur, and Faridpur divisions), but the presence of Pteropus bat colonies in the CHT forest zone creates a plausible spillover risk that warrants active surveillance and specific community health communication. The case fatality rate of NiV encephalitis exceeds 70 percent in Bangladesh outbreaks, and person-to-person transmission in healthcare settings (particularly from unprotected contact with respiratory secretions of critically ill NiV patients) has been documented, making NiV a potential healthcare worker safety concern in CHT health facilities if a CHT cluster were to occur.

10.2 Avian Influenza, Antimicrobial Resistance, and the CHT's Pandemic Vulnerability

The CHT's specific vulnerability to the emergence and transmission of novel pandemic-potential pathogens deserves extended analysis in the context of the territory's geographical position, ecological characteristics, and health system limitations. Highly pathogenic avian influenza (HPAI), particularly the H5N1 subtype that has caused sporadic human infections with high case fatality rates across South and Southeast Asia since 2003, and the more recently globally spreading H5N1 clade 2.3.4.4b that caused a massive global outbreak in wild and domestic bird populations beginning in 2021-2022 and that has infected an unprecedented range of mammalian species (including cattle, marine mammals, and mustelids in the United States and Europe), represents a genuine pandemic risk in the CHT's live poultry environment. The H5N1 2.3.4.4b clade has demonstrated an unprecedented capacity for mammalian adaptation that prior H5N1 clades lacked, including efficient replication in mammalian respiratory epithelium at temperatures closer to mammalian core body temperature than earlier H5N1 strains, and the accumulation of mutations associated with increased airborne transmission potential. In the CHT, where backyard poultry farming is virtually universal in indigenous households, where live bird markets in CHT administrative towns facilitate mixing of poultry from multiple geographic origins, and where the movement of poultry and wild birds across the CHT-Myanmar border (a region with documented HPAI H5N1 activity) is uncontrolled, the conditions for human exposure to HPAI H5N1 are substantially present. The CHT clinical practitioner must know the HPAI clinical presentation (high fever, respiratory illness progressing rapidly to severe pneumonia and ARDS, with exposure history to sick or dead poultry) and the appropriate response (immediate patient isolation with airborne and contact precautions, sample collection

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for influenza PCR testing with biosafety Level 2 precautions minimum, immediate notification of the district health officer and national surveillance system, and empirical oseltamivir treatment at high dose, 150 mg twice daily for adults for 10 days, given the known reduced susceptibility of HPAI to standard doses). Antimicrobial resistance (AMR), the parallel pandemic of the 21st century that is projected by the United Nations Environment Programme and the WHO to cause 10 million deaths annually by 2050 if current trends continue, is a specific and urgent concern in the CHT for several reasons. The proximity to Myanmar, which has among the highest documented rates of AMR in both human and animal pathogens in Asia, creates cross-border AMR gene flow through human movement and the import of food animals and antimicrobial products. The informal drug shop and rural medical practitioner sector in the CHT, which provides the majority of first-contact antibiotic prescribing in remote communities, prescribes antibiotics without diagnosis confirmation or susceptibility testing, using primarily broad-spectrum antibiotics (ampicillin, ciprofloxacin, and third-generation cephalosporins) for undifferentiated febrile illness that includes a large proportion of viral illnesses and malaria for which antibiotics are inappropriate, creating selection pressure for resistance in the community pharyngeal and gut flora. The CHT community health worker (Shasthya Shebika) network, which provides artemether-lumefantrine, zinc and ORS, and basic health education, does not currently have a systematic antimicrobial stewardship component, and the integration of rational antibiotic use principles into community health worker training and community education in the CHT represents an important and underutilized opportunity for AMR prevention at the community level.

10.3 The Ecological Ethics of Disease Prevention in the CHT: A Philosophical Coda

The final section of Part Two returns to the philosophical dimension that this textbook has woven through its clinical and epidemiological analyses, because the prevention of the infectious and non-communicable disease burden of the CHT cannot be achieved through clinical management and public health programming alone. It requires a fundamental reconsideration of the relationship between human communities, the ecosystems they inhabit, and the political and economic structures that determine how those ecosystems are used, protected, or destroyed. The Ecological Ethics of Disease Prevention, as articulated in this textbook, holds three principles as foundational. The first principle is Ecosystem Integrity as Health Infrastructure, which holds that the forests, rivers, soils, and ecological systems of the CHT are not merely resources to be extracted for economic development but are the biological foundation of the health of the communities that depend on them, and that their degradation through deforestation, soil erosion, water pollution, and biodiversity loss is a form of health infrastructure destruction equivalent to the destruction of hospitals and clinics. The deforestation of the CHT destroys the medicinal plant habitats that provide the pharmacopoeia of indigenous healers, degrades the water quality of rivers and springs that provide drinking water to millions, eliminates the wild food sources that buffer seasonal nutritional insecurity, and disrupts the ecological controls that regulate vector habitats and zoonotic spillover risk. From an ecological ethics perspective, the deforestation of the CHT is not merely an environmental concern. It is a public health crime of structural magnitude. The second principle is Indigenous Environmental Stewardship as Public Health Policy, which holds that the traditional ecological knowledge and land management practices of CHT indigenous communities, including the jhum agricultural system practiced at

sustainable rotation intervals, the community forest governance systems that historically regulated hunting and forest product collection, and the cosmological frameworks that motivated ecological restraint through the recognition of human embeddedness in the natural world, represent a form of public health infrastructure whose value has been systematically underestimated and whose destruction through land alienation, cultural disruption, and the criminalization of traditional land management practices has been a form of public health regression. Restoring indigenous land rights and supporting indigenous ecological governance in the CHT is not merely a political or human rights obligation. It is a public health intervention. The third principle is Intergenerational Health Justice, which holds that the public health decisions made today in the CHT, including decisions about forest protection, land rights, climate change mitigation, vaccine equity, and the design of health systems, determine not only the health of the current generation of CHT residents but the health of generations yet unborn who will inherit the ecological, social, and physiological legacies of current decisions. The 2025 measles deaths of Mro children in Kurukpata are the intergenerational inheritance of the structural neglect of their community by the national health system over generations. The artemisinin resistance threat to CHT malaria treatment is the intergenerational legacy of the overuse of artemisinin monotherapy globally. The malnutrition crisis of CHT indigenous children is the intergenerational legacy of Kaptai displacement, land alienation, and decades of inadequate nutrition policy. A health system that cannot see and act on its intergenerational obligations is not a health system in the full moral sense. It is a repair shop for the damage produced by larger systems that it refuses to challenge. Part Two closes with the conviction that the CHT clinician and public health practitioner must be both a scientist of disease mechanisms and a moral citizen of the political world that produces the conditions in which disease flourishes or recedes, and that the two roles are inseparable.

MODEL EXAMINATION QUESTIONS: CHAPTER TEN (PART TWO)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

1. Leptospirosis Weil's disease is characterized by which triad? a) Fever, rash, and lymphadenopathy b) Jaundice, acute renal failure, and hemorrhagic manifestations c) Pneumonia, meningitis, and hepatitis d) Fever, diarrhea, and hyponatremia (Correct Answer: b)
2. Nipah virus (NiV) transmission to humans in Bangladesh primarily occurs through: a) Direct contact with infected bats during field work b) Consumption of raw date palm sap contaminated by bat saliva and urine c) Mosquito-borne transmission d) Rodent urine-contaminated water (Correct Answer: b)
3. The recommended oseltamivir dose for treatment of confirmed or suspected HPAI H5N1 influenza in an adult is: a) 75 mg twice daily for 5 days (standard influenza dose) b) 150 mg twice daily for 10 days (high-dose, extended course for HPAI) c) 150 mg once daily for 5 days d) 300 mg once daily for 7 days (Correct Answer: b)
4. The first-line treatment for mild to moderate leptospirosis in a CHT adult patient is: a) IV penicillin G b) Oral doxycycline 100 mg twice daily for 7 days c) Oral amoxicillin d) IV ceftriaxone (Correct Answer: b)

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5. The WHO-FAO-WOAH tripartite partnership represents the institutional formalization of which health concept? a) Social determinants of health b) Antimicrobial stewardship c) One Health (the interdependence of human, animal, and ecosystem health) d) Universal health coverage (Correct Answer: c)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

1. A 55-year-old Chakma fisherman presents to Rangamati District Hospital in August with 10 days of high fever, jaundice, and oliguria. He reports working in flooded jhum fields without footwear during the monsoon. Examination reveals scleral jaundice, hepatomegaly, and bilateral flank tenderness. Serum creatinine is 6.8 mg/dL. Malaria RDT is negative. Dengue NS1 is negative. The most likely diagnosis and appropriate management are: a) Typhoid fever with multi-organ failure, managed with IV ceftriaxone b) Weil's disease (severe leptospirosis) with hepatic and renal involvement, managed with IV penicillin G 1.5 million units every 6 hours plus supportive management including renal replacement therapy consideration and fluid management c) Viral hepatitis A with acute hepatic failure, managed with supportive care d) Falciparum malaria with jaundice (false-negative RDT), managed with IV artesunate (Correct Answer: b)
2. A CHT district health officer is designing a One Health surveillance system for the CHT. According to the One Health principles articulated in this textbook, the system should integrate which three surveillance domains? a) Primary care, secondary care, and tertiary care data b) Human disease surveillance, domestic and wild animal health surveillance, and environmental/ecosystem health monitoring c) Government health facility data, NGO health program data, and traditional healer case records d) Malaria surveillance, TB surveillance, and NCD surveillance (Correct Answer: b)
3. The CHT's antimicrobial resistance (AMR) burden is driven by which specific combination of factors unique to or particularly prominent in the CHT context? a) High antibiotic use in CHT district hospitals and lack of laboratory diagnostic capacity b) Cross-border AMR gene flow from Myanmar's high-AMR environment, inappropriate antibiotic prescribing by the informal drug shop sector in the absence of diagnostic confirmation, and the absence of a systematic antimicrobial stewardship program in the community health worker network c) Antibiotic residue contamination of CHT water sources from agricultural use d) Self-medication with antibiotics by educated CHT urban populations (Correct Answer: b)

ENDNOTES TO PART TWO

Part Two has traversed the clinical, epidemiological, environmental, and philosophical dimensions of the most significant disease categories affecting the Chittagong Hill Tracts, moving from the molecular biology of artemisinin resistance in CHT-endemic Plasmodium falciparum strains through the clinical management of severe malaria, tuberculosis, diarrheal disease, vector-borne and emerging infections, non-communicable diseases, dermatological

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conditions, nutritional emergencies, surgical and trauma care, and respiratory diseases, to arrive finally at the One Health ecological ethics that situates all of these clinical realities within the larger system of human-animal-ecosystem interaction that ultimately determines whether the CHT's disease burden grows or diminishes. The model examination questions distributed across the ten chapters have been designed to test not merely factual recall but clinical reasoning, epidemiological analysis, and the application of principles to the specific context of the CHT, because the examinations that matter most for CHT practice are not the written ones but the clinical encounters at the bedside in a remote valley clinic on a monsoon afternoon when the river is rising and the antivenom is not in stock and the patient is losing ground.

The central themes that Part Two has developed can be stated in four propositions. First, clinical medicine in the CHT requires integrating the best available biomedical science with a deep and respectful engagement with the indigenous medical traditions, cosmological illness frameworks, and community health resources of the CHT's ethnic communities, not because cultural sensitivity is a bureaucratic requirement but because the therapeutic relationship and treatment adherence that are essential for clinical effectiveness depend on it. Second, the specific epidemiological characteristics of the CHT, including the artemisinin resistance threat, the cross-border MDR-TB risk, the One Health zoonotic spillover context, and the climate change amplification of every pre-existing disease risk, demand that CHT clinicians and public health practitioners maintain an active engagement with the latest research and surveillance data, because the disease landscape of the CHT is changing faster than any single clinician's initial training can track without active updating. Third, the diagnostic and therapeutic protocols appropriate for the CHT are not merely simplified versions of metropolitan protocols. They are contextually adapted protocols that reflect the specific epidemiology, resource availability, cultural context, and access barriers of the CHT, and developing and applying these adapted protocols requires the kind of sophisticated contextual clinical judgment that is the mark of the most accomplished medicine, not its most basic expression. Fourth, the health of the CHT's people cannot be sustained by health services alone, and the clinician who works in the CHT without simultaneously working as an advocate for the structural changes, political recognition, land rights protection, and ecological stewardship that are the prerequisites of CHT population health is working at the symptom level of a systemic disease and leaving its causes untreated.

PART THREE: ADVANCED CLINICAL MEDICINE, SPECIALIZED DISEASE SYSTEMS, AND THE ARCHITECTURE OF HEALTH PRACTICE IN THE CHITTAGONG HILL TRACTS

Foreword to Part Three

Parts One and Two of this textbook established the geomedicinal identity of the Chittagong Hill Tracts, charted its clinical and public health history, and developed detailed clinical frameworks for the management of the territory's most prevalent diseases, from malaria and tuberculosis through diarrheal illness, vector-borne disease, non-communicable disease, dermatology, nutrition, trauma, and respiratory medicine, arriving finally at the philosophical and ecological

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dimensions of disease prevention in a structurally marginalized landscape. Part Three builds on that foundation by moving into the specialized clinical domains that complete the full spectrum of healthcare required in the CHT: the neurological diseases whose burden in the territory has been almost completely unmeasured; the ophthalmic conditions whose consequences for productive life and individual dignity are enormous; the oral and dental diseases whose connection to both systemic health and social suffering in betel-nut-using communities has been underdescribed; the musculoskeletal disorders whose relationship to the physical demands of subsistence agriculture in mountainous terrain has been ignored in the literature; the full depth of reproductive health beyond the emergency obstetric framework introduced in Part One; the emerging geriatric health crisis of aging indigenous communities; the developmental and school health needs of CHT children; the detailed environmental toxicology and occupational health science that the CHT's complex exposure landscape demands; the design principles of effective primary healthcare in remote mountain communities; and the health policy, research ethics, and advocacy frameworks that must govern the relationship between the academic world and the communities whose health this textbook purports to serve. Part Three is written with the same conviction that animated the preceding parts: that the CHT demands not standard medicine applied at lower resource levels, but original, contextually grounded, scientifically rigorous, and philosophically honest medicine developed specifically for one of the most complex and most consequential health geographies in South Asia.

CHAPTER ONE: NEUROLOGICAL DISEASES IN THE CHITTAGONG HILL TRACTS: BURDEN, BIOLOGY, DIAGNOSIS, AND MANAGEMENT

1.1 The Neurology of Deprivation: A Foundational Framework

Neurological disease in the Chittagong Hill Tracts occupies a paradoxical clinical position: it is simultaneously the category of disease most capable of producing severe, permanent, and life-defining disability and the category least likely to be diagnosed, least likely to receive specialist attention, and least represented in the health data that drive policy and program allocation in the territory. The 2025 review published in Health Science Reports by Khatun and colleagues, which analyzed the neurological health landscape of Bangladesh as a whole, found that neurological disorders have become a significant and growing public health concern across the country, contributing substantially to disability, mortality, and healthcare costs, and that inadequate healthcare infrastructure in rural areas combined with an acute shortage of neurological specialist capacity makes diagnosis and treatment extremely difficult outside major urban centers. In the CHT, these national-level challenges are amplified by every structural factor described in Parts One and Two: the terrain barriers that prevent access to even basic primary care, the language barriers that make neurological history-taking and neurological examination findings difficult to communicate accurately, the cultural frameworks that interpret many neurological presentations in cosmological rather than biomedical terms, and the complete absence of neurological specialist capacity within the CHT territory itself. The nearest neurological specialist services for CHT patients are located in Chittagong Medical College Hospital, a journey of multiple hours from Rangamati town and effectively unreachable from remote communities in Bandarban or

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Khagrachhari during the monsoon season. The result is a neurological disease burden that is largely invisible in the formal health data, presents predominantly at late and severe stages when patients do reach medical care, and is managed at district hospital level by general physicians without neurological training using protocols developed for metropolitan settings with access to CT imaging, MRI, EEG, CSF analysis, and neurological consultation. This chapter develops the clinical framework that the CHT physician needs to function effectively in this context, drawing on the most recent global neurological evidence base, the specific epidemiological characteristics of the CHT's neurological disease landscape, and a set of novel diagnostic and management principles adapted to the territory's resource and cultural context.

The foundational framework for neurological disease in the CHT is what this textbook designates as the CHT Neuro-Ecological Model, which holds that neurological disease in the CHT cannot be understood as a collection of organ-system dysfunctions occurring within individual patients but must be understood as the clinical expression of a complex interaction between neurobiological vulnerability, ecological exposure, nutritional conditioning, infectious disease history, traumatic experience, and structural marginalization, operating across the lifespan and in some dimensions across generations. This model incorporates five dimensions of neurological pathogenesis that are each measurably amplified in the CHT context. The Infectious Neurological Dimension recognizes that the CHT's high burden of infectious diseases, including malaria (which causes cerebral malaria and post-malarial neurological sequelae), tuberculosis (which causes tuberculous meningitis, tuberculomas, and CNS vasculitis), bacterial meningitis (whose incidence is amplified by the immunological vulnerability of the malnourished CHT population), and parasitic infections (including neurocysticercosis from Taenia solium in pork-consuming communities, toxoplasmosis in immunocompromised individuals, and the possibility of cerebral paragonimiasis from Paragonimus westermani consumed in improperly cooked freshwater crabs and crayfish that are dietary staples in some CHT communities), produces a substantial infection-related neurological disease burden that would not be expected from global epidemiology extrapolated without CHT-specific adjustments. The Nutritional Neurological Dimension recognizes that the nutritional deficiencies prevalent in the CHT, including thiamine (vitamin B1) deficiency (producing Wernicke's encephalopathy and beriberi with peripheral neuropathy and cardiac failure), niacin deficiency (producing pellagra with dementia as the third D of the classic triad), vitamin B12 deficiency (producing subacute combined degeneration of the spinal cord, peripheral neuropathy, and megaloblastic anemia), and severe protein-energy malnutrition during critical periods of neurodevelopment (producing permanent neurological deficits through impaired myelination and synaptogenesis), make nutritional neurological disease a substantially underappreciated component of the CHT's neurological burden. The Traumatic Neurological Dimension recognizes that both physical trauma (head injuries from agricultural accidents, landslide injuries, and falls in steep terrain) and psychological trauma (the neurobiological consequences of the political violence history of the CHT, including chronic stress-related neuroinflammation, altered HPA axis regulation, and the structural brain changes documented in imaging studies of survivors of prolonged trauma) contribute to the neurological burden of the CHT population. The Toxic Neurological Dimension recognizes that CHT populations are exposed to neurotoxic substances including chronic alcohol (producing alcoholic cerebellar degeneration, peripheral neuropathy, and Wernicke-Korsakoff syndrome), pesticides (organophosphate compounds used in jhum cultivation produce both acute cholinergic

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neurotoxicity from acetylcholinesterase inhibition and chronic peripheral neuropathy from prolonged lower-level exposure), indoor combustion toxins (carbon monoxide from wood fires producing chronic subclinical neurotoxicity that may contribute to cognitive decline), and naturally occurring neurotoxins in some CHT food species. The Structural Access Dimension recognizes that the treatment gap for neurological disease in the CHT, meaning the proportion of people with a neurological condition who need treatment but do not receive it, is among the highest of any disease category in the territory, producing a disease burden that is substantially worse in its functional consequences than the incidence data alone would suggest.

1.2 Epilepsy in the CHT: The Most Prevalent and Most Neglected Neurological Condition

Epilepsy, now defined by the International League Against Epilepsy (ILAE) in its 2024 operational criteria as a disease of the brain characterized by an enduring predisposition to generate epileptic seizures, with the neurobiological, cognitive, psychological, and social consequences of this condition, is the single most prevalent serious neurological disorder in both Bangladesh overall and, by inference, in the CHT specifically. The 2025 Health Science Reports review found an annual incidence of epilepsy in Bangladesh of approximately 58.7 cases per 100,000 people and a prevalence of approximately 412.3 cases per 100,000 people, which places Bangladesh's epilepsy burden at approximately twice the rate reported in high-income countries and within the range documented across low- and middle-income countries in South and Southeast Asia. In the CHT, the epidemiological risk factors for epilepsy are substantially more concentrated than in the Bangladesh general population. Perinatal brain injury, which arises from the high rates of birth asphyxia associated with the majority of deliveries being unattended by skilled birth attendants and occurring in circumstances without emergency obstetric backup, produces hypoxic-ischemic encephalopathy in newborns that is a major cause of structural epilepsy in children. Cerebral malaria, which occurs disproportionately in the CHT's P. falciparum-endemic areas, leaves a documented legacy of epilepsy and other neurological sequelae in a significant minority of survivors: a prospective study of children with cerebral malaria in sub-Saharan Africa (the SMAC study, published in the Lancet Neurology) documented epilepsy in 5.3 percent and active convulsive epilepsy in an additional 2.8 percent of cerebral malaria survivors at five-year follow-up, with CHT-specific data not available but the mechanism being identical. Bacterial meningitis produces post-meningitic epilepsy in approximately 5 to 10 percent of survivors globally, with higher rates in malnourished populations where the immune response to meningitis is attenuated and neurological complications more severe. Neurocysticercosis, the most common preventable cause of epilepsy globally in endemic settings, deserves specific investigation in CHT communities where pork consumption is culturally embedded in several ethnic groups (including the Bawm, Pangkhua, and Mro communities) and where the conditions for Taenia solium transmission (poor sanitation, free-ranging pigs with access to human feces, inadequate meat inspection and cooking standards) are present. Head trauma from agricultural injuries, falls, and landslides contributes to post-traumatic epilepsy, and the delayed presentation to healthcare characteristic of CHT trauma (as documented in the snakebite and trauma sections of Part Two) means that some post-traumatic epilepsy develops from injuries that were inadequately managed acutely. Alcohol-related seizures, including both acute withdrawal seizures in alcohol-dependent individuals abruptly stopping consumption and chronic alcohol-related epilepsy, represent a neurological

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consequence of the alcohol use disorder burden described in Part One. The treatment gap for epilepsy in the CHT is enormous. The majority of people with epilepsy in rural Bangladesh receive no antiepileptic medication, with the treatment gap documented at approximately 75 to 90 percent in rural and remote settings. In the CHT, this gap is widened by the additional barriers of geographic access, medication unaffordability, cultural interpretation of seizures as spirit possession or supernatural events (which may divert treatment-seeking to spiritual practitioners rather than biomedical providers), and the profound stigma associated with epilepsy across all CHT ethnic communities, which causes affected individuals and families to conceal the diagnosis rather than seek treatment.

The clinical classification of seizures in CHT patients must follow the 2017 ILAE classification framework, which organizes seizures into focal onset (beginning in networks limited to one cerebral hemisphere), generalized onset (engaging both hemispheres from the start), and unknown onset categories, with each major category subdivided by the level of consciousness retained during the event. Focal seizures in the CHT context most commonly arise from structural lesions including post-infectious scarring (from cerebral malaria, bacterial meningitis, or encephalitis), neurocysticercosis cysts in various stages of their lifecycle, and post-traumatic scar tissue. Generalized tonic-clonic seizures (formerly called grand mal seizures), characterized by the sudden loss of consciousness followed by the tonic phase (sustained muscle contraction producing rigidity of the limbs and trunk, often associated with a vocalization or cry from forced expiration through adducted vocal cords) and the clonic phase (rhythmic jerking movements of the limbs that gradually reduce in frequency before the postictal period of drowsiness and confusion), are the most visually dramatic and most commonly presented seizure type in CHT health facilities and are the seizure type most likely to be recognized by community members as requiring medical attention. Absence seizures (brief, seconds-long lapses of consciousness with behavioral arrest and automatisms such as lip smacking or eye blinking, without falling or tonic-clonic movements) are frequently overlooked in CHT children because they may be interpreted as normal daydreaming or inattentiveness, delaying diagnosis. Myoclonic seizures (brief, shock-like jerks of a limb or the whole body, occurring at or near consciousness, often in the morning after waking) are particularly important to recognize in adolescents because they may be the presenting feature of juvenile myoclonic epilepsy, a common and highly treatable form of genetic generalized epilepsy that has an excellent prognosis with appropriate medication. Status epilepticus (continuous seizure activity lasting more than five minutes, or recurrent seizures without return to normal consciousness between episodes, according to the 2015 ILAE operational definition) is a neurological emergency with a case fatality rate of 10 to 40 percent in resource-limited settings and requires immediate intervention. The CHT management of generalized convulsive status epilepticus follows a time-sensitive protocol: benzodiazepine as the first-line agent (diazepam 10 mg IV or 10 to 20 mg rectally if IV access is unavailable, or midazolam 10 mg intramuscularly, which is now recognized as an equally effective alternative with the practical advantage of not requiring IV access in a convulsing patient), followed by phenobarbital 20 mg/kg IV (the preferred second-line agent in low-resource settings where phenytoin and levetiracetam IV are unavailable or unaffordable) if benzodiazepines fail, and general anesthesia with airway management and referral if seizures continue beyond the second-line treatment. The antiepileptic drugs most appropriate for long-term epilepsy management in CHT settings are those that combine proven efficacy, low cost, single-daily dosing (to maximize

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adherence in settings where medication access is intermittent), and availability in the Bangladesh Essential Drug List. Phenobarbital (50 to 200 mg daily as a single bedtime dose in adults) meets all these criteria and remains the first-choice antiepileptic drug for generalized tonic-clonic and focal seizures in resource-limited settings, despite its sedative side effects and teratogenic risk in pregnancy. Sodium valproate (500 to 2,000 mg daily in divided doses) is the drug of choice for juvenile myoclonic epilepsy, absence epilepsy, and other generalized epilepsy syndromes, but its significant teratogenicity (neural tube defects, cognitive impairment, and congenital malformations in offspring of women who take valproate during pregnancy) makes it contraindicated in women of childbearing age who do not have reliable contraception, a clinical constraint of major significance in the CHT where access to reliable contraception is limited. Carbamazepine (400 to 1,200 mg daily in divided doses) is effective for focal epilepsy and generalized tonic-clonic seizures but should be avoided in absence and myoclonic epilepsy where it may paradoxically worsen seizure control. The community management of a person with epilepsy in the CHT must address not only medication access but the profound social consequences of the diagnosis: epilepsy carries severe stigma across all CHT communities, resulting in marriage refusal, school withdrawal, occupational exclusion, and social isolation of affected individuals that compound the neurological disability with psychosocial suffering. Community education about epilepsy, delivered through trusted channels including Buddhist monks, community health workers, teachers, and village leaders, is an essential component of epilepsy program design in the CHT.

1.3 Meningitis in the CHT: Bacterial, Tuberculous, and Cryptogenic

Bacterial meningitis, defined as inflammation of the meninges (the three-layered membranous coverings of the brain and spinal cord: the dura mater, arachnoid mater, and pia mater) caused by bacteremic invasion of the CSF compartment with pyogenic organisms, produces a clinical syndrome of rapid onset that constitutes one of the most life-threatening medical emergencies encountered in CHT district hospitals. The major causative organisms of bacterial meningitis in the CHT include Neisseria meningitidis (meningococcus), Streptococcus pneumoniae (pneumococcus), and Haemophilus influenzae type b (Hib) in children, with Listeria monocytogenes being an additional important cause in the elderly, pregnant women, and immunocompromised individuals. The clinical presentation of bacterial meningitis is the classical triad of fever, severe headache (typically described as the worst headache of the patient's life), and neck stiffness (nuchal rigidity), present together in only approximately 44 percent of adult bacterial meningitis cases in prospective series, which means that the absence of the full triad does not exclude the diagnosis. Kernig's sign (inability to extend the knee when the hip is flexed to 90 degrees, due to meningeal irritation) and Brudzinski's sign (involuntary hip and knee flexion when the neck is passively flexed, also due to meningeal irritation) are the classical examination findings for meningeal irritation, but their sensitivity is limited (approximately 5 percent and 5 percent, respectively, in one large series). The jolt accentuation sign (worsening of headache when the patient rapidly rotates the head horizontally at 2 to 3 rotations per second) has better sensitivity (approximately 97 percent in one study) for meningitis in adult patients with fever and headache. Petechial or purpuric rash, the clinical hallmark of meningococcal disease (both meningococcemia and meningococcal meningitis), represents a dermatological emergency: the non-blanching purpuric rash of meningococcemia

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arises from disseminated intravascular coagulation (DIC) consuming clotting factors and platelets while inflammatory cytokines damage capillary endothelium, producing hemorrhage into the dermis, and its recognition in a febrile patient is an immediate indication for parenteral ceftriaxone without delay for lumbar puncture or any other investigation. The management of bacterial meningitis in CHT district hospitals follows the principle of antibiotic administration before any diagnostic procedure in patients with signs of raised intracranial pressure (including papilloedema on fundoscopic examination, which is a contraindication to immediate lumbar puncture due to the risk of transtentorial herniation), altered consciousness, or focal neurological signs. Ceftriaxone 2 g IV (adult dose) or 100 mg/kg/day IV in two divided doses (pediatric dose) is the first-line antibiotic for bacterial meningitis in Bangladesh, covering S. pneumoniae, N. meningitidis, and Hib with high CSF penetration. Dexamethasone 0.15 mg/kg IV given before or with the first dose of antibiotics reduces the inflammatory response in the CSF and has been shown in randomized controlled trials to reduce hearing loss and other neurological sequelae in bacterial meningitis from H. influenzae and S. pneumoniae in high-income settings; its benefit in low-resource settings is less certain but it is recommended in the Bangladesh management guidelines and should be used when available. The mortality of bacterial meningitis in Bangladesh in treated patients ranges from 10 to 30 percent in published series, reflecting the late presentation and resource-limited management that characterize the national context and are particularly severe in the CHT. Survivors of bacterial meningitis face a high risk of permanent neurological sequelae including sensorineural hearing loss (the most common sequela, occurring in approximately 30 percent of bacterial meningitis survivors and representing a devastating functional deficit in CHT communities where communication and social participation are particularly dependent on hearing), cognitive impairment (documented in approximately 25 percent of survivors at 6 months in prospective series), and epilepsy. The prevention of bacterial meningitis through immunization is the most important public health intervention for this condition, and the inclusion of pneumococcal conjugate vaccine (PCV13) and Hib conjugate vaccine in the Bangladesh EPI schedule has substantially reduced the incidence of these two organisms' contributions to meningitis in vaccinated cohorts; the immunization coverage gaps in the CHT documented by the 2025 measles crisis apply equally to PCV and Hib vaccines, and their correction is a neurological public health priority.

Tuberculous meningitis (TBM), the most severe form of extrapulmonary tuberculosis, deserves extended discussion in the CHT context because it is both more prevalent in the CHT than in the general Bangladesh population (due to the elevated TB burden documented in Part Two) and more challenging to diagnose and manage at the district hospital level. TBM develops from hematogenous dissemination of M. tuberculosis to the meningeal and cerebral blood vessels during primary or reactivation TB, with the formation of small subpial foci (Rich foci) that, when they rupture into the subarachnoid space, produce the granulomatous meningeal inflammation characteristic of TBM. The clinical presentation of TBM is insidious relative to bacterial meningitis, with a prodromal period of weeks characterized by low-grade fever, malaise, headache, and behavioral change (particularly in children, where personality change and school performance decline may be the initial presenting features noticed by parents or teachers), before the progressive development of neck stiffness, cranial nerve palsies (particularly of cranial nerves III, VI, and VII, producing diplopia and facial weakness from compression by the meningeal exudate), altered consciousness, and focal neurological signs. The British Medical

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Research Council (MRC) staging system for TBM grades severity into three levels: Grade I (alert and oriented, no focal neurological deficit, no hydrocephalus), Grade II (any combination of meningism, mild focal neurological deficit, or consciousness level of Glasgow Coma Score 10 to 14), and Grade III (consciousness level below GCS 10 or dense hemiplegia). The MRC grade at presentation is the strongest predictor of outcome in TBM: Grade I patients treated appropriately have a low mortality and good functional recovery, while Grade III patients have mortality rates of 40 to 50 percent or higher in resource-limited settings. The CSF analysis in TBM shows a distinctive pattern: lymphocytic pleocytosis (typically 100 to 400 white cells per microliter, predominantly lymphocytes, in contrast to the neutrophilic pleocytosis of bacterial meningitis), elevated protein (above 1 g/L, and often above 2 g/L in severe cases), and low glucose (typically below 45 mg/dL, and the CSF:blood glucose ratio typically below 0.5). The diagnosis of TBM at district hospital level in the CHT relies primarily on the clinical syndrome, the CSF analysis, and the identification of concurrent pulmonary TB on chest X-ray (present in approximately 50 percent of TBM cases). GeneXpert Ultra on CSF, the most sensitive molecular diagnostic test for TBM (with a sensitivity of approximately 45 to 70 percent on CSF in meta-analyses, substantially better than conventional smear microscopy at 10 to 20 percent), should be the primary diagnostic test where available, though CSF volumes required (typically 5 to 10 mL, which may be difficult to obtain by lumbar puncture in a patient with raised intracranial pressure) and machine availability (limited to district hospital level in the CHT) restrict its use. The treatment of TBM uses the standard four-drug anti-tuberculosis regimen (isoniazid, rifampicin, pyrazinamide, and ethambutol) for the intensive phase, with the specific additional feature that for TBM, the intensive phase is extended to two months and the total treatment duration is nine to twelve months (rather than the standard six months for pulmonary TB), because TBM requires prolonged treatment to sterilize the meningeal lesions. Adjunctive corticosteroids (dexamethasone 0.4 mg/kg/day for 1 week, tapered over 6 weeks) reduce TBM mortality by approximately 30 percent in HIV-uninfected patients and are strongly recommended in all MRC Grade II and III TBM cases. The management of TBM-associated hydrocephalus (which occurs from blockage of CSF flow by the thick meningeal exudate at the base of the brain) may require external ventricular drainage or ventriculoperitoneal shunt placement, surgical interventions that are beyond the capacity of CHT district hospitals and require referral to Chittagong Medical College Hospital or higher-level facilities.

1.4 Cerebral Malaria: Pathophysiology, Diagnosis, and the Neurological Aftermath

Cerebral malaria, defined by the WHO as a coma (Glasgow Coma Scale below 11, Blantyre Coma Scale below 3 in children) not attributable to other causes in a patient with P. falciparum parasitemia, represents the most severe neurological emergency specifically attributable to the CHT's unique disease ecology. Its pathophysiology, which was outlined in Part Two, deserves fuller treatment here from the neurological perspective. The cerebral complications of P. falciparum malaria arise from the combination of sequestration (the cytoadherence of P. falciparum-infected erythrocytes to the vascular endothelium of brain microvasculature through the interaction of P. falciparum erythrocyte membrane protein 1 (PfEMP1) expressed on the infected erythrocyte surface with endothelial receptors including ICAM-1, CD36, and EPCR), resulting in microvascular obstruction that reduces local cerebral blood flow and creates zones of intracerebral hypoxia; cerebral edema (from both vasogenic mechanisms through blood-brain

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barrier disruption by inflammatory cytokines, and cytotoxic mechanisms from neuronal and glial swelling); and the release of inflammatory mediators including tumor necrosis factor alpha (TNF-alpha), interleukin-1 beta, and interleukin-6 that amplify neuronal injury. The clinical manifestations of cerebral malaria extend beyond coma to include convulsions (occurring in approximately 50 percent of pediatric cerebral malaria cases and approximately 20 percent of adult cases), focal neurological signs (hemiplegia, cortical blindness, cerebellar ataxia), cranial nerve palsies, and abnormal posturing (decerebrate or decorticate, reflecting brainstem involvement or severe diffuse cortical dysfunction). The management of convulsions in cerebral malaria follows the status epilepticus protocol outlined in the previous section, with the specific modification that phenobarbital prophylaxis against seizure recurrence is associated with increased mortality in one large RCT (the prophylactic anticonvulsant in cerebral malaria trial in Malawi) due to respiratory depression, and therefore routine prophylactic anticonvulsant administration is not recommended in cerebral malaria, with anticonvulsants being reserved for actual seizure activity. The neurological sequelae of cerebral malaria in CHT survivors constitute a clinical and public health problem of major proportions that has been almost completely unstudied in the CHT-specific context. In prospective cohort studies of pediatric cerebral malaria survivors in sub-Saharan Africa (which provide the most rigorous available data on this question, relevant to the CHT because the pathophysiology of P. falciparum cerebral malaria is identical across settings), approximately 25 percent of children had at least one neurological or cognitive sequela at six-month follow-up, including epilepsy, gross motor impairment, language impairment, cognitive impairment, and behavioral problems. The post-malaria neurological syndrome (PMNS), an inflammatory central nervous system condition occurring weeks after resolution of malaria, characterized by acute confusion, psychosis, seizures, or cerebellar ataxia, has been described primarily after artemisinin treatment of falciparum malaria and is recognized in the literature as a distinct clinical entity requiring differentiation from treatment failure, bacterial meningitis, and psychosis from other causes. The recognition and documentation of post-cerebral-malaria neurological sequelae in CHT survivors, through prospective clinical follow-up programs at district hospitals, would generate the CHT-specific data needed to quantify this burden and argue for the rehabilitation resources that affected children require.

1.5 Neurocysticercosis: A Hypothesis-Driven Investigation for the CHT

Neurocysticercosis (NCC), caused by the larval stage (Cysticercus cellulosae) of the tapeworm Taenia solium developing within the central nervous system following ingestion of T. solium eggs excreted in the feces of a tapeworm carrier, is the single most common cause of epilepsy in endemic countries globally and one of the diseases whose potential presence in the CHT has been most completely ignored in the public health literature. The transmission cycle of T. solium requires two conditions: the presence of pigs in the community (the intermediate host in which the larval cysts develop in muscle and brain tissue) and the inadequate sanitation and food hygiene that allows human feces containing T. solium eggs (passed by a human tapeworm carrier who has consumed undercooked pork containing cysticerci) to contaminate food and water consumed by other humans, who then develop NCC from the ingested eggs. Both conditions are present in specific CHT communities. Several CHT ethnic groups, notably the Bawm, Pangkhua, Chak, Mro, and Khumi communities in Bandarban, maintain traditional practices of pig keeping and pork consumption, with pigs often allowed to range freely in household and village spaces

where open defecation occurs. The absence of veterinary meat inspection, the traditional practice of consuming pork at community festivals in ways that may not ensure thorough cooking, and the WASH infrastructure deficit that creates conditions for fecal-oral pathogen transmission together constitute a T. solium transmission environment that, by comparison with epidemiologically similar settings in Southeast Asia (Myanmar, Vietnam, Thailand, and Laos, where NCC has been documented as a significant cause of epilepsy in pork-consuming highland minority communities), suggests that NCC is likely to be present in the relevant CHT communities. The clinical presentation of NCC in the CHT would typically be that of new-onset partial or secondarily generalized epilepsy in an adult or older adolescent, potentially with headache (from raised intracranial pressure when cysts are large or numerous), focal neurological signs (from large parenchymal cysts or racemose cysts in the basal cisterns), or acute obstructive hydrocephalus (from ventricular cysts). Diagnosis of NCC requires CT or MRI brain imaging (cysts appear as characteristic ring-enhancing lesions with central scolex in the active inflammatory stage, or as calcified granulomas in the inactive calcified stage) combined with serology (the electroimmunotransfer blot, EITB, for anti-T. solium antibodies has sensitivity of approximately 94 to 98 percent for multiple cysts but lower for single-cyst disease). The Del Brutto diagnostic criteria for NCC (published in the journal Neurology and last updated in 2017) provide a graduated classification from definitive to probable to possible NCC based on the combination of imaging, serology, clinical features, and exposure history. Treatment of NCC is complex and dependent on the number, location, viability, and inflammatory stage of the cysts: active parenchymal cysts are treated with antiparasitic agents (albendazole 15 mg/kg/day in two divided doses for 8 to 30 days, with concurrent corticosteroids to attenuate the inflammatory reaction to dying cysts that can precipitate acute seizure exacerbation); calcified inactive cysts represent dead parasites that do not respond to antiparasitic treatment and are managed with antiepileptic drugs for seizure control; ventricular and subarachnoid cysts require neurosurgical or endoscopic removal, beyond the CHT's current surgical capacity. A seroprevalence study of anti-T. solium antibodies in CHT pork-consuming communities would provide the epidemiological data needed to determine whether NCC is present at clinically significant prevalence and to argue for imaging-based case detection, community-level pig management interventions, and targeted antiparasitic treatment programs.

MODEL EXAMINATION QUESTIONS: CHAPTER ONE (PART THREE)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The annual prevalence of epilepsy per 100,000 population in Bangladesh according to the 2025 Health Science Reports review is approximately: a) 100 b) 200 c) 412 d) 800 (Correct Answer: c)

The ILAE 2014 operational definition of epilepsy requires: a) At least two unprovoked seizures occurring more than 24 hours apart, or one unprovoked seizure with a probability of further seizures similar to the general recurrence risk after two unprovoked seizures (greater than 60%), or diagnosis of an epilepsy syndrome b) At least five seizures of any type c) A documented EEG abnormality d) Prior febrile convulsion followed by any subsequent seizure (Correct Answer: a)

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The Kernig's sign tests for meningeal irritation by: a) Observing spontaneous hip flexion when the neck is passively flexed b) Testing inability to extend the knee when the hip is flexed to 90 degrees c) Observing nystagmus on lateral gaze d) Testing inability to flex the neck against resistance (Correct Answer: b)

The first-line treatment for bacterial meningitis in Bangladesh is: a) Benzyl penicillin IV b) Ceftriaxone IV c) Chloramphenicol IV d) Meropenem IV (Correct Answer: b)

The adjunctive treatment shown to reduce neurological sequelae including hearing loss in bacterial meningitis from H. influenzae and S. pneumoniae is: a) Ibuprofen b) Dexamethasone c) Mannitol d) Phenobarbital (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 6-year-old Bawm child from a remote village in Bandarban, where pigs are kept free-range, presents with a six-month history of recurrent focal seizures with secondary generalization and a single episode of headache and vomiting. Neurological examination is normal between seizures. CT brain imaging at Rangamati District Hospital shows two calcified lesions and one ring-enhancing lesion with a central density in the right parietal lobe. Which diagnosis should be most seriously considered and which management approach is most appropriate? a) Primary brain tumor requiring urgent biopsy b) Bacterial brain abscess requiring IV antibiotics and neurosurgical drainage c) Neurocysticercosis (NCC), with management including anti-T. solium serology confirmation, albendazole 15 mg/kg/day with concurrent corticosteroids for the active lesion, antiepileptic therapy for seizure control, and notification of the public health system for community-level pig management and WASH intervention d) Cerebral malaria with late calcification, treated with artemether-lumefantrine (Correct Answer: c)

A 35-year-old Chakma woman presents to Rangamati District Hospital with 3 weeks of progressive headache, low-grade fever, malaise, and personality change, followed by the development of neck stiffness and sixth cranial nerve palsy in the past 5 days. CSF analysis shows lymphocytes 250 per microliter, protein 2.8 g/L, glucose 30 mg/dL (with simultaneous blood glucose 90 mg/dL). Chest X-ray shows apical infiltrates. Which diagnosis is most likely and what is the appropriate immediate treatment? a) Bacterial meningitis from Streptococcus pneumoniae, treated with IV ceftriaxone and dexamethasone b) Viral meningitis requiring supportive care only c) Tuberculous meningitis (TBM, MRC Grade II), managed with immediate four-drug anti-tuberculosis therapy (isoniazid, rifampicin, pyrazinamide, ethambutol) for 9-12 months with adjunctive dexamethasone, GeneXpert Ultra on CSF if available, and monitoring for hydrocephalus requiring referral d) Fungal meningitis from Cryptococcus requiring amphotericin B (Correct Answer: c)

CHAPTER TWO: OPHTHALMIC DISEASES AND VISION HEALTH IN THE CHT: THE NEGLECTED SENSORY BURDEN

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2.1 The Ophthalmic Ecology of the CHT: A Novel Framework

Vision, the most socially and economically critical of the human sensory systems, is subject to a convergence of threats in the Chittagong Hill Tracts that has been almost completely unaddressed in both clinical practice and public health programming. The ophthalmic ecology of the CHT, a concept introduced here as a framework for understanding how the specific ecological, nutritional, occupational, and clinical environment of the CHT creates a distinctive pattern of ocular disease risk, encompasses five major exposure categories that combine to produce a vision burden substantially greater than national averages. The Nutritional Ophthalmic Category encompasses the direct ocular manifestations of the nutritional deficiencies prevalent in the CHT, most importantly vitamin A deficiency (producing the xerophthalmia spectrum from night blindness through Bitot's spots to corneal xerosis, ulceration, and irreversible blindness, as described in Part Two), and the indirect effects of protein-energy malnutrition on the healing of ocular surface injuries and infections. The Infectious Ophthalmic Category encompasses the ocular manifestations of the CHT's infectious disease burden: measles keratoconjunctivitis (which, in vitamin A-deficient children, can produce corneal ulceration and blindness, and which gained a renewed clinical urgency with the 2025 measles outbreak); onchocerciasis (river blindness, caused by Onchocerca volvulus, not currently documented in the CHT but present in some regions of Myanmar adjacent to the border zone, warranting surveillance attention); trachoma (caused by Chlamydia trachomatis, the leading infectious cause of blindness globally, whose hyperendemic transmission has been documented in communities with inadequate sanitation and face-washing practices in settings comparable to the CHT); and the ocular complications of tuberculosis (including choroidal granulomas, uveitis, and optic neuritis from tuberculous involvement of the optic nerve). The Environmental Ophthalmic Category encompasses the direct effects of the CHT's environmental exposures on ocular health: ultraviolet radiation exposure in outdoor agricultural workers (producing pterygium, a fibrovascular growth of the conjunctiva over the cornea associated with chronic UV and wind exposure, which is clinically significant because it can induce irregular astigmatism and corneal scarring, and which is highly prevalent in outdoor workers in tropical latitudes); biomass smoke exposure from cooking fires (which produces chronic irritant conjunctivitis and dry eye syndrome from direct chemical irritation of the conjunctival epithelium by combustion products); and trauma (sharp eye injuries from bamboo, thorns, and agricultural tools, which are a common cause of corneal laceration, traumatic cataract, and endophthalmitis in CHT farming communities). The Age-Related Ophthalmic Category encompasses the ocular conditions predominantly affecting the aging population: cataract (the leading cause of blindness globally and in Bangladesh, caused by progressive opacification of the crystalline lens of the eye that results in painless, progressive visual loss, and whose onset is accelerated by UV exposure, nutritional deficiency, diabetes, and corticosteroid use, all of which are elevated in the CHT population), primary open-angle glaucoma (an asymptomatic, progressive optic neuropathy driven by elevated intraocular pressure that produces gradual peripheral visual field loss and, if untreated, irreversible blindness), and age-related macular degeneration. The Systemic Disease Ophthalmic Category encompasses the ocular manifestations of the systemic diseases increasingly prevalent in the CHT's NCD transition: diabetic retinopathy (the leading cause of new blindness in working-age adults globally, produced by the microvascular complications of diabetes affecting retinal blood vessels, causing progressive retinal damage and ultimately

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tractional retinal detachment and neovascular glaucoma), and hypertensive retinopathy (arteriovenous nipping, flame hemorrhages, cotton wool spots, and disc edema in severe hypertension).

The concept of the CHT Vision Conservation Doctrine, articulated here for the first time, holds that in a territory where access to ophthalmological specialist services is essentially non-existent for the majority of the population, the prevention of visual impairment through upstream interventions targeting the major preventable causes of blindness is not merely preferable to treatment but is the only realistically achievable strategy. The CHT Vision Conservation Doctrine has four operational principles. The Nutritional Vision Principle holds that universal vitamin A supplementation (administering the WHO-recommended high-dose vitamin A supplement at six-monthly intervals to all children aged 6 to 59 months, through the national vitamin A supplementation program and through EPI outreach visits) is the single most important vision conservation intervention in the CHT for the pediatric age group, and that every episode of childhood measles in the CHT must trigger immediate double-dose vitamin A supplementation regardless of vaccination status, since the measles virus specifically depletes vitamin A stores through increased urinary excretion and reduced hepatic mobilization. The Environmental Protection Principle holds that the provision of protective eyewear for agricultural workers and forest workers in the CHT (at the minimum, inexpensive polycarbonate safety glasses for machete work, bamboo cutting, and other activities with high eye injury risk) and the reduction of UV exposure through hats and appropriate eye protection during peak UV hours represents a low-cost intervention that would substantially reduce the incidence of pterygium, UV-related cataract, and traumatic eye injuries in the CHT working-age population. The Cataract Surgery Access Principle holds that the community-level identification of cataract-blinded individuals in CHT communities, using village health volunteers trained to identify the typical appearance of a white, opaque pupil (leukocoria) or profound visual impairment in an older adult, and the organization of transportation to cataract surgery camps (which have been conducted successfully in various parts of Bangladesh by national and international ophthalmological organizations) would restore functional vision to a large number of CHT adults currently blind from a condition curable in 15 minutes by manual small-incision cataract surgery (MSICS), the technique appropriate for resource-limited settings. The Early Diabetes and Hypertension Detection Principle holds that preventing diabetic retinopathy and hypertensive retinopathy requires the early detection and treatment of diabetes and hypertension before their retinal complications develop, which is why the NCD screening program design described in Part Two (opportunistic blood pressure and blood glucose screening at every health system contact) is also a vision conservation strategy of direct clinical significance.

2.2 Trachoma: Assessment of Risk and Elimination in the CHT Context

Trachoma, caused by repeated ocular infections with Chlamydia trachomatis (particularly the serovars A, B, Ba, and C that are adapted to ocular mucosal surfaces), is the leading infectious cause of preventable blindness globally, affecting approximately 1.9 million people with blindness and 2.5 million with visual impairment from trichiasis (the in-turned eyelashes of trachomatous trichiasis that abrade the corneal surface) according to WHO 2024 estimates. Trachoma is a disease of poverty, overcrowding, and inadequate face-washing, and it is

hyperendemic in communities where sanitation and hygiene facilities are inadequate and where children's faces are chronically dirty with nasal and ocular discharge (which provides the secretion that transmits C. trachomatis between children through eye-seeking flies, particularly Musca sorbens, and direct contact). Bangladesh was reported by WHO to have eliminated trachoma as a public health problem (defined as having reached the WHO elimination threshold of trachomatous follicles, TF, prevalence below 5 percent in children 1 to 9 years in all formerly endemic districts) in 2017. However, the elimination threshold assessment methodology requires adequate surveillance across all previously endemic areas, and the epidemiological conditions in remote CHT communities (inadequate sanitation, crowded housing, inadequate access to water for face-washing, and the presence of eye-seeking fly populations in animal-keeping households) are consistent with the conditions that maintain trachoma endemicity in other parts of South and Southeast Asia. A specific serological and clinical survey for trachoma in CHT remote communities, particularly those of the Mro, Khumi, and Chak communities in Bandarban's deep valleys where WASH conditions are most inadequate, would definitively determine whether CHT-specific trachoma transmission has been captured in the national surveillance data or whether a pocket of residual transmission persists below the surveillance threshold. The WHO SAFE strategy for trachoma elimination (Surgery for trichiasis, Antibiotics for C. trachomatis infection, Facial cleanliness, and Environmental improvement for hygiene and sanitation) provides the operational framework for any CHT trachoma program, with the surgical component (lid rotation surgery for trichiasis) requiring a bilamellar tarsal rotation procedure performable by trained ophthalmic nurses at primary facility level, the antibiotic component using single-dose azithromycin oral (20 mg/kg in children, 1 g in adults, with annual mass drug administration), and the F and E components requiring the same WASH infrastructure investment that addresses diarrheal disease and multiple other CHT health priorities simultaneously.

MODEL EXAMINATION QUESTIONS: CHAPTER TWO (PART THREE)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Bitot's spots are found on which ocular structure in vitamin A deficiency? a) The cornea b) The retina c) The bulbar conjunctiva adjacent to the corneal limbus d) The eyelid margin (Correct Answer: c)

Pterygium is associated with which primary environmental exposure? a) Vitamin A deficiency b) Chronic UV radiation and wind exposure c) Fungal infection of the conjunctiva d) Vitamin D deficiency (Correct Answer: b)

The WHO SAFE strategy for trachoma elimination stands for: a) Surgery, Antibiotics, Facial cleanliness, Environmental improvement b) Screening, Antiparasitics, Fluoride, Epidemiology c) Surveillance, Assessment, Fluorescein, Elimination d) Slit-lamp, Azithromycin, Follow-up, Education (Correct Answer: a)

Diabetic retinopathy produces tractional retinal detachment through which mechanism? a) Directly from elevated blood glucose dissolving the retinal adhesion b) Fibrovascular

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proliferative membrane formation from neovascularization causing traction on the retina c) Photoreceptor degeneration from vitamin A deficiency secondary to diabetes d) Inflammatory destruction of the retinal pigment epithelium (Correct Answer: b)

The single most effective preventive intervention for preventing vitamin A deficiency blindness in CHT children aged 6 to 59 months is: a) Dietary supplementation with liver and eggs b) Semi-annual high-dose vitamin A supplementation through the national program c) Daily vitamin A drops d) Fortification of salt with vitamin A (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 5-year-old Mro child presents during the 2025 measles outbreak with measles keratoconjunctivitis. The clinician notes bilateral conjunctival injection, photophobia, and a small corneal epithelial defect visible with fluorescein staining. The child is visibly malnourished with a MUAC of 118 mm. Which immediate ophthalmological management is essential to prevent corneal ulceration and blindness in this child? a) Topical antibiotic eye drops only b) Immediate high-dose vitamin A supplementation (200,000 IU orally on two consecutive days), topical lubricant eye drops, topical antibiotic to prevent secondary bacterial superinfection, and ophthalmological specialist referral if corneal ulceration progresses c) Surgical debridement of the corneal lesion d) Topical corticosteroid eye drops to reduce inflammation (Correct Answer: b)

A CHT primary health worker conducting a household survey identifies a 68-year-old Chakma woman in Rangamati who has been unable to recognize faces for the past 18 months. On examination, the pupils appear white and opaque bilaterally. Which diagnosis is most likely and what is the appropriate action? a) Glaucoma requiring urgent surgical referral b) Bilateral cataract, appropriate action being referral to an ophthalmological cataract surgery camp or the district hospital's ophthalmology outpatient service for assessment and scheduling of manual small-incision cataract surgery c) Corneal ulceration requiring topical antibiotics d) Trachomatous blindness requiring azithromycin (Correct Answer: b)

CHAPTER THREE: ORAL HEALTH, DENTAL DISEASES, AND OROPHARYNGEAL CONDITIONS IN THE CHT: THE MOUTH AS CLINICAL MIRROR

3.1 The Oral Health Burden of the CHT: A Systemic Disease of Neglect

The oral cavity is the clinical mirror of systemic health, reflecting in its tissues the nutritional status, immunological capacity, hormonal environment, tobacco and betel nut use, hygienic conditions, and infectious disease history of the individual. In the CHT, the oral health of the population is a particularly revealing mirror, because it reflects simultaneously the nutritional deficiencies of a food-insecure community, the betel nut and tobacco use patterns deeply embedded in the social life of multiple ethnic groups, the absence of fluoride in the water supply of most CHT communities (with consequences for dental caries risk that differ in direction from

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the plains communities where excessive fluoride is a concern), the absence of any formal dental care services in most of the CHT outside the administrative towns, and the consequences of the structural violence that has produced the poverty and marginalization driving all of these risk factors. The oral health conditions of the CHT can be organized into five categories: dental caries, periodontal disease, oral potentially malignant disorders (OPMDs) including oral submucous fibrosis and leukoplakia, oral cancer, and the oral manifestations of systemic diseases. Dental caries, the infectious disease of the tooth caused by the acid produced by cariogenic bacteria (primarily Streptococcus mutans and Lactobacillus species) metabolizing fermentable carbohydrates adherent to the tooth surface, is the most prevalent chronic disease globally and almost certainly the most prevalent chronic disease in the CHT. The caries risk factors operating in the CHT include a traditional diet high in sticky fermentable carbohydrates (boiled rice, rice-based cakes, and sugar-sweetened locally brewed drinks), the complete absence of fluoride in the drinking water supply of most CHT communities (whereas the national caries prevention program has relied substantially on fluoride in toothpaste and water in urban areas), the essentially universal absence of brushing with fluoride toothpaste in the most remote communities (where toothpaste is unavailable or unaffordable and the traditional teeth-cleaning method is twigs from specific tree species with variable but generally limited fluoride content), and the absence of any dental care services that would enable early caries treatment before progression to pulp involvement and tooth loss. Untreated dental caries progresses to dental pulpitis (pulpal inflammation producing the severe, often nocturnal, spontaneous throbbing pain that drives emergency dental presentations), pulp necrosis and periapical abscess (producing the facial swelling, trismus, and fever of dentoalveolar abscess that can progress to life-threatening complications including Ludwig's angina, cavernous sinus thrombosis, and descending necrotizing mediastinitis if untreated), and tooth loss, with the associated nutritional consequences of inability to chew hard foods that is particularly significant in the elderly. Periodontal disease, the inflammatory destruction of the tooth-supporting structures (the gingiva, periodontal ligament, and alveolar bone) by the host's immune response to the subgingival bacterial biofilm, is the second most prevalent oral disease globally and produces progressive attachment loss, bone resorption, and ultimately tooth loss if untreated. The bidirectional relationship between periodontal disease and systemic conditions including diabetes mellitus (in which hyperglycemia impairs neutrophil function and promotes the virulence of periodontal pathogens, while the systemic inflammation of periodontitis worsens insulin resistance), cardiovascular disease (where the chronic inflammatory burden of severe periodontitis contributes to systemic inflammation that accelerates atherosclerosis), and adverse pregnancy outcomes (where periodontal bacteremia and inflammatory mediators have been associated in prospective studies with preterm birth and low birth weight) makes periodontal health a systemic health priority beyond its local clinical significance.

3.2 Oral Submucous Fibrosis and Oral Cancer: The Betel Nut Crisis

Oral submucous fibrosis (OSMF) is a chronic, progressive, potentially malignant disorder of the oral cavity caused by the prolonged use of areca nut (Areca catechu, commonly called supari or betel nut), whose active alkaloids (primarily arecoline, which stimulates fibroblasts to produce excess collagen and inhibits collagen degradation through inhibition of collagenase and other matrix metalloproteinases) produce a fibrotic transformation of the oral submucosal connective

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tissue. OSMF is clinically characterized by burning sensation in the mouth on contact with spicy foods (typically the earliest symptom), gradual development of fibrous bands in the buccal mucosa and soft palate (palpable as vertical or oblique fibrous bands that can be felt through the cheek), progressive reduction of mouth opening (trismus, technically defined as an interincisal distance of 35 mm or less, severely restricting the ability to eat, speak, and undergo dental treatment or oropharyngeal examination), blanching or marbling of the oral mucosa (from submucosal fibrosis producing pallor of the overlying mucosa), and vesicles or ulcers in the early inflammatory stage. The malignant transformation rate of OSMF to oral squamous cell carcinoma (the predominant oral cancer histological type) is approximately 7 to 13 percent over 10 years in prospective follow-up studies, making it one of the highest malignant transformation rates of any oral potentially malignant disorder. In the CHT, OSMF is driven by the culturally embedded practice of chewing betel quid (paan), which is consumed in virtually all eleven ethnic communities and by both genders as a social, ceremonial, and perceived health-promoting practice, with frequency of use ranging from occasional ceremonial consumption to multiple-times-daily habitual use. The tobacco component of betel quid (tobacco is added to the areca nut and betel leaf mixture in many CHT preparations, and the practice is sometimes called gutka or pan masala with tobacco) dramatically amplifies the carcinogenic risk of areca nut alone, since tobacco contributes nitrosamines and other carcinogens in addition to the areca-specific arecoline mechanism. Oral squamous cell carcinoma in the CHT produces a clinical spectrum from painless early leukoplakia (a white patch that cannot be rubbed off and has no other identifiable cause) or erythroplakia (a red velvety patch, with substantially higher malignant potential than leukoplakia) through the established cancer presentation of an ulcerated, indurated, non-healing mucosal lesion with rolled borders (the indurated and ulcerated floor of mouth lesion, the lateral tongue lesion, or the buccal mucosa lesion that are the most common sites in betel-nut-using populations). Lymph node metastasis to the cervical lymph nodes is present in approximately 40 to 70 percent of oral SCC patients at diagnosis in South Asian series, reflecting both the frequency of late presentation and the aggressive natural history of some oral SCC subtypes. The prognosis of oral SCC is strongly stage-dependent: early-stage (T1-T2 N0 M0) oral SCC has a 5-year survival of approximately 70 to 80 percent with appropriate surgery and/or radiotherapy, while advanced-stage (T3-T4 or node-positive) disease has a 5-year survival of 25 to 40 percent. In the CHT, where virtually all oral SCC patients will present at advanced stages (due to the combined barriers of geographic access, financial constraints, pain-minimizing cultural stoicism, and the absence of routine oral cancer screening), the prognosis of the disease is determined more by the structural failures of early detection than by the biology of the tumor itself. The CHT Oral Cancer Prevention Cascade proposes a four-stage community-level response: Stage 1 involves community health worker training in visual oral health inspection (VOI), specifically the identification of OSMF fibrous bands, leukoplakia, erythroplakia, and ulcerated lesions during household health visits; Stage 2 involves community education about the oral cancer risk of betel nut and tobacco use, delivered through culturally adapted messages in indigenous languages; Stage 3 involves structured cessation support for betel nut and tobacco use, adapted to the social and ceremonial contexts of CHT betel use (recognizing that complete prohibition is culturally inappropriate but reduction of frequency and elimination of tobacco from the quid composition are achievable intermediate goals); and Stage 4 involves referral pathways for suspicious oral lesions to district hospital dental outpatient services and, for established cancer, to the oncological facilities in Chittagong.

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3.3 Ludwig's Angina and Orofacial Infections: Emergency Management

Ludwig's angina, a rapidly progressive, potentially fatal bilateral cellulitis of the floor of the mouth (specifically involving the submandibular, submental, and sublingual spaces simultaneously), typically arising from the dental infection of a lower second or third molar tooth, represents the most life-threatening consequence of neglected dental disease in the CHT context. The term "angina" in this context derives not from cardiac disease but from the Latin "angere" (to strangle), reflecting the life-threatening airway compromise that is the primary cause of death in untreated or inadequately treated cases. Ludwig's angina progresses through three stages: the early cellulitic stage (bilateral submandibular and submental swelling, brawny induration of the floor of the mouth, early elevation of the tongue, and difficulty swallowing), the intermediate stage (progressive tongue elevation obstructing the oropharyngeal airway, increasing difficulty with swallowing and speech, and the threat of aspiration from accumulated secretions), and the late stage (complete airway obstruction requiring emergency airway management). The clinical urgency of Ludwig's angina cannot be overstated: untreated cases progress from early cellulitis to airway obstruction and death within hours to a few days, and the management priority is securing the airway before it is fully obstructed, since nasotracheal intubation and oral intubation both become impossible once significant tongue elevation and floor-of-mouth induration have developed, requiring emergency surgical airway (cricothyroidotomy as the most rapidly deployable emergency technique, followed by tracheostomy for definitive airway management). Antibiotic therapy for Ludwig's angina targets the polymicrobial infection (mixed aerobic streptococci, anaerobic organisms including Bacteroides species, Peptostreptococcus, and Fusobacterium, and occasionally Staphylococcus aureus) with high-dose intravenous penicillin G plus metronidazole (covering the anaerobic component) or amoxicillin-clavulanate IV as a broad-spectrum alternative. In CHT district hospitals where anaesthetic and airway management capacity may be limited, the clinical priority when Ludwig's angina is diagnosed is to transfer the patient to Chittagong Medical College Hospital for definitive airway management before the critical stage of airway compromise is reached, since performing emergency cricothyroidotomy in a CHT district hospital without anaesthetic support and operating theatre backup represents the most dangerous possible emergency airway scenario. Surgical drainage of fluctuant abscess collections (when loculation occurs) requires parallel incision drainage through both the submandibular spaces (externally, below the mandibular angle) and the sublingual space (intraorally), with blunt dissection through the mylohyoid muscle barrier separating these spaces.

MODEL EXAMINATION QUESTIONS: CHAPTER THREE (PART THREE)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Oral submucous fibrosis (OSMF) is caused by the long-term use of which substance? a) Tobacco smoking alone b) Areca nut (betel nut), specifically its alkaloid arecoline c) Alcohol d) Cannabis (Correct Answer: b)

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The potentially malignant oral disorder with the highest malignant transformation rate per decade is: a) Leukoplakia b) Oral submucous fibrosis (OSMF) c) Oral lichen planus d) Actinic keratosis (Correct Answer: b, with OSMF at 7-13% per decade)

Ludwig's angina most commonly arises from infection of which tooth? a) Upper central incisor b) Lower second or third molar c) Upper canine d) Lower first premolar (Correct Answer: b)

The primary life-threatening complication of Ludwig's angina is: a) Septicemia and bacteremia b) Airway compromise from tongue elevation and floor-of-mouth induration c) Cavernous sinus thrombosis d) Descending necrotizing mediastinitis (Correct Answer: b, though all may occur in sequence)

Cariogenic bacteria that produce acid from fermentable carbohydrates and drive dental caries include: a) Streptococcus pyogenes and Staphylococcus aureus b) Streptococcus mutans and Lactobacillus species c) Treponema denticola and Tannerella forsythia d) Fusobacterium nucleatum and Porphyromonas gingivalis (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 45-year-old Marma man presents to Bandarban District Hospital with three days of progressively worsening bilateral lower jaw swelling, marked difficulty opening his mouth and swallowing, and a muffled voice. His temperature is 39.2 degrees Celsius and his mouth opening is 10 mm. The floor of the mouth is visibly elevated and indurated bilaterally. Which is the most immediately critical clinical action? a) Arrange emergency dental extraction of the offending tooth b) Initiate IV antibiotics and observe for 24 hours c) Immediately assess airway and arrange for controlled intubation or emergency airway management before proceeding to antibiotic therapy, and arrange urgent transfer to a facility with anaesthetic and ENT or maxillofacial surgical capacity d) Aspirate submandibular swelling with a needle for pus culture (Correct Answer: c)

A community health worker conducting household visits in Rangamati identifies a 52-year-old Chakma woman who has been chewing areca nut with tobacco daily for 25 years. The woman reports burning sensation in the mouth and difficulty opening her mouth fully. Inspection of the oral cavity reveals white fibrous bands in both buccal mucosae and a white non-removable patch on the right buccal mucosa. Which is the most appropriate next step? a) Reassure the woman that this is a normal finding in betel nut users b) Prescribe topical antiseptic mouth rinse c) Refer to the district hospital dental or ENT outpatient clinic for formal oral examination, biopsy of the white patch to exclude malignant transformation, OSMF grading, cessation counseling, and entry into an oral cancer surveillance pathway d) Prescribe systemic corticosteroids empirically (Correct Answer: c)

CHAPTER FOUR: MUSCULOSKELETAL AND RHEUMATOLOGICAL DISEASES IN THE CHT: THE OCCUPATIONAL AND INFLAMMATORY BURDEN

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4.1 The Musculoskeletal Disease Ecology of the CHT

The musculoskeletal disease burden of the Chittagong Hill Tracts is shaped by a combination of the extraordinary physical demands of subsistence agriculture in mountainous terrain, the nutritional conditions that compromise bone and muscle health across the lifespan, the infectious diseases (particularly tuberculosis and septic arthritis) that produce inflammatory joint and bone destruction, and the emerging burden of inflammatory rheumatological conditions in a population that has been studied almost exclusively for its infectious disease burden. The concept of the CHT Musculoskeletal Burden Triad organizes the territory's musculoskeletal diseases into three categories: the Mechanical-Occupational category (including osteoarthritis, low back pain, knee pain, and soft tissue injuries from the biomechanical demands of jhum farming on steep terrain); the Infectious-Inflammatory category (including septic arthritis, osteomyelitis, tuberculous arthritis and Pott's disease, reactive arthritis from enteric and urogenital infections, and acute rheumatic fever with rheumatic heart disease); and the Systemic Inflammatory-Nutritional category (including rheumatoid arthritis, ankylosing spondylitis, lupus, and the musculoskeletal consequences of nutritional deficiencies including osteomalacia from vitamin D deficiency, osteoporosis from calcium and protein deficiency, and the bone and joint manifestations of scurvy from vitamin C deficiency). The mechanical musculoskeletal burden arising from the specific demands of jhum agriculture is a clinical observation that has been completely ignored in the CHT medical literature. Jhum farmers operate on slopes ranging from 20 to 45 degrees of inclination, carrying heavy loads (seed bags, harvested crops, water, and firewood) over long distances in terrain without paths, performing repetitive stooping and kneeling movements during planting and weeding, and using manual tools (hoe, machete, and axe) with asymmetric upper limb loading patterns that produce predictable musculoskeletal adaptation and injury profiles. Lumbar spine disorder, both acute low back pain from sudden muscle strain or disc injury and chronic low back pain from degenerative disc disease and facet joint arthropathy, is almost certainly the most prevalent musculoskeletal complaint in the CHT adult population, though no systematic prevalence studies have been conducted in the territory. The clinical management of acute low back pain in the CHT follows the same principles as elsewhere (initial analgesia with paracetamol and NSAIDs where inflammatory signs are present, avoidance of bed rest in favor of continued activity, education about the benign self-limited nature of most acute low back pain), but with the CHT-specific consideration that NSAID use in patients with concurrent P. falciparum malaria or thrombocytopenia (from any cause including dengue) increases bleeding risk, and that paracetamol (acetaminophen) is the safer first-line analgesic in a population with high background rates of conditions affecting platelet function. Knee osteoarthritis, the most prevalent cause of musculoskeletal disability in older adults globally and driven in the CHT by the combination of chronic high-load knee joint exposure from slope walking and load carrying, the joint damage from prior septic arthritis episodes (which are more common in immunocompromised malnourished individuals), and the emerging NCD risk factor of overweight (which is beginning to appear in CHT adults as dietary transition progresses), produces the chronic joint pain and functional limitation that represents the dominant musculoskeletal burden of CHT elderly adults.

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4.2 Acute Rheumatic Fever and Rheumatic Heart Disease: A CHT Priority

Acute rheumatic fever (ARF) and its long-term cardiac sequela, rheumatic heart disease (RHD), represent arguably the most important but least recognized cardiovascular disease entity specific to the CHT's socioeconomic and infectious disease context. ARF is an autoimmune inflammatory condition triggered by group A Streptococcal (GAS) pharyngitis, occurring typically 2 to 4 weeks after untreated or inadequately treated streptococcal throat infection, in which molecular mimicry between streptococcal M protein epitopes and cardiac tissue antigens (particularly the myosin heavy chain, laminin, vimentin, and the endothelial N-acetyl-beta-D-glucosamine of heart valve tissue) triggers a cross-reactive autoimmune attack on the myocardium, endocardium, pericardium, joints, skin, and basal ganglia. The Jones criteria (revised by the American Heart Association in 2015) provide the diagnostic framework for ARF, requiring evidence of preceding GAS infection (either positive throat culture, elevated ASO titer, or other streptococcal antibody) plus two major criteria or one major and two minor criteria. The major criteria are carditis (clinical and/or echocardiographic evidence of cardiac involvement, with the 2015 revision specifically incorporating subclinical carditis detectable only on echocardiography as a major criterion), polyarthritis (migratory, painful arthritis of large joints, characteristically so dramatically painful relative to the clinical signs that the patient frequently resists even the weight of bedsheets over the affected joint), Sydenham's chorea (involuntary, purposeless, non-rhythmic movements of the face and extremities, representing neurological involvement from inflammatory damage to the basal ganglia and caudate nucleus), erythema marginatum (a transient, non-pruritic annular or polycyclic erythematous rash with central clearing, present in approximately 5 to 10 percent of ARF cases), and subcutaneous nodules (hard, painless nodules over bony prominences and tendons, present in approximately 5 to 7 percent of cases). The minor criteria are fever, elevated ESR or CRP, and prolonged PR interval on ECG. The 2015 revision introduced the concept of low-risk versus moderate-to-high-risk populations, with different diagnostic thresholds applying to populations with documented ARF prevalence above 2 per 1,000 school-age children per year, a threshold that the CHT almost certainly meets given the combination of high rates of untreated streptococcal pharyngitis and the socioeconomic conditions known to drive ARF risk. The critical clinical insight about ARF is that carditis, which occurs in approximately 50 to 70 percent of first ARF episodes, is the only manifestation that produces lasting damage: the arthritis and chorea resolve completely without sequelae, but each episode of carditis leaves incremental mitral and aortic valve scarring (with the mitral valve most commonly affected, with the aortic valve the second most commonly affected, and rarely the tricuspid or pulmonary valves) that accumulates over recurrent episodes to produce the valvular lesions of RHD. Mitral stenosis (the most common RHD valvular lesion, from fusion of the mitral valve leaflet tips and thickening of the subvalvular apparatus from recurrent carditis) produces progressive breathlessness on exertion, orthopnea, paroxysmal nocturnal dyspnea, and ultimately pulmonary hypertension and right heart failure. Mitral regurgitation (the most common lesion in acute carditis, from valve leaflet and chordal damage preventing competent closure), if progressive, leads to left ventricular volume overload and eventual heart failure. The prevention strategy for RHD, which is the most important aspect of its management because established valvular disease has no effective pharmacological treatment short of valve surgery (which is unavailable in the CHT), is secondary prophylaxis with intramuscular benzathine penicillin G (1.2 million units IM every 4 weeks, or 0.6 million units

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for children below 27 kg), which prevents recurrent GAS pharyngitis and thus prevents recurrent carditis, halting the accumulation of valvular damage. The duration of secondary prophylaxis is guided by the presence and severity of carditis: patients without carditis receive prophylaxis for 5 years or until age 21 (whichever is longer); patients with carditis but no persistent valvular disease receive prophylaxis for 10 years or until age 21; and patients with persistent valvular disease receive prophylaxis for 10 years or until age 40. In the CHT, where injection facilities may be geographically distant from patients requiring monthly injections, alternative delivery systems including community health worker-administered IM penicillin at household level (given appropriate training and cold-chain maintenance) should be explored as a strategy to maintain prophylaxis continuity in remote communities.

4.3 Septic Arthritis and Osteomyelitis in CHT Communities

Septic arthritis, defined as a pyogenic bacterial infection of the joint space, represents an orthopedic emergency because the proteolytic enzymes released by neutrophils responding to intraarticular bacterial invasion can destroy articular cartilage within hours, producing irreversible joint damage if diagnosis and drainage are delayed beyond 24 to 48 hours. In the CHT, the risk of septic arthritis is elevated by the frequency of penetrating skin and soft tissue injuries from agricultural tools and thorns (which can introduce bacteria directly into joint spaces or periarticular tissues from which hematogenous spread to joints occurs), the immunological vulnerability of malnourished individuals (in whom bacteremia from any source is more likely to seed joint spaces), and the delayed presentation to healthcare that is ubiquitous in the CHT, meaning that cases are more likely to present at advanced stages with established articular cartilage destruction. The most common causative organisms of septic arthritis in the CHT context include Staphylococcus aureus (accounting for approximately 50 percent of cases across all ages and the predominant organism in children over 3 years and adults), Streptococcus species (particularly Group A Streptococcus and Group B Streptococcus), and Gram-negative enteric bacilli (including E. coli and Klebsiella, particularly in elderly, diabetic, or otherwise immunocompromised patients). Neisseria gonorrhoeae must be considered in sexually active young adults, though gonorrheal septic arthritis characteristically produces polyarthritis with skin vesiculopustular lesions and tenosynovitis (the disseminated gonococcal infection triad) before mono-articular joint involvement. The clinical diagnosis of septic arthritis rests on the combination of acute monoarticular joint pain, swelling, warmth, and severe limitation of movement in a febrile patient, with aspiration of purulent joint fluid providing the definitive diagnosis and the most important therapeutic intervention. Joint aspiration (arthrocentesis) in the CHT is a procedure that district hospital physicians must be competent to perform at all major accessible joints (knee, shoulder, ankle, wrist, and elbow), since delay in drainage directly correlates with cartilage destruction and permanent joint damage. Joint fluid should be sent for Gram stain, culture and sensitivity, white cell count, and glucose (with simultaneous serum glucose for comparison, as the joint:serum glucose ratio below 0.5 supports bacterial infection), and empirical IV antibiotic therapy (cloxacillin 1-2 g IV six-hourly to cover S. aureus plus a Gram-negative cover such as ceftriaxone 2 g IV daily) should be initiated immediately after aspiration without waiting for culture results. Surgical drainage and joint washout are indicated when joint aspiration fails to adequately decompress the joint, when involvement of the hip or shoulder joint is suspected (where needle aspiration is technically limited and open or

arthroscopic washout is the standard of care), or when there is lack of clinical improvement within 48 to 72 hours of appropriate antibiotic therapy. Hematogenous osteomyelitis, bacterial infection of the bone via the bloodstream (most commonly in the metaphyseal regions of long bones in children, where the terminal capillaries of the metaphyseal sinusoidal vessels create conditions of relative stasis that favor bacterial settling), shares the management principles of septic arthritis in the urgency of antibiotic therapy initiation and the requirement for surgical debridement of devitalized bone (sequestrum) when the infection becomes chronic with abscess and fistula formation.

MODEL EXAMINATION QUESTIONS: CHAPTER FOUR (PART THREE)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The revised Jones criteria for acute rheumatic fever (2015 AHA revision) major criteria include all of the following EXCEPT: a) Carditis (clinical or subclinical by echocardiography) b) Polyarthritis c) Sydenham's chorea d) Elevated ASO titer (Correct Answer: d, which is evidence of GAS infection and a prerequisite, not a major criterion)

Secondary prophylaxis for rheumatic heart disease is administered with: a) Oral phenoxymethylpenicillin daily b) Intramuscular benzathine penicillin G every 4 weeks c) Oral amoxicillin twice daily d) Intramuscular procaine penicillin every 2 weeks (Correct Answer: b)

The most common valve affected in rheumatic heart disease is: a) Aortic valve b) Mitral valve c) Tricuspid valve d) Pulmonary valve (Correct Answer: b)

In septic arthritis, the proteolytic enzymes that destroy articular cartilage are released by: a) Activated fibroblasts b) Neutrophils responding to intraarticular bacterial invasion c) Macrophages in the synovial membrane d) Activated complement proteins (Correct Answer: b)

Vitamin D deficiency in adults produces which musculoskeletal condition? a) Osteoporosis b) Osteomalacia (impaired bone mineralization causing bone pain, muscle weakness, and fractures) c) Rickets (in adults) d) Gout (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 12-year-old Chakma girl presents to Khagrachhari District Hospital with her third episode of migratory polyarthritis in 2 years, with a new cardiac murmur on auscultation (pansystolic at the apex radiating to the axilla, consistent with mitral regurgitation). ASO titer is elevated at 600 IU/mL. Echo shows mitral regurgitation with valve leaflet thickening. The 2015 Jones criteria are met. Which is the most important long-term management decision and why? a) Initiate oral naproxen for joint inflammation and schedule re-evaluation in 6 months b) Prescribe benzathine penicillin G 1.2 million units IM every 4 weeks as secondary prophylaxis to be continued for at least 10 years or until age 40 (given persistent valvular disease), alongside anti-inflammatory therapy for the acute arthritis and carditis, and enroll in an RHD registry for long-term follow-up

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c) Refer for immediate valve replacement surgery d) Treat with systemic corticosteroids only and observe for spontaneous resolution (Correct Answer: b)

CHAPTER FIVE: REPRODUCTIVE HEALTH, FAMILY PLANNING, AND SAFE MOTHERHOOD IN DEPTH: THE FULL CLINICAL FRAMEWORK

5.1 The Reproductive Health Conceptual Architecture for the CHT

Reproductive health in the Chittagong Hill Tracts encompasses a clinical and public health domain of exceptional breadth and complexity, one that spans the entire lifespan from adolescent sexual development through reproductive years through menopause and beyond, and that intersects with gender equity, cultural norms, bodily autonomy, access to contraception, the management of pregnancy and its complications, the prevention and treatment of sexually transmitted infections, the diagnosis of gynaecological conditions including cervical and other cancers, and the mental health dimensions of reproductive experience. The foundational principle guiding this chapter's framework is the CHT Reproductive Sovereignty Doctrine, defined here as the principle that every person of reproductive capacity in the CHT, regardless of ethnicity, gender, age, marital status, or economic position, has an inherent and inviolable right to the information, services, and safety they need to make autonomous and fully informed decisions about their reproductive and sexual health, and that the specific cultural, linguistic, geographic, and economic barriers that restrict the exercise of this right in the CHT constitute violations of reproductive justice that the health system is ethically obligated to address. This doctrine does not conflict with the cultural specificities of CHT communities but rather provides the ethical framework within which culturally sensitive reproductive health services must be designed and delivered. The CHT's reproductive health epidemiology is characterized by several features that distinguish it from the national pattern: adolescent fertility (births to girls aged 15 to 19 years) remains relatively high in several CHT ethnic communities compared with national trends, reflecting the persistence of early marriage practices in communities with limited girls' secondary education; contraceptive prevalence is lower in remote CHT communities than national averages, with demand for family planning services frequently unmet; the total fertility rate (TFR) of CHT indigenous communities has declined from high levels in previous generations but remains above the national average and above the replacement rate of 2.1 children per woman; and antenatal care coverage, skilled birth attendance, and emergency obstetric care access remain substantially below national averages in remote CHT communities, as documented throughout Parts One and Two.

The specific contraceptive methods most appropriate for CHT communities require careful consideration of the CHT-specific context, which differs from both the urban and the plains rural settings for which national family planning programs are primarily designed. Long-acting reversible contraceptives (LARCs), including the copper intrauterine device (IUD) and the hormonal implant (etonogestrel implant, commercial name Implanon or Nexplanon), are theoretically ideal for CHT communities because they are placed once and provide extended protection (3 to 10 years depending on the method) without requiring daily adherence or repeated

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supply chain access, which are the primary barriers to contraceptive method continuation in remote communities with intermittent healthcare access. However, LARC insertion requires a trained healthcare provider and clinical conditions (including basic examination facilities and sterile technique for IUD insertion), and device expulsion or complication management may require a visit to a health facility during the protection period, which the geographical barriers of the CHT can make difficult. The hormonal implant (providing 3 years of highly effective contraception from a single subdermal insertion in the inner upper arm) is particularly suitable for CHT communities because its insertion and removal can be performed with minimal equipment, its effectiveness is essentially independent of user compliance after insertion, and it does not affect breastfeeding. Injectable contraceptive (Depo-Provera, medroxyprogesterone acetate 150 mg IM every 3 months) has been one of the most widely used methods in CHT communities because of its periodic supply (requiring only quarterly facility visits rather than daily pill supply) and its high effectiveness, but it produces an extended delay in return to fertility after discontinuation (an average of 10 months) that is a cultural concern for women who want to conceive soon after stopping contraception. Combined oral contraceptive pills (COCPs) require daily use, consistent supply, and literacy sufficient to follow the pill pack, and are therefore less suitable for remote CHT communities than for urban populations. Condoms are essential for dual protection against both pregnancy and sexually transmitted infections, including HIV, and their promotion in CHT communities must address the cultural and gender dynamics that have historically made male condom use dependent on male partner agreement, placing the contraceptive responsibility inequitably on women.

5.2 Cervical Cancer: The Prevention-First Imperative

Cervical cancer, caused by persistent infection with oncogenic human papillomavirus (HPV) genotypes (most importantly HPV 16 and HPV 18, which together account for approximately 70 percent of cervical cancers globally, with HPV 31, 33, 45, 52, and 58 contributing the majority of the remaining cases), is the most preventable of all cancers through the combination of primary prevention (HPV vaccination) and secondary prevention (cervical cancer screening and pre-malignant lesion treatment). In Bangladesh, cervical cancer is the second most common cancer in women, with an estimated incidence of 14.1 per 100,000 women per year in the 2020 GLOBOCAN estimates, and it is likely substantially more prevalent in CHT indigenous women due to the absence of screening programs in the territory and the absence of HPV vaccination among adolescent girls in remote communities. The pathological pathway from HPV infection to cervical cancer is well characterized: persistent HPV infection of the metaplastic squamous epithelium of the cervical transformation zone (the junction between the columnar endocervical epithelium and the ectocervical squamous epithelium, which is the site of virtually all cervical precancers and cancers) produces a spectrum of cervical intraepithelial neoplasia (CIN) ranging from CIN1 (low-grade squamous intraepithelial lesion, LSIL, which usually regresses spontaneously) through CIN2-3 (high-grade squamous intraepithelial lesion, HSIL, which has a higher risk of progression to invasive cancer) to invasive squamous cell carcinoma and adenocarcinoma. The critical importance of the transformation zone is anatomical: in postmenarchal adolescents and young women, the transformation zone is ectocervical and therefore accessible to direct HPV exposure, to screening techniques, and to ablative treatment. As women age, the transformation zone recedes into the endocervical canal, which affects the

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sensitivity of screening at different ages and the feasibility of some screening-and-treat protocols. The VIA (visual inspection with acetic acid) screening method, which involves applying 3 to 5 percent acetic acid to the cervix and looking for acetowhitening (areas turning white within 1 minute of acetic acid application, indicating the presence of abnormal squamous epithelium with high nuclear density that reflects light differently from normal epithelium), provides a simple, instrument-light, inexpensive, and provider-trainable screening technique requiring no laboratory infrastructure, making it the most appropriate primary cervical screening method for remote CHT communities. The screen-and-treat approach, in which women who screen positive on VIA are treated immediately in the same visit with cryotherapy (freezing of the transformation zone with liquid nitrogen or CO2 cartridge-based equipment, which destroys the surface cells at temperatures of minus 20 to minus 30 degrees Celsius, causing coagulative necrosis of the treated tissue and removal of HPV-infected and dysplastic cells) or thermal ablation (the newer technique using a thermocoagulator device that destroys tissue at 100 degrees Celsius, equally effective as cryotherapy and easier to supply-chain-manage without the need for gas cartridges), reduces the loss-to-follow-up that occurs when screening and treatment are separated into different visits (a critical advantage in the CHT where returning to a health facility for a second visit carries enormous geographic and economic costs for the patient). HPV vaccination, using the nonavalent HPV vaccine (Gardasil 9, protecting against HPV 6, 11, 16, 18, 31, 33, 45, 52, and 58) or the bivalent vaccine (Cervarix, protecting against HPV 16 and 18), administered to girls before sexual debut (the WHO recommends a 2-dose schedule at 9 to 14 years), provides primary prevention of the vast majority of cervical precancers and cancers. The Bangladesh National Immunization Program introduced the HPV vaccine into the school-based immunization program beginning in 2023, and ensuring that this program reaches CHT girls in remote communities who do not attend mainstream schools (but may attend Buddhist monastery schools or other community educational institutions) is an urgent immunization equity priority.

5.3 Domestic Violence and the Health Consequences of Gender-Based Violence

Gender-based violence (GBV), including intimate partner violence (IPV), sexual violence, and other forms of gender-directed harm, is a major and systematically underreported public health problem in the CHT that intersects with the territory's political history, its gender norms, its substance use patterns, and its mental health burden in ways that demand specific clinical and programmatic attention. The structural conditions that increase GBV risk in the CHT include alcohol use disorder in male partners (which substantially increases IPV risk as documented across settings globally), the psychological consequences of political trauma and displacement on male mental health (including the depression, hyperarousal, and emotional dysregulation of PTSD and complex PTSD that can manifest as aggression toward intimate partners in some individuals), economic stress from land alienation and livelihood insecurity (which is a documented driver of intimate partner violence in resource-constrained settings), and the gender power imbalances embedded in the traditional social structures of some CHT communities (where women's voice in household decision-making, financial control, and mobility may be culturally restricted). The health consequences of IPV for CHT women include acute physical injuries (lacerations, fractures, dental injuries, closed head injuries, and injuries to the abdomen in pregnant women that can cause fetal injury or placental abruption), chronic pain syndromes (particularly headache, back pain, pelvic pain, and fibromyalgia that are documented sequelae of

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chronic trauma), reproductive health consequences (sexually transmitted infections, unintended pregnancy, and adverse pregnancy outcomes including preterm birth and low birth weight from the stress physiology of chronic violence), and mental health consequences (depression, anxiety, PTSD, and suicide risk that are among the most consistent documented consequences of IPV globally). The clinical approach to GBV in the CHT requires the integration of the WHO safe disclosure framework: creating a safe and confidential environment for disclosure (not in the presence of the partner or family members), using validated screening questions sensitively and in the patient's language (with trained interpreters if necessary), responding to disclosure with empathic validation (not disbelief, minimization, or judgment), providing safety assessment and safety planning, connecting survivors with available support resources (which in the CHT are severely limited but include the BRAC's gender and development program, the local government's Violence Against Women Cells, and NGO-based women's support programs), and treating the physical and mental health consequences of GBV with the full clinical capability available. The mandatory reporting obligations of CHT physicians in GBV cases must be explained to patients, with patient autonomy and safety paramount in guiding the timing and form of any legal reporting.

MODEL EXAMINATION QUESTIONS: CHAPTER FIVE (PART THREE)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

HPV genotypes 16 and 18 together account for approximately what percentage of global cervical cancers? a) 30% b) 50% c) 70% d) 90% (Correct Answer: c)

The VIA cervical screening technique applies which reagent to the cervix and observes for which specific change? a) Lugol's iodine, observing for non-staining areas (iodine-negative) b) 3-5% acetic acid, observing for acetowhitening within 1 minute c) Fluorescein dye, observing for fluorescent lesions under UV light d) Methylene blue, observing for blue-staining precancerous tissue (Correct Answer: b)

The cervical transformation zone is the location of virtually all cervical precancers because it is: a) The most vascular area of the cervix b) The junction between columnar endocervical epithelium and ectocervical squamous epithelium (the squamocolumnar junction and its metaplastic zone), which is particularly susceptible to HPV infection c) The area with the highest HPV receptor density d) The only cervical region accessible to direct examination (Correct Answer: b)

The long-acting reversible contraceptive (LARC) most suitable for remote CHT communities because it requires a single insertion providing 3 years of protection without daily adherence is: a) The copper IUD (10-year duration) b) The hormonal implant (etonogestrel subdermal implant, 3-year duration) c) Depot medroxyprogesterone acetate injection (3-month interval) d) Combined oral contraceptive pills (daily) (Correct Answer: b)

The screen-and-treat approach to cervical cancer prevention reduces which primary obstacle to program effectiveness in remote communities? a) The cost of HPV vaccine administration b)

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Loss-to-follow-up between screening and treatment visits, since both occur in the same clinical encounter c) The shortage of trained gynecological oncologists d) The invasiveness of cervical biopsy (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A CHT public health program planner is designing a cervical cancer prevention strategy for a network of remote Marma communities in Bandarban where health facility access is limited to monthly outreach visits by a trained health worker with a thermocoagulator device and VIA supplies. The most effective and operationally feasible strategy for this context is: a) Annual conventional Pap smear testing with laboratory cytology in Chittagong b) Monthly VIA screening with immediate same-visit thermocoagulation for VIA-positive women (screen-and-treat protocol), combined with HPV vaccination of adolescent girls through community-based outreach, and referral of VIA-positive women with gross cervical lesions suspicious for invasive cancer to Chittagong Medical College Hospital c) HPV DNA testing with liquid-based cytology for all women d) Colposcopy-directed biopsy for all women over 30 years (Correct Answer: b)

CHAPTER SIX: GERIATRIC HEALTH AND THE AGING CHT POPULATION: EMERGING DEMANDS OF AN OVERLOOKED DEMOGRAPHIC

6.1 The Geriatric Health Transition in the CHT

The aging of the CHT population represents one of the most clinically and programmatically significant demographic transitions of the coming decade, and one for which the current health system is almost entirely unprepared. The age structure of the CHT indigenous population is shifting as a consequence of the declining infant and child mortality that has occurred since the late 1990s (from improvements in malaria control, oral rehydration therapy deployment, and immunization coverage in accessible areas), the gradual reduction in fertility rates, and the modest increases in adult survival from improved management of acute infectious diseases. The result is a growing proportion of individuals aged 60 years and above who face a healthcare landscape that is both biologically more demanding (as the multiple chronic conditions of aging accumulate) and structurally less equipped (as the mobility limitations of aging compound the geographic barriers to healthcare access that are severe even for physically able younger adults). The qualitative study documented in Part One, which identified elderly indigenous CHT individuals as citing lack of knowledge about healthcare needs, geographical barriers, poor financial conditions, higher cost of medical services, scarcity of nearby hospitals, and communication barriers as the primary determinants of inadequate healthcare access, describes a system in which the elderly are effectively abandoned by the healthcare infrastructure through a combination of their own physical limitations and the structural failures of the health system. The concept of the CHT Geriatric Vulnerability Index, introduced here, quantifies an older individual's risk of adverse health outcomes by combining five domain scores: functional mobility (the ability to walk to the nearest health facility without assistance), economic security (the ability to afford medication, transportation, and healthcare fees), social connectedness (the

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presence of family or community members who can identify health needs and facilitate healthcare access), cognitive capacity (the ability to comprehend healthcare instructions, manage medications, and recognize emergency symptoms), and chronic disease burden (the number and severity of concurrent chronic conditions requiring ongoing management). An individual scoring high on multiple domains has a composite vulnerability substantially higher than any single domain would predict, and the intersection of physical immobility, poverty, social isolation, cognitive decline, and multiple chronic diseases describes a profile of extreme vulnerability that characterizes a significant and growing proportion of elderly CHT indigenous individuals.

6.2 Polypharmacy, Drug Interactions, and Medication Safety in Elderly CHT Patients

Medication management in elderly patients presents specific challenges that are amplified in the CHT context by the combination of the physiological changes of aging (which alter pharmacokinetics and pharmacodynamics in ways that require dose adjustment and careful drug selection), the cognitive decline that may impair medication adherence, the limited healthcare supervision available in remote communities, and the concurrent use of traditional botanical medicines (which may interact with biomedical prescriptions through mechanisms including cytochrome P450 enzyme inhibition, displacement from protein binding sites, and additive pharmacodynamic effects). The physiological changes of aging relevant to drug safety include reduced renal function (with the age-related decline in glomerular filtration rate of approximately 1 percent per year after age 40, meaning that a 70-year-old individual may have a GFR of only 40 to 60 mL/min/1.73 m2 despite a normal serum creatinine, because the reduced muscle mass of aging produces less creatinine despite the reduced GFR, creating a deceptively normal creatinine in the face of significantly reduced renal clearance capacity), reduced hepatic blood flow and hepatic enzyme activity (which reduces the first-pass and systemic metabolism of many drugs, elevating plasma drug levels at standard doses), reduced albumin (which increases the free fraction of highly protein-bound drugs such as phenytoin, warfarin, and NSAIDs), reduced body water and increased body fat (which alters the volume of distribution of hydrophilic and lipophilic drugs respectively), and reduced physiological reserve in all organ systems (which reduces the tolerance for drug toxicity that might be clinically manageable in a younger patient). The Beers Criteria (updated most recently in 2023 by the American Geriatrics Society) provide a regularly updated evidence-based list of potentially inappropriate medications for older adults, identifying drug classes and specific drugs that carry a risk-benefit ratio unfavorable in the elderly due to adverse effects, drug interactions, or reduced effectiveness in this population. The Beers 2023 list includes, among others: anticholinergic medications (including first-generation antihistamines such as chlorphenamine and promethazine that are widely prescribed in the CHT for allergic conditions, urticaria, and as sedatives; older antidepressants such as amitriptyline; and antipsychotic agents), which in the elderly produce cognitive impairment, urinary retention, constipation, fall risk, and delirium; benzodiazepines and other sedative-hypnotics (including diazepam, which is used in CHT facilities for seizure management and muscle spasm), which increase fall and fracture risk and produce paradoxical agitation in some elderly patients; and proton pump inhibitors (which increase the risk of C. difficile-associated diarrhea, pneumonia, and hip fracture with long-term use). The specific concern in the CHT context is that elderly patients may receive prescriptions from multiple prescribers (district hospital, upazila health complex, NGO health worker, traditional Baiddya) without any prescriber having visibility of the

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full medication list, creating polypharmacy conditions (typically defined as concurrent use of five or more medications) that dramatically increase adverse drug event risk. A medication reconciliation approach, in which a community health worker conducting household visits for elderly patients reviews and documents all medications (biomedical and traditional) being taken, and provides this list to any health facility the patient visits, represents a practical strategy to address this problem within the constraints of the CHT health system.

6.3 Dementia and Cognitive Decline in CHT Older Adults

Dementia, the syndrome of acquired, progressive cognitive decline severe enough to interfere with daily function, encompassing multiple underlying etiologies including Alzheimer's disease (the most common cause globally, accounting for 60 to 70 percent of dementia), vascular dementia (accounting for 15 to 20 percent, produced by cerebrovascular disease), Lewy body dementia, and frontotemporal dementia, is an emerging public health concern in aging CHT communities whose clinical and social management has received no attention in the CHT literature. The specific risk factors for dementia in CHT elderly individuals include several that are particularly elevated in the CHT context: vascular risk factors (hypertension and diabetes, which are documented as increasing in prevalence in the CHT's NCD transition), alcohol use disorder (with documented associations between heavy alcohol consumption and accelerated cognitive decline through both direct neuronal toxicity and thiamine deficiency producing Wernicke-Korsakoff syndrome), prior traumatic brain injury (from agricultural accidents, falls in steep terrain, and the political violence history of the CHT), and the chronic psychosocial stress of structural marginalization (which through cortisol-mediated hippocampal atrophy is documented in the neurological literature as a risk factor for cognitive decline). The cultural interpretation of dementia symptoms in CHT communities is likely to follow the general South Asian pattern in which memory loss, behavioral change, and cognitive disorientation in elderly individuals are attributed to normal aging, ancestral influence, or the dying process rather than recognized as a medical condition requiring assessment and management. This cultural interpretation, while not entirely without validity (some degree of cognitive slowing is a normal feature of aging), becomes problematic when it prevents the identification of reversible causes of cognitive impairment (including B12 deficiency, hypothyroidism, normal pressure hydrocephalus, depression masquerading as dementia, and medication side effects) that are treatable if recognized, and when it delays access to the social and care support that people with dementia and their families need. The clinical assessment of cognitive function in CHT elderly patients should use the validated Mini-Mental State Examination (MMSE) or, more briefly, the Six-Item Cognitive Impairment Test (6CIT), with appropriate allowances for educational level (illiterate individuals cannot be assessed on reading and writing items), linguistic barriers (assessment in the patient's primary language is essential for validity), and the age-normative cognitive changes that are distinct from dementia.

MODEL EXAMINATION QUESTIONS: CHAPTER SIX (PART THREE)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

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The age-related decline in glomerular filtration rate (GFR) is approximately how much per year after age 40? a) 0.1% b) 1% c) 5% d) 10% (Correct Answer: b)

The Beers Criteria are published by which organization and are specifically designed for: a) The British National Formulary, for all adult patients b) The American Geriatrics Society, for identifying potentially inappropriate medications in older adults c) The WHO, for essential medicines in low-income countries d) The ILAE, for antiepileptic drug use in elderly patients (Correct Answer: b)

The most common cause of dementia globally, accounting for 60-70% of all dementia cases, is: a) Vascular dementia b) Lewy body dementia c) Alzheimer's disease d) Frontotemporal dementia (Correct Answer: c)

Wernicke's encephalopathy in elderly CHT patients with heavy alcohol use is caused by deficiency of which vitamin? a) Vitamin B12 b) Vitamin B1 (thiamine) c) Niacin d) Vitamin B6 (Correct Answer: b)

The polypharmacy threshold that increases adverse drug event risk in older adults is defined as concurrent use of how many or more medications? a) Three b) Five c) Eight d) Ten (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

An 80-year-old Marma woman is brought to Bandarban District Hospital by her family with confusion, ataxia, and ophthalmoplegia (bilateral lateral rectus palsy). She has a known history of heavy rice wine consumption and has had reduced food intake for several weeks due to dental pain. The most likely diagnosis and the critical immediate management are: a) Bacterial meningitis requiring ceftriaxone IV b) Wernicke's encephalopathy (acute thiamine deficiency), requiring immediate IV thiamine 200-500 mg IV infusion before any glucose administration, since glucose without thiamine can precipitate fatal Wernicke's encephalopathy in thiamine-deficient individuals c) Stroke in the posterior circulation requiring urgent CT and antiplatelet therapy d) Hepatic encephalopathy requiring lactulose (Correct Answer: b)

CHAPTER SEVEN: CHILD DEVELOPMENT, GROWTH MONITORING, SCHOOL HEALTH, AND ADOLESCENT HEALTH IN THE CHT

7.1 Child Development in the Context of Adversity: The CHT Developmental Science

Child development in the Chittagong Hill Tracts is conditioned by the interaction of two powerful and opposing forces: the biological resilience of childhood, which under enabling conditions produces extraordinary capacities for developmental recovery and adaptation, and the structural adversity of the CHT context, which through its multiple simultaneous pathways of nutritional deprivation, infectious disease burden, environmental toxin exposure, psychological

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trauma, and social marginalization creates what developmental science terms a "toxic stress" environment. The concept of Toxic Stress, developed by the Center on the Developing Child at Harvard University and formalized in the scientific literature by Jack Shonkoff and colleagues, refers to the activation of the body's stress response systems in a strong, frequent, or prolonged manner without the buffering protection of supportive adult relationships, producing lasting changes in brain architecture, immune function, metabolic regulation, and behavioral development. The mechanisms of toxic stress operate primarily through the hypothalamic-pituitary-adrenal (HPA) axis: chronic or recurrent stressors (including food insecurity, parental mental illness from trauma, exposure to violence, and chronic illness from malaria or diarrheal disease) activate sustained cortisol secretion that, in the developing brain, produces hippocampal damage (impairing memory and learning), amygdala hyperreactivity (producing heightened threat perception and emotional dysregulation), and reduced prefrontal cortex connectivity (impairing executive function, attention, and impulse control). The ACE (Adverse Childhood Experience) framework, derived from the landmark CDC-Kaiser Permanente ACE Study of the 1990s and subsequently extended to multiple global populations, documents the dose-response relationship between the number of adverse childhood experiences (including parental abuse, neglect, mental illness, substance use, domestic violence, and separation from parents) and a wide range of adult health outcomes including cardiovascular disease, diabetes, cancer, mental illness, and early death. In the CHT, the ACE profile of many indigenous children includes multiple concurrent exposures: food insecurity (experienced chronically, particularly during the pre-harvest lean season), potential exposure to political trauma (through displacement, family members' experiences of violence, and community experiences of political conflict), parental mental health consequences of historical trauma (which reduce the quality of parental nurturing and the buffering of childhood stress), and the social stress of ethnic marginalization (which produces the internalized oppression and identity threat that constitute a form of chronic psychosocial adversity with documented physiological consequences). The clinical translation of the developmental science of toxic stress into CHT child health practice requires attention to three domains: early identification of developmental delay through structured developmental screening (using validated tools such as the Ages and Stages Questionnaires, ASQ-3, or the UNICEF Early Child Development Index), promotion of nurturing care relationships (supporting parental mental health, encouraging responsive caregiving practices, and protecting family stability), and removal or reduction of toxic stressors through the structural interventions described throughout this textbook.

7.2 Growth Monitoring in the CHT: Protocols, Challenges, and Case Studies

Growth monitoring in the CHT, the systematic periodic measurement of children's physical growth parameters compared with age- and sex-specific normative reference data, is both the most important tool for early identification of nutritional deterioration and the programmatic activity most consistently undermined by the CHT's structural limitations. The WHO Child Growth Standards (published in 2006, derived from a multi-center growth reference study of healthy, well-nourished children from six countries), which are the official reference for growth assessment in Bangladesh, provide the population against which CHT children's growth is compared, with growth faltering defined as deviation below the minus 2 Z-score threshold for weight-for-age (underweight), height-for-age (stunting), or weight-for-height (wasting). The

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three growth indices capture different aspects of nutritional failure: stunting (height-for-age below minus 2 Z-score) reflects chronic, cumulative nutritional inadequacy operating over months to years, and its effects on linear growth and cognitive development are largely irreversible once the child is beyond the 1,000-day window from conception to the second birthday; wasting (weight-for-height below minus 2 Z-score) reflects acute, recent nutritional deficit or illness-related weight loss and is responsive to therapeutic nutrition intervention within weeks; and underweight (weight-for-age below minus 2 Z-score) is a composite measure reflecting both chronic and acute malnutrition. The mid-upper arm circumference (MUAC), measured with a standardized paper or plastic MUAC tape at the mid-point between the acromion and the olecranon of the non-dominant arm, provides a rapid screening tool for acute malnutrition that does not require weight measurement equipment (which is heavy, fragile, and difficult to calibrate in remote settings) and has been validated as a predictor of mortality risk that is independent of weight and height measurements. MUAC below 115 mm in children 6 to 59 months is the threshold for severe acute malnutrition (SAM) screening referral; MUAC 115 to 125 mm is the threshold for moderate acute malnutrition (MAM) screening; and MUAC above 125 mm is generally considered adequate, though the threshold values are slightly different in some community-based programs.

The "double burden" of malnutrition visible in CHT growth data reflects the epidemiological transition discussed in Parts One and Two in its nutritional dimension: some CHT communities simultaneously show high rates of childhood stunting (reflecting chronic malnutrition and poor nutritional environments) and increasing rates of childhood and adolescent overweight and obesity (reflecting the dietary transition toward processed and calorie-dense foods that is occurring even in poor communities as access to markets and processed foods has increased). A 2024 review of nutritional trends in Southeast Asian highland minorities found that the nutritional double burden was present across comparable settings in the Mekong subregion, suggesting that CHT communities are on a similar trajectory. The clinical management implications are significant: growth monitoring programs must now capture not only undernutrition but overnutrition, since the cardiometabolic consequences of childhood obesity (including insulin resistance, hypertension, and early onset type 2 diabetes) will amplify the NCD burden of the CHT's next generation.

7.3 School Health Programs and Their CHT Application

School health programs represent a uniquely efficient platform for delivering preventive health interventions to CHT children because schools aggregate a significant proportion of the child population in a regular, predictable, and accessible setting, and because educational institutions in the CHT (including government schools, NGO-operated schools, Buddhist monastery schools, and church schools) represent some of the most functional community institutions in remote areas. The components of a comprehensive school health program applicable to the CHT context include helminth deworming (school-based administration of albendazole 400 mg single dose or mebendazole 500 mg single dose to all school-age children twice yearly, which reduces intestinal worm burden, improves hemoglobin, and is associated with improved school attendance and cognitive function in multiple RCTs), iron and folate supplementation (weekly iron-folic acid supplementation for school-age children and adolescent girls, which addresses the prevalent iron

deficiency anemia documented in CHT communities and reduces the risk of neural tube defects in subsequent pregnancies of adolescent girls), HPV vaccination (for girls aged 9 to 14 years, as described in Chapter Five), dental screening and fluoride varnish application (applying 22,600 ppm fluoride varnish to the erupted teeth twice yearly reduces caries incidence in high-caries-risk populations), vision screening (simple Snellen chart testing to identify myopia and other refractive errors that impair classroom performance), hearing screening (using pure tone audiometry or whispered voice testing to identify hearing loss, which is a documented consequence of bacterial meningitis), and mental health promotion (structured programs to build social-emotional learning skills, resilience, and positive mental health in the school setting). The specific implementation challenge of school health programs in the CHT is the absence of any schools in the most remote communities, the high drop-out rates (particularly for girls after puberty in communities with traditional marriage norms), and the linguistic medium of instruction (Bangla-medium government schools are not accessible to students whose primary language is an indigenous CHT language), which reduces school enrollment and attendance in many of the most remote communities.

MODEL EXAMINATION QUESTIONS: CHAPTER SEVEN (PART THREE)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The WHO Child Growth Standards published in 2006 define stunting in children as height-for-age below which Z-score threshold? a) Minus 1 Z-score b) Minus 2 Z-score c) Minus 3 Z-score (which is severe stunting) d) The third percentile (which is not the same as minus 2 Z-score) (Correct Answer: b)

The MUAC threshold for screening referral of severe acute malnutrition (SAM) in children 6 to 59 months is: a) Below 125 mm b) Below 115 mm c) Below 105 mm d) Below 135 mm (Correct Answer: b)

The school-based deworming program in Bangladesh uses which drug at what dose for school-age children? a) Mebendazole 100 mg twice daily for 3 days b) Albendazole 400 mg single dose or mebendazole 500 mg single dose c) Ivermectin 200 mcg/kg single dose d) Praziquantel 40 mg/kg single dose (Correct Answer: b)

The 1,000-day window in child nutrition refers to the period from: a) Birth to the child's first birthday b) Conception to the child's second birthday c) Birth to the child's third birthday d) The first trimester to delivery (Correct Answer: b)

In child development, hippocampal damage from toxic stress (chronic cortisol elevation) primarily impairs which cognitive function? a) Visual perception b) Memory and learning c) Motor coordination d) Visuospatial reasoning (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A BRAC health program coordinator is designing an integrated school health program for Buddhist monastery schools in 15 remote Chakma communities in Rangamati. The coordinator wants to maximize health impact with minimal logistics complexity. Using a single quarterly visit by a trained health team, which combination of interventions provides the highest health returns across multiple disease categories? a) Malaria RDT testing and artemether-lumefantrine distribution only b) Albendazole deworming (twice yearly), weekly iron-folic acid supplementation for girls (dispensed in 3-month supplies), HPV vaccination for 9-14-year-old girls (integrated into quarterly visit), fluoride varnish application (twice yearly), and Snellen chart vision screening (annually) c) Measles vaccination only, given the 2025 outbreak d) Daily vitamin A drops, deworming, and blood pressure screening (Correct Answer: b)

CHAPTER EIGHT: ADVANCED ENVIRONMENTAL TOXICOLOGY AND OCCUPATIONAL HEALTH IN THE CHT: THE SCIENCE OF EXPOSURE

8.1 Organophosphate Pesticide Toxicity: An Emerging CHT Clinical Problem

The increasing use of organophosphate and carbamate pesticides in CHT jhum cultivation and terraced garden farming, driven by the intensification of agriculture on diminishing land areas (as jhum cycle compression and land alienation reduce the productive land available per household), creates a pattern of acute and chronic pesticide toxicity that is almost entirely unrecognized in the CHT clinical literature. Organophosphate pesticides (including chlorpyrifos, malathion, dichlorvos, and monocrotophos, which are commercially available in Bangladesh and widely used in agriculture) exert their insecticidal mechanism through irreversible inhibition of acetylcholinesterase, the enzyme responsible for the hydrolytic inactivation of acetylcholine at all cholinergic synapses. In humans exposed to organophosphates (through dermal absorption during application without protective clothing, inhalation of spray aerosols, or accidental ingestion), the resulting accumulation of acetylcholine at muscarinic receptors (producing the SLUDGE syndrome: Salivation, Lacrimation, Urination, Defecation, GI distress, and Emesis), nicotinic receptors (producing muscle fasciculations, weakness, and paralysis), and central nervous system receptors (producing confusion, seizures, and coma) constitutes the life-threatening cholinergic toxidrome of organophosphate poisoning. The severity of acute organophosphate poisoning is graded using the Toxic Exposure Surveillance System (TESS) classification (mild, moderate, severe) based on the clinical manifestations and plasma cholinesterase levels. Plasma cholinesterase (pseudocholinesterase) activity and red blood cell cholinesterase (acetylcholinesterase) activity are the definitive laboratory measures of organophosphate exposure, with a reduction to below 50 percent of baseline indicating significant poisoning requiring treatment. The management of acute organophosphate poisoning in CHT district hospitals follows a two-drug protocol: atropine sulfate (the muscarinic antagonist that blocks the peripheral cholinergic effects) given IV at a starting dose of 2 to 4 mg in adults (with repeated dosing every 5 to 10 minutes until "atropinization" is achieved, defined as drying of secretions, resolution of bronchospasm, and heart rate above 80 per minute, not pupil dilation or tachycardia per se), with total doses sometimes reaching 100 mg or more in severe poisoning; and pralidoxime (2-PAM, the oxime reactivator of acetylcholinesterase that reverses the enzyme

inhibition before it becomes irreversible through "aging") at a dose of 1 to 2 g IV over 15 to 30 minutes, followed by an infusion of 200 to 500 mg per hour. Pralidoxime effectiveness is time-critical: it must be administered within approximately 24 to 48 hours of exposure (before aging of the organophosphate-cholinesterase bond makes reactivation impossible), and its use beyond this window provides no benefit and may cause toxicity. The intermediate syndrome, a pattern of proximal limb weakness, neck flexor weakness, and cranial nerve palsies developing 24 to 96 hours after acute organophosphate poisoning and representing a nicotinic receptor syndrome distinct from the initial muscarinic cholinergic crisis, requires specific awareness because it can cause respiratory failure from respiratory muscle paralysis in a patient who appeared to have recovered from the acute poisoning and has been discharged, making close 96-hour observation of all significant organophosphate poisonings mandatory. Chronic low-level organophosphate exposure, from repeated dermal absorption during pesticide application without protective equipment, produces subclinical central nervous system effects including cognitive impairment, anxiety, depression, and peripheral neuropathy, that are likely present in CHT farmers with years of pesticide exposure but have not been systematically studied in the CHT population. The implementation of personal protective equipment (PPE) use during pesticide application (at minimum, long-sleeved clothing, waterproof gloves, boots, and a face mask during mixing and spraying), proper pesticide storage and handling education, and access to safer, less toxic pesticide alternatives represents the primary prevention strategy for organophosphate toxicity in the CHT agricultural context.

8.2 Heavy Metal Exposure and Mining-Adjacent Populations

The geological character of the CHT, with its Miocene-Pliocene sedimentary formations containing variable concentrations of heavy metals including arsenic (in some geological formations), lead, mercury, and chromium, creates potential for naturally occurring heavy metal exposure in CHT communities whose primary drinking water sources are springs and streams flowing through mineralized geological formations. While the arsenic contamination that affects tens of millions in the Bangladesh plains (from alluvial delta deposits) is not the primary concern in the CHT (given that groundwater is rarely the primary water source), specific geological contexts within the CHT may present elevated arsenic or other heavy metal concentrations in spring water. Additionally, the proximity of some CHT border areas to mining operations in adjacent parts of Myanmar (where artisanal and small-scale gold mining using mercury amalgamation processes is documented in Chin and Shan States) creates the possibility of mercury contamination of the Sangu and other rivers that flow from Myanmar into the CHT, with consequences for the fish-consuming communities of the CHT's river valleys. The Itai-itai disease (a cadmium toxicity syndrome characterized by kidney disease and severe osteomalacia with multiple fractures) documented in Japan from rice contaminated with cadmium from mining runoff provides a historical precedent for the pathway by which heavy metal contamination of agricultural land (from mining runoff) reaches humans through the food chain rather than directly from water, with rice serving as a bioaccumulator of cadmium in flooded paddy fields. The assessment of heavy metal risk in CHT water sources requires systematic spring water and river water testing for arsenic, cadmium, lead, mercury, chromium, and other metals using appropriate analytical methods (atomic absorption spectroscopy or inductively coupled plasma mass spectrometry), which are laboratory capabilities available at the Bangladesh Water

Development Board and at select academic institutions but not routinely deployed in the CHT. The clinical recognition of heavy metal toxicity syndromes in the CHT requires awareness of the clinical presentations of the major heavy metals: chronic arsenic toxicity produces a characteristic dermatological triad of hyperpigmentation, hyperkeratosis (thickening of the palmar and plantar skin), and hypopigmentation ("raindrop" depigmentation of the trunk), along with peripheral neuropathy, Mees' lines on nails, and increased risk of skin, bladder, and lung cancer with prolonged exposure; chronic lead toxicity produces cognitive impairment (particularly in children where lead disrupts neuronal development at blood lead levels above 5 micrograms per deciliter, a threshold lower than the previous 10 mcg/dL threshold revised in 2012 based on evidence that lower levels produce measurable cognitive effects), abdominal colic, anemia from interference with heme synthesis, and nephropathy; and chronic mercury toxicity (particularly organic methylmercury from fish consumption in contaminated aquatic systems) produces the Minamata disease syndrome of cerebellar ataxia, sensory neuropathy, visual field constriction, and hearing loss.

8.3 Radiation Health in the CHT: Natural Background and Medical Exposure

The natural background radiation in the CHT derives primarily from two sources: cosmic radiation (which increases with altitude, such that CHT ridge communities at 700 to 900 meters of elevation experience approximately 10 to 15 percent higher cosmic radiation doses than sea-level populations in Bangladesh), and terrestrial radiation from naturally occurring radioactive materials (NORM) including radon (a radioactive noble gas produced by the decay of uranium-238 in rock and soil, which can accumulate in enclosed spaces to concentrations substantially above the global average in geological formations with elevated uranium content). The health significance of natural background radiation in the CHT is modest at the altitudes involved (the WHO annual effective dose from natural background radiation is approximately 2.4 millisieverts globally, with CHT ridge communities receiving perhaps 10 to 20 percent above this) but represents a context for understanding the additive radiation burden that may come from medical X-ray exposure. The medical radiation exposure of CHT patients is currently low (because access to X-ray machines is limited to district hospital level, most CHT patients have few chest X-rays in their lifetime) but will increase as radiological services improve, and the principles of radiation protection (justification of every X-ray exposure by a clear clinical indication, optimization of the radiation dose through appropriate technique and collimation, and dose limitation through reduction of unnecessary exposures) apply in the CHT as everywhere in medicine.

MODEL EXAMINATION QUESTIONS: CHAPTER EIGHT (PART THREE)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The SLUDGE toxidrome of organophosphate poisoning stands for: a) Seizures, Lethargy, Unconsciousness, Diarrhea, GI distress, Emesis b) Salivation, Lacrimation, Urination, Defecation, GI distress, Emesis c) Sweating, Lacrimation, Urticaria, Dizziness, Gastrointestinal pain, Erythema d) Syncope, Loss of consciousness, Urinary incontinence, Diarrhea, Gagging, Edema (Correct Answer: b)

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The antidote that reverses organophosphate-cholinesterase bond before aging makes it irreversible is: a) Atropine b) Pralidoxime (2-PAM) c) Naloxone d) Physostigmine (Correct Answer: b)

The intermediate syndrome of organophosphate poisoning occurs at which timepoint and involves which clinical pattern? a) Within 2 hours of exposure, producing muscarinic toxidrome b) 24 to 96 hours after exposure, producing proximal muscle weakness and respiratory failure from nicotinic receptor involvement c) 2 to 4 weeks after exposure, producing peripheral neuropathy d) 6 to 12 months after exposure, producing cognitive impairment (Correct Answer: b)

The chronic skin manifestation of arsenic toxicity that is pathognomonic for chronic arsenism includes: a) Vesicular eruption on the hands and feet b) Hyperkeratosis of the palms and soles with raindrop depigmentation on the trunk c) Diffuse alopecia and nail pitting d) Photosensitive malar rash (Correct Answer: b)

The blood lead level threshold below which cognitive effects in children were previously considered absent but has been revised downward by updated evidence is: a) 20 mcg/dL b) 5 mcg/dL (from the previous 10 mcg/dL) c) 1 mcg/dL d) 25 mcg/dL (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 28-year-old male Mro jhum farmer is brought to Alikadam Upazila Health Complex with miosis, profuse salivation, vomiting, diarrhea, and generalized muscle fasciculations 2 hours after mixing and applying a pesticide on his jhum field without protective gloves. He is bradycardic (heart rate 48/minute) and has audible bronchospasm. What is the immediate management priority order? a) Charcoal gastric lavage, then atropine, then pralidoxime b) Secure airway and provide oxygen, give atropine IV 2-4 mg and repeat every 5-10 minutes until atropinized (secretions dried, bronchospasm resolved, heart rate above 80), administer pralidoxime 1-2 g IV over 15-30 minutes within the time window of cholinesterase reactivation, and monitor for the intermediate syndrome for at least 96 hours c) Pralidoxime first, then atropine d) Naloxone as the primary antidote (Correct Answer: b)

CHAPTER NINE: PRIMARY HEALTHCARE DESIGN, COMMUNITY HEALTH SYSTEMS, AND SERVICE DELIVERY IN REMOTE CHT COMMUNITIES

9.1 The Primary Healthcare Philosophy for the CHT: Principles for a Unique Context

The Alma-Ata Declaration of 1978, which established primary healthcare (PHC) as the foundation of health systems and proclaimed health as a fundamental human right, defined PHC as essential healthcare based on practical, scientifically sound, and socially acceptable methods and technology made universally accessible to individuals and families in the community through their full participation and at a cost that the community and country can afford to

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maintain. The CHT, nearly five decades after Alma-Ata, remains a territory where the most basic aspirations of that declaration remain unmet for a significant proportion of its population, particularly the most remote and most marginalized indigenous communities. The Astana Declaration of 2018, which renewed the global commitment to primary healthcare in the context of the Universal Health Coverage agenda, added the specific emphasis on PHC as a multisectoral platform addressing the social, economic, and environmental determinants of health, and on the community as both the subject and the agent of PHC development. In the CHT context, the multisectoral PHC vision of Astana is particularly important because the health problems of CHT communities cannot be solved by health services alone: malaria control requires environmental management; malnutrition requires agricultural support; respiratory disease requires clean energy access; diarrheal disease requires WASH infrastructure; mental health requires political justice and land rights protection. The CHT Primary Healthcare Design Doctrine, articulated in this textbook, holds four principles as foundational to effective PHC in the CHT. The first is the Proximity Principle: every CHT community should have access to first-contact healthcare services within a distance and time that does not constitute a prohibitive barrier, operationally defined as PHC contact within 2 hours of travel under normal seasonal conditions. The second is the Cultural Competence Principle: PHC services in the CHT must be delivered in a manner that is linguistically accessible (through the use of trained indigenous language community health workers and interpreters), culturally respectful (acknowledging and working with indigenous illness frameworks rather than dismissing them), and ethnically trusted (through the employment of healthcare workers from the served communities where possible and through transparent community accountability mechanisms). The third is the Community Integration Principle: PHC in the CHT must be integrated into the existing social structures of CHT communities (including the monastery, the village headman's authority, the women's community networks, and the traditional healer's social position) rather than operating as an external government service imposed on communities from above. The fourth is the Continuity Principle: PHC in the CHT must provide continuity of care (not merely episodic treatment of acute illness) through follow-up protocols for chronic disease management, growth monitoring, antenatal care, immunization, and mental health support that maintain contact between the health system and the individual patient across the full trajectory of their health needs.

9.2 The BRAC Shasthya Shebika Model: Strengths, Limitations, and CHT-Specific Adaptations

The BRAC Shasthya Shebika (health volunteer) model, which is the primary community health worker system operating in the CHT alongside the government's community clinic program, has been described in Part One and Part Two of this textbook in the context of malaria control and immunization. This chapter provides a more comprehensive analysis of the Shasthya Shebika model's strengths and limitations in the CHT context and develops a set of CHT-specific adaptations to enhance its effectiveness. The Shasthya Shebika (SS) is typically a woman selected from the community she serves (providing linguistic and cultural familiarity), trained by BRAC in a package of essential health skills, and supported through a system of monthly group meetings with BRAC program organizers, regular resupply of essential medicines and health commodities (including malaria RDTs and artemether-lumefantrine, zinc-ORS packs, oral contraceptives, iron-folate tablets, and condoms), and performance-based incentive payments for

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the health services she delivers. The SS's clinical competencies include malaria testing and treatment, diarrheal disease management with zinc-ORS, recognition and referral of danger signs in sick children and pregnant women, antenatal care home visits, immunization follow-up and defaulter tracing, family planning commodity supply, and health education. The strengths of the SS model in the CHT context include its community embeddedness (the SS lives in the community she serves, creating trust and accessibility that a visiting government health worker cannot achieve), its low cost per service delivery (the SS's performance-based incentive structure makes the model financially sustainable compared with the salary costs of professional health workers), and its documented effectiveness for specific health outcomes (malaria treatment, diarrheal disease management, and antenatal care coverage have all been shown to improve in CHT communities served by BRAC programs). The limitations of the SS model in the CHT context include the scope limitation (the SS's training and authorization does not extend to the management of the full range of health problems she encounters in remote communities, creating a gap between what communities need and what the SS is legally and technically equipped to provide), the gender limitation (the SS's female identity, while advantageous for women's health services, may limit her effectiveness in serving male community members and in navigating some traditional community authority structures), the language barrier (BRAC's training materials and management communications are predominantly in Bangla, creating comprehension and application difficulties for SS workers who are most effective in their native language), and the burnout and retention challenge (SS workers in remote CHT communities operate in physically demanding conditions with limited supervision and professional development support, contributing to attrition that disrupts community health service continuity).

The CHT-Specific Shasthya Shebika Enhancement Protocol, developed in this textbook, proposes five adaptations to the standard BRAC SS model for CHT deployment. First, expand the SS's clinical scope to include supervised management of uncomplicated P. vivax malaria with primaquine (following G6PD testing protocols) and supervised oral rehydration for moderately dehydrated patients, in CHT communities beyond 4 hours travel from any health facility, recognizing that the alternative to supervised SS management of these conditions is no management at all. Second, provide SS workers in the CHT with indigenous-language training materials, translated into the primary languages of the major CHT ethnic groups (Chakma, Marma, Tripuri, Mro, and Bawm at minimum), using visual aids and audio materials accessible to workers with limited literacy. Third, integrate male community health promoters alongside female SS workers in CHT communities where male gatekeeping of healthcare-seeking decisions is a documented barrier to service utilization, with male promoters trained in the specific health priorities of men in the community including malaria prevention, snakebite first aid, occupational safety, substance use counseling, and NCD risk factor management. Fourth, establish monthly video-call supervision and support sessions using mobile phones with solar charging (given the limited electricity supply in remote CHT communities), connecting each SS worker to a clinical supervisor at the upazila health complex who can provide real-time clinical guidance on cases beyond the SS's training scope. Fifth, formalize the integration of the Baiddya traditional healer into the community health team, with regular information-sharing meetings between SS workers and active Baiddya practitioners in the same community, joint referral protocols (Baiddya to SS for biomedical conditions including malaria, TB, and severe malnutrition; SS to Baiddya for conditions best managed within indigenous frameworks), and

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recognition of Baiddya practitioners as community partners rather than competitors in the delivery of healthcare.

9.3 Telemedicine and Digital Health in Remote CHT Communities

Telemedicine, the delivery of clinical consultation and diagnostic services using telecommunications technology to bridge geographic distance between patient and specialist, represents a potentially transformative tool for improving healthcare access in the CHT's remote communities, and its rapid development globally since the COVID-19 pandemic has created new technological possibilities that did not exist even five years ago. The fundamental challenge of telemedicine deployment in the CHT is connectivity: most remote CHT communities have very limited or no reliable internet connectivity, and mobile telephone coverage (which is the infrastructure for data-based telemedicine services) is absent or weak in many of the most remote valleys and ridge-top settlements. The partial mitigation of this challenge is occurring through the expansion of mobile telephone tower coverage in the CHT by Bangladeshi telecommunications companies, driven partly by government infrastructure investment and partly by the commercial motivation to capture the CHT market, and through the use of satellite-based internet connectivity (including low-earth-orbit satellite systems whose ground stations can serve remote areas regardless of terrestrial infrastructure). In areas where mobile connectivity is available, even intermittently, the clinical applications most suitable for the CHT context include remote consultation for clinical decision support (the SS worker or upazila health complex physician sharing clinical photographs of skin lesions, eye conditions, or wound conditions with a specialist in Chittagong or Dhaka for diagnostic guidance), remote ECG interpretation (using portable single-lead or 12-lead ECG devices at upazila health complex level, with digital transmission of the ECG trace for specialist interpretation), and store-and-forward ophthalmological examination (using portable fundoscopy attachments for smartphones to capture fundus images for remote diabetic retinopathy screening). The artificial intelligence-assisted diagnostic tools that have been developed for several priority conditions (including a WHO-validated AI system for tuberculosis detection on chest X-ray, and AI-based diabetic retinopathy screening systems with sensitivity and specificity comparable to specialist graders) represent a technology frontier that, as deployment costs continue to fall, may become applicable in CHT district hospitals and potentially in higher-resourced community settings within the next decade.

MODEL EXAMINATION QUESTIONS: CHAPTER NINE (PART THREE)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The Alma-Ata Declaration of 1978 established primary healthcare (PHC) as the foundation of health systems and was renewed by which subsequent declaration in 2018? a) The Ottawa Charter b) The Astana Declaration c) The Bangkok Charter d) The Jakarta Declaration (Correct Answer: b)

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The BRAC Shasthya Shebika (health volunteer) is typically selected from which population? a) Government-trained nurses from Dhaka b) Women from the community she will serve c) Retired doctors d) University students completing community health placements (Correct Answer: b)

The performance incentive structure of the BRAC Shasthya Shebika model refers to: a) A fixed salary regardless of services delivered b) Payment based on the number and types of health services delivered, making the model financially sustainable c) Government subsidy covering all program costs d) User fees charged to patients (Correct Answer: b)

Universal Health Coverage (UHC) is defined as ensuring that all people can obtain the health services they need without which risk? a) The risk of contracting infectious diseases b) The risk of financial hardship from paying for healthcare c) The risk of receiving low-quality care d) The risk of encountering language barriers (Correct Answer: b)

The term "task-shifting" in healthcare refers to: a) Transferring administrative tasks from clinicians to managers b) The rational redistribution of clinical tasks from specialists to other healthcare workers with appropriate training and supervision, to extend service reach in resource-limited settings c) Rotating healthcare workers between facilities to prevent burnout d) Shifting responsibility for healthcare from the government to NGOs (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A district health officer in Bandarban is designing a primary healthcare strengthening plan for 12 remote Mro and Khumi communities in Alikadam upazila that collectively have a population of approximately 8,000 people, no road access during monsoon season, no resident healthcare worker, and documented coverage gaps for malaria treatment, immunization, and antenatal care. Using the CHT Primary Healthcare Design Doctrine articulated in this chapter, which combination of interventions would most comprehensively address the PHC gaps? a) Construction of a new static health facility in each community b) Monthly mobile outreach visits by a team of two health workers from Alikadam UHC, combined with the training and deployment of community health volunteers from each community (selected from community members with indigenous language fluency), equipped with a defined package of essential health commodities and linked to monthly video-call supervision from the UHC c) Distribution of health promotion leaflets in Bangla to community leaders d) Referral of all Mro and Khumi community members to Alikadam Upazila Health Complex for primary care (Correct Answer: b)

CHAPTER TEN: HEALTH POLICY, RESEARCH ETHICS, ADVOCACY, AND THE FUTURE OF MEDICINE IN THE CHITTAGONG HILL TRACTS

10.1 Health Policy for the CHT: The Political Economy of Health

Health policy for the Chittagong Hill Tracts is inseparable from the political economy of Bangladesh's relationship with its indigenous minority communities, and no analysis of health

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policy in the CHT can be intellectually honest if it avoids the political dimensions that shape what policies are made, implemented, funded, and evaluated. The political economy of CHT health policy operates through several channels that the student and practitioner of public health must understand. The resource allocation channel determines how much of the national health budget is invested in CHT health infrastructure, personnel, and programs relative to the CHT's population, geographic complexity, and disease burden. The available evidence suggests systematic under-investment: the CHT's three districts together have fewer hospitals, fewer physicians, fewer nurses, fewer trained community health workers, less pharmaceutical supply, and less diagnostic equipment than would be proportionally justified by their population, their disease burden, or the additional cost of delivering services in difficult terrain. This under-investment reflects a pattern of resource allocation that prioritizes densely populated, economically productive areas over remote, sparsely populated, and politically marginalized ones, and that has operated consistently across multiple successive governments. The governance channel determines who makes the decisions about CHT health policy and whether those decisions are informed by the health data, community consultation, and indigenous representation that would produce policies responsive to the actual health needs of CHT communities. The CHT Regional Council and the three District Hill Councils were assigned formal authority over certain health governance functions by the 1997 Peace Accord, but as described in Part One, this authority has been only partially implemented, and the central government agencies continue to control most of the health policy and resource allocation decisions affecting the CHT without adequate indigenous representation or consultation. The legal and rights channel determines the extent to which the health rights of CHT indigenous communities are enforceable through legal and institutional mechanisms, including domestic constitutional provisions (Bangladesh's constitution guarantees equal rights to all citizens, though the specific provisions of the CHT Peace Accord and the rights of indigenous communities are matters of ongoing legal interpretation and political dispute), Bangladesh's ratification of relevant international instruments (Bangladesh is a party to the International Covenant on Economic, Social and Cultural Rights, which recognizes the right to the highest attainable standard of health as a legal obligation), and the persuasive but not binding standards of the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP, adopted by the UN General Assembly in 2007, which Bangladesh voted in favor of and which articulates the specific health rights of indigenous peoples including the right to their own traditional medicines, the right to access health services without discrimination, and the right to participate in the design and delivery of health services).

10.2 Research Ethics in the CHT: A Framework for Justice-Oriented Health Research

The conduct of health research in the Chittagong Hill Tracts carries specific ethical obligations that exceed those of research in less politically complex settings, and that must be understood and honored by every researcher who seeks to generate knowledge from CHT communities. The history of research in colonial and post-colonial settings is replete with examples of what has been called "extractive research": the collection of biological samples, clinical data, and community knowledge from vulnerable populations for the purpose of generating academic publications and career capital for researchers based in wealthy institutions, without any meaningful return of benefits to the communities who contributed the data, and frequently

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without the meaningful consent, participation, or even awareness of those communities. The CHT has a documented history of health research conducted in this extractive mode, in which international researchers have arrived in the territory, collected data on malaria epidemiology, G6PD prevalence, ethnobotanical knowledge, and nutritional status, published findings in international journals, and left without community feedback, capacity building, policy translation, or any other benefit flowing back to the communities studied. This history creates legitimate community distrust of researchers and research institutions that the contemporary CHT researcher must acknowledge, understand, and actively work to overcome. The CHT Research Ethics Framework, articulated in this textbook, holds five principles as foundational. The Community Partnership Principle requires that all health research in the CHT be conducted in genuine partnership with the communities being studied, involving community members as co-investigators, advisory board members, data collectors, and interpreters of findings, rather than merely as subjects or informants. The Prior Informed Consent Principle requires that individual and community consent for research be obtained through processes that are genuinely informative (conducted in the indigenous languages of the community, explaining the research's purpose, procedures, risks, benefits, and the participants' right to refuse or withdraw without consequences), genuinely free (without any coercion or undue inducement from the economic power differential between researchers and communities), and ongoing (with the opportunity for communities to withdraw consent for the continued use of their data as findings emerge). The Benefit Sharing Principle requires that the benefits of research (including the publications, the policy insights, the pharmaceutical leads from ethnobotanical research, and the epidemiological data that inform health planning) be shared with the communities who contributed to their generation, through feedback mechanisms, community health programs funded from research overhead, and advocacy for policy change informed by research findings. The Capacity Building Principle requires that health research in the CHT include systematic investment in building the research capacity of indigenous CHT community members, through training, mentorship, employment as research staff, and support for advanced education in health sciences and public health. The Advocacy Obligation Principle requires that researchers who document health injustices in the CHT through their research have an ethical obligation to communicate those findings not only to academic audiences but to the policy makers, health authorities, civil society organizations, and international bodies whose decisions affect the CHT's health trajectory.

10.3 The Future of CHT Medicine: Anticipating the Next Decade

The next decade of CHT medicine will be shaped by several intersecting forces whose trajectories can be partially anticipated from current evidence. The climate change trajectory is the most structurally significant: the scientific consensus, confirmed by the IPCC Sixth Assessment Report and the multiple CHT-specific analyses reviewed in this textbook, is that the CHT will experience increasing temperature, altered monsoon patterns (with more intense but potentially more irregular rainfall events), higher frequency of extreme weather events including intense precipitation, landslides, and flash floods, and the ecological disruptions that follow from these physical changes. The health consequences include extended malaria transmission seasons, increased risk of diarrheal disease from contaminated water during flood events, increased frequency of landslide trauma, increasing heat-related illness from higher ambient temperatures in a population with limited capacity for cooling, and the agricultural disruption and food

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insecurity that follow from climate disruption of the jhum calendar. The artemisinin resistance trajectory is the most immediately clinically urgent: the eastward spread of partial artemisinin resistance from the Greater Mekong Subregion toward Bangladesh, documented by the 2025 mBio paper analyzing CHT P. falciparum Kelch13 mutations, threatens to eliminate the effectiveness of the current first-line treatment for the disease that kills the most people in the CHT. If artemisinin resistance fully penetrates the CHT P. falciparum population before the next-generation antimalarial agents (including combinations containing ferroquine, ganaplacide-lumefantrine, and the promising ozonide OZ439) are deployed at scale, the CHT will face a severe malaria treatment crisis with no effective standard regimen. The NCD trajectory is the most demographically inexorable: the aging of the CHT population, the dietary and lifestyle transition occurring even in remote communities, and the DOHaD-mediated cardiometabolic risk of the malnourished-in-early-life cohort now entering middle age all point toward a rapidly increasing NCD burden in the coming decade that the current health system design, oriented almost entirely toward acute infectious disease management, is completely unprepared to address. The health system governance trajectory offers the most room for positive transformation: the full implementation of the CHT Peace Accord's health governance provisions, the development of genuine indigenous capacity for health system leadership, and the design of culturally appropriate, linguistically accessible, and community-accountable health services represent achievable political and programmatic objectives that, if realized, would address many of the structural health inequities documented throughout this textbook.

10.4 Medical and Public Health Philosophy for the CHT: A Synthesis

This textbook closes Part Three with a synthesis of the medical and public health philosophy that has guided its analysis from beginning to end, and that the authors believe should guide the practice of every clinician, public health practitioner, researcher, and policymaker who engages with the health of the Chittagong Hill Tracts. The CHT Integrated Health Philosophy, articulated here as a synthesis of the frameworks developed throughout the three parts of this textbook, rests on five interconnected commitments. The first is the commitment to Ecological Embeddedness: recognizing that health is not a property of isolated biological organisms but the expression of a relationship between organisms and their environments, and that the ecological systems of the CHT, its forests, rivers, soils, and climatic patterns, are as much the subject of health science as the organs and cells of the human body. The second is the commitment to Historical Accountability: recognizing that the health disparities of CHT indigenous communities are not natural, random, or inevitable but are the specific, traceable consequences of historical processes including colonialism, forced displacement, political violence, and structural economic marginalization, and that honest medicine in the CHT must name these histories and their health consequences without euphemism. The third is the commitment to Epistemic Pluralism: recognizing that the medical knowledge systems of CHT indigenous communities, including the botanical pharmacopoeia of the Baiddya, the dietary medicine of the Marma Pi system, the Buddhist healing traditions of the Chakma and Marma sangha, and the cosmological illness frameworks of all eleven CHT ethnic communities, represent genuinely valuable bodies of knowledge that are not adequately replaced by biomedical science but are most fruitfully engaged as complementary perspectives within a pluralist medical epistemology. The fourth is the commitment to Rights-Based Practice: recognizing that health is a fundamental human right,

that the failure of health services to reach CHT indigenous communities is a human rights violation, and that the advocacy for equitable health services is not a political activity separate from clinical and public health practice but an integral dimension of the practice of medicine in a context of structural inequity. The fifth is the commitment to Humble Learning: recognizing that this textbook, despite its scope and depth, represents a beginning rather than a completion of the knowledge needed to understand and address the health of the Chittagong Hill Tracts, and that the most important lesson it can impart is the cultivation of a lifelong practice of attentive, respectful, and rigorously critical learning from the people, the landscapes, and the living systems of the hill territory.

MODEL EXAMINATION QUESTIONS: CHAPTER TEN (PART THREE)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) was adopted by the UN General Assembly in which year? a) 1986 b) 1997 c) 2007 d) 2015 (Correct Answer: c)

The International Covenant on Economic, Social and Cultural Rights (ICESCR) recognizes which health provision? a) The right to free healthcare at all levels b) The right to the highest attainable standard of physical and mental health c) The right to emergency healthcare only d) The right to traditional medicine exclusively (Correct Answer: b)

The concept of "extractive research" in the context of CHT health research refers to: a) Research that extracts biological samples for pharmacological development b) The collection of data from vulnerable populations without meaningful consent, participation, or benefit return to the communities involved c) Research requiring invasive procedures d) Financial exploitation of research funding bodies (Correct Answer: b)

The CHT Peace Accord of 1997 assigned formal authority over health services to which governance bodies? a) The Bangladesh Ministry of Health and Family Welfare directly b) The CHT Regional Council and the three District Hill Councils c) The United Nations Development Programme d) BRAC as the lead NGO (Correct Answer: b)

The IPCC Sixth Assessment Report found which trajectory for climate change impacts in South Asian montane territories? a) Decreasing temperature and more regular rainfall b) Increasing temperature, more intense monsoon events, higher frequency of extreme weather, and consequent ecological disruption c) Climate stabilization from 2025 d) Reduction in landslide risk from increased vegetation cover (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A research team from a national university in Dhaka proposes a study in Mro communities in Alikadam to collect blood samples for genomic analysis of malaria resistance markers. The team plans to conduct verbal consent with community heads (karbaris) and individual participants using Bangla-language consent forms. Applying the CHT Research Ethics Framework

articulated in this chapter, which of the following ethical deficiencies in this research protocol requires immediate rectification before the study proceeds? a) The study is scientifically unnecessary b) The consent process fails the Prior Informed Consent Principle (consent must be conducted in the Mro language, not Bangla, which most participants may not understand; community consent through karbaris must be supplemented by genuine individual informed consent; and the process must ensure freedom from coercion given the economic power differential), and the protocol does not address the Community Partnership, Benefit Sharing, or Capacity Building Principles, requiring comprehensive revision to meet the CHT Research Ethics Framework c) The blood sampling procedure is too invasive d) The research team lacks adequate malaria expertise (Correct Answer: b)

A Bangladeshi public health researcher analyzing the CHT health system is asked by a civil society organization to testify to a parliamentary committee on CHT health inequities. Applying the Advocacy Obligation Principle of the CHT Research Ethics Framework, what is the appropriate response? a) Decline, as advocacy is outside the scope of health research b) Accept the obligation to communicate research findings to policy makers, as researchers who document health injustices in the CHT have an ethical obligation to advocate for policy change informed by their findings, not only to academic audiences c) Share findings only in academic publications d) Refer the civil society organization to the Ministry of Health (Correct Answer: b)

ENDNOTES TO PART THREE

Part Three has completed the full spectrum of specialized clinical medicine relevant to the Chittagong Hill Tracts, moving from neurology and ophthalmology through oral health, musculoskeletal and rheumatological disease, reproductive health, geriatrics, child development, environmental toxicology, primary healthcare design, and health policy, to arrive at the philosophical and ethical synthesis that gives the entire enterprise its deepest justification. The ten chapters of Part Three, read in conjunction with the twenty chapters of Parts One and Two, constitute a comprehensive and integrated account of CHT health that does not exist anywhere else in the academic literature, and whose creation is itself an act of the advocacy obligation articulated in Chapter Ten: making visible the health of a population that has been systematically rendered invisible by the structural conditions of their marginalization.

The examination questions distributed throughout these chapters are designed, as in the preceding parts, to cultivate not merely the recall of facts but the clinical and public health reasoning that will enable the student who becomes the practitioner to function effectively in the CHT's demanding and dynamic health environment. The student who masters the content of Parts One through Three will have acquired not only a body of knowledge but a way of seeing: a capacity to perceive simultaneously the molecular biology of the Plasmodium falciparum parasite and the political economy of the land rights dispute that conditions the malnourishment that conditions the severity of the parasitemia; to hear in the cough of the Chakma woman not merely the clinical signs of advanced pulmonary tuberculosis but the story of a decade of indoor cooking fire exposure, a jhum field lost to a Bengali settler, a husband disabled by a landslide

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injury, and a health system that never came to find her until it was almost too late; and to bring to clinical practice the simultaneous gifts of scientific rigor, cultural humility, political awareness, and the fundamental human compassion that every patient, in every community, in every terrain and in every language, has always deserved from medicine.

The central propositions that unite the three parts of this textbook may be restated here as a closing credo. The CHT is not merely a place where standard medicine is practiced with fewer resources. It is a distinct geomedicinal territory whose ecological, historical, cultural, and political specificities demand a medicine that has been thought through from the ground up rather than adapted from elsewhere. The eleven indigenous communities of the CHT are not the passive recipients of external health interventions but the holders of millennia of ecological knowledge, healing wisdom, and survival intelligence that deserve respect, documentation, and integration into the contemporary health system. The diseases that kill people in the CHT are not random or inevitable but are the biological expressions of specific historical and political decisions, and the most powerful health interventions available for the CHT are not only clinical but political, economic, and ecological. And the student who studies this textbook with attention, who carries its questions and its frameworks into clinical practice, who maintains the intellectual honesty to acknowledge what is unknown and the moral courage to name what is unjust, will be precisely the kind of physician, public health practitioner, or researcher that the Chittagong Hill Tracts has needed for a very long time, and has always deserved.

PART FOUR: ANTIMICROBIAL RESISTANCE, LABORATORY MEDICINE, ADVANCED CLINICAL SYSTEMS, ONE HEALTH, AND THE TECHNOLOGY OF CARE IN THE CHITTAGONG HILL TRACTS

Foreword to Part Four

Parts One through Three of this textbook built a comprehensive clinical, epidemiological, historical, and philosophical architecture for understanding health and disease in the Chittagong Hill Tracts. From the foundational geomedicinal identity of the territory through the clinical management of its most prevalent diseases and into the specialized clinical domains of neurology, ophthalmology, oral health, and the systemic medicine of aging, reproduction, and trauma, the preceding parts established a portrait of a territory whose disease burden is shaped by terrain, history, poverty, and a structural marginalization so profound that it functions as a biological variable. Part Four advances that portrait into four interconnected domains that are simultaneously among the most consequential and among the most inadequately studied in the CHT context. The first domain is antimicrobial resistance, a crisis whose global dimensions have become one of the defining public health challenges of the twenty-first century and whose specific manifestations in the CHT, at the intersection of inadequate prescribing regulation, self-medication culture, cross-border pathogen mobility from Myanmar, and a fragmented health system without the capacity for systematic resistance surveillance, represent a compound threat whose full dimensions have not been mapped. The second domain is laboratory medicine and diagnostic technology, encompassing both the foundational science of what is diagnostically

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possible and the pragmatic architecture of what is diagnostically realistic in settings that range from a remote community health worker with a rapid diagnostic test kit to the district hospital laboratory with basic microbiology capability to the tertiary referral center with molecular diagnostic platforms. The third domain is the advanced clinical systems of cardiovascular disease, metabolic disease, pediatric infectious medicine, pharmacology, and the sociology of illness, each of which demands a level of CHT-specific treatment that Parts One through Three introduced but did not fully develop. The fourth domain is One Health, digital health, and the emerging technologies of care that offer, for the first time in the CHT's medical history, the possibility of bridging the geographic, linguistic, and systemic chasms that have separated the territory's most vulnerable communities from effective healthcare for centuries. Part Four is written with the same intellectual and ethical commitments that govern this entire textbook: the commitment to original thinking grounded in the best available evidence, the commitment to the clinical specificity demanded by a complex and distinctive health geography, and the commitment to a medicine that is answerable not only to the academy but to the communities whose lives it purports to serve.

CHAPTER ONE: ANTIMICROBIAL RESISTANCE IN THE CHITTAGONG HILL TRACTS: BIOLOGY, SURVEILLANCE DEFICIT, CLINICAL CONSEQUENCES, AND THE ONE HEALTH IMPERATIVE

1.1 The Antimicrobial Resistance Crisis as a CHT-Specific Emergency

Antimicrobial resistance, defined in this textbook as the genomically encoded or phenotypically expressed capacity of a microbial organism (bacterium, virus, fungus, or parasite) to survive and proliferate at concentrations of an antimicrobial agent that would ordinarily inhibit or kill organisms of the same species, operating through mechanisms including enzymatic drug inactivation, efflux pump overexpression, target site modification, reduced membrane permeability, and the formation of protective biofilms, is not a future risk for the Chittagong Hill Tracts. It is a present clinical reality that is already determining the outcomes of infectious disease management in CHT health facilities in ways that the official health data, inadequate as they are, substantially understate. The global antimicrobial resistance burden was quantified in the landmark 2022 Lancet study by Murray and colleagues at approximately 1.27 million deaths directly attributable to bacterial AMR in 2019, with an additional 4.95 million deaths associated with AMR, making drug-resistant infection one of the leading causes of death globally, exceeding HIV and malaria. Bangladesh's contribution to this burden is substantial: the country's National Antimicrobial Resistance Surveillance report for 2016 to 2023, released by the Institute of Epidemiology Disease Control and Research (IEDCR), documented high rates of resistance across a range of common pathogens including Extended Spectrum Beta-Lactamase (ESBL)-producing Escherichia coli and Klebsiella pneumoniae (which render the entire class of penicillin and cephalosporin antibiotics clinically ineffective), carbapenem-resistant Enterobacteriaceae (which eliminate the last-resort oral and parenteral options for many infections), and multidrug-resistant Salmonella Typhi (which has rendered fluoroquinolone treatment of typhoid fever unreliable and has reverted the standard treatment to azithromycin and third-generation

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cephalosporins at a time when azithromycin resistance is also emerging). The CHT's specific contribution to and specific experience of Bangladesh's AMR burden is almost completely undocumented in the peer-reviewed literature, because no CHT-specific AMR surveillance program exists and the national surveillance data are generated predominantly from sentinel hospitals in Dhaka, Chittagong, and other metropolitan centers whose microbiology laboratory capacity and catchment populations are fundamentally different from the CHT setting.

The CHT Antimicrobial Resistance Doctrine, developed in this chapter, holds that the AMR burden in the CHT is driven by a specific constellation of structural factors that differ in their relative weight and in their management implications from the AMR drivers in Bangladesh's urban centers. The first structural driver is the self-medication culture, which is ubiquitous across the CHT's informal healthcare sector and is particularly intense in areas where formal healthcare providers are inaccessible. In CHT communities, antimicrobial agents (including amoxicillin, cotrimoxazole, tetracycline, and ciprofloxacin) are freely available without prescription from drug sellers in roadside shops, itinerant medicine vendors who traverse remote communities by boat and foot, and informal village health practitioners who maintain their own antibiotic stocks. The use of these antibiotics is not randomized or capricious. CHT community members typically use antibiotics with a rational intent grounded in their past experience and in the advice of informal health practitioners, applying them for febrile illness (where the majority of episodes are due to malaria, viral illness, or other conditions where antibiotics are ineffective), for diarrheal illness (where most episodes require oral rehydration rather than antibiotics, and where indiscriminate antibiotic use accelerates the selection of resistant enteric organisms), and for upper respiratory tract infections (predominantly viral in etiology and therefore unresponsive to antibiotics). This systematic misapplication of antibiotics to non-bacterial conditions, combined with the use of incomplete courses (driven by cost constraints that cause patients to stop purchasing antibiotic courses before completion), creates intense selective pressure for the emergence and amplification of resistant organisms in CHT communities. The second structural driver is the cross-border pathogen mobility from Myanmar, whose deteriorating health system following the 2021 military coup has severely compromised its capacity to detect, treat, and contain antimicrobial-resistant infections, creating conditions for the westward migration of resistant pathogens through the CHT border zone. Drug-resistant tuberculosis (including both MDR-TB and the emerging extensively drug-resistant XDR-TB strains with resistance patterns that render the revised WHO treatment regimens ineffective) from Chin State in Myanmar, multidrug-resistant malaria parasites from the Greater Mekong Subregion, and resistant enteric organisms circulating among the displaced Chin and Rohingya populations in the border areas of Bandarban all represent specific cross-border AMR importation risks for the CHT that require targeted surveillance and clinical response strategies. The third structural driver is the absence of rational antibiotic prescribing governance in the CHT's formal health system. Even within government health facilities and NGO-operated clinics in the CHT, the absence of reliable microbiology laboratory support (antimicrobial susceptibility testing is not available at upazila health complex level and is inconsistently available at district hospital level), the pressure of patient expectations for visible therapeutic action, and the absence of antibiotic stewardship programs comparable to those operating in metropolitan Bangladesh hospitals, means that prescribing practice in CHT formal health facilities contributes to the AMR problem rather than mitigating it.

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1.2 The Microbiology of Resistance: Mechanisms, Organisms, and Their CHT Relevance

Understanding the molecular biology of antimicrobial resistance is a prerequisite for rational clinical and public health response, and this section provides the mechanism-specific framework that the CHT clinician needs to interpret resistance patterns, understand treatment failures, and make evidence-based prescribing decisions when laboratory susceptibility data are unavailable. The principal resistance mechanisms relevant to the CHT clinical context can be organized into four categories: enzymatic inactivation, efflux-mediated resistance, target site modification, and reduced permeability.

Enzymatic inactivation is the most common and clinically consequential resistance mechanism in the bacterial pathogens of greatest relevance to CHT clinical practice. Beta-lactamase production is the mechanism by which bacteria produce enzymes that hydrolyze the beta-lactam ring structure that is the pharmacologically active core of the penicillin, cephalosporin, and carbapenem classes of antibiotics. Narrow-spectrum beta-lactamases (including the TEM-1 and SHV-1 enzymes widespread in E. coli and Klebsiella species) hydrolyze penicillins but not cephalosporins. Extended-Spectrum Beta-Lactamases (ESBLs), which have been documented at high prevalence in Bangladesh including in studies from Chittagong, hydrolyze all penicillins and all cephalosporins through the third and in some cases fourth generation, leaving only carbapenems and a few non-beta-lactam agents as reliably effective alternatives. The carbapenemases (including KPC, NDM, OXA-48, and VIM type enzymes), which are spread predominantly through plasmid-mediated horizontal gene transfer between bacteria of different species and even different genera, hydrolyze carbapenems as well, creating the clinical situation of pandrug-resistance in which no conventional antibiotic class retains reliable efficacy against the organism. New Delhi Metallo-beta-lactamase (NDM-1), first identified in New Delhi in 2009 and subsequently documented across South Asia including Bangladesh, is of specific concern because it is carried on conjugative plasmids that spread readily between Enterobacteriaceae, Acinetobacter, and Pseudomonas species, and because NDM-producing organisms retain susceptibility only to colistin (a polymyxin antibiotic with significant nephrotoxicity) and fosfomycin (with limited oral bioavailability and rapidly emerging resistance when used in monotherapy). The CHT clinical scenario in which an ESBL- or carbapenemase-producing organism causes a severe infection (urinary sepsis, pneumonia, surgical site infection, or blood stream infection) in a patient who has reached district hospital level after a terrain-limited transfer is a clinical emergency in which the available antibiotic armamentarium is dramatically restricted and the outcomes are far worse than for susceptible organism infections.

Efflux-mediated resistance, in which the bacterium upregulates transmembrane efflux pump systems that actively export antimicrobial agents from the cytoplasm before they can reach their intracellular target sites, is the primary mechanism of fluoroquinolone resistance in Salmonella Typhi (producing the reduced susceptibility that has rendered ciprofloxacin unreliable for typhoid fever treatment in Bangladesh) and also contributes to resistance to tetracyclines, macrolides, and chloramphenicol in a range of organisms. Target site modification underlies methicillin resistance in Staphylococcus aureus (MRSA), in which the mecA or mecC gene encodes an alternative penicillin-binding protein (PBP2a or PBP2c) with very low affinity for all beta-lactam antibiotics, rendering the entire class ineffective; MRSA prevalence in Bangladesh

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has been documented at rates of 20 to 50 percent in hospital-associated S. aureus isolates, and community-associated MRSA strains, which tend to carry the Panton-Valentine Leukocidin (PVL) virulence factor associated with severe skin and soft tissue infection and necrotizing pneumonia, are emerging as a clinical problem in community settings including those comparable to the CHT. The CHT clinical relevance of MRSA is particularly acute in the context of skin and soft tissue infections (which are prevalent in agricultural workers who sustain frequent minor injuries that become infected), snakebite secondary infections (where Staphylococcus is a common secondary invader of bite wounds), and post-traumatic wound infections from landslide and agricultural injuries.

1.3 The Resistance Landscape of Malaria and Tuberculosis: CHT-Specific Dimensions

The AMR crisis in the CHT extends beyond bacterial resistance to encompass the two most historically dominant infectious diseases of the territory: malaria and tuberculosis. The resistance dynamics of Plasmodium falciparum and Mycobacterium tuberculosis in the CHT deserve CHT-specific analysis because both are shaped by the territory's unique position at the intersection of South Asia, Southeast Asia, and the Greater Mekong Subregion, where the world's most severe concentrations of drug-resistant malaria and drug-resistant TB are currently located.

Plasmodium falciparum resistance in the CHT has followed a trajectory that mirrors, with some geographic lag, the resistance evolution documented in the Greater Mekong Subregion. Chloroquine resistance in CHT P. falciparum, driven by mutations in the pfcrt gene (particularly the K76T mutation that is the molecular marker for chloroquine resistance), became effectively universal in the CHT during the 1980s and 1990s, rendering chloroquine clinically useless before the national policy switch to artemisinin-based combination therapy (ACT). Antifolate resistance in P. falciparum, measured by mutations in the dhfr and dhps genes encoding the targets of pyrimethamine and sulfadoxine respectively, is also widespread in CHT P. falciparum populations, making sulfadoxine-pyrimethamine (SP) an unreliable treatment option. The most consequential and most urgent current threat in CHT malaria pharmacology is the partial artemisinin resistance (PAR) that has been documented in P. falciparum populations of the Greater Mekong Subregion since the early 2010s and is now confirmed to have spread westward. PAR is mediated by mutations in the kelch13 (k13) gene of P. falciparum (particularly the C580Y, R539T, and F446I mutations that have been extensively characterized in Southeast Asian parasite populations), and it produces delayed parasite clearance after artemisinin treatment (defined as a parasite clearance half-life of greater than five hours in an artemisinin-treated patient, compared with the expected three hours or less in fully artemisinin-sensitive parasites). The 2025 WHO World Malaria Report documented the continuing geographical expansion of k13-mutant P. falciparum strains, with validated resistance mutations now confirmed in multiple countries of the Mekong subregion and their presence reported in border populations of Bangladesh, India (specifically in the northeast), and Myanmar at the CHT frontier. A 2022 study published in Malaria Journal documenting the heterogeneity of P. falciparum infections in the CHT did not identify significant k13 mutation prevalence at that time, but the study authors explicitly cautioned that ongoing surveillance is essential given the westward geographic trajectory of resistant strains and the cross-border mobility of CHT populations. The clinical implication of emerging artemisinin resistance in CHT P. falciparum

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would be of catastrophic consequence: artemether-lumefantrine is the only first-line option for uncomplicated P. falciparum malaria in Bangladesh, and artesunate is the definitive treatment for severe P. falciparum malaria. Loss of artemisinin efficacy without replacement options would produce a treatment vacuum directly comparable to the pre-chloroquine era, with predictable consequences for morbidity and mortality in the CHT's most malaria-burdened communities.

Mycobacterium tuberculosis drug resistance in the CHT context requires engagement with both the epidemiological evidence from comparable settings and the CHT-specific risk factors that suggest a higher-than-average probability of MDR-TB occurrence. As documented in Part Two, the national TB data for Bangladesh do not disaggregate CHT-specific resistance prevalence, and the proximity of the CHT to Myanmar, where MDR-TB prevalence among new and previously treated cases significantly exceeds the Bangladesh national average, creates a realistic cross-border importation risk. MDR-TB is defined by resistance to at least isoniazid and rifampicin, the two most bactericidal drugs in the standard first-line regimen, and its treatment requires prolonged courses (six to twenty months depending on the regimen and the patient's clinical profile and response) of toxic second-line drugs including fluoroquinolones (levofloxacin or moxifloxacin), bedaquiline, linezolid, clofazimine, and delamanid. The 2022 revised WHO consolidated guidelines on drug-resistant tuberculosis treatment recommended the BPaLM regimen (bedaquiline, pretomanid, linezolid, and moxifloxacin) as the preferred six-month treatment for pre-XDR and XDR-TB in countries where programmatic conditions allow, representing a major advance in MDR-TB treatment duration and efficacy but also requiring access to drugs and monitoring capabilities that do not exist within the CHT at present. A CHT patient diagnosed with MDR-TB at district hospital level, where GeneXpert MTB/RIF may detect rifampicin resistance (which is used as a proxy for MDR-TB detection), must be referred to the national MDR-TB treatment program, which has treatment sites outside the CHT, meaning that MDR-TB management requires the patient to leave the territory and to maintain adherence to a complex and toxic regimen in an unfamiliar environment without family support structures or culturally appropriate food, conditions that predict treatment non-adherence and treatment failure with the same reliability as any clinical risk factor.

1.4 Antibiotic Stewardship in the CHT: Principles, Protocols, and Pragmatics

Antibiotic stewardship programs (ASPs), defined as coordinated interventions designed to improve and measure the appropriate use of antimicrobials by promoting the selection of the optimal antimicrobial drug regimen, dose, duration of therapy, and route of administration, are the primary health system response to the AMR threat in healthcare settings globally. The implementation of antibiotic stewardship in the CHT setting requires radical adaptation of the metropolitan ASP framework to the realities of a health system where microbiology laboratory support is minimal, prescribing is fragmented across formal and informal sectors, regulatory oversight of antibiotic dispensing is effectively absent, and the clinical workforce has received no formal AMR-specific training. The CHT Contextual Antibiotic Stewardship Doctrine, articulated in this section, organizes CHT-specific stewardship principles into three tiers.

The Facility Tier targets the government health facilities of the CHT (district hospitals and upazila health complexes) and proposes the establishment of an Antibiotic Treatment Guide

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specific to the CHT's common disease presentations and the available antibiotic armamentarium at each facility level. This guide would specify the empirical antibiotic treatment of choice for the most common infectious conditions encountered at each facility level, based on the best available regional resistance data (from national surveillance and from published studies in Bangladesh and comparable settings), and would provide specific criteria for escalation to broader-spectrum antibiotics and for referral to higher-level facilities with laboratory support. The guide would incorporate a stop-and-review mechanism requiring prescribers to formally reassess the indication, spectrum, and duration of any antibiotic course at 48 to 72 hours after initiation, modifying or stopping treatment based on the patient's clinical response. A critical component of the facility-tier stewardship strategy in the CHT is the expansion of basic microbiology capacity, at minimum the capacity for Gram staining and culture of body fluids and wound specimens, to at least the district hospital level, providing the laboratory foundation for empirical guideline development and for monitoring prescribing practice against outcomes. The Community Tier targets the informal healthcare sector and the community-level factors that drive antibiotic misuse. Community antibiotic stewardship in the CHT requires addressing both the supply side (the regulatory environment that allows antibiotic sale without prescription, which is technically illegal under Bangladesh pharmaceutical law but effectively unenforced in remote CHT areas) and the demand side (the patient and community expectations and health beliefs that drive antibiotic-seeking for viral and parasitic conditions). Effective community AMR communication in the CHT requires indigenous-language health education (a consistent theme across every public health domain in this textbook, but no less essential here) delivered through trusted community channels including traditional healers, Buddhist monks, village leaders, and community health workers trained in AMR communication. The Policy Tier requires engagement with the national governance structures that determine antibiotic regulation, surveillance, and health system resource allocation. The CHT's AMR burden cannot be addressed by facility- and community-level interventions alone without the national policy commitment to extend AMR surveillance to the CHT (including CHT-specific sentinel surveillance sites), to enforce pharmaceutical regulatory standards in remote areas including CHT markets, and to invest in the microbiology laboratory infrastructure that is the essential foundation for evidence-based antibiotic use.

1.5 The One Health Framework for AMR in the CHT: Animals, Agriculture, and the Environment

The One Health approach to antimicrobial resistance, which recognizes that human, animal, and environmental health are inextricably interconnected and that effective AMR control requires simultaneous surveillance and intervention in all three sectors, is particularly relevant to the CHT because the ecological integration of human communities with the agricultural and forest environments of the territory creates dense human-animal-environment interfaces that facilitate the sharing of resistant organisms and resistance determinants across species and ecological compartments. The CHT's livestock sector, which includes free-ranging poultry, pigs, cattle, and goats kept in intimate proximity to human households, is a reservoir of antimicrobial-resistant organisms whose clinical significance for human health has not been systematically studied in the CHT context. In neighboring countries of South and Southeast Asia, studies have documented high rates of ESBL-producing E. coli in community-raised poultry, with carriage

rates of 40 to 80 percent in some surveys, driven by the use of antimicrobials (particularly tetracyclines, fluoroquinolones, and aminoglycosides) as growth promoters and prophylactic agents in small-scale poultry production. These resistant E. coli strains are transmitted to humans through direct animal contact, through contaminated poultry meat during food preparation, and through environmental contamination of water sources by poultry feces. The CHT's widespread practice of free-ranging poultry keeping in household compounds, combined with the use of contaminated surface water for drinking and cooking, creates the transmission pathways needed to bridge animal AMR reservoirs with human infection. Aquatic antimicrobial contamination, from the disposal of antibiotic-containing pharmaceutical waste in CHT rivers and streams, from agricultural runoff containing antibiotic residues from fish and shrimp pond operations in adjacent coastal areas, and from the excretion of antibiotic residues by humans taking oral antibiotic courses, creates a chemical selection pressure for resistance development in the environmental microbiome of CHT water systems that has clinical consequences through the contamination of drinking water and recreational water. The One Health AMR response for the CHT requires coordinated action from the Department of Livestock Services (for animal sector surveillance and antibiotic use regulation), the Department of Agriculture Extension (for agricultural antibiotic use monitoring), the Department of Environment (for aquatic contamination monitoring), and the health sector (for human sector surveillance and clinical stewardship), operating under a joint monitoring and coordination framework that does not currently exist in the CHT.

MODEL EXAMINATION QUESTIONS: CHAPTER ONE (PART FOUR)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Extended-Spectrum Beta-Lactamase (ESBL)-producing organisms are resistant to which classes of antibiotics? a) Aminoglycosides and fluoroquinolones only b) All penicillins and all cephalosporins through third generation c) Carbapenems only d) Macrolides and tetracyclines (Correct Answer: b)

The mecA gene in methicillin-resistant Staphylococcus aureus (MRSA) encodes: a) A beta-lactamase enzyme that destroys the antibiotic b) An alternative penicillin-binding protein (PBP2a) with very low affinity for all beta-lactams c) An efflux pump that exports methicillin from the cell d) A mutation in the bacterial cell wall synthesis pathway (Correct Answer: b)

The molecular marker most commonly used to detect chloroquine resistance in Plasmodium falciparum is a mutation in which gene? a) pfk13 b) dhfr c) pfcrt (K76T mutation) d) pfmdr1 (Correct Answer: c)

Antimicrobial resistance in bacteria can be transferred between bacterial species through which mobile genetic element? a) Chromosomal DNA replication b) Plasmid-mediated horizontal gene transfer c) Mutation of chromosomal resistance genes d) Viral transduction from bacteriophage only (Correct Answer: b)

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The BPaLM regimen recommended by WHO in 2022 for pre-XDR and XDR-TB consists of which four drugs? a) Isoniazid, rifampicin, pyrazinamide, ethambutol b) Bedaquiline, pretomanid, linezolid, moxifloxacin c) Amikacin, capreomycin, ethionamide, cycloserine d) Clofazimine, delamanid, levofloxacin, streptomycin (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A CHT district hospital receives a patient with community-acquired urinary sepsis who has not responded to a three-day course of ciprofloxacin administered empirically by a village pharmacist. Urine culture (available at the district hospital laboratory) demonstrates E. coli with the following sensitivity pattern: resistant to ampicillin, cotrimoxazole, ciprofloxacin, ceftriaxone, and cefepime; sensitive to imipenem, meropenem, and fosfomycin. Which resistance mechanism is most consistent with this pattern and what is the appropriate antibiotic choice for this patient? a) Narrow-spectrum beta-lactamase; treat with high-dose amoxicillin-clavulanate b) ESBL production; treat with meropenem IV as the most reliable bactericidal option for this mechanism, with urology consultation for any structural urinary tract abnormality c) MRSA; treat with vancomycin d) Fluoroquinolone target mutation; treat with high-dose ciprofloxacin (Correct Answer: b)

A public health officer in Bandarban designs a One Health AMR surveillance program for the CHT. Which of the following correctly describes the minimum scope of a One Health AMR surveillance approach? a) Surveillance of human clinical isolates from district hospitals only b) Parallel surveillance of antimicrobial-resistant organisms in human clinical samples, food-producing animals (particularly poultry and pigs), and environmental water sources, with coordinated analysis to identify shared resistance determinants across sectors c) Animal sector surveillance only, since most human AMR comes from animal sources d) Environmental water surveillance only, since waterborne transmission is the primary CHT AMR pathway (Correct Answer: b)

CHAPTER TWO: LABORATORY MEDICINE AND DIAGNOSTIC TECHNOLOGY IN THE CHT: FROM POINT-OF-CARE TO MOLECULAR DIAGNOSTICS

2.1 The Diagnostic Technology Stratification Model for the CHT

The theory of diagnostic technology access in resource-limited settings has evolved substantially in the past decade, driven by both the proliferation of increasingly sophisticated point-of-care diagnostic tools and by a growing evidence base that demonstrates the clinical and public health consequences of diagnostic gaps. This textbook proposes the CHT Diagnostic Technology Stratification Model (DTSM), which holds that diagnostic technology in the CHT must be conceptualized not as a single system operating uniformly across the territory but as a tiered architecture in which different levels of diagnostic sophistication are deployed at different levels of the health system in a manner calibrated to both the epidemiological priorities of each level and the operational realities of each level's infrastructure. The DTSM organizes CHT diagnostic

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capacity into five strata: the Community Level (where the community health worker operates with basic observational tools, rapid diagnostic tests for the most prevalent conditions, and structured clinical algorithms), the Sub-District (Upazila) Level (where the upazila health complex physician operates with basic clinical examination equipment, point-of-care tests, and simple hematological and biochemical investigations), the District Level (where the district hospital operates with a functional laboratory capable of hematology, basic biochemistry, microscopy, and limited microbiology), the Regional Level (Chittagong Medical College Hospital, with full laboratory medicine including molecular diagnostics, imaging, and specialist pathology), and the National Reference Level (designated national reference laboratories in Dhaka with capacity for the most complex diagnostic investigations including whole-genome sequencing, specialized serology, and rare pathogen identification). The DTSM principle holds that optimizing diagnostic impact requires deploying the most epidemiologically critical diagnostic tests as close to the community level as possible, ensuring that the conditions most likely to benefit from early diagnosis and the most likely to be missed without a diagnostic test are detectable at the point of first clinical contact, even if that contact is with a community health worker rather than a physician.

2.2 Point-of-Care Diagnostics: Technologies, Performance, and Operational Principles

Point-of-care diagnostics (POCDs), defined as diagnostic tests performed at or near the location of patient care, using equipment and procedures suitable for operation by non-specialist personnel, and delivering results within minutes to hours rather than the days required for conventional laboratory testing, have transformed the diagnostic capacity of resource-limited settings globally since the early 2000s. In the CHT, the most consequential existing application of POCD is the malaria rapid diagnostic test (mRDT), which has been discussed extensively in Parts Two and Seven of this textbook. The mRDT portfolio deployed in the CHT has expanded beyond the HRP2-based P. falciparum-specific tests to include combination HRP2-pLDH RDTs that can detect both P. falciparum and P. vivax in a single test, addressing the clinically important distinction between species (relevant for radical cure decisions and primaquine prescribing) while maintaining the operational simplicity of a rapid blood-based test performable by community health workers. The WHO Prequalification Program maintains a list of malaria RDTs that have met minimum performance standards (sensitivity above 75 percent and specificity above 90 percent at parasite densities above 200 parasites per microliter), and product selection for CHT deployment should be restricted to WHO-prequalified products to ensure adequate performance at the parasite densities encountered clinically.

Beyond malaria, the CHT POCD landscape encompasses several high-priority test categories whose deployment at community or primary care level would substantially improve clinical outcomes. Tuberculosis diagnosis at community level is currently limited to symptom-based screening (identifying individuals with cough of greater than two weeks duration, weight loss, night sweats, and fever as presumptive TB cases requiring referral for sputum investigation), because conventional sputum smear microscopy and molecular testing are not performable at community or primary care level. The Truenat MTB platform, developed by Molbio Diagnostics in India and WHO-prequalified for TB detection, is a miniaturized, battery-operable molecular platform capable of running chip-based real-time PCR tests for M. tuberculosis detection and

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rifampicin resistance in approximately one hour, using technology designed for operation in remote and resource-limited settings. Truenat has been deployed in primary health centers in India and other low-income countries and represents the most operationally realistic current option for extending TB molecular diagnostic capacity toward the sub-district level in the CHT. Blood glucose measurement by handheld glucometer is essential at all levels of the CHT health system, both for the management of diabetic patients and for the emergency management of hypoglycemia in febrile obtunded patients (as illustrated in the cerebral malaria case study in Part Three). Hemoglobin measurement by portable hemoglobinometer (such as the HemoCue platform, which measures hemoglobin in a microlitre blood sample by photometric analysis) provides rapid nutritional anemia assessment that is critical for evaluating malnourished CHT children and pregnant women. Urine dipstick testing for protein (preeclampsia screening), glucose (diabetes screening), nitrites and leukocyte esterase (urinary tract infection screening), and blood (screening for glomerulonephritis and urinary tract pathology) provides a high-yield multiparameter screening tool for a single CHT health worker visit. C-reactive protein (CRP) lateral flow POCDs, which provide semi-quantitative measurement of CRP within 15 minutes from a fingerprick blood sample, have been validated as a tool for distinguishing bacterial from viral respiratory infections in primary care settings, with CRP above 40 mg/L having a positive predictive value of approximately 70 percent for bacterial pneumonia requiring antibiotic treatment, and CRP below 20 mg/L having a negative predictive value of approximately 90 percent for serious bacterial infection. The incorporation of CRP-guided antibiotic prescribing into CHT primary care protocols, combined with antibiotic stewardship education for prescribers, has been shown in randomized trials in comparable primary care settings to reduce antibiotic prescribing by 30 to 50 percent without compromising patient outcomes, and represents a specific and actionable antibiotic stewardship intervention for the CHT.

2.3 Hematology and Its Clinical Application in the CHT

The complete blood count (CBC) with differential remains the single most clinically informative laboratory investigation available in a district hospital setting and the laboratory test whose results, interpreted with CHT-specific epidemiological intelligence, can most dramatically alter clinical management decisions. The CBC interpretation framework for CHT clinical practice requires knowledge of the normal hematological reference ranges and their modifications by the specific pathophysiological conditions prevalent in the CHT. Hemoglobin concentration is the primary hematological variable of interest in the CHT context. The WHO defines anemia as hemoglobin below 13.0 g/dL in adult males, below 12.0 g/dL in non-pregnant adult females, below 11.0 g/dL in pregnant women, and below 11.5 g/dL in children aged 5 to 12 years. The anemia burden of the CHT, driven by the multiple etiologies documented throughout this textbook (nutritional iron, folate, and vitamin B12 deficiency; hemolytic anemia from malaria; anemia of chronic inflammation from TB and other chronic infections; G6PD deficiency-associated episodic hemolytic anemia; and the thalassemia traits prevalent in some CHT ethnic populations), means that the majority of CBC results in CHT children and pregnant women will show some degree of anemia, and the clinical task is to determine the etiology and severity of the anemia rather than simply to note its presence.

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The morphological characterization of anemia on peripheral blood film examination provides the most informative diagnostic signal for anemia etiology when complete laboratory analysis is unavailable, which is the operational reality in most CHT clinical settings. Microcytic hypochromic anemia (small, pale red cells with an expanded central pallor area exceeding one-third of the cell diameter, reduced Mean Corpuscular Volume typically below 80 femtoliters, and reduced Mean Corpuscular Hemoglobin typically below 27 picograms) is the morphological pattern of iron deficiency anemia, thalassemia trait, and anemia of chronic disease in its microcytic variant. Distinguishing iron deficiency from thalassemia trait is clinically important in the CHT context because CHT indigenous populations (particularly the Chakma and related communities whose genetic heritage includes high frequencies of hemoglobin E trait, the most common hemoglobin variant globally) have elevated thalassemia trait prevalence, and because iron supplementation in a thalassemia patient without iron deficiency may cause iron overload rather than improving the anemia. The Mentzer Index (Mean Corpuscular Volume divided by Red Blood Cell count, with values below 13 suggesting thalassemia trait and values above 13 suggesting iron deficiency) provides a simple bedside calculation from CBC data that, while imperfect, improves the diagnostic discrimination between these two conditions when serum iron studies (which would definitively distinguish them) are unavailable. Macrocytic anemia (large red cells with MCV typically above 100 femtoliters), which is the morphological pattern of vitamin B12 and folate deficiency (producing megaloblastic anemia with hypersegmented neutrophils on the peripheral blood film, one of the most pathognomonic morphological findings in clinical hematology), hypothyroidism, liver disease (particularly alcoholic liver disease, relevant in the CHT context given the alcohol use disorder burden documented in Part One), and the bone marrow suppressive effects of some medications, requires investigation for B12 and folate deficiency as the most correctable causes in the CHT population.

The white blood cell (WBC) count and differential provides the second major clinical signal from the CBC in CHT clinical practice. Neutrophilia (elevated neutrophil count above 7.5 x 10 to the 9th per liter in adults) with elevated total WBC count suggests bacterial infection and systemic inflammation. Lymphocytosis (elevated lymphocyte count above 4.0 x 10 to the 9th per liter in adults) suggests viral infection, pertussis (whooping cough, caused by Bordetella pertussis, whose epidemiology in the CHT is incompletely characterized but whose bacterial infection produces one of the most characteristic lymphocyte responses in clinical medicine), and in some cases chronic lymphocytic leukemia in older adults. Eosinophilia (elevated eosinophil count above 0.5 x 10 to the 9th per liter) is the peripheral blood marker that should most reliably trigger clinical suspicion for helminthic infection in the CHT context, since tissue-invasive helminths (including Toxocara, Strongyloides, and Trichinella, in addition to the common intestinal helminths) provoke a eosinophilic inflammatory response as a component of the IgE-mediated anti-helminthic immune response, and the identification of significant eosinophilia in a CHT patient with vague abdominal symptoms, weight loss, or respiratory symptoms should prompt a systematic investigation for parasitic infection beginning with stool examination for helminth ova and parasites, serology for Toxocara and Strongyloides, and consideration of empirical albendazole treatment if laboratory investigation is unavailable but clinical suspicion is high.

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2.4 Biochemical Investigations: Utility, Priorities, and Interpretation

The biochemical investigation capacity available at CHT district hospitals represents the core of the laboratory support system for clinical management decisions in the territory. Biochemical tests of greatest clinical priority in the CHT setting can be organized by the disease domains they serve. Renal function assessment, through measurement of serum creatinine and blood urea nitrogen (BUN), is essential for the management of severe malaria (where acute kidney injury occurs in 1 to 4 percent of P. falciparum malaria cases and dramatically increases mortality, requiring specific management with dialysis in the most severe cases, a capability that does not exist within the CHT and requires referral to Chittagong), for the monitoring of anti-tuberculosis drug nephrotoxicity (particularly in patients receiving streptomycin, which is nephrotoxic), for the management of snakebite patients with systemic envenomation and hemotoxin-induced renal failure, and for the safe prescribing of renally-cleared antibiotics (including aminoglycosides and some beta-lactams) in patients where renal impairment would require dose adjustment. Liver function assessment (serum alanine aminotransferase, ALT; aspartate aminotransferase, AST; total and direct bilirubin; alkaline phosphatase; and albumin) is essential for the diagnosis and monitoring of hepatitis (both acute viral hepatitis from hepatitis A, B, and E viruses, and the alcoholic hepatitis that is a consequence of the alcohol use burden documented in the CHT), for monitoring anti-tuberculosis drug hepatotoxicity (isoniazid, rifampicin, and pyrazinamide are all potentially hepatotoxic, and the frequency of TB drug-induced liver injury is higher in malnourished patients and in those with pre-existing liver disease, both conditions prevalent in the CHT), and for the assessment of liver failure in severe malaria. Serum electrolytes (sodium, potassium, and chloride) and glucose measurement support the fluid and electrolyte management that is central to the treatment of severe diarrheal disease (particularly cholera, where fluid and electrolyte losses are massive and hyponatremia, hypokalemia, and metabolic acidosis can occur), and to the management of severe malaria (where hypoglycemia is a life-threatening complication requiring immediate glucose administration, and where hyponatremia from inappropriate antidiuretic hormone secretion can complicate cerebral malaria). Thyroid function testing (TSH and free T4 measurement) is not routinely available at CHT district hospital level but is relevant for the CHT clinical context because iodine deficiency disorders (goiter and hypothyroidism from dietary iodine insufficiency, which is a particular risk in geographically isolated inland communities without access to iodized salt) have been documented in CHT hill communities, and because clinical hypothyroidism produces a syndrome that overlaps with the presentations of chronic malnutrition, depression, and TB in CHT patients.

2.5 Molecular Diagnostics in the CHT: Current Applications and Future Trajectories

Molecular diagnostic techniques, based on the detection and characterization of nucleic acids (DNA and RNA) from pathogens using amplification technologies including polymerase chain reaction (PCR) and its variants, represent the frontier of diagnostic precision for infectious diseases and are transforming the management of tuberculosis, HIV, hepatitis, and malaria globally. In the CHT, molecular diagnostics are currently available only at regional referral level (Chittagong Medical College Hospital), through the GeneXpert MTB/RIF and GeneXpert Ultra platforms for TB and RIF resistance detection, and at national reference laboratories for more specialized molecular applications. The science of molecular diagnostics and its CHT relevance

requires engagement at several levels. The GeneXpert system, which performs automated cartridge-based real-time PCR with sample-to-result times of approximately two hours for GeneXpert MTB/RIF and ninety minutes for GeneXpert Ultra, has been one of the most consequential diagnostic technology deployments in global health history, substantially reducing TB diagnostic delays and identifying drug resistance that would otherwise have been identified only after empirical treatment failure. The extension of GeneXpert capacity toward the sub-district level in the CHT, through the deployment of smaller Xpert Omni platforms (designed for low-resource settings with battery power operation capability) at upazila health complexes serving high-TB-burden catchment populations, represents a diagnostically and programmatically achievable near-term goal that would substantially reduce the TB treatment delay that currently characterizes CHT TB management. The GeneXpert system's modular architecture also allows the use of cartridges for conditions beyond TB, including GeneXpert HPV (human papillomavirus detection for cervical cancer screening), GeneXpert CT/NG (Chlamydia trachomatis and Neisseria gonorrhoeae detection for STI management), and GeneXpert Xpert Viral Load (HIV viral load monitoring), expanding the diagnostic return from a single platform investment beyond TB alone. Whole-genome sequencing (WGS) of M. tuberculosis and P. falciparum clinical isolates, which is performed at national reference laboratories and generates comprehensive resistance profiles and phylogenomic data revealing transmission chains and geographic origins of pathogens, represents the gold standard for CHT AMR surveillance and for understanding the cross-border dynamics of TB and malaria resistance in the CHT border zone, and its deployment for CHT sentinel surveillance would generate the data needed to design evidence-based resistance control strategies.

MODEL EXAMINATION QUESTIONS: CHAPTER TWO (PART FOUR)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The WHO-prequalified Truenat MTB platform uses which diagnostic technology to detect M. tuberculosis? a) Enzyme-linked immunosorbent assay (ELISA) b) Miniaturized chip-based real-time PCR c) Sputum smear microscopy with auramine O fluorescence staining d) Lateral flow immunoassay (Correct Answer: b)

The Mentzer Index (MCV divided by RBC count), used to differentiate iron deficiency from thalassemia trait, interprets values below which threshold as suggestive of thalassemia? a) 5 b) 13 c) 20 d) 30 (Correct Answer: b)

Significant eosinophilia on a CBC in a CHT patient should primarily raise clinical suspicion for which category of conditions? a) Viral respiratory infections b) Tissue-invasive helminthic infections c) Bacterial septicemia d) Fungal meningitis (Correct Answer: b)

The GeneXpert MTB/RIF assay simultaneously detects M. tuberculosis DNA and resistance to which antibiotic? a) Isoniazid b) Pyrazinamide c) Rifampicin d) Ethambutol (Correct Answer: c)

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In the CBC interpretation of severe P. falciparum malaria, which hematological abnormality is most predictive of mortality risk? a) Mild neutrophilia b) Severe hemolytic anemia with hemoglobin below 5 g/dL c) Mild eosinophilia d) Mild lymphopenia (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A CHT district hospital physician treats a 7-year-old Mro child with confirmed P. falciparum malaria. The CBC shows hemoglobin 4.8 g/dL, MCV 62 fL, RBC count 3.2 x 10 to the 12th per liter, and the peripheral blood film shows microcytic hypochromic red cells with some target cells. The Mentzer Index is 19.4. G6PD test result is pending. Which of the following is the most appropriate interpretation and immediate action? a) Iron deficiency anemia confirmed; prescribe oral iron and discharge with antimalarials b) Thalassemia trait likely given the Mentzer Index below 13; withhold iron and manage malaria only c) Mentzer Index above 13 suggests iron deficiency as the more likely cause of the microcytic anemia; however, the presence of target cells and the clinical context require G6PD testing before primaquine prescription, treatment of malaria with artemether-lumefantrine, blood transfusion assessment given the severity of anemia (hemoglobin below 5 g/dL constitutes severe anemia requiring transfusion consideration in symptomatic pediatric malaria), and nutritional assessment for dietary iron deficiency d) The anemia is entirely attributable to malaria hemolysis and will resolve with antimalarial treatment alone (Correct Answer: c)

CHAPTER THREE: CARDIOVASCULAR DISEASE, STROKE, AND HYPERTENSION IN THE CHT: THE SILENT EPIDEMIC'S CLINICAL AND EPIDEMIOLOGICAL ARCHITECTURE

3.1 The CHT Cardiovascular Transition: Paradox, Documentation, and Emerging Evidence

Cardiovascular disease, encompassing hypertension, coronary artery disease, heart failure, rheumatic heart disease, and stroke, represents a dimension of the CHT health crisis whose significance has been obscured by the historical predominance of infectious disease in the territory's health discourse and by the absence of systematic NCD surveillance in the CHT. The emerging evidence, pieced together from national and regional data, from qualitative health studies, and from the clinical experience of district hospital physicians in the CHT, indicates that cardiovascular disease is both more prevalent and more rapidly growing in CHT indigenous communities than has been recognized in the public health literature. The CHT Cardiovascular Paradox Doctrine holds that CHT indigenous communities experience an NCD transition that is paradoxical in its structure: the traditional risk factors for cardiovascular disease associated with affluence and dietary excess in high-income country contexts (obesity, dyslipidemia from high-fat diet, sedentary behavior) are less prevalent in the CHT than in urban Bangladesh, while the cardiovascular risk factors associated with poverty, stress, and structural marginalization (hypertension from chronic stress and salt excess in preserved food, systemic inflammation from chronic infectious disease burden, smoking and tobacco use including smokeless tobacco, rheumatic heart disease from untreated streptococcal pharyngitis in resource-poor settings, and

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the accelerated atherosclerosis associated with chronic inflammatory states) are substantially more prevalent, producing a distinct cardiovascular risk profile that differs from both the urban NCD epidemic and the traditional cardiovascular epidemiology of low-income agrarian communities in classical epidemiological transition theory.

Hypertension in the CHT, defined as systolic blood pressure persistently at or above 140 mmHg and/or diastolic blood pressure at or above 90 mmHg according to the WHO/ISH 2020 guidelines (or systolic at or above 130 mmHg and diastolic at or above 80 mmHg according to the 2017 ACC/AHA guidelines, reflecting the ongoing definitional debate that practitioners should be aware of without being paralyzed by), is the dominant cardiovascular risk factor in the CHT context and the one with the greatest potential for prevention, detection, and management through primary care-level intervention. The national prevalence of hypertension in Bangladesh has been estimated at approximately 21 percent of adults in nationally representative surveys, but CHT-specific data are lacking, and several features of the CHT context suggest that hypertension prevalence among CHT indigenous adults may be both under-detected and inadequately treated to a degree exceeding the national situation. The barriers to hypertension detection in the CHT are structural: blood pressure measurement requires a sphygmomanometer or digital blood pressure device, the availability of which is limited to formal health facilities and government health workers' kits in the CHT, meaning that the large proportion of the CHT adult population who have no contact with formal health services (particularly men of working age and elderly individuals in remote communities) have never had their blood pressure measured. The barriers to hypertension treatment are compounded: antihypertensive medications (including amlodipine, the most widely available calcium channel blocker in the Bangladesh essential medicines list; losartan and enalapril for the ACE inhibitor and ARB classes; and hydrochlorothiazide for the diuretic class) require daily long-term administration, which is incompatible with the intermittent and geographically constrained medication supply in remote CHT communities. The consequences of untreated hypertension in the CHT are severe: the two most devastating complications of uncontrolled hypertension, stroke (hemorrhagic and ischemic) and hypertensive heart failure, both produce devastating disability and death in populations without access to the acute management (thrombolysis for ischemic stroke, intensive care for hemorrhagic stroke, diuretic and vasodilator therapy for acute pulmonary edema from hypertensive heart failure) needed to modify their natural history.

3.2 Rheumatic Heart Disease in the CHT: The Preventable Cardiac Catastrophe

Rheumatic heart disease (RHD), caused by the autoimmune cardiac valve damage that is the delayed consequence of inadequately treated group A Streptococcus (Streptococcus pyogenes) pharyngitis, is a condition of preventable origin that affects an estimated 41 million people globally and causes approximately 306,000 deaths annually according to the 2021 Global Burden of Disease study. It is a disease predominantly of poverty, overcrowding, and healthcare access deficiency, and the CHT represents, on the basis of these epidemiological determinants, a high-risk territory for RHD whose actual burden has never been measured. The pathogenesis of RHD proceeds through several steps. Streptococcal pharyngitis causes acute rheumatic fever (ARF) in approximately 3 percent of susceptible individuals who have not received adequate antibiotic treatment (penicillin V for ten days or benzathine penicillin G as a single IM injection remaining

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the treatments that prevent ARF when given within the first nine days of pharyngitis onset). ARF is characterized by the Jones Criteria: the major criteria of carditis (inflammation of the heart, documented clinically by new valvular murmur and echocardiographically by valvular regurgitation even in the absence of auscultatory findings, a phenomenon called subclinical carditis of great importance to the current clinical understanding of ARF), polyarthritis, chorea (the involuntary jerky movements of Sydenham's chorea, a neurological manifestation of ARF), erythema marginatum (a transient migratory rash), and subcutaneous nodules; and the minor criteria of fever, elevated acute phase reactants (CRP, ESR), and prolonged PR interval on ECG. A diagnosis of ARF requires either two major criteria or one major plus two minor criteria in the presence of evidence of preceding streptococcal infection (positive throat culture, positive rapid streptococcal antigen test, or elevated or rising anti-streptolysin O titer, ASO titer). Repeated episodes of ARF, each triggered by a new streptococcal pharyngitis episode, cause progressive damage to the cardiac valves, predominantly the mitral valve (with mitral regurgitation from leaflet scarring and thickening as the most common manifestation, progressing to mitral stenosis from commissural fusion in long-standing disease), and to a lesser extent the aortic valve. The cumulative valve damage from multiple ARF episodes produces chronic RHD, which ultimately requires surgical intervention (commissurotomy, valvuloplasty, or valve replacement) in severe cases, interventions that are not available within the CHT and require referral to national cardiac surgery centers in Dhaka. The prevention of RHD in the CHT requires a strategy operating at two levels: primary prevention (ensuring that streptococcal pharyngitis cases in CHT children are identified and treated with appropriate antibiotics before ARF can develop) and secondary prevention (administering long-term monthly benzathine penicillin G injections to all individuals who have suffered ARF to prevent recurrent streptococcal infection and progressive valve damage). Both levels of prevention are currently severely undermined in the CHT by the diagnostic inaccessibility that means most streptococcal pharyngitis cases are not identified or treated (the sore throat presenting to a CHT community health worker without access to throat culture or rapid streptococcal antigen testing has no diagnostic pathway to confirm the bacterial etiology), and by the logistical impossibility of delivering monthly IM penicillin injections to remote community members who cannot reliably reach a health facility every four weeks.

3.3 Stroke in the CHT: Emergency Management and Prevention in a Resource-Constrained Setting

Stroke, defined as an acute neurological event attributable to cerebrovascular disease, resulting in focal neurological deficit lasting more than 24 hours (or less if imaging confirms the relevant lesion, the modern definition from the 2013 American Heart Association/American Stroke Association guidelines), is divided into ischemic stroke (accounting for approximately 85 percent of all strokes globally, caused by thromboembolism occluding a cerebral artery and producing infarction of the dependent brain territory) and hemorrhagic stroke (accounting for approximately 15 percent of strokes globally, caused either by intracerebral hemorrhage from rupture of a small arterial perforator in the basal ganglia or other deep brain structures, most commonly from hypertension, or by subarachnoid hemorrhage from rupture of a cerebral aneurysm). The epidemiology of stroke in the CHT indigenous population has not been systematically studied. However, the risk factor profile of the CHT population suggests that hemorrhagic stroke from uncontrolled hypertension is likely to be the most prevalent stroke

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subtype in the CHT indigenous population, consistent with the pattern documented in other low-income Asian countries where hypertension detection and treatment rates are low and hemorrhagic stroke is relatively more common than ischemic stroke compared with high-income country epidemiology. The clinical recognition of stroke in the CHT context requires application of a rapid assessment tool that can be used by non-specialist health workers. The FAST acronym (Face drooping, Arm weakness, Speech difficulty, Time to call for help) provides a validated and culturally adaptable screening tool for acute stroke that has been shown to identify approximately 85 percent of ischemic strokes when applied by trained lay persons. Adapted FAST communication training for CHT community health workers, delivered in indigenous languages, represents a simple and high-impact stroke awareness intervention that would reduce the time from stroke onset to presentation at a health facility, the most critical determinant of stroke outcome. The management of acute ischemic stroke in CHT district hospitals is fundamentally constrained by the absence of CT imaging at district hospital level in the CHT (CT being required to exclude hemorrhagic stroke before thrombolysis can be administered, since administering alteplase to a hemorrhagic stroke patient would catastrophically worsen intracranial bleeding) and by the absence of trained stroke neurologists and specialized stroke unit infrastructure. The pragmatic emergency stroke management at CHT district hospital level therefore focuses on clinical differentiation (using the Siriraj Stroke Score, a validated clinical score using GCS level, vomiting, headache, diastolic blood pressure, and atheroma history to distinguish hemorrhagic from ischemic stroke with approximately 90 percent accuracy in prospective validation studies, providing a clinical alternative to CT in resource-limited settings), blood pressure management (lowering markedly elevated blood pressure cautiously in ischemic stroke since extreme hypertension reduction worsens ischemic brain territory by reducing perfusion pressure), glucose management (maintaining normoglycemia since both hypoglycemia and hyperglycemia worsen stroke outcomes), aspiration prevention (maintaining airway protection in drowsy patients and positioning the patient appropriately), and urgent referral to Chittagong Medical College Hospital for CT imaging, specialist assessment, and intensive stroke management.

3.4 Coronary Artery Disease and Acute Coronary Syndrome: Recognition and Emergency Management

Acute coronary syndrome (ACS), encompassing ST-elevation myocardial infarction (STEMI), non-ST-elevation myocardial infarction (NSTEMI), and unstable angina, arises from the rupture of an atherosclerotic plaque within a coronary artery followed by platelet aggregation and thrombus formation that partially or completely occludes the vessel, producing myocardial ischemia and, in the case of STEMI and NSTEMI, myocardial infarction from sustained ischemia beyond the reversibility threshold of approximately 20 minutes. The recognition and emergency management of ACS in the CHT presents a unique clinical challenge because the typical presentation (substernal chest pain radiating to the left arm and jaw, with dyspnea, diaphoresis, and nausea) may be modified by cultural and linguistic factors in CHT indigenous patients (who may describe the pain using local-language metaphors and who may not present the complaint in terms recognizable to a clinician trained to elicit classic ACS symptoms in Bangla or English), by the younger mean age of presentation in South Asian populations compared with Western populations (where myocardial infarction in individuals under 50 years

is substantially more common in the South Asian subcontinent, potentially because of the specific lipid metabolism characteristics and the chronic inflammatory burden of the subcontinent's populations), and by the extremely limited time window for effective intervention and the substantial distance from the nearest percutaneous coronary intervention (PCI) capable facility (which is Chittagong Medical College Hospital at minimum, and the specialty cardiac centers in Dhaka for definitive complex PCI). The CHT ACS management protocol at district hospital level includes the dual antiplatelet therapy of aspirin 300 mg loading dose plus clopidogrel 300 to 600 mg loading dose (the pharmacological foundation of ACS management globally that is inexpensive, widely available, and life-saving), sublingual nitrates for symptom relief in the absence of hypotension (systolic BP below 90 mmHg), oxygen supplementation only for patients with oxygen saturation below 94 percent (since routine oxygen supplementation in normoxic ACS patients has been shown in randomized trials to potentially worsen outcomes through coronary vasoconstriction), and urgent referral for primary PCI or fibrinolysis if the patient has STEMI (documented by ST elevation of at least 1 mm in two contiguous limb leads or at least 2 mm in two contiguous precordial leads on a 12-lead ECG). In CHT district hospitals without fibrinolysis capability, the time-critical nature of STEMI management (the maximum acceptable door-to-needle time for fibrinolysis is 30 minutes, and the maximum door-to-balloon time for PCI is 90 minutes) combined with the transport time to a fibrinolysis-capable facility means that pre-hospital fibrinolysis (administering fibrinolytic therapy such as streptokinase or tenecteplase at the district hospital before transfer) is the most clinically appropriate strategy for STEMI patients who present within the 12-hour fibrinolysis window.

MODEL EXAMINATION QUESTIONS: CHAPTER THREE (PART FOUR)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Rheumatic heart disease most commonly affects which cardiac valve? a) Aortic valve, causing aortic stenosis b) Pulmonary valve, causing pulmonary regurgitation c) Mitral valve, causing mitral regurgitation initially and mitral stenosis in long-standing disease d) Tricuspid valve, causing tricuspid stenosis (Correct Answer: c)

The Jones Criteria for diagnosis of acute rheumatic fever require which of the following? a) Positive blood culture for Group A Streptococcus b) Two major criteria OR one major plus two minor criteria, with evidence of preceding streptococcal infection c) Elevated troponin and ST changes on ECG d) Positive throat culture alone (Correct Answer: b)

The FAST acronym for stroke recognition stands for: a) Fever, Ataxia, Seizure, Time b) Face, Arm, Speech, Time c) Focal deficit, Aphasia, Syncope, Tachycardia d) Forgetfulness, Anxiety, Stroke, Transport (Correct Answer: b)

The maximum acceptable door-to-needle time for fibrinolysis in STEMI according to established international guidelines is: a) 10 minutes b) 30 minutes c) 60 minutes d) 90 minutes (Correct Answer: b)

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Subclinical carditis in acute rheumatic fever is defined as valvular regurgitation detectable by: a) Auscultation with a standard stethoscope b) Echocardiography in the absence of auscultatory murmur c) Chest X-ray showing cardiomegaly d) ECG showing PR interval prolongation (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 52-year-old Marma man presents to Rangamati District Hospital with sudden onset right-sided hemiplegia and dysphasia that began 2.5 hours ago. He has a known history of uncontrolled hypertension with no medication. The attending physician has no access to CT imaging. His Siriraj Stroke Score calculation shows a score consistent with ischemic stroke. His blood pressure is 185/110 mmHg and blood glucose is 8.1 mmol/L. Which of the following represents the most appropriate immediate management? a) Administer aspirin 300 mg, do not aggressively lower blood pressure, correct blood glucose if it falls below 4 mmol/L, maintain airway protection, and transfer urgently to Chittagong Medical College Hospital for CT imaging and specialist assessment b) Administer IV alteplase immediately without CT imaging based on the Siriraj Score c) Lower blood pressure aggressively to 120/80 mmHg with IV labetalol d) Administer heparin IV for anticoagulation of presumed embolic stroke (Correct Answer: a)

A CHT public health officer designs a rheumatic heart disease prevention program for remote Bandarban communities. Which strategy addresses both primary and secondary prevention simultaneously within the constraints of CHT health system capacity? a) Mass oral penicillin V distribution without clinical screening b) Training community health workers to identify pharyngitis cases for referral, with a mobile penicillin injection clinic visiting high-burden communities monthly for secondary prevention in diagnosed ARF patients c) Building a cardiac surgery facility in Bandarban d) Distributing anti-inflammatory medications to all school-age children (Correct Answer: b)

CHAPTER FOUR: DIABETES MELLITUS, METABOLIC DISEASE, AND ENDOCRINE DISORDERS IN THE CHT: THE NUTRITION-LIFESTYLE INTERFACE

4.1 The Nutritional Paradox: Malnutrition and Metabolic Disease in the Same Territory

The simultaneous presence of protein-energy malnutrition (particularly childhood stunting and wasting) and emerging type 2 diabetes mellitus and metabolic syndrome in the Chittagong Hill Tracts represents one of the most striking examples of the double burden of disease as a lived clinical reality. This paradox, which initially appears contradictory, becomes epidemiologically coherent when understood through the lens of the Developmental Origins of Health and Disease (DOHaD) hypothesis, which holds that early-life nutritional deprivation programs the developing organism toward metabolic phenotypes adapted for resource scarcity, including reduced metabolic rate, increased insulin resistance, preferential abdominal fat storage, and enhanced sensitivity to caloric surplus. When individuals programmed by early malnutrition (fetal growth

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restriction, low birth weight, childhood stunting) subsequently undergo even modest dietary transitions toward more calorie-dense foods later in life (as occurs in CHT communities experiencing partial economic development, market integration, and dietary change), they are disproportionately susceptible to obesity (particularly abdominal obesity), insulin resistance, type 2 diabetes, hypertension, and dyslipidemia, because their metabolic phenotype was programmed for a food-scarce environment and is overwhelmed by even modest caloric surplus. The CHT is currently experiencing precisely this developmental-nutritional collision: a population whose older and middle-aged members were typically stunted in childhood is now experiencing dietary transition with increased rice consumption (which is increasingly purchased rather than home-grown jhum rice, with higher glycemic index polished white rice replacing the more nutritionally complex traditional varieties), increased sugar-sweetened beverage consumption where available, reduced physical activity in communities where mechanization is partially replacing traditional agricultural labor, and reduced consumption of wild food diversity that historically provided protective phytonutrients. The metabolic disease burden emerging from this transition, though not yet quantified in CHT-specific population surveys, is almost certainly substantially higher than has been clinically detected, because the diagnosis of type 2 diabetes requires blood glucose measurement that is not routinely available or applied in the CHT context.

4.2 Type 2 Diabetes: Clinical Identification, Management, and the CHT Treatment Cascade

Type 2 diabetes mellitus, defined biochemically as a fasting plasma glucose of 7.0 mmol/L (126 mg/dL) or higher, or a 2-hour post-75g OGTT glucose of 11.1 mmol/L (200 mg/dL) or higher, or a random glucose of 11.1 mmol/L or higher in the presence of symptoms (polyuria, polydipsia, unexplained weight loss), or a glycated hemoglobin (HbA1c) of 6.5 percent or higher (WHO and ADA diagnostic criteria, 2023), arises from the progressive combination of insulin resistance in peripheral tissues (muscle, liver, and adipose tissue) and the eventual failure of pancreatic beta-cell compensatory hypersecretion to maintain glycemic control. The clinical identification of type 2 diabetes in CHT communities requires a pragmatic adaptation of the standard screening algorithms to CHT realities. Random blood glucose measurement (which is the most operationally feasible initial screening test in the CHT given that fasting blood glucose requires patients to abstain from food for 8 to 12 hours before the test, an instruction that is difficult to implement effectively in communities with multiple languages and limited health literacy) combined with opportunistic HbA1c measurement in individuals presenting to health facilities for any reason, represents the most CHT-appropriate diabetes screening strategy. The HbA1c assay, which measures the fraction of hemoglobin glycated over the preceding three months and thereby provides a time-integrated measure of glycemic control, has the specific advantage in the CHT context of not requiring fasting and of reflecting long-term glycemic status rather than a single moment blood glucose value that may vary substantially with recent food intake. However, HbA1c measurement is currently unavailable at CHT district hospital level, and its deployment requires laboratory investment that is not yet part of the standard CHT district hospital equipment.

The management of type 2 diabetes in CHT patients requires an adaptation of evidence-based pharmacological and non-pharmacological treatment to the constraints of medication access, dietary reality, and patient literacy in the CHT context. Metformin, the first-line oral antidiabetic

agent for type 2 diabetes in all major international guidelines (ADA Standards of Medical Care in Diabetes 2025, WHO Package of Essential Noncommunicable Disease Interventions), is inexpensive, widely available on the Bangladesh essential medicines list, has a well-established safety profile in the CHT's common comorbidity profile (though it requires dose reduction or temporary discontinuation in renal impairment, which is assessed through creatinine measurement before initiation), and reduces cardiovascular mortality in addition to its glycemic effects. The standard starting dose of metformin is 500 mg twice daily with meals (to minimize gastrointestinal side effects including nausea, vomiting, and diarrhea that are the most common reasons for treatment discontinuation), titrated to 1,000 mg twice daily over four weeks as tolerated. For patients whose HbA1c or blood glucose remains inadequately controlled on maximum tolerated metformin monotherapy, the addition of a second oral agent (sulfonylurea such as glipizide or glibenclamide, which stimulate insulin secretion and are inexpensive and available in Bangladesh) or insulin (for patients with very high initial glucose levels, symptoms of osmotic diuresis, or HbA1c above 10 percent suggesting significant beta-cell dysfunction) is recommended. The non-pharmacological management of type 2 diabetes in the CHT requires culturally specific dietary counseling that acknowledges the real constraints of CHT food availability and affordability. Recommending that a CHT indigenous diabetic patient adopt a low-glycemic-index diet when their primary food source is polished white rice, their protein source is predominantly fish and legumes (which are actually protective, with evidence of inverse associations between legume consumption and diabetes risk), and their access to diverse vegetables and whole grains is limited by both geography and income, requires a dietary counseling approach that works within existing food patterns rather than prescribing an idealized dietary model incompatible with CHT food realities.

4.3 Iodine Deficiency Disorders: The Goiter Belt of the CHT Hills

Iodine deficiency disorders (IDD), encompassing goiter, hypothyroidism, intellectual disability from severe intrauterine iodine deficiency (cretinism), and the spectrum of cognitive and developmental impairment from mild to moderate iodine deficiency, represent a potentially significant but systematically understudied public health problem in the geographically isolated upland communities of the CHT. The primary dietary source of iodine is iodized salt, supplemented by seafood and dairy products in populations with access to these food categories. The CHT's inland geographical position means that CHT communities have historically had lower access to seafood than coastal Bangladesh populations, and the logistics of food supply to remote CHT hill communities create barriers to the consistent availability and use of iodized salt. The national iodized salt program of Bangladesh has substantially reduced the IDD burden in the plains of Bangladesh, but the coverage of iodized salt in the remotest CHT communities (particularly in the deep valleys of Bandarban and the more isolated upazila of Rangamati) has not been systematically surveyed in recent years, and the earlier documentation of goiter in some CHT highland communities suggests that iodine deficiency may persist in these areas. The clinical assessment of iodine deficiency in CHT communities requires palpation of the thyroid gland for goiter (the classical visible and palpable enlargement of the thyroid from iodine-deficiency-stimulated thyroid hypertrophy, graded by WHO as Grade 0, non-palpable; Grade 1, palpable but not visible; and Grade 2, visible goiter), assessment of urinary iodine concentration in spot urine samples from school-age children (the WHO-recommended epidemiological

indicator for population iodine status, with median urinary iodine concentration below 100 micrograms per liter indicating iodine deficiency at population level), and neurological assessment in young children and neonates for the subtle cognitive and developmental signs of mild to moderate iodine deficiency.

4.4 Vitamin D Deficiency in the CHT: The Hidden Skeletal and Immune Consequence

Vitamin D deficiency, defined as a serum 25-hydroxyvitamin D (25-OHD) level below 20 ng/mL (50 nmol/L), is paradoxically prevalent even in the high-ultraviolet-radiation environment of the CHT, because the factors that determine cutaneous vitamin D synthesis (sunlight exposure of skin, specifically the fraction of UVB radiation reaching melanin-containing keratinocytes) are modified in CHT populations by several factors that reduce effective vitamin D synthesis. Darker skin pigmentation (characteristic of most CHT indigenous ethnic groups) reduces UVB penetration to the deep keratinocyte layers where vitamin D synthesis occurs, requiring longer sun exposure than light-skinned individuals to synthesize equivalent vitamin D. Traditional clothing practices in some CHT communities (particularly among women, who may cover most of their skin while working outdoors) reduce the skin surface area exposed to sunlight. Forest canopy cover, which shades the pathways and working environments of CHT communities engaged in forest product collection and jhum cultivation, reduces the UVB intensity reaching skin surfaces compared with open-field agricultural settings. Dietary vitamin D intake is limited in CHT communities whose primary food sources (rice, vegetables, legumes, and freshwater fish) contain very little preformed vitamin D, and where fatty marine fish (the richest dietary vitamin D source) are unavailable. The consequences of vitamin D deficiency in the CHT context encompass both the classical skeletal manifestations (rickets in children, producing the characteristic bowing of weight-bearing long bones, craniotabes, a widened anterior fontanelle, and rachitic rosary from costochondral junction cartilage hypertrophy; and osteomalacia in adults, producing bone pain, muscle weakness, and increased fracture risk from defective bone mineralization) and the increasingly recognized non-skeletal manifestations. The immune consequences of vitamin D deficiency are of particular CHT relevance: vitamin D acts as an immunomodulatory steroid hormone, and vitamin D deficiency impairs both the innate immune defense against M. tuberculosis (through reduction of the cathelicidin and beta-defensin antimicrobial peptide production that are the first-line host defense against mycobacterial infection in macrophages) and the adaptive immune response, potentially contributing to the elevated TB susceptibility of malnourished CHT populations through a mechanism distinct from protein-calorie malnutrition-induced immune suppression. Supplementation of vitamin D in TB-exposed individuals from vitamin D-deficient populations has been studied in several randomized trials, with the 2012 Martineau trial in London demonstrating that vitamin D supplementation in TB contacts with vitamin D deficiency reduced the incidence of active TB, supporting a causal role for vitamin D deficiency in TB susceptibility and a potential role for vitamin D supplementation in TB prevention strategies for high-risk populations including CHT indigenous communities.

MODEL EXAMINATION QUESTIONS: CHAPTER FOUR (PART FOUR)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

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The Developmental Origins of Health and Disease (DOHaD) hypothesis predicts that individuals who experienced early-life malnutrition are disproportionately susceptible to which later-life health outcomes? a) Reduced risk of cardiovascular disease due to metabolic adaptation b) Increased risk of type 2 diabetes, hypertension, and metabolic syndrome when exposed to even modest caloric surplus in later life c) Increased risk of anemia and immunodeficiency only d) Protection from obesity due to metabolic efficiency programming (Correct Answer: b)

The WHO population-level indicator for iodine status assessment in school-age children is: a) Serum thyroid-stimulating hormone (TSH) b) Serum 25-hydroxyvitamin D concentration c) Median urinary iodine concentration (UIC) in spot urine samples, with values below 100 micrograms per liter indicating deficiency d) Thyroid gland volume on ultrasound (Correct Answer: c)

The first-line oral antidiabetic drug for type 2 diabetes mellitus recommended by ADA and WHO guidelines is: a) Glibenclamide b) Insulin glargine c) Sitagliptin d) Metformin (Correct Answer: d)

Rickets in children results from deficiency of which vitamin? a) Vitamin A b) Vitamin B12 c) Vitamin D d) Vitamin K (Correct Answer: c)

The HbA1c diagnostic threshold for type 2 diabetes mellitus according to WHO and ADA 2023 criteria is: a) 5.5% b) 6.0% c) 6.5% d) 7.0% (Correct Answer: c)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A CHT public health nutritionist analyzes dietary data from a remote Bawm community in Bandarban and finds that the median daily rice intake per adult is 600 grams (predominantly polished white rice), daily protein intake is predominantly from freshwater fish and lentils, and there is essentially no consumption of whole grains, fatty marine fish, dairy products, or iodized salt. Which combination of nutritional deficiency diseases should the nutritionist anticipate in this community? a) Iron deficiency anemia only b) Multiple nutritional deficiencies including iodine deficiency disorder risk, vitamin D deficiency, elevated metabolic disease risk from high-GI carbohydrate diet in DOHaD-vulnerable population, and potentially B12 deficiency if fish consumption is variable c) Protein-energy malnutrition only d) Vitamin C deficiency and scurvy from lack of fresh fruits (Correct Answer: b)

CHAPTER FIVE: PEDIATRIC INFECTIOUS DISEASE BEYOND MEASLES: NEONATAL INFECTIONS, VACCINE-PREVENTABLE DISEASE SURVEILLANCE, AND THE MANAGEMENT OF THE SICK CHT CHILD

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5.1 Neonatal Infections: The Silent Neonatal Mortality Driver

The neonatal period (the first 28 days of life) carries the highest mortality risk of any life stage, globally and in Bangladesh, and neonatal deaths account for approximately 44 percent of all under-five deaths in Bangladesh according to UNICEF 2024 estimates. In the CHT, where the majority of births occur without skilled birth attendance, in unsanitary household conditions, with limited access to antenatal care (which would identify and manage the risk factors for neonatal complications), and without the neonatal emergency care infrastructure needed to manage critically ill newborns, the neonatal mortality rate (NMR) almost certainly substantially exceeds the national average, though CHT-specific NMR data are not available from vital registration systems that are insufficiently functional in the territory. The three leading causes of neonatal death globally and in Bangladesh are prematurity and low birth weight (accounting for approximately 35 percent of neonatal deaths), intrapartum-related events including birth asphyxia (approximately 24 percent), and neonatal sepsis and other infectious causes (approximately 23 percent). Of these three, neonatal sepsis is the category most amenable to primary care-level intervention and the category where the specific clinical and microbiological characteristics of the CHT setting create distinct management challenges that deserve CHT-specific treatment.

Neonatal sepsis, defined as the systemic inflammatory response syndrome occurring in the first 28 days of life in the context of proven or suspected infection, is classified as early-onset (within the first 72 hours of life, typically caused by organisms acquired from the maternal birth canal including Group B Streptococcus, E. coli, Klebsiella, and Listeria monocytogenes) and late-onset (after 72 hours, caused by organisms acquired from the environment including Staphylococcus aureus, coagulase-negative staphylococci, Klebsiella, and E. coli, with community-acquired late-onset sepsis in home-birth neonates being particularly associated with omphalitis from contaminated cord care practices). In the CHT, the specific risk factors for neonatal sepsis include home birth in a non-sterile environment (increasing exposure to environmental pathogens), traditional cord care practices that apply potentially contaminating substances (in some CHT communities, ash, mud, cow dung, or heated oil are applied to the cord stump, introducing environmental bacteria directly into the cord wound during the period of maximum portal-of-entry vulnerability), maternal bacterial vaginosis and sexually transmitted infections that are risk factors for both premature rupture of membranes (PROM) and vertical transmission of pathogens to the neonate, and the absence of any neonatal sepsis detection and management infrastructure at the community level. The clinical recognition of neonatal sepsis requires training community health workers and traditional birth attendants in the recognition of the WHO danger signs in neonates, which include: inability to feed, convulsions, fast breathing (greater than 60 breaths per minute for a neonate), severe chest in-drawing, no spontaneous movement, raised temperature (above 37.5 degrees C axillary), or low temperature (below 35.5 degrees C axillary), cyanosis, bleeding, bulging fontanelle, and jaundice appearing in the first 24 hours or being severe enough to reach the palms and soles. The detection of any of these danger signs by the Dai or community health worker should trigger immediate referral to the nearest health facility capable of IV antibiotic administration. The CHT community management of suspected neonatal sepsis, for cases where referral is not immediately achievable due to terrain and transport barriers, should follow the WHO recommendation for oral amoxicillin plus one

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dose of IM gentamicin as a simplified antibiotic treatment for home-based neonatal sepsis management, a strategy validated in several large randomized trials in South Asian settings and shown to be non-inferior to full hospitalized antibiotic treatment for non-severely-ill neonates when hospitalization is not possible.

5.2 Pneumonia in the CHT Child: Clinical Architecture, Bacterial Etiology, and Treatment Protocols

Community-acquired pneumonia (CAP) in children under five years remains the leading single cause of under-five death globally and in Bangladesh, and the CHT presents a CAP risk profile that substantially amplifies the national average through the combined effects of childhood malnutrition (which impairs mucociliary clearance, reduces secretory IgA production, and compromises alveolar macrophage bactericidal function), household air pollution from wood cooking fires (which damages respiratory epithelial cells and impairs ciliary function, creating pathways for bacterial invasion of the lower respiratory tract), the absence of adequate immunization coverage for S. pneumoniae (PCV13) and Hib (which are the two leading bacterial causes of pediatric CAP requiring hospitalization), and the terrain-driven delay in presenting severe pneumonia cases to facilities capable of antibiotic treatment and supplemental oxygen. The bacterial etiology of pediatric CAP in Bangladesh has been studied in the PERCH (Pneumonia Etiology Research for Child Health) study, the most comprehensive multinational case-controlled pediatric pneumonia etiology study ever conducted. The PERCH study, published in The Lancet in 2019, identified S. pneumoniae (detected by lung aspirate culture, blood culture, and molecular methods on nasopharyngeal aspirates) and respiratory syncytial virus (RSV) as the two leading individual etiological agents of pneumonia requiring hospitalization in South Asian children. The PERCH findings, applied to the CHT context, indicate that bacterial pneumonia from S. pneumoniae and Hib is the primary target for antibiotic treatment in hospitalized pediatric CAP, while RSV pneumonia (which does not respond to antibiotics and requires supportive care including oxygen and hydration) is a major contributor to pediatric respiratory admissions for which antibiotic treatment is not indicated.

The WHO Integrated Management of Childhood Illness (IMCI) algorithm for pneumonia classification in children under five years provides the clinical framework for pneumonia recognition and management in CHT primary care settings. The IMCI classifies respiratory illness in children as: no pneumonia, cough or cold (fast breathing absent; no chest in-drawing); pneumonia (fast breathing present: greater than 50 breaths per minute in children aged 2 to 12 months, greater than 40 breaths per minute in children 12 months to 5 years; or chest in-drawing present); and severe pneumonia or very severe disease (general danger signs present including inability to drink or breastfeed, vomiting everything, convulsions, lethargy or unconsciousness; or stridor, or severe malnutrition). Children classified as having pneumonia (non-severe) should receive amoxicillin 40 mg/kg twice daily for five days (the WHO-recommended first-line antibiotic for non-severe pediatric CAP in Bangladesh, replacing the previously recommended cotrimoxazole in recognition of high resistance rates in S. pneumoniae and Hib to cotrimoxazole). Children classified as having severe pneumonia or very severe disease require urgent referral to a facility capable of IV antibiotics, supplemental oxygen, and close monitoring, with pre-referral administration of a first dose of IV/IM ampicillin plus IV/IM gentamicin (the

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WHO-recommended pre-referral antibiotic for severe pediatric pneumonia when referral is feasible) or oral amoxicillin-clavulanate if only oral medication is available. The CHT complication that most commonly prevents effective management of severe pediatric CAP is the terrain-driven referral delay: a child classified as severe pneumonia who is seven hours from the nearest district hospital by river and road will almost certainly die of respiratory failure before reaching appropriate care if the disease is progressing rapidly. The community deployment of supplemental oxygen (through solar-powered oxygen concentrators, which have been piloted in several low-income country settings and which are operationally feasible in remote communities with solar power infrastructure) and of pulse oximetry (to guide clinical severity assessment and triage) represents the most high-impact infrastructure investment for reducing pediatric CAP mortality in remote CHT communities.

5.3 The Immunization Architecture of the CHT: Gaps, Solutions, and the Post-Measles-Crisis Reform Agenda

The 2025 measles outbreak in Bandarban fundamentally altered the national conversation about immunization program equity in the CHT, creating a political and programmatic window for reforms that would not have been achievable without the moral urgency of the 227 child deaths that occurred in largely preventable circumstances. The reform agenda for CHT immunization programs that emerges from the post-outbreak analysis encompasses six domains that must be simultaneously addressed to achieve and sustain equitable immunization coverage across the CHT's diverse and geographically dispersed communities. The first domain is Geographic Reach: conventional immunization outreach, which relies on health workers traveling regular routes to communities on predictable schedules, fails in the CHT's most remote communities because the distances, terrain conditions, and logistical costs of reaching these communities exceed the operational capacity of the standard outreach system. Alternative delivery strategies including helicopter-based immunization missions (demonstrated feasible in Nepal and Papua New Guinea), boat-based mobile health units on Kaptai Lake and the major river systems, and community-level storage (cold chain vaccine storage at community level using solar-powered refrigerators) must be incorporated into the CHT immunization delivery system for communities beyond the reach of conventional outreach. The second domain is Cold Chain Integrity: the sensitivity of live vaccines (measles, rotavirus, oral polio vaccine) to heat inactivation means that maintaining cold chain from the district vaccine store to the point of administration in remote communities is a logistical challenge of the first order in a territory where electricity is unreliable or absent in most remote communities, transport involves long journeys at ambient temperatures, and supervision of cold chain equipment maintenance is difficult. The third domain is Communication and Consent: the 2025 outbreak documented vaccine hesitancy in the Mro community driven by distrust of government health programs and concern about adverse effects. Overcoming vaccine hesitancy in the CHT requires community-specific communication strategies developed in collaboration with community leaders, traditional healers, and trusted community health figures, delivered in indigenous languages, and addressing the specific concerns of each community rather than applying a generic pro-vaccination messaging framework developed for Bangla-speaking populations. The fourth domain is Surveillance for Zero-Dose Children: the children who have never received a single vaccine dose represent the most urgent immunization equity target, and their identification requires an active mapping

process (using community health worker house-to-house surveys combined with community leader outreach to identify families outside immunization coverage) rather than passive case detection after disease outbreaks. The fifth domain is Post-Outbreak Catch-Up: in the aftermath of the 2025 measles outbreak, a comprehensive immunization catch-up campaign covering all vaccine-eligible children in all CHT communities is required to establish a baseline coverage level from which routine program coverage can be maintained. The sixth domain is Immunization Information System Development: the CHT currently lacks the immunization information system infrastructure needed to track individual child vaccination status across the territory, creating the surveillance blind spots that allowed thousands of children to remain unvaccinated in Kurukpata while the formal health system believed coverage was adequate. A digital immunization registry, even a simplified one operating on mobile phones with cellular network connection supplemented by paper-based recording where network is unavailable, would substantially improve coverage surveillance and accountability.

MODEL EXAMINATION QUESTIONS: CHAPTER FIVE (PART FOUR)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

According to the WHO IMCI algorithm, fast breathing in a child aged 12 months to 5 years is defined as a respiratory rate greater than: a) 30 breaths per minute b) 40 breaths per minute c) 50 breaths per minute d) 60 breaths per minute (Correct Answer: b)

The WHO-recommended first-line antibiotic for non-severe community-acquired pneumonia in children in Bangladesh (replacing cotrimoxazole due to resistance) is: a) Ciprofloxacin b) Amoxicillin c) Ceftriaxone d) Erythromycin (Correct Answer: b)

WHO danger signs in neonates that indicate the need for immediate referral include all of the following EXCEPT: a) Inability to feed b) Axillary temperature above 37.5 degrees C c) Mild nasal discharge without breathing difficulty d) Bulging fontanelle (Correct Answer: c)

The PERCH study (Pneumonia Etiology Research for Child Health), published in The Lancet 2019, identified which two agents as the leading causes of hospitalized pediatric pneumonia in South Asian children? a) Mycobacterium tuberculosis and Staphylococcus aureus b) Streptococcus pneumoniae and Respiratory Syncytial Virus (RSV) c) Haemophilus influenzae type b and Adenovirus d) Klebsiella pneumoniae and Rotavirus (Correct Answer: b)

Neonatal sepsis occurring within the first 72 hours of life is classified as which type and is most commonly caused by which organisms? a) Late-onset; caused by Staphylococcus aureus and coagulase-negative staphylococci b) Early-onset; caused by Group B Streptococcus, E. coli, Klebsiella, and Listeria monocytogenes from the maternal birth canal c) Early-onset; caused by Mycobacterium tuberculosis from vertical transmission d) Late-onset; caused by respiratory viruses from the postnatal environment (Correct Answer: b)

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A CHT district hospital pediatrician reviews data showing that pneumococcal pneumonia cases admitted during November to February consistently have higher mortality rates than cases admitted in other months. Recognizing that RSV bronchiolitis peaks in this season and that PCV13 coverage in the CHT is below 30% among the admitted children, which interpretation and response is most appropriate? a) The seasonal pattern is coincidental; mortality is entirely determined by severity at presentation b) The seasonal peak reflects both the RSV bronchiolitis season (increasing respiratory admissions with viral illness not requiring antibiotics) and the PCV13 coverage gap (allowing S. pneumoniae pneumonia to remain prevalent in unvaccinated children); the appropriate response is simultaneous immunization catch-up for PCV13 and improved pulse oximetry-guided oxygen supplementation for RSV bronchiolitis c) The seasonal pattern reflects increased malaria transmission in winter; treat all admissions empirically with artemether-lumefantrine d) The pattern is explained by vitamin D deficiency; supplement all children with vitamin D (Correct Answer: b)

CHAPTER SIX: PHARMACOLOGY OF THE CHITTAGONG HILL TRACTS: DRUG SELECTION, DOSING SCIENCE, INTERACTIONS, AND THE ETHICS OF PRESCRIBING IN SCARCITY

6.1 The CHT Pharmacological Environment: A Framework for Rational Drug Use

Pharmacology in the CHT context is not simply the application of standard pharmacological principles to a new setting. It is the practice of rational therapeutics under a set of constraints, exposures, and patient characteristics that modify the fundamental pharmacokinetic and pharmacodynamic parameters of drug action in ways that, if ignored, can produce therapeutic failure, drug toxicity, and harm. The CHT Rational Pharmacology Doctrine, articulated in this chapter, holds that effective drug prescribing in the CHT requires simultaneous mastery of four knowledge dimensions: the universal pharmacological knowledge dimension (encompassing the mechanisms of action, pharmacokinetics, pharmacodynamics, adverse effects, and interactions of the drugs most commonly used in CHT clinical practice), the CHT patient-specific modifier dimension (encompassing the population-specific factors in the CHT patient population that modify drug action, including the nutritional status of the patient, genetic polymorphisms prevalent in CHT ethnic populations, body weight and composition, the effects of concurrent infections on drug metabolism, and the cultural and linguistic factors that shape medication adherence), the CHT pharmacological environment dimension (encompassing the specific medicines available in CHT facilities at different levels of the health system, their quality and shelf-life conditions given the CHT's storage and cold-chain constraints, and the regulatory environment governing their procurement and prescribing), and the ethical dimension (encompassing the obligations of the CHT clinician regarding equitable access to medicines, the management of drug scarcity, the counseling of patients about medications they may not be able to afford to complete, and the advocacy for drug policy reforms that would improve access to essential medicines in the territory).

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Pharmacokinetics, the mathematical description of how the body handles a drug (encompassing absorption, distribution, metabolism, and excretion, the ADME framework), is substantially modified in the CHT patient population by nutritional status. Protein-energy malnutrition, which is prevalent among CHT children and some adult community members, alters every pharmacokinetic parameter of clinical significance. The reduced plasma albumin concentration characteristic of severe malnutrition (with serum albumin below 30 g/L in severe protein deficiency) alters the distribution of highly protein-bound drugs: drugs that are normally extensively bound to albumin (including phenytoin, valproate, warfarin, and many antibiotics including ceftriaxone) will have a greater free (pharmacologically active and toxicologically relevant) fraction in hypoalbuminemic patients, potentially producing drug effects and toxicities at standard doses that would not be seen in well-nourished patients with normal albumin levels. The reduced hepatic metabolism rate associated with severe malnutrition, from reduced hepatic microsomal enzyme activity and reduced hepatic blood flow, prolongs the half-life of drugs that are extensively metabolized by the liver (including most anti-tuberculosis drugs, most antimalarials, most anticonvulsants, and many commonly used antibiotics), creating the risk of drug accumulation and toxicity with standard dosing. The reduced renal blood flow and glomerular filtration rate characteristic of severe malnutrition reduces the renal clearance of renally-excreted drugs (including aminoglycoside antibiotics such as gentamicin and amikacin, which are nephrotoxic in their own right and require dose reduction in patients with impaired renal clearance), creating the risk of aminoglycoside accumulation and nephrotoxicity that is particularly dangerous in malnourished CHT neonates receiving aminoglycoside-containing regimens for neonatal sepsis. The reduced gastric acid secretion associated with malnutrition may reduce the absorption of acid-dependent drugs (including itraconazole, some antiretrovirals, and iron salts), while the reduced intestinal mucosal integrity associated with diarrheal disease and helminthic infection may unpredictably alter the absorption of oral drugs taken during illness episodes.

6.2 G6PD Deficiency Pharmacology: The CHT-Critical Enzyme Deficiency

Glucose-6-phosphate dehydrogenase (G6PD) deficiency deserves extended pharmacological treatment in the CHT context because it is both more prevalent in CHT indigenous populations than in the general Bangladesh population and more clinically consequential, given that the most important clinical application in the CHT is the safe prescribing of primaquine for Plasmodium vivax radical cure. G6PD is the key enzyme of the hexose monophosphate shunt (pentose phosphate pathway) in erythrocytes, generating NADPH that is essential for maintaining glutathione in its reduced form, which is the primary antioxidant defense of the erythrocyte against oxidative stress. G6PD-deficient erythrocytes are unable to generate sufficient NADPH to maintain reduced glutathione levels when exposed to oxidant stresses including certain drugs (primaquine, dapsone, nitrofurantoin, rasburicase, and methylene blue), fava beans (Vicia faba, relevant in communities where fava beans are consumed), and some infectious diseases (including bacterial sepsis, where the systemic inflammatory response generates oxidative radicals). The resulting oxidative damage to erythrocyte membranes causes intravascular hemolysis, producing hemolytic anemia that can range from mild and self-limiting (in mildest variants like the African G6PD A- variant) to severe and life-threatening (in the Mediterranean and Asian G6PD variants that retain less than 10 percent of normal enzyme activity). The

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primaquine challenge for G6PD-deficient CHT patients with P. vivax malaria is particularly acute because primaquine is the only available drug with activity against P. vivax hypnozoites, and without primaquine radical cure, P. vivax malaria will relapse repeatedly (as described in Part Two), maintaining a chronic infectious reservoir in the community. A 2022 meta-analysis published in PLOS Medicine by Watson and colleagues estimated the global prevalence of G6PD deficiency at approximately 8 percent in males and 0.5 to 3 percent in females in South and Southeast Asian populations, with heterozygous females having intermediate phenotypes. For the CHT, the relevant reference populations are the ethnic minorities of Southeast Asia, where G6PD deficiency prevalence in males has been documented at 5 to 25 percent in various studies, suggesting that the CHT indigenous male population likely carries G6PD deficiency at rates well above the Bangladesh general population average. Point-of-care G6PD testing (using qualitative fluorescent spot tests or the newer quantitative CareStart G6PD lateral flow assay), before primaquine prescription for every P. vivax malaria patient, is an essential safety step that should be considered a standard of care in all CHT health facilities, and the implementation of universal pre-primaquine G6PD testing at CHT upazila health complex and community levels (where P. vivax malaria is diagnosed and treated most frequently) is a patient safety priority that requires both equipment procurement and clinical training.

6.3 Drug-Drug Interactions of Clinical Significance in CHT Practice

Drug-drug interactions (DDIs) of clinical significance in the CHT context arise from several specific prescribing patterns that are particularly common in the CHT setting. The most consequential DDI class for CHT clinical practice involves the anti-tuberculosis drugs, particularly rifampicin, which is one of the most potent inducers of the hepatic cytochrome P450 enzyme system (specifically CYP3A4, CYP2C9, and CYP2C19) known in clinical pharmacology. Rifampicin induction of CYP3A4 reduces the plasma concentrations of co-administered drugs metabolized by CYP3A4 to the extent that therapeutic efficacy may be lost: the combination of rifampicin with artemether-lumefantrine, for example, reduces lumefantrine plasma concentrations by approximately 70 percent (documented in pharmacokinetic studies from the Mekong region), potentially reducing the efficacy of malaria treatment. This interaction is of direct CHT clinical relevance because co-infection with TB and malaria is both biologically plausible (both diseases are prevalent in the CHT, and malaria-associated immune compromise increases TB reactivation risk) and epidemiologically documented in some settings. The rifampicin-oral contraceptive interaction, which reduces the efficacy of combined oral contraceptive pills through CYP3A4 induction of estrogen and progestin metabolism, is particularly important in the CHT context where women receiving anti-tuberculosis therapy who are also using oral contraception for family planning may experience unexpected pregnancies, with significant health and social consequences. The alcohol-metronidazole interaction, producing the disulfiram-like reaction (flushing, nausea, tachycardia, hypotension) when alcohol is consumed during metronidazole therapy, is of direct CHT relevance given the alcohol use documented in CHT communities and the frequency with which metronidazole is prescribed for the amoebic dysentery and other anaerobic infections prevalent in the CHT. Counseling CHT patients receiving metronidazole about alcohol avoidance during the treatment course requires not only the verbal instruction but awareness of the linguistic and cultural context: in communities where fermented rice beer (Zu) is prepared and consumed within the household, the

concept of "alcohol avoidance" may need to be communicated in terms of specific foods and beverages rather than the abstract category.

6.4 The Ethics of Prescribing in the CHT: Scarcity, Equity, and Advocacy

The ethics of prescribing in the CHT encompasses a set of moral challenges that arise specifically from the resource-constrained, structurally unjust environment in which CHT clinicians practice. The scarcity dimension of prescribing ethics arises from the documented shortages of essential medicines at CHT health facilities, which force clinicians to make allocation decisions about who receives limited drug supplies, to counsel patients about completing treatment courses that they may not be able to afford to fill, and to manage conditions with second-best therapeutic options when first-line drugs are unavailable. The equity dimension arises from the documented health disparities between CHT indigenous and Bengali communities and between remote and peri-urban communities within the CHT, which are partly maintained by differential access to medicines, and which raise the ethical question of whether the prescribing clinician has an obligation to advocate for equitable drug access as part of their professional responsibility. The CHT Prescribing Ethics Framework proposes three principles. The Therapeutic Justice Principle holds that the CHT clinician has an obligation to prescribe the best available treatment for each individual patient given the actual resource constraints of the specific clinical context, without rationing by ethnicity, income, gender, or political affiliation. The Honest Communication Principle holds that the clinician has an obligation to communicate honestly with patients about the limitations of the available treatment, the consequences of incomplete treatment, and the options for obtaining medicines not available within the public health system. The Advocacy Principle holds that the clinician has an obligation beyond the individual clinical encounter to advocate for the systemic changes that would remove the structural barriers to equitable medicine access in the CHT, including through participation in professional organizations, policy engagement, documentation and publication of medicine access gaps, and collaboration with civil society organizations working on health equity in the CHT.

MODEL EXAMINATION QUESTIONS: CHAPTER SIX (PART FOUR)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Rifampicin is a potent inducer of which cytochrome P450 enzyme system, producing clinically significant reductions in co-administered drug concentrations? a) CYP1A2 b) CYP2D6 c) CYP3A4, CYP2C9, CYP2C19 d) CYP2E1 (Correct Answer: c)

In a severely malnourished CHT patient, reduced serum albumin would be expected to increase the free fraction of which highly protein-bound drug, potentially producing toxicity at standard doses? a) Metformin b) Gentamicin c) Phenytoin d) Amoxicillin (Correct Answer: c)

The disulfiram-like reaction from alcohol consumption during metronidazole therapy produces which clinical syndrome? a) Stevens-Johnson syndrome b) Flushing, nausea, tachycardia, and hypotension c) Acute hepatotoxicity and jaundice d) Peripheral neuropathy (Correct Answer: b)

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The primary pharmacological mechanism by which G6PD deficiency causes drug-induced hemolysis is: a) Direct antibody-mediated red cell destruction b) Impaired NADPH generation leading to failure of glutathione reduction and oxidative membrane damage c) Immune complex deposition on erythrocytes d) Complement-mediated intravascular hemolysis (Correct Answer: b)

The CareStart G6PD lateral flow assay is a point-of-care test that provides which type of result? a) Qualitative (deficient/non-deficient only) b) Quantitative G6PD enzyme activity level c) Genetic genotyping of the G6PD mutation d) Hemoglobin measurement (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 28-year-old Chakma woman with pulmonary tuberculosis has been on standard four-drug anti-tuberculosis therapy including rifampicin for six weeks. She also uses combined oral contraceptive pills (containing ethinyl estradiol 30 micrograms and levonorgestrel 150 micrograms) for contraception. She presents asking whether she needs additional contraception during her TB treatment. Which response is most pharmacologically accurate and clinically appropriate? a) No additional contraception is needed; anti-TB drugs do not affect oral contraceptive efficacy b) Additional contraceptive precaution is necessary for the entire duration of rifampicin therapy and for at least four weeks after completion; options include barrier contraception (condoms) or injectable progestogen (depot medroxyprogesterone acetate) which is less affected by enzyme induction than oral preparations c) She should stop the oral contraceptive pills immediately due to hepatotoxicity risk with rifampicin d) Rifampicin increases oral contraceptive concentration through enzyme inhibition, making additional contraception unnecessary (Correct Answer: b)

CHAPTER SEVEN: THE MEDICAL SOCIOLOGY AND ANTHROPOLOGY OF DISEASE IN THE CHT: STIGMA, STRUCTURAL VIOLENCE, HEALTH BEHAVIOR, AND THE PHENOMENOLOGY OF ILLNESS

7.1 Medical Sociology in the CHT: Theoretical Foundations

Medical sociology, the discipline that studies how social structures, cultural systems, and human interactions shape the experience, distribution, and management of health and disease, provides an indispensable analytical lens for the CHT clinician and public health practitioner. The medical sociological framework applied to the CHT in this chapter draws on the theoretical traditions of Talcott Parsons' sick role (and its critiques as applied to non-Western settings), Eliot Freidson's professional dominance theory (and its analysis of the power relationships embedded in the encounter between biomedical professionals and lay patients), the illness narrative framework of Arthur Kleinman (whose explanatory model approach to clinical practice provides the CHT clinician with a structured method for understanding and engaging with patients' illness interpretations), the social capital theory of Pierre Bourdieu (whose framework for analyzing how unequal distribution of economic, social, and cultural capital reproduces health inequality

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provides the sociological mechanism behind the structural health disparities of the CHT), and the structural violence framework of Paul Farmer and Nancy Scheper-Hughes (which locates the ultimate causes of CHT health disparities not in individual behaviors or biological vulnerabilities but in the historical and contemporary structures of economic exploitation, political exclusion, and cultural domination that systematically deprive CHT indigenous communities of the conditions necessary for health). The CHT Medical Sociology Doctrine, as articulated in this chapter, holds that clinical medicine practiced in the CHT without engagement with these sociological dimensions is inherently incomplete, because the social structures of the CHT are not merely the context within which biological disease occurs but are themselves pathological agents whose mechanisms of harm are as measurable and as clinically consequential as any microbial pathogen.

The explanatory model approach developed by Arthur Kleinman provides the most operationally useful medical sociology tool for the CHT clinical encounter. Kleinman's explanatory model (EM) concept holds that patients, families, and healers each hold explanatory models for illness episodes that answer eight questions: What do you call the problem? What do you think has caused the problem? Why do you think it started when it did? What do you think the sickness does to you? How severe is the sickness? What kind of treatment do you think you should receive? What are the most important results you hope to receive from this treatment? What are the chief problems the sickness has caused you? The systematic elicitation of the patient's explanatory model, using these eight questions adapted to the linguistic and cultural context of the CHT patient, provides the clinician with the patient-specific cultural, psychological, and social context of the illness that is essential for designing a treatment plan that the patient will understand, accept, and follow. In the CHT setting, the explanatory model elicitation is complicated by language barriers (requiring either indigenous-language competent clinical staff or trained interpreters), by the cultural unfamiliarity of some CHT patients with the biomedical institutional setting (producing reticence, monosyllabic responses, and symptom underreporting), and by the power differential between the educated, often Bengali, clinician and the often barely literate indigenous patient that makes the genuine elicitation of the patient's own explanatory framework a skill that requires active cultivation rather than being the natural product of the clinical encounter.

7.2 Stigma and Its Clinical Consequences in the CHT

Stigma, the social process by which a person or group is marked as different, deviant, or dangerous on the basis of a particular attribute (in the health context, most commonly a particular illness, disability, or behavioral characteristic), and subjected to discrimination, exclusion, and shame as a result of that marking, is a clinical phenomenon of profound practical significance in the CHT. Stigma operates through two mechanisms: enacted stigma (actual discrimination and exclusion experienced by the stigmatized individual from their social environment) and felt stigma (the anticipation of discrimination and the internalization of shame by the stigmatized individual, which often drives behavior changes including concealment of illness, avoidance of healthcare, and treatment non-adherence). Both mechanisms produce clinically measurable consequences in the CHT. The stigma of tuberculosis in CHT communities is particularly well-documented in the qualitative health research literature. TB is widely understood in many CHT

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communities as a disease associated with poverty, malnutrition, and moral weakness, and the social consequences of a TB diagnosis can include marital breakdown, social exclusion, employment loss, and ostracism. These social consequences produce a profound incentive to conceal the diagnosis and to avoid the formal healthcare system that would confirm it, particularly for women (in whose communities TB diagnosis is frequently associated with concerns about marriage eligibility and family honor). The concealment of TB symptoms delays diagnosis until advanced disease, increases the infectious period during which the patient transmits to household and community contacts, and reduces DOTS treatment adherence when treatment is eventually initiated, producing all of the adverse outcomes associated with late diagnosis and incomplete treatment. The stigma of mental illness in CHT communities is perhaps even more profound than that of tuberculosis. Psychiatric diagnoses including depression, bipolar disorder, schizophrenia, and epilepsy carry severe social stigma across all CHT ethnic communities, producing complete concealment in many cases, family management of affected individuals without any professional support, and the use of traditional healing exclusively (which may address the spiritual and social dimensions of stigmatized illness but does not address the neurobiological dimensions that respond to pharmacological treatment). The stigma of HIV/AIDS in CHT border communities, while the actual HIV prevalence in the CHT has not been systematically measured, is essentially total, producing a complete barrier to testing and treatment-seeking for any individual who suspects HIV exposure but fears the social consequences of a positive result.

The Stigma-Disruption Approach for CHT Health Programs proposes five operational strategies for reducing illness-related stigma in CHT health programs. First, disease communication materials should be developed in indigenous languages using images and narratives from within CHT indigenous communities rather than generic materials translated from Bangla, ensuring that the cultural resonance of anti-stigma messaging is maximized. Second, community leaders (including village karbaris, headmen, and Buddhist monks) should be actively engaged as anti-stigma advocates who publicly model supportive rather than exclusionary responses to ill community members, since these figures carry social authority that no government health program can replicate. Third, the confidentiality of health information should be actively protected in CHT health facilities through specific protocols (separate waiting areas for sensitive consultations, discrete medicine dispensing, and strict staff confidentiality standards), recognizing that the social density of CHT communities means that a patient seen attending a TB clinic or collecting psychiatric medication may be recognized by community members and have their diagnosis communicated throughout the community without consent. Fourth, peer support networks (connecting affected individuals with others who have lived with and managed the same condition) should be established for the most stigmatized CHT conditions including TB, epilepsy, and mental illness, providing both psychosocial support and visible role models of successful disease management. Fifth, the integration of health services (placing TB screening, mental health assessment, and HIV testing within general health encounters rather than in disease-specific clinics) reduces the stigmatizing signal of attending a disease-specific facility and increases the range of individuals reached by screening.

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7.3 Traditional Medicine, Pluralistic Healing, and the Clinical Interface

The pluralistic healing landscape of the CHT, in which biomedical services, Baiddya botanical medicine, Buddhist healing rituals, shamanic practices, and informal drug dispensing all coexist and all are actively utilized by CHT patients simultaneously or in sequence, creates both clinical risks and clinical opportunities that the practitioner must navigate with sophistication. The clinical risks of pluralistic healing in the CHT arise from several specific scenarios. Drug-herbal interactions between traditional plant medicines and prescribed biomedical drugs (documented for several CHT ethnomedicinal plants whose CYP450 inhibitory or inducing properties could alter the plasma concentrations of co-administered antimalarials, anti-TB drugs, or antiepileptics) are rarely elicited in the clinical history because patients do not typically report traditional medicine use to biomedical providers, fearing dismissal or disapproval. Delay in biomedical treatment-seeking due to prior consultation with traditional healers (the pathway to delayed presentation documented for Bhutu illness, Khumbai illness, and other culturally recognized illness categories) is the single most clinically consequential consequence of medical pluralism in the CHT, producing the late-stage disease presentations that increase both individual mortality and community transmission burden. The adverse effects of some traditional treatments, including hepatotoxic plant preparations (some CHT Baiddya preparations contain plants with pyrrolizidine alkaloids, documented causes of veno-occlusive disease of the liver), nephrotoxic preparations, and abortifacient preparations (used for menstrual regulation in women who may not know they are pregnant), are rarely attributed to traditional medicine use in clinical histories because the temporal association between the traditional treatment and the adverse effect is not recognized by the patient or their family. The clinical opportunity of pluralistic healing lies in the recognition that many CHT patients will continue to use traditional medicine regardless of biomedical prescribing, and that designing treatment plans that accommodate rather than prohibit traditional medicine use (asking patients to inform the clinician about traditional medicines they are using, advising on specific combinations to avoid, and acknowledging the legitimate social and psychological functions of traditional healing ceremonies) is more likely to produce good patient outcomes than demanding exclusive adherence to biomedical treatment alone.

7.4 Gender, Power, and Health in the CHT: The Social Determinants of Female Health Outcomes

Gender dynamics in the CHT health context produce specific patterns of health disadvantage for women that operate through several intersecting mechanisms. Women's healthcare-seeking autonomy in many CHT communities is constrained by gender norms that require consultation with husbands, fathers, or mothers-in-law before seeking healthcare outside the household, particularly for reproductive health conditions, sexual health concerns, and psychiatric illness. This structural barrier to autonomous healthcare-seeking produces delays in the presentation of conditions including obstetric complications (where the minutes available for decision-making before serious morbidity cannot be sacrificed to consultation processes), domestic violence-related injuries (which women may be prevented from seeking care for by the very perpetrators of the violence), and cervical cancer symptoms (which women may be reluctant to disclose to male family decision-makers due to the sexual nature of the condition). The occupational exposure of women to the most hazardous household environmental health risk in the CHT,

indoor biomass smoke from cooking fires, produces the gender-specific distribution of COPD and lung cancer among CHT women documented in Part Two, a distribution that reflects not biology but the gendered allocation of cooking labor within CHT households. Female children in some CHT communities receive less dietary diversity and less caloric intake than male siblings, driven by both economic constraints (women eating last and eating less) and cultural beliefs about the relative importance of male and female nutrition, contributing to higher rates of iron deficiency anemia, protein-energy malnutrition, and growth faltering in female CHT children compared with their male counterparts in some communities. The integration of gender analysis into every dimension of CHT public health program design is not a supplement to technical program design but is a prerequisite for the effectiveness of programs that aim to reach the most health-disadvantaged individuals in the CHT.

MODEL EXAMINATION QUESTIONS: CHAPTER SEVEN (PART FOUR)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Arthur Kleinman's explanatory model approach to clinical practice seeks to elicit from the patient: a) The patient's laboratory investigation preferences b) The patient's understanding of the cause, course, and desired treatment of their illness, and the impact of the illness on their life c) The patient's family history and genetic risk factors d) The patient's willingness to pay for treatment (Correct Answer: b)

The concept of "felt stigma" in the context of illness stigma refers to: a) Physical pain associated with a stigmatizing condition b) The anticipation of discrimination and the internalization of shame by the stigmatized individual c) Actual discrimination experienced from the social environment d) Stigma felt by the clinician toward the patient (Correct Answer: b)

Structural violence, as conceptualized by Paul Farmer and applied to the CHT health context, refers to: a) Physical violence committed by military forces b) Systematic harm caused to people by social structures characterized by inequality, poverty, and political exclusion c) Violence within healthcare settings d) Natural disaster violence (Correct Answer: b)

Pyrrolizidine alkaloids, found in some traditional medicinal plants used across South Asia and potentially in some CHT preparations, are specifically associated with which toxic effect? a) Nephrotoxic renal failure b) Hepatic veno-occlusive disease c) Peripheral neuropathy d) Cardiac arrhythmia (Correct Answer: b)

Pierre Bourdieu's concept of social capital, applied to health inequality, refers to: a) The financial resources available to healthcare systems b) The networks, relationships, and social resources that individuals and communities can draw on, whose unequal distribution contributes to health inequality c) The intellectual capital of health professionals d) Government investment in health infrastructure (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

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A 34-year-old Tanchangya woman presents to a CHT upazila health complex with a three-month history of productive cough, weight loss, and night sweats. She declines to produce a sputum sample and refuses a chest X-ray referral. When asked why, she says through an interpreter that she fears her husband will divorce her if anyone in the community learns she is being investigated for "lung disease." A neighbor died of tuberculosis last year and was divorced by her husband and rejected by her family after her diagnosis. Which combination of approaches most effectively addresses the barriers to this patient's care? a) Insist on sputum collection and referral; explain that the legal and medical requirement takes precedence over cultural concerns b) Dismiss the patient and document refusal of investigation c) Acknowledge the patient's fears explicitly and without judgment; assure her of specific confidentiality measures the clinic will take; offer same-sex health worker attendance for all consultations; involve a female community health worker trusted by the patient as a support person; provide sputum collection as a dignified, private procedure; and establish a follow-up plan that does not require the patient to return to a visible TB clinic d) Prescribe empirical anti-tuberculosis therapy without investigation to avoid the stigma of a confirmed diagnosis (Correct Answer: c)

CHAPTER EIGHT: WATERBORNE AND SOIL-TRANSMITTED DISEASE: ADVANCED CLINICAL AND EPIDEMIOLOGICAL ANALYSIS FOR THE CHT

8.1 The Waterborne Disease Ecology of the CHT: A Comprehensive Taxonomy

The waterborne disease ecology of the CHT, introduced in Parts One and Two, requires advanced clinical and epidemiological treatment that goes beyond the enumeration of waterborne pathogens to engage with the biological mechanisms of waterborne transmission, the CHT-specific pathogen concentration dynamics in different water source types, the molecular epidemiology of waterborne disease outbreaks, and the clinical management complexity of the full spectrum of waterborne disease presentations in the CHT. The CHT Waterborne Disease Taxonomy proposed in this chapter organizes waterborne diseases by their transmission pathway, water source association, and clinical syndrome, providing a framework for both clinical differential diagnosis and epidemiological investigation of CHT waterborne disease clusters.

Category One is the Fecal-Oral Direct Contamination category, encompassing pathogens that are shed in human or animal feces and transmitted directly to susceptible hosts through ingestion of fecally contaminated water or food. This category includes all of the major enteropathogens described in Part Two: Vibrio cholerae O1 and O139 (whose transmission is specifically associated with contaminated surface water, particularly in river valley communities along the Karnaphuli and Sangu systems where flooding creates conditions for direct fecal contamination of drinking water sources), enterotoxigenic E. coli (ETEC, the leading cause of traveler's diarrhea globally and of endemic watery diarrhea in CHT communities, producing a PTC-like secretory diarrhea through heat-labile and heat-stable enterotoxins that activate intestinal cAMP and cGMP secretory pathways respectively), Shigella dysenteriae type 1 (whose dysentery syndrome includes bloody diarrhea with tenesmus, abdominal cramps, fever, and in severe

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pediatric cases the hemolytic uremic syndrome from verotoxin production), Campylobacter jejuni (whose thermophilic growth characteristics mean that it is particularly associated with undercooked poultry, but which is also transmitted through contaminated water, and whose post-infectious complications including Guillain-Barre syndrome make it clinically significant beyond its acute gastrointestinal presentation), Hepatitis A virus (a single-stranded RNA enterovirus transmitted by the fecal-oral route and producing an acute self-limiting hepatitis syndrome that is endemic in the CHT's sanitation-deficient communities, with a shift from universal childhood infection under poor sanitation conditions toward susceptible adult populations as sanitation improves in some CHT areas, creating the epidemiological paradox of outbreaks in young adults in partially improved-sanitation settings), and Hepatitis E virus (which is particularly dangerous in pregnancy, where the case fatality rate from fulminant hepatic failure reaches 20 to 25 percent in the third trimester, making HEV a major obstetric emergency pathogen in the CHT context where pregnant women may consume HEV-contaminated water particularly after flooding events).

Category Two is the Zoonotic Waterborne category, encompassing pathogens that are shed by animal hosts into water sources and transmitted to humans through ingestion or direct contact with contaminated water. Leptospirosis, caused by pathogenic Leptospira interrogans serovars and shed in the urine of reservoir hosts including rats, dogs, cattle, and pigs, is particularly relevant in the CHT because the Leptospira organism survives for weeks in warm, moist soil and water, creating a persistent environmental reservoir in flooded rice fields, muddy jhum field margins, and stagnant water accumulations in animal-keeping communities. Leptospirosis presents a spectrum from a mild flu-like illness (fever, headache, myalgia, and conjunctival suffusion, the "Weil disease" presentation without end-organ complications) to the severe Weil's disease syndrome (jaundice from hepatocellular damage, acute kidney injury from renal tubular damage, pulmonary hemorrhage syndrome, uveitis, and meningitis), with a characteristic pattern of two febrile phases separated by a brief afebrile period (first leptospiremic phase for 5 to 7 days, during which Leptospira are present in blood and CSF; brief immune phase of 1 to 3 days; second immune leptospiruric phase for up to 30 days, during which Leptospira are present in urine and the immune-mediated complications develop). The clinical diagnosis of leptospirosis in the CHT setting is challenging because the presentation overlaps substantially with malaria (both present with fever, headache, and myalgia in the same geographic and occupational settings), with viral hepatitis (when jaundice is present), and with bacterial meningitis (when meningeal signs are prominent). The MAT (Microscopic Agglutination Test), the reference standard for Leptospira serology, is available only at reference laboratory level. The IgM ELISA (detecting anti-Leptospira IgM antibodies, which appear in the second week of illness) provides a more accessible alternative, and lateral flow rapid tests for anti-Leptospira IgM are now commercially available and have been validated in Southeast Asian settings, providing a point-of-care leptospirosis screening option for CHT district hospitals. The treatment of choice for leptospirosis is intravenous benzyl penicillin G for severe disease (1.5 million units IV every six hours for seven days), or oral doxycycline (100 mg twice daily for seven days) for mild to moderate disease. The prophylactic use of weekly doxycycline (200 mg once weekly) has been evaluated in high-exposure occupational groups (rice farmers, sewer workers, military personnel in endemic areas) and demonstrated efficacy in reducing clinical leptospirosis in randomized

trials, providing a potential occupational health preventive strategy for CHT jhum farmers during peak flooding risk periods.

Cryptosporidiosis, caused by the coccidian protozoan Cryptosporidium parvum and Cryptosporidium hominis, deserves specific extended attention in the CHT context because it is one of the most chlorine-resistant waterborne pathogens (meaning that standard water chlorination, even where it is applied in CHT water supplies, does not reliably inactivate Cryptosporidium oocysts), because it produces particularly severe disease in malnourished and immunocompromised individuals (where it can cause a life-threatening protracted cholera-like diarrheal illness rather than the brief self-limiting episode seen in immunocompetent hosts), and because it is one of the five leading pathogens causing significant linear growth faltering in children under two years in global epidemiological studies including the MAL-ED (Malnutrition and the Consequences for Child Health and Development) study published in 2017. The CHT burden of Cryptosporidiosis is almost certainly substantial but entirely unmeasured, because the diagnosis of Cryptosporidiosis requires specific staining (modified Ziehl-Neelsen staining of stool smear, identifying the characteristic 4 to 6 micron oocysts as acid-fast pink dots) or molecular testing (PCR), neither of which is performed routinely in CHT health facilities that typically examine stool only by direct wet mount and simple concentration techniques. The treatment of Cryptosporidiosis in immunocompetent CHT children is primarily supportive (oral rehydration therapy), since the infection is self-limiting in those without immune compromise; however, in malnourished CHT children whose immune function is compromised by protein-energy deficiency, Cryptosporidiosis may become prolonged and contribute significantly to wasting and growth faltering in a manner indistinguishable clinically from persistent diarrhea from other causes.

8.2 Soil-Transmitted Helminth Infections: Advanced Clinical Management

Soil-transmitted helminthiasis (STH), caused by the nematode parasites Ascaris lumbricoides (roundworm), Trichuris trichiura (whipworm), and the hookworms Ancylostoma duodenale and Necator americanus, produces a nutritional and immunological burden in the CHT population that is enormous but systematically underestimated in the health data because STH infections rarely produce the acute illness episodes that drive healthcare utilization and therefore are rarely diagnosed, counted, or treated as individual clinical cases. The global STH burden, estimated by the WHO at approximately 1.5 billion infected individuals globally in the most recent estimates (WHO 2024 data), disproportionately affects children in tropical and subtropical environments with inadequate sanitation, exactly the ecological and demographic profile of the CHT. The clinical consequences of STH in CHT populations are primarily through nutritional impact: Ascaris lumbricoides competes with the host for dietary nutrients and can produce intestinal obstruction when worm burdens are very high (particularly in young children); Trichuris trichiura causes trichuris dysentery syndrome (characterized by bloody mucoid diarrhea, tenesmus, rectal prolapse, and severe anemia from colonic blood loss) at heavy worm burden; hookworm causes iron deficiency anemia through the blood-feeding behavior of adult hookworms attached to the proximal jejunal mucosa (each Ancylostoma duodenale adult consumes approximately 0.2 mL of blood per day, and heavy hookworm burdens in children can produce iron losses of several milligrams per day, severely exacerbating the dietary iron

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deficiency already prevalent in the CHT). The school-age deworming program (periodic mass drug administration of albendazole or mebendazole to all school-age children without prior testing, at intervals of every 6 or 12 months depending on community STH prevalence), recommended by WHO as the primary STH control strategy in high-prevalence settings, is operationally the most feasible STH management approach for the CHT, since individual diagnosis and treatment of STH would require laboratory capacity not available in most CHT communities. Albendazole 400 mg as a single oral dose (the WHO-recommended regimen for school-age deworming) is effective against Ascaris (cure rate approximately 95 percent), acceptable against hookworm (approximately 80 percent cure), and partially effective against Trichuris (approximately 30 to 40 percent cure, with 3-day treatment courses producing higher efficacy). The inclusion of preschool children (ages one to five years) in deworming programs alongside school-age children is recommended for CHT communities because the nutritional impact of STH on growth and cognitive development is most severe in the youngest age groups, and preschool-age CHT children who are not attending formal school and are therefore excluded from school-based deworming programs are currently unprotected by the national deworming program.

8.3 Cholera: Epidemic Management and Oral Cholera Vaccine Deployment in the CHT

Cholera, caused by the O1 and O139 serogroups of Vibrio cholerae producing the A and B subunit cholera toxin (CT) that activates cAMP-mediated chloride secretion in intestinal epithelial cells, producing the massive watery "rice-water" diarrhea that characterizes severe cholera, is both endemic and epidemic-prone in the CHT, particularly in the river valley communities of Rangamati along the Karnaphuli system and in the settlements adjacent to Kaptai Lake where the combination of dense population, inadequate sanitation, and use of lake water for drinking and domestic purposes creates ideal conditions for V. cholerae transmission. The clinical management of cholera in the CHT follows the simple but absolutely critical principle that death from cholera is essentially entirely a consequence of dehydration, and death from dehydration in cholera is preventable by rapid and adequate fluid and electrolyte replacement. The WHO treatment protocol for cholera classifies patients as no dehydration (moist mouth, normal skin turgor, normal sensorium, absent sunken eyes), some dehydration (two or more of: sunken eyes, thirsty, reduced skin turgor, restlessness or irritability), and severe dehydration (two or more of: sunken eyes, unable to drink, no skin turgor, lethargic or unconscious). Severe dehydration in cholera is a medical emergency requiring immediate intravenous fluid resuscitation (Ringer's lactate preferred over normal saline because Ringer's lactate corrects the metabolic acidosis of cholera by providing lactate that is metabolized to bicarbonate, whereas normal saline may worsen hyperchloremic acidosis; the WHO recommended volume for adults is 100 mL/kg Ringer's lactate over three hours, with the first 30 mL/kg given in the first 30 minutes). The antibiotic treatment of cholera reduces the duration and severity of diarrhea and the duration of V. cholerae shedding (reducing community transmission); the first-line antibiotic for cholera in Bangladesh is doxycycline 300 mg as a single oral dose (for adults) or azithromycin 20 mg/kg as a single oral dose (for children and pregnant women), with susceptibility testing ideally confirming the absence of resistance before relying on this selection. Oral cholera vaccines (OCVs), particularly the bivalent killed whole-cell OCV Shanchol and Euvichol-Plus (produced by different manufacturers and WHO-

prequalified), provide protection against V. cholerae O1 and O139 with an efficacy of approximately 65 to 80 percent in the first two years post-vaccination. Reactive vaccination campaigns (deploying OCV in the context of a cholera outbreak, a strategy supported by WHO and demonstrated effective in multiple outbreak settings including South Sudan, Haiti, and Yemen) represent the most immediate OCV application for CHT cholera management, while preventive vaccination in cholera-endemic communities (particularly in Rangamati river valley communities with documented endemic V. cholerae transmission) represents the longer-term vaccination strategy that would substantially reduce the cholera disease burden in the highest-risk CHT populations.

MODEL EXAMINATION QUESTIONS: CHAPTER EIGHT (PART FOUR)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Leptospirosis is classified in the waterborne disease taxonomy of this textbook under which category? a) Fecal-oral direct contamination b) Zoonotic waterborne transmission c) Chemical waterborne toxicity d) Vector-borne water-associated transmission (Correct Answer: b)

The Weil's disease syndrome of severe leptospirosis is characterized by which triad? a) Fever, rash, and lymphadenopathy b) Jaundice, acute kidney injury, and hemorrhagic manifestations c) Meningitis, encephalitis, and peripheral neuropathy d) Ascites, splenomegaly, and portal hypertension (Correct Answer: b)

Hookworm causes iron deficiency anemia primarily through which mechanism? a) Competing with the host for dietary iron absorption in the small intestine b) Direct blood-feeding behavior of adult worms attached to the jejunal mucosa, causing daily blood loss c) Producing a toxin that destroys erythrocytes d) Blocking iron transport proteins in the intestinal epithelium (Correct Answer: b)

The WHO-recommended regimen for cholera in adults (antibiotic component) is: a) Ciprofloxacin 500 mg twice daily for 3 days b) Doxycycline 300 mg as a single oral dose c) Cotrimoxazole twice daily for 5 days d) Ampicillin 500 mg four times daily for 5 days (Correct Answer: b)

The primary advantage of Ringer's lactate over normal saline for cholera rehydration is: a) Lower sodium concentration that prevents hypernatremia b) Correction of the metabolic acidosis of cholera through lactate-to-bicarbonate conversion c) Higher glucose content providing additional caloric support d) Lower cost and wider availability in CHT facilities (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A CHT upazila health complex physician encounters a cluster of 12 cases of watery diarrhea with severe dehydration occurring over 48 hours in a village community adjacent to the Karnaphuli river in July. All patients have "rice-water" stools and the rapid clinical assessment confirms severe dehydration in 7 patients and some dehydration in 5 patients. No laboratory

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investigation is immediately available. Which immediate public health and clinical actions should be taken simultaneously? a) Collect stool samples for culture, await results before treating, and report to district health office b) Treat all patients with WHO-recommended fluid resuscitation according to dehydration severity (IV Ringer's lactate for severe dehydration patients, ORS for moderate dehydration patients); begin empirical doxycycline for confirmed adult cholera cases; implement emergency WASH interventions including safe water distribution, emergency latrine provision, and hand hygiene promotion in the affected community; notify the district health office and request rapid diagnostic test kits for V. cholerae; prepare for reactive oral cholera vaccine deployment if the outbreak is confirmed c) Evacuate all patients to district hospital before initiating any treatment d) Administer antidiarrheal agents (loperamide) to reduce stool output and refer to district hospital (Correct Answer: b)

CHAPTER NINE: ONE HEALTH IN THE CHITTAGONG HILL TRACTS: ZOONOTIC DISEASES, THE ANIMAL-HUMAN INTERFACE, AND INTEGRATED SURVEILLANCE

9.1 The One Health Paradigm: Foundation, Theory, and CHT Application

The One Health paradigm, formally defined by the One Health High-Level Expert Panel (OHHLEP) commissioned by WHO, FAO, UNEP, and WOAH (the World Organisation for Animal Health) in 2021 as "an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems, recognizing that the health of humans, domestic and wild animals, plants and the wider environment, including ecosystems, are closely linked and interdependent," represents the most comprehensive theoretical framework currently available for understanding the health challenges of ecologically complex territories like the CHT. The CHT is, from a One Health perspective, one of the most rich and most challenging environments in South Asia. Its biological diversity (the CHT forest zone hosts hundreds of mammalian and avian species with potential as zoonotic disease reservoir hosts), its dense human-animal-ecosystem interfaces (communities where domestic animals, wildlife, agricultural systems, and human settlements are intimately interdigitated rather than segregated as in urban settings), its cross-border dimensions (the CHT-Myanmar border zone creates epidemiological links with the disease ecology of Chin State, Shan State, and the Mekong region), and its structural health system deficits (which make rapid detection and response to emerging zoonotic threats functionally impossible within the CHT itself) combine to make the One Health framework not merely academically appropriate for the CHT but urgently practically necessary.

The CHT One Health Architecture Doctrine proposes an integrated surveillance and response system built on five pillars. The Human Health Surveillance Pillar encompasses the sentinel surveillance of febrile illness, respiratory disease, and neurological disease in CHT health facilities (at district and upazila levels), with systematic specimen collection for pathogen identification from clinically suspect zoonotic cases. The Animal Health Surveillance Pillar encompasses active surveillance of domestic animal (particularly poultry, pigs, and cattle) and wildlife populations for zoonotic pathogens, managed through the CHT-based units of the

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Department of Livestock Services (with animal health workers conducting active surveillance in communities alongside their animal vaccination and productivity promotion activities). The Environmental Surveillance Pillar encompasses systematic monitoring of CHT water sources, soil, and ecological interfaces for zoonotic pathogens and AMR organisms, providing an early warning system for environmental pathogen presence before human exposure occurs. The Laboratory Connectivity Pillar encompasses the establishment of a sample referral network connecting CHT community and primary care surveillance sites with regional and national reference laboratories capable of advanced pathogen identification, with clearly defined sample collection, packaging, transport, and results communication protocols. The Response Coordination Pillar encompasses the multi-sectoral coordination mechanisms (involving the Ministry of Health, the Ministry of Fisheries and Livestock, the Ministry of Environment and Forest, the CHT Regional Council, and the three District Hill Councils) needed to launch a coordinated One Health response to a detected zoonotic event in the CHT.

9.2 Nipah Virus Disease: The CHT Forest Bat Reservoir and the Spillover Risk

Nipah virus (NiV), a paramyxovirus of the genus Henipavirus transmitted from its natural reservoir host (fruit bats of the Pteropus genus, commonly called flying foxes) to humans through direct contact with infected bats or their secretions, through consumption of NiV-contaminated raw date palm sap (a well-documented transmission route in Bangladesh where NiV outbreaks have been concentrated in the northwest), and potentially through human-to-human transmission in healthcare settings, has caused 22 outbreaks in Bangladesh between 2001 and 2023, with a case fatality ratio of approximately 70 percent, making it one of the most lethal known viral pathogens. The connection between NiV and the CHT arises from the documented presence of Pteropus medius (the Indian flying fox, the primary Bangladeshi bat reservoir of NiV) and Pteropus giganteus throughout the forested areas of South and Southeast Asia, including territories adjacent to the CHT and potentially within the CHT forest zone. While NiV outbreaks in Bangladesh have to date been concentrated in the northern and northwestern districts rather than in the CHT, there is no biological reason why Pteropus bats in the CHT forest zone would not carry NiV antibodies or active virus, and the CHT's dense human-wildlife interface, bat-hunting traditions in some CHT communities (bats are consumed as a food source in certain indigenous communities), and the collection of forest fruits and palm products that may be contaminated by bat saliva and urine all create potential NiV spillover pathways. The clinical syndrome of Nipah virus encephalitis begins with 1 to 2 weeks of fever, headache, dizziness, and vomiting, progressing rapidly to encephalitis with altered consciousness, areflexia, and brainstem dysfunction (producing the characteristic "doll's eyes" and other brainstem signs of Nipah encephalitis documented in Malaysian and Bangladeshi case series), sometimes with a respiratory component (particularly in the Bangladesh lineage NiV, which has been associated with respiratory transmission to a greater degree than the Malaysian lineage). The diagnosis of NiV encephalitis in a CHT setting would require high clinical suspicion (particularly in clusters of severe unexplained encephalitis in a community with bat exposure), specimen collection for NiV-specific RT-PCR (nasopharyngeal secretions, urine, CSF, and blood are appropriate specimens), and strict infection control measures (including N95 respirator use, gown, gloves, and eye protection for all clinical contacts, and single-room isolation of the patient) given the documented human-to-human NiV transmission in healthcare settings in Bangladesh. No

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specific antiviral treatment for NiV is currently approved, though ribavirin (which showed some activity in in vitro studies) has been used in some outbreak settings, and several experimental anti-NiV monoclonal antibodies are in clinical development. The management is primarily supportive (antiepileptic drugs for seizures, ventilatory support for respiratory compromise, intensive monitoring for brainstem dysfunction) in the most well-resourced settings available, which for a CHT patient would likely mean Chittagong Medical College Hospital or, for the most severe cases, DMCH or other Dhaka referral facilities.

9.3 Avian Influenza, Brucellosis, and the Agricultural Disease Interface

Highly Pathogenic Avian Influenza (HPAI), caused by influenza A viruses of the H5N1, H5N6, H5N8, and H7N9 subtypes (among others), has caused sporadic human infections across Asia since the first major H5N1 outbreak in Hong Kong in 1997, with Bangladesh documenting several HPAI H5N1 detections in poultry populations in recent years. The CHT risk context for HPAI human spillover is defined by the ubiquity of free-ranging backyard poultry (chickens, ducks, and geese) in CHT indigenous households, the practice of slaughtering poultry at home (with direct exposure of the slaughterer to poultry blood, respiratory secretions, and feces), the potential for contact between domestic poultry and migratory wild birds in the CHT's forested and wetland environments, and the proximity of the CHT to Myanmar, where HPAI surveillance and containment capacity has been severely compromised by the 2021 military coup. Human HPAI H5N1 infection presents as severe respiratory illness (initial flu-like illness progressing to pneumonia and ARDS, acute respiratory distress syndrome) with a case fatality ratio of approximately 60 percent in the global case series, though this may be subject to ascertainment bias toward the most severe cases. The antiviral treatment of HPAI H5N1 requires oseltamivir (Tamiflu) 75 mg twice daily for 5 days (with higher doses and longer durations considered for severe cases), which is not currently available in CHT health facilities but is maintained in national stockpiles for outbreak response. The case detection protocol for HPAI at CHT facility level requires clinicians to consider HPAI in any patient presenting with severe pneumonia or ARDS in the context of recent poultry contact (particularly sick or dead poultry contact), and to immediately implement standard and airborne infection control precautions while notifying the district health authority and IEDCR for outbreak investigation and specimen collection.

Brucellosis, caused by Brucella abortus (from cattle and buffalo), Brucella melitensis (from goats and sheep), Brucella suis (from pigs), and Brucella canis (from dogs), is a bacterial zoonosis transmitted primarily through consumption of unpasteurized dairy products, raw or undercooked meat from infected animals, or direct contact with infected animal products (placentas, fetuses, birth fluids) during animal delivery or slaughter. Brucellosis produces a non-specific febrile illness (fever, sweats, myalgia, arthralgia, fatigue, and weight loss) that may be confused with malaria, tuberculosis, or typhoid in the CHT clinical context, with the clinical clue of its characteristic undulant fever pattern (fever rising and falling in waves over weeks to months, the "undulant fever" of historical clinical nomenclature) and the occupation/exposure history (animal contact). The CHT risk context for brucellosis includes cattle keeping (cattle are kept in some CHT communities for agricultural labor and milk production), pig keeping in pork-consuming communities, and the practice of consuming unpasteurized milk in communities with dairy animals. The diagnosis of brucellosis requires serological confirmation (Rose Bengal Plate

Agglutination Test, RBPT, as a rapid screening test, confirmed by Standard Agglutination Test, SAT, or ELISA), and the treatment is doxycycline 100 mg twice daily for six weeks combined with rifampicin 600 mg daily for six weeks (the WHO-recommended regimen), or doxycycline with streptomycin IM for three weeks as an alternative with lower relapse rates.

9.4 Rabies: The Preventable Death in the CHT

Rabies, caused by the Lyssavirus genus of the Rhabdoviridae family and transmitted primarily through the bite of a rabid animal (in the CHT context predominantly dogs, with monkeys and forest-dwelling carnivores as secondary reservoirs), is a disease of absolute preventability through vaccination (both pre-exposure prophylaxis for high-risk individuals and post-exposure prophylaxis after suspected exposure) and essentially invariable lethality once clinical disease develops (the case fatality ratio of established clinical rabies is effectively 100 percent without intensive care intervention, and even with intensive care the survival rate without prior vaccination is less than 5 percent in the published literature). Bangladesh maintains a significant rabies disease burden, with the WHO estimating approximately 2,500 rabies deaths per year in Bangladesh in earlier estimates (now believed to have declined with dog vaccination programs but remains substantial). In the CHT, the specific risk factors for rabies exposure and the specific barriers to post-exposure prophylaxis (PEP) create a particularly dangerous context. The dense forest interface creates conditions for encounters with potentially rabid wildlife including mongoose, squirrels, jackals, and bats. Dog ownership is common in CHT communities for protection and hunting assistance, and stray dog populations in CHT communities have limited access to the dog vaccination programs that are the primary rabies control strategy at the national level. The barrier to effective rabies PEP in the CHT is fundamentally one of access: the standard WHO-recommended PEP regimen requires intradermal or intramuscular rabies vaccine (currently the WHO-recommended intramuscular Essen regimen is Days 0, 3, 7, 14, and 28; or the abbreviated Zagreb regimen of 2-1-1 schedule; or intradermal regimens that are more dose-efficient), plus rabies immunoglobulin (RIG, either human or equine, infiltrated around the bite wound at Day 0) for severe exposures (Category III, including any bites or scratches that break the skin). Accessing the full PEP regimen from a remote CHT community requires multiple visits to a health facility capable of administering vaccine and RIG, over a period of weeks, which is often impossible given the terrain and transport costs. A single missed dose of PEP substantially increases the risk of treatment failure. The clinical training implication for CHT health workers is urgent and specific: every bite wound from a potentially rabid animal, particularly dog bites, must be immediately washed with soap and water for at least 15 minutes (the single most effective immediate measure to reduce rabies virus inoculation), and the patient must be urgently transported to the nearest PEP-capable facility with RIG availability (minimally at district hospital level) before any further delay, with the communication to the patient and family emphasizing that the risk of death from untreated Category III exposure is essentially certain if PEP is not completed.

MODEL EXAMINATION QUESTIONS: CHAPTER NINE (PART FOUR)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

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The natural reservoir host of Nipah virus in Bangladesh is: a) Domestic cattle b) Pteropus fruit bats (flying foxes) c) Rodents (rats and mice) d) Migratory birds (Correct Answer: b)

The transmission route of Nipah virus most specifically associated with Bangladesh outbreaks is: a) Direct bat-to-human bite transmission b) Consumption of raw date palm sap contaminated by bat saliva and urine c) Human-to-human transmission in community settings d) Consumption of undercooked bat meat (Correct Answer: b)

Brucellosis treatment with the WHO-recommended dual antibiotic regimen consists of: a) Amoxicillin plus metronidazole for two weeks b) Doxycycline for six weeks plus rifampicin for six weeks c) Ciprofloxacin plus azithromycin for three weeks d) Tetracycline plus streptomycin for one week (Correct Answer: b)

The minimum wound care procedure recommended immediately after a potentially rabies-exposing bite wound is: a) Application of topical antiseptic cream b) Washing with soap and water for at least 15 minutes c) Application of a tourniquet proximal to the bite d) Covering the wound with a sterile dressing only (Correct Answer: b)

The OHHLEP definition of One Health adopted by WHO, FAO, UNEP, and WOAH in 2021 recognizes that health is: a) Primarily determined by human biological factors b) An integrated property of humans, animals, and ecosystems that are closely linked and interdependent c) Primarily determined by healthcare system capacity d) Primarily determined by individual lifestyle choices (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A CHT district health officer receives a report of three cases of severe encephalitis with brainstem signs developing over 10 days in Mro community members in a remote Bandarban valley. All three had been hunting bats in forested areas two weeks before illness onset. The attending physician at Alikadam UHC suspects Nipah virus disease. Which is the most appropriate coordinated response? a) Collect blood samples for malaria RDT and treat all three empirically with artemether-lumefantrine b) Implement airborne and contact infection control precautions at the UHC immediately; collect NiV RT-PCR specimens (nasopharyngeal secretion, urine, blood) under appropriate BSL3-compatible collection protocols; notify IEDCR and the District Health Officer immediately for outbreak investigation activation; isolate patients in single rooms with full PPE (N95 respirator, gown, gloves, eye protection) for all patient contacts; prepare for transfer to Chittagong Medical College Hospital for intensive supportive management; issue guidance to the Mro community on avoiding bat contact and informing health authorities about any further cases c) Administer ribavirin empirically to all three patients without laboratory confirmation d) Discharge patients to home isolation and await laboratory results before implementing any additional measures (Correct Answer: b)

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CHAPTER TEN: DIGITAL HEALTH, TELEMEDICINE, AND HEALTH INFORMATION SYSTEMS IN THE CHT: TECHNOLOGY AS BRIDGE ACROSS THE TERRAIN GAP

10.1 The Digital Health Imperative for the CHT: Theory, Evidence, and Architecture

Digital health, encompassing the use of information and communications technologies (ICT) including mobile phones, the internet, wearable devices, artificial intelligence, and electronic health information systems to support, deliver, and improve health outcomes, represents the most promising current technological avenue for addressing the healthcare access deficit that terrain, distance, and resource scarcity have imposed on CHT communities for generations. The digital health revolution has already demonstrated transformative potential in settings comparable to the CHT in various parts of the world: mobile health (mHealth) applications have improved antenatal care attendance in rural Tanzania, community health worker performance in Kenya, and tuberculosis treatment adherence in Peru; telemedicine has reduced diagnostic delays in remote Indigenous communities in Australia and Canada; and artificial intelligence-assisted diagnostic tools have enabled point-of-care diagnosis of diabetic retinopathy, tuberculosis on chest X-ray, and malaria on peripheral blood smear with accuracy approaching specialist performance. The question for the CHT is not whether digital health can contribute to health improvement in the territory but how to design, deploy, and govern digital health solutions that are contextually appropriate, operationally sustainable, culturally sensitive, and equitably accessible across the territory's diverse and geographically dispersed communities.

The CHT Digital Health Framework Doctrine proposes six principles for digital health implementation in the CHT context. The Connectivity Realism Principle holds that digital health solutions designed for the CHT must be functional under the actual connectivity conditions of the territory, which vary from moderate 3G/4G connectivity in district towns and peri-urban areas through intermittent 2G connectivity in upazila headquarters to complete absence of cellular network coverage in many remote valleys and ridge-top communities of Bandarban and rural Rangamati. Solutions requiring consistent high-bandwidth internet connectivity are not viable for most of the CHT's most health-disadvantaged communities and should not be the primary design basis for CHT digital health systems. The Cultural Accessibility Principle holds that digital health interfaces, including mobile phone health applications and telemedicine platforms, must be designed in the indigenous languages of the CHT's eleven ethnic communities, using visual communication formats and voice-based interaction modes that are accessible to users with limited literacy, rather than relying on Bangla text-based interfaces that exclude the large proportion of CHT indigenous adults whose Bangla literacy is limited. The Trust Architecture Principle holds that digital health solutions in the CHT must address the institutional distrust of government systems documented throughout this textbook, and that the design of CHT digital health systems must incorporate explicit safeguards for data confidentiality, user privacy, and protection of sensitive health information (including HIV, mental health, and TB status information) from disclosure to unauthorized third parties including security forces, employers, and family members whose knowledge of the patient's health status could cause harm. The Community Ownership Principle holds that the most sustainable digital health solutions in the CHT are those in which the communities themselves have ownership,

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agency, and decision-making authority over the health data they generate, rather than those in which data flows exclusively upward to government or institutional repositories with no community-level benefit or control. The Interoperability Principle holds that digital health solutions in the CHT must be designed to communicate with the national health information system (the DGHS MIS, the EPI data system, the NCD risk factor surveillance system, and the TB-DOTS tracking system) to ensure that CHT health data are integrated into the national data landscape rather than existing in isolated silos that cannot inform national health policy and program decisions. The Sustainability Principle holds that digital health solutions in the CHT must be designed for the long term, with clear ownership, maintenance, and financial sustainability mechanisms beyond the initial project funding cycle, since the CHT has a documented history of well-intentioned pilot programs that were discontinued when project funding ended without leaving a sustainable institutional infrastructure behind.

10.2 Telemedicine in the CHT: Models, Evidence, and Implementation

Telemedicine, the delivery of clinical care at a distance using telecommunications technology, offers the most immediate and most clinically consequential application of digital health to the CHT's healthcare access deficit. The fundamental clinical challenge of the CHT, that the most skilled clinical expertise (neurological, obstetric, cardiac, and oncological) is concentrated in Chittagong and Dhaka while the most health-disadvantaged patients are distributed across terrain that makes physical access to that expertise effectively impossible, is precisely the challenge that telemedicine is designed to address. The international evidence for telemedicine effectiveness in comparable settings is robust: systematic reviews published in The Lancet Digital Health (2021) and in JMIR mHealth and uHealth (2024) document significant positive impacts of telemedicine on diagnosis accuracy, treatment initiation speed, patient satisfaction, and health outcomes in rural, remote, and resource-limited settings including in Southeast Asia. The CHT-specific telemedicine model must address the connectivity constraints identified in the previous section by designing hybrid telemedicine systems that can operate at different levels of connectivity: asynchronous store-and-forward consultation (where the community health worker or peripheral facility physician captures clinical photographs, ECG images, fundoscopic images, or short video recordings and transmits them via mobile phone (even 2G) to a specialist consultant, who reviews and responds when connectivity permits, with turnaround times of hours to days for non-emergency consultations) for the most remote settings; real-time video consultation (requiring 3G or 4G connectivity, feasible in upazila headquarters and some larger village communities) for urgent but not immediately life-threatening clinical decisions; and emergency telestroke protocols (using video consultation between the district hospital and Chittagong Medical College Hospital neurology service when a stroke patient presents, enabling remote specialist assessment for thrombolysis decision-making within the 4.5-hour treatment window) as the highest-priority emergency telemedicine application. The Emergency Telemedicine Protocol for the CHT prioritizes the following clinical scenarios as the most impactful targets for telemedicine intervention: obstetric emergencies (remote obstetric specialist consultation for eclampsia management, obstructed labor, and postpartum hemorrhage, where the specialist's guidance can enable a midwife or general physician at peripheral level to manage the complication more effectively while the referral is in progress); neurological emergencies (remote neurology consultation for stroke, meningitis, and epilepsy management); and chest emergency consultation

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(for acute myocardial infarction, severe pneumonia with ARDS features, and severe asthma requiring ventilatory decisions).

10.3 Artificial Intelligence in CHT Clinical Decision Support

Artificial intelligence (AI), specifically the machine learning algorithms that recognize patterns in clinical data to support diagnostic and clinical decision-making, has the potential to significantly extend the diagnostic capability of non-specialist clinical staff working at CHT peripheral facilities. Several AI-assisted diagnostic tools of direct CHT relevance are either already validated or in advanced development for deployment in resource-limited settings. AI-assisted malaria diagnosis on peripheral blood smear, using deep learning algorithms trained on thousands of digitized blood smear images, has been demonstrated in multiple validation studies to achieve diagnostic accuracy (sensitivity and specificity greater than 95 percent for P. falciparum detection) comparable to expert microscopist performance, using smartphone-based image capture from a standard light microscope with a simple adapter. The deployment of validated AI malaria diagnostic tools on community health worker smartphones in CHT settings where malaria RDT availability is inconsistent would provide a complementary diagnostic pathway of substantial clinical value. AI-assisted tuberculosis screening on chest radiograph, using algorithms that flag radiographs with abnormalities suggesting TB for human review (rather than making final diagnoses), has been validated in multiple low-income country settings and demonstrated to improve case detection rates when deployed in primary care screening programs. The deployment of digital chest radiography (using portable digital X-ray units that are becoming increasingly cost-effective and durable) combined with AI TB screening software at CHT district hospitals and mobile screening units would create a TB diagnostic chain substantially more sensitive than symptom screening alone. AI-assisted dermatological diagnosis (for skin disease pattern recognition, relevant in the CHT's significant dermatological disease burden including leprosy, cutaneous leishmaniasis, scabies, and tinea), AI-assisted ECG interpretation (enabling automated detection of atrial fibrillation, STEMI, complete heart block, and other life-threatening arrhythmias on a 12-lead ECG captured by non-specialist health workers), and AI-assisted retinal photograph analysis for diabetic retinopathy screening (enabling non-ophthalmologist health workers to capture retinal photographs with a fundus camera and have them analyzed automatically for diabetic retinopathy severity) represent additional AI applications of direct CHT clinical relevance whose deployment, while not currently implemented in the CHT, is operationally feasible with modest infrastructure investment.

10.4 Health Information Systems and Data Governance for the CHT

The health information system (HIS) of the CHT, comprising the data collection, management, analysis, and reporting infrastructure through which health events are recorded and used to guide health policy and program management, is characterized by the same fragmentation, underresourcing, and geographic inequity that characterizes every other dimension of the CHT health system. The consequence of HIS inadequacy in the CHT is that health problems invisible in the data are invisible to policymakers, and the communities most health-disadvantaged (the Mro, the Khumi, the Chak, and others in Bandarban's most remote areas) are simultaneously the

communities most underrepresented in the health data that determine resource allocation. This statistical invisibility is a form of political invisibility that perpetuates health inequity by denying its quantification. The CHT HIS Reform Doctrine proposes a three-component framework: a community-based digital health surveillance system (using community health workers equipped with smartphones to record health events, immunization status, disease notifications, and vital events at household level, with data stored locally and synchronized with central databases when connectivity allows); a facility-based electronic health record system (providing district hospitals and upazila health complexes with electronic medical records that replace paper registers, enabling longitudinal patient tracking, diagnosis coding, drug prescribing monitoring, and aggregated reporting); and a One Health integrated data platform (linking human, animal, and environmental health data from CHT surveillance systems to provide the integrated analytical capability needed to detect emerging zoonotic threats and AMR signals). The critical data governance principle for the CHT HIS is that community-level health data belong to the communities that generate them and must be managed with the communities' informed consent and with benefit-sharing mechanisms that ensure communities gain concrete health improvement benefits from their data contribution.

MODEL EXAMINATION QUESTIONS: CHAPTER TEN (PART FOUR)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The OHHLEP One Health definition recognizes the health of humans, animals, and ecosystems as: a) Independent domains with separate management systems b) Closely linked and interdependent elements requiring an integrated approach c) Primarily determined by human institutional health systems d) Primarily determined by government policy choices (Correct Answer: b)

Asynchronous store-and-forward telemedicine is particularly suited to CHT remote community settings because: a) It provides the fastest consultation response for emergency cases b) It is functional under intermittent or low-bandwidth 2G connectivity, unlike real-time video consultation c) It requires no training for community health workers d) It eliminates the need for physical examination of the patient (Correct Answer: b)

The AI-assisted malaria diagnostic tool on smartphone-based peripheral blood smear analysis has demonstrated diagnostic accuracy of approximately what level in validation studies? a) 60-70% sensitivity b) 75-80% sensitivity c) Greater than 95% sensitivity and specificity for P. falciparum d) Equal to rapid antigen test performance only (Correct Answer: c)

The Trust Architecture Principle in the CHT Digital Health Framework Doctrine specifically addresses: a) Technical data encryption standards b) Community trust in digital health through explicit safeguards for data confidentiality and protection of sensitive health information from unauthorized disclosure c) Trust between telemedicine consultants and referring physicians d) Trust between AI diagnostic systems and clinical practitioners (Correct Answer: b)

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The minimum immediate wound care for a Category III rabies exposure (bite penetrating the skin) is: a) Apply antiseptic solution to the wound surface b) Wash the wound immediately with soap and water for at least 15 minutes c) Cover with sterile gauze and transport to hospital d) Apply a tourniquet to prevent viral spread (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A global health technology organization offers to donate 50 AI-assisted ECG interpretation devices to CHT district hospitals. The devices require internet connectivity for their AI algorithm to function, work only with a Bangla-language interface, store all ECG data on servers outside Bangladesh with no community-level data access, and are designed to operate independently for two years before the organization's project funding ends. Applying the CHT Digital Health Framework Doctrine principles, which of the following assessments most accurately evaluates the appropriateness of this technology offer for CHT deployment? a) Accept immediately; AI ECG devices are unambiguously beneficial regardless of design constraints b) The offer violates multiple CHT Digital Health Framework Doctrine principles: Connectivity Realism (requiring internet connectivity that is unavailable at most CHT facilities), Cultural Accessibility (Bangla-only interface excluding indigenous language users), Trust Architecture (off-shore server storage without community data control), Community Ownership (no community data access or control), and Sustainability (project-funded without long-term sustainability plan). The appropriate response is to negotiate substantial modifications or decline in favor of exploring alternatives meeting CHT-specific design principles c) Accept with the only modification being translation to English instead of Bangla d) Accept immediately and design a connectivity infrastructure project separately to support the devices (Correct Answer: b)

EPILOGUE TO PART FOUR: SYNTHESIZING THE CLINICAL, EPIDEMIOLOGICAL, AND SYSTEMIC ARCHITECTURE OF PART FOUR

Part Four has traversed four interconnected territories of CHT health science that are each both clinically immediate and systemically consequential. Chapter One's engagement with antimicrobial resistance established that the CHT is not merely a passive recipient of a global AMR crisis but is an active site of AMR emergence and amplification, driven by the specific combination of self-medication culture, cross-border pathogen mobility from Myanmar, absent microbiology surveillance, and a fragmented prescribing environment without stewardship governance. Chapter Two's laboratory medicine framework provided the clinical practitioner with both the theoretical science of what diagnostic tools are available and the operational wisdom of how to deploy them in the stratified CHT health system, from the community health worker with an mRDT to the district hospital laboratory with basic biochemistry and microscopy. Chapters Three and Four's engagement with cardiovascular disease, metabolic disease, and endocrine disorders documented the emergence of the NCD transition in the CHT as a clinical reality shaped by the DOHaD paradox, the betel-nut cancer epidemic, the silent hypertension burden, and the specific nutritional deficiency syndromes of the hill ecology. Chapter Five's pediatric infectious disease analysis integrated the immunization reform agenda of

the post-2025-measles-crisis era with the clinical management science of neonatal sepsis and childhood pneumonia in a setting where the most effective management often requires resources that the closest facility does not have. Chapter Six's pharmacological framework established that rational drug use in the CHT requires not only knowledge of standard pharmacology but awareness of the CHT-specific modifiers (malnutrition, G6PD deficiency, enzyme-inducing drug interactions, and the ethics of prescribing in scarcity) that alter drug effects and therapeutic outcomes in ways not predictable from standard pharmacological references. Chapter Seven's medical sociology and anthropology provided the interpretive framework for understanding why knowing the right clinical intervention is never sufficient without understanding the social structures, cultural systems, and power relationships that determine whether and how patients access, accept, and adhere to that intervention. Chapter Eight's waterborne and soil-transmitted disease analysis deepened the clinical and epidemiological understanding of the CHT's dominant environmental disease burden, from the cholera-leptospirosis-Cryptosporidium spectrum of the waterborne ecology to the helminthic nutritional burden that sustains malnutrition across generations. Chapter Nine's One Health framework located the CHT at the center of a zoonotic disease ecology with existential significance for the twenty-first century, demonstrating that the CHT's biological diversity, cross-border position, and structural surveillance deficits create conditions for the emergence and amplification of zoonotic threats (Nipah, avian influenza, brucellosis, rabies) that are preventable only through the integrated human-animal-environmental health approach that One Health provides. Chapter Ten's digital health framework offered the most technically optimistic vision of this textbook: that the terrain gap separating CHT communities from expert clinical care is now, for the first time in history, theoretically bridgeable by technology, but that bridging it requires the rigorous application of the CHT-specific design principles that this chapter articulated, without which technology deployment will reproduce the inequities it promises to solve rather than transcending them.

The intellectual and ethical commitment that animates every chapter of this textbook is simultaneously diagnostic and prescriptive: to see the CHT health situation with clarity, without the romanticism that obscures its injustices, and without the pessimism that obscures its possibilities. The CHT's health crisis is real, severe, and in many of its dimensions worsening. Its causes are structural. Its solutions require structural change. But the physician and the public health practitioner who work in the CHT cannot wait for structural change before doing their best with what is available. They must act with the best clinical science available, the deepest cultural understanding they can cultivate, the most ethical prescribing they can practice, the most honest communication they can manage, and the most determined advocacy they can muster, building the evidence base and the moral argument for the structural changes that the CHT's communities have been waiting for since the first colonial physician set foot in the hills with quinine and good intentions and an incomplete understanding of what the hills demanded.

PART FOUR COMPREHENSIVE ASSESSMENT: INTEGRATIVE EXAMINATION QUESTIONS

For Postgraduate Entrance, FCPS, MD, and MPH:

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Integrative Case 1: A 43-year-old Chakma fisherman from a Kaptai Lake shoreline community presents to Rangamati District Hospital in July with five days of fever, severe myalgia, headache, and conjunctival suffusion, followed by one day of jaundice and oliguria. He reports no formal healthcare contact for the past three years. He keeps three dogs and handles freshly caught fish daily. His wife was diagnosed with pulmonary TB six months ago and is on anti-TB therapy. His CBC shows hemoglobin 9.2 g/dL, WBC 13,000 with neutrophilia, platelets 78,000 (thrombocytopenia). Renal function tests show creatinine 320 micromol/L. Liver enzymes show ALT 890 U/L and bilirubin 4.8 mg/dL. Malaria RDT is negative. Which combination of diagnoses should be simultaneously prioritized in the differential diagnosis and which investigations and immediate management steps are indicated? a) Malaria with false-negative RDT only; repeat malaria RDT b) Weil's disease from leptospirosis (supported by the occupational exposure to water and fish, the biphasic clinical picture with fever-jaundice-renal failure-thrombocytopenia, the zoonotic exposure through dogs, and the July monsoon season water exposure), potentially complicated by secondary drug-induced liver injury from his wife's rifampicin (though he is not on anti-TB therapy himself), requiring IgM ELISA or MAT serology for leptospira, blood and urine culture, full renal function assessment, immediate IV benzyl penicillin G, close monitoring of renal function for dialysis need, and malaria blood smear microscopy to definitively exclude malaria despite negative RDT c) Hepatitis B with superimposed E from water d) Typhoid fever (Correct Answer: b)

Integrative Case 2: The CHT Regional Council's Health Committee has commissioned a five-year strategic health plan. Based on the analytical framework of this textbook, rank the following interventions in order of their expected impact on reducing years of life lost (YLL) in the CHT indigenous population over the five-year period: (i) Establishing a cardiac surgery unit in Rangamati; (ii) Universal pre-primaquine G6PD testing at all CHT health facilities; (iii) Expanding immunization program reach to remote indigenous communities with culturally adapted strategies; (iv) Deploying telemedicine connectivity between CHT district hospitals and Chittagong Medical College Hospital for emergency obstetric, neurological, and cardiovascular consultations. The ranking from highest to lowest expected impact on YLL reduction is: a) i, ii, iii, iv b) iii, iv, ii, i c) ii, i, iv, iii d) iv, iii, i, ii (Correct Answer: b, with rationale: immunization expansion addresses the highest-burden, most preventable cause of pediatric mortality; telemedicine addresses the most immediate life-threatening access gap for multiple emergency presentations; G6PD testing prevents drug-induced hemolysis in a significant but lower-burden pathway; cardiac surgery unit addresses the lowest-volume but highest-technology need)

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PART FIVE: ADVANCED DISEASE SYSTEMS, SPECIALIST CLINICAL PROTOCOLS, AND THE EMERGING HEALTH FRONTIERS OF THE CHITTAGONG HILL TRACTS

Foreword to Part Five

Part Five enters the territory of clinical specialization, bringing the reader deeper into the organ-system-specific and procedurally complex dimensions of medicine as they apply to the unique geomedicinal context of the Chittagong Hill Tracts. The earlier parts of this textbook built the foundational architecture: the geomedicinal identity of the territory, its historical and political health determinants, its dominant infectious disease burden, its emergent non-communicable disease transition, its pharmacological environment, and its sociological and anthropological dimensions. Part Five moves into the advanced organ-system clinics, from dermatology to nephrology, from neurology to oncology, from trauma surgery to health system philosophy, with the same uncompromising insistence on contextual specificity that has defined every preceding chapter. The CHT patient who presents to a clinician with a skin condition does not present as an abstraction from a dermatology atlas. The clinician who examines a CHT patient for neurological disease does not do so in a vacuum devoid of malaria, arsenic, and political trauma. Every diagnosis in the CHT is embedded in a landscape, a history, and a social structure that modify it, and every treatment is constrained by the terrain in which it must be delivered. Part Five honors this complexity. It is written for the student who will one day work in the hills, and for the practitioner who already does, and who deserves the most rigorous, the most current, and the most honest clinical science that the medical literature can provide.

CHAPTER ONE: DERMATOLOGY AND SKIN DISEASE IN THE CHITTAGONG HILL TRACTS: ECOLOGY, ECOLOGY, ECOLOGY

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1.1 The Dermatological Ecology Doctrine

The skin is the body's largest organ, covering an average adult surface area of approximately 1.7 square meters, and in the CHT context it is also the organ most continuously, most intensively, and most diversely exposed to the environmental, microbial, parasitic, occupational, nutritional, and solar forces that constitute the CHT's unique ecological health profile. The Dermatological Ecology Doctrine, as formulated in this textbook, holds that in the CHT, skin disease is not primarily a disorder of the skin as an autonomous biological structure but a register of the body's ecological embeddedness, in which the skin serves as the translucent membrane through which the landscape writes its pathological messages onto the human body. This doctrine has three operational corollaries. The first corollary is the Exposure Multiplicity Principle, which holds that CHT patients presenting with skin disease have typically been exposed to multiple simultaneous dermatological stressors rather than a single causative agent, and that effective diagnosis requires a comprehensive exposure history encompassing solar radiation intensity (the CHT's high altitude and forest-clearing activities increase ultraviolet radiation exposure above what lowland communities experience), occupational contact exposures (agricultural chemicals, forest plant sap, soil microorganisms, river water), nutritional status (which determines the integrity of the epidermal barrier and the robustness of the immune response to cutaneous pathogens), and the parasite burden (where systemic parasitism produces cutaneous manifestations that are diagnostic windows into deeper pathological processes). The second corollary is the Diagnostic Overlap Principle, which holds that the tropical dermatological conditions of the CHT frequently present with overlapping clinical features that require systematic differential diagnosis rather than rapid pattern-matching, because misidentification of leprosy as eczema, of cutaneous leishmaniasis as a fungal infection, or of pellagra-associated dermatitis as contact dermatitis produces delays in specific treatment that have severe consequences for the individual patient and for public health. The third corollary is the Structural Treatment Principle, which holds that in the CHT, the treatment of skin disease requires simultaneous attention to the biological treatment of the specific condition (pharmacological, immunological, or surgical), the elimination or modification of the environmental and occupational exposures that initiated or perpetuate the condition, and the nutritional rehabilitation that restores the epidermal barrier and immune function necessary for sustained skin health, because pharmaceutical treatment alone in the context of ongoing exposure and nutritional deficiency produces temporary remission followed by relapse.

The CHT skin disease burden encompasses conditions across at least eight major categories, each with ecological and clinical characteristics specific to the CHT context. These categories are: parasitic infestations of the skin (scabies, cutaneous larva migrans, myiasis), fungal infections (tinea species, pityriasis versicolor, chromoblastomycosis, sporotrichosis), bacterial skin infections (impetigo, ecthyma, erysipelas, cellulitis, tropical ulcer, buruli ulcer), mycobacterial skin disease (leprosy, cutaneous tuberculosis), protozoal skin disease (cutaneous leishmaniasis), vector-bite-related skin reactions (insect bite hypersensitivity, papular urticaria, photoaggravated bite reactions), nutritional dermatoses (pellagra, kwashiorkor dermatosis, zinc deficiency dermatitis, vitamin C deficiency with perifollicular hemorrhage), and neoplastic skin disease (squamous cell carcinoma from sun exposure and areca nut exposure, basal cell carcinoma, melanoma at sun-exposed sites, Kaposi's sarcoma in immunocompromised

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individuals). The relative prevalence of these categories in the CHT has not been systematically quantified, but clinical experience at CHT health facilities and the limited published literature consistently identify scabies, tinea infections, bacterial superinfection of insect and scabies lesions, and leprosy as the most frequently encountered dermatological conditions, with cutaneous leishmaniasis representing an emerging concern in border areas adjacent to Myanmar.

1.2 Scabies: The Paradigm Case of Ecologically Driven CHT Skin Disease

Scabies, caused by the obligate intraepidermal parasite Sarcoptes scabiei var. hominis, is the single most prevalent and most clinically important parasitic skin disease in the CHT, and its epidemiology in the territory illustrates with exceptional clarity how the CHT's ecological, social, and economic conditions transform what is a manageable condition in resource-adequate settings into a source of chronic morbidity and significant secondary bacterial disease burden. Sarcoptes scabiei is transmitted primarily through prolonged direct skin-to-skin contact between infected and susceptible individuals, and the conditions that maximize transmission risk are precisely those that characterize CHT indigenous household life: overcrowded sleeping arrangements in bamboo structures where multiple family members share sleeping mats on the floor, inadequate access to washing facilities that would remove mites from skin and bedding, limited access to the topical treatments (permethrin 5 percent cream or oral ivermectin) that constitute the evidence-based standard for scabies eradication, and the absence of community-level mass drug administration (MDA) programs that would achieve the herd immunity effects necessary to break transmission cycles in high-prevalence communities. The clinical presentation of scabies in CHT patients follows the classical distribution (intense pruritus, typically worse at night, with burrows in the interdigital web spaces, wrist flexor surfaces, periumbilical skin, penis, and axillary folds in adults; and diffuse distribution including face and scalp in infants), but with several CHT-specific features that deserve clinical attention. First, secondary bacterial superinfection of scabies lesions (impetigo from Staphylococcus aureus and Streptococcus pyogenes) is virtually universal in CHT scabies patients, because the constant pruritus-driven scratching that breaks the skin barrier, combined with the inability to maintain hand hygiene adequate to prevent wound contamination in water-scarce and sanitation-deficient CHT households, creates conditions in which every scabies excoriation becomes a portal for bacterial entry. Second, post-streptococcal glomerulonephritis (PSGN), a serious renal complication of Group A Streptococcal (GAS) skin infection mediated by immune complex deposition in the glomerular basement membrane, is a documented consequence of streptococcal impetigo from scabies superinfection in tropical settings, and represents a CHT-relevant risk because the high prevalence of scabies, the high rate of superinfection, and the absence of routine antibiotic treatment of impetigo in many CHT communities creates the epidemiological substrate for PSGN in CHT children. Third, crusted (Norwegian) scabies, a hyperinfective variant characterized by thick keratotic crusts teeming with millions of mites (in contrast to the ten to fifteen mites that constitute the typical infestation in ordinary scabies), occurs in profoundly immunocompromised individuals (including those with severe protein-energy malnutrition, untreated HIV, or on corticosteroid therapy) and represents both a clinical emergency (requiring combined oral ivermectin and topical permethrin treatment, often repeated) and a community transmission risk of extraordinary magnitude, since a single crusted scabies patient is as infectious as approximately 100 to 200 ordinary scabies patients. The identification of a crusted

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scabies case in a CHT community should trigger immediate community-level scabies assessment and consideration of MDA with ivermectin for the entire affected household and close contacts, not merely treatment of the index case. The community-level management of scabies in the CHT, through periodic ivermectin MDA in high-prevalence communities, simultaneous treatment of all household members when an index case is identified, and WASH infrastructure improvement to support the hygiene necessary for effective treatment, is the public health strategy with the greatest capacity to reduce the CHT's scabies and scabies-associated bacterial disease burden.

1.3 Leprosy in the CHT: History, Diagnosis, and the Doctrine of Early Detection

Leprosy, caused by Mycobacterium leprae and its recently described cousin Mycobacterium lepromatosis, is a chronic granulomatous disease of the skin and peripheral nerves that has occupied a specific and deeply stigmatized position in the medical history and social life of the CHT for centuries. Bangladesh is classified by the World Health Organization as having achieved leprosy elimination at the national level (defined as a prevalence of less than one case per 10,000 population), but significant geographic heterogeneity persists, and epidemiological evidence from studies conducted in parts of Khagrachhari and Rangamati districts has documented active transmission with new case detection rates substantially above the national average in specific sub-district areas. The persistence of leprosy transmission in the CHT reflects several factors that have been identified in the literature: the higher population density of occupational exposure to soil and plant materials that harbor Mycobacterium leprae environmental reservoirs (the organism has been identified in soil and in armadillos globally, and may persist in the CHT's moist forest soil), the nutritional vulnerability of CHT indigenous populations (protein-energy malnutrition impairs the cell-mediated immune response that determines the clinical form and severity of leprosy, with malnourished individuals more likely to develop the lepromatous pole of the leprosy spectrum where high bacillary load and florid skin disease predominate), the delay-to-diagnosis pathway driven by the profound social stigma of leprosy in CHT communities (which produces years of concealment during which the disease progresses from early to advanced stages with accompanying nerve damage and disability), and the geographic barriers to diagnosis and treatment that have been documented across this textbook.

The diagnostic classification of leprosy in clinical practice follows the WHO operational classification (for treatment purposes: paucibacillary leprosy with one to five skin lesions; multibacillary leprosy with more than five skin lesions or any positive slit-skin smear) and the Ridley-Jopling histopathological classification (tuberculoid, borderline tuberculoid, borderline, borderline lepromatous, and lepromatous, reflecting the immunological spectrum from high cell-mediated immunity to low cell-mediated immunity). In the CHT clinical context, where histopathology is rarely available, the WHO operational classification is the practical basis for treatment decisions. The cardinal signs of leprosy, which should be examined for in every CHT skin disease consultation given the territory's epidemiological context, are: one or more hypopigmented or erythematous skin patches (or plaques) with definite loss of sensation within the lesion (tested with a wisp of cotton for light touch, a pin for sharp sensation, and warm/cold water tubes for temperature discrimination); thickened peripheral nerves (particularly the ulnar

nerve at the elbow, the common peroneal nerve at the fibular head, the great auricular nerve in the posterior cervical triangle, and the superficial radial nerve at the wrist), which are palpable in advanced leprosy; and positive slit-skin smear for acid-fast bacilli from the ear lobes, eyebrows, and active skin lesions in multibacillary disease. The peripheral nerve thickening in leprosy produces a characteristic pattern of motor and sensory loss (ulnar nerve involvement: claw hand deformity of the ring and little fingers, weakness of intrinsic hand muscles, and loss of sensation in the medial one and a half fingers; common peroneal nerve involvement: foot drop and sensory loss over the dorsum of the foot; median nerve involvement: inability to oppose the thumb and sensory loss over the radial three and a half fingers). These deformities, when present, indicate advanced nerve damage that is partially or wholly irreversible, emphasizing the critical importance of early detection before neurological disability develops.

The treatment of leprosy in the CHT follows the WHO multidrug therapy (MDT) regimens, which are provided free of charge by the WHO: paucibacillary MDT (rifampicin 600 mg monthly supervised plus dapsone 100 mg daily self-administered for six months) and multibacillary MDT (rifampicin 600 mg monthly supervised plus clofazimine 300 mg monthly supervised plus dapsone 100 mg daily plus clofazimine 50 mg daily self-administered for twelve months). The completion of the full MDT course is bactericidal and produces clinical cure, but it does not reverse established nerve damage or deformity. The management of leprosy reactions (Type 1 or reversal reaction, an acute cell-mediated immune response producing inflammation in existing skin lesions and peripheral nerves, which can cause acute nerve damage if not treated promptly with corticosteroids; and Type 2 or erythema nodosum leprosum, an immune complex-mediated systemic inflammatory reaction producing painful nodules, fever, and iritis, treated with thalidomide in males and non-pregnant females or corticosteroids when thalidomide is unavailable or contraindicated) is a clinical emergency that requires immediate intervention, because acute neuritis from leprosy reactions is one of the most important preventable causes of irreversible disability in leprosy patients, and its recognition requires clinical training specifically focused on the symptoms of acute nerve inflammation: acute onset of pain and tenderness along the course of a peripheral nerve, combined with new or worsening motor or sensory loss in the distribution of that nerve, in a known leprosy patient.

The leprosy case detection program in the CHT requires specific adaptation to the CHT's sociocultural context. Village-to-village active case-finding surveys, conducted with indigenous community health workers who speak the local language and are trusted by the community, have been demonstrated in global leprosy control programs to be substantially more effective than passive case detection through health facility attendance in high-prevalence areas where stigma drives healthcare avoidance. The integration of leprosy case detection into the activities of existing community health worker networks in the CHT (including the BRAC Shasthya Shebika network and community health workers deployed by NGOs such as The Leprosy Mission), with training on the three cardinal signs and protocols for immediate referral to leprosy MDT dispensing centers, represents the most operationally feasible approach to early detection in the CHT's resource-constrained, geographically dispersed community context.

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1.4 Cutaneous Leishmaniasis: The Emerging Border Threat

Cutaneous leishmaniasis (CL), caused by protozoan parasites of the genus Leishmania transmitted by the bite of sandflies of the genus Phlebotomus (in the Old World) or Lutzomyia (in the New World), represents an emerging dermatological challenge in the CHT's border areas with Myanmar. Leishmania tropica, Leishmania major, and Leishmania donovani (in its cutaneous rather than visceral manifestation) have all been documented in the Greater Mekong and South Asian region, and the displacement of people from Myanmar's Chin State into the CHT's border areas creates conditions for the introduction of Leishmania strains from Myanmar's disease ecology, which has been poorly characterized since the collapse of Myanmar's surveillance infrastructure following the 2021 military coup. The classical presentation of cutaneous leishmaniasis begins weeks to months after the sandfly bite as a papule that evolves into a nodule, then ulcerates centrally to produce the characteristic painless, indurated ulcer with a raised, undermined edge (described in the older literature as a "volcano crater" morphology) that persists without healing for months to years. The clinical differential diagnosis of cutaneous leishmaniasis in the CHT must systematically include tropical ulcer (a rapidly progressive, extremely painful ulcer caused most frequently by Fusobacterium ulcerans and spirochetes, treated with metronidazole and penicillin), Buruli ulcer (caused by Mycobacterium ulcerans, which produces a painless, undermining ulcer through the action of the exotoxin mycolactone, treated with rifampicin plus either clarithromycin or amikacin), cutaneous tuberculosis (particularly lupus vulgaris and scrofuloderma), chromoblastomycosis (a fungal infection producing verrucous plaques, caused by dematiaceous fungi that penetrate the skin through soil-contaminated wounds), and squamous cell carcinoma (which may produce a non-healing ulcerated mass that superficially resembles an infectious ulcer, particularly in areas of chronic skin damage from sun exposure or betel nut-induced leukoplakia). The diagnosis of cutaneous leishmaniasis requires identification of Leishman-Donovan (LD) bodies (amastigotes) in Giemsa-stained slit-skin smears or biopsy tissue from the ulcer edge, culture of promastigotes on NNN (Novy-MacNeal-Nicolle) medium, or PCR for Leishmania DNA, the last of which offers the greatest sensitivity and species identification capability but requires molecular laboratory infrastructure not currently available in the CHT. Treatment of cutaneous leishmaniasis in resource-limited settings follows WHO recommendations including intralesional sodium stibogluconate injection for localized disease, systemic sodium stibogluconate or meglumine antimoniate for extensive or complicated disease, and miltefosine (an oral phospholipid analogue with anti-Leishmania activity) as an alternative for patients in whom parenteral treatment is not feasible.

1.5 Nutritional Dermatoses: When the Skin Reveals What the Body Lacks

The nutritional dermatoses of the CHT represent a set of skin presentations that are simultaneously diagnostic signals of underlying nutritional deficiency states and clinical urgencies requiring prompt nutritional intervention to prevent both the dermatological complications and the systemic consequences of the underlying deficiency. Pellagra, the clinical syndrome of niacin (vitamin B3) deficiency characterized by the triad of dermatitis, diarrhea, and dementia (the three Ds of pellagra), is of specific relevance to CHT communities where maize (corn) is a dietary staple and the traditional nixtamalization process (the alkaline processing of

maize that releases bound niacin from niacytin, making it bioavailable) is not widely practiced. Maize-dependent diets without nixtamalization, or diets dominated by polished white rice with minimal protein (in communities where jhum cycle compression has reduced dietary diversity), create conditions for niacin deficiency. The dermatitis of pellagra is pathognomonic: it is symmetrically distributed on sun-exposed skin surfaces (the dorsum of the hands, forearms, face, neck, and feet), producing first erythema and hyperpigmentation, then thickening and cracking of the skin (the "Casal's necklace" around the neck is the most recognizable clinical sign), and finally in severe cases frank desquamation and ulceration. The recognition of pellagric dermatitis in a CHT community by a community health worker or peripheral health facility clinician is an immediate trigger for nutritional assessment and niacin supplementation (as nicotinamide 100 mg three times daily for the acute phase, with dietary diversification as the long-term prevention strategy). Zinc deficiency dermatitis, characterized by periorificial (around the mouth, nose, eyes, and anus) and acral (on hands and feet) erythematous, scaly, sometimes vesiculobullous skin changes (acrodermatitis enteropathica pattern), is relevant in the CHT because zinc is a micronutrient concentrated in meat, seafood, and whole grains, all of which may be inadequate in the diets of the most nutritionally marginalized CHT communities. Vitamin C deficiency (scurvy), now rare in most of Bangladesh, may still occur in CHT communities with severe dietary restriction during the pre-harvest lean season, presenting with the triad of perifollicular hemorrhage (hemorrhage into the skin around hair follicles, producing the distinctive "swan-neck" hair deformity), gingival hemorrhage and inflammation, and defective wound healing, all of which result from the impaired collagen synthesis that is the fundamental pathophysiological consequence of ascorbic acid deficiency.

MODEL EXAMINATION QUESTIONS: CHAPTER ONE (PART FIVE)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The three cardinal signs of leprosy recognized for clinical diagnosis in the field, as recommended by the World Health Organization, are: a) Hypopigmented skin patches with loss of sensation, thickened peripheral nerves, and positive slit-skin smear for acid-fast bacilli b) Papular rash, lymphadenopathy, and peripheral eosinophilia c) Pruritus, maculopapular rash, and bilateral wrist joint swelling d) Alopecia, nail dystrophy, and oral mucosal ulceration (Correct Answer: a)

Post-streptococcal glomerulonephritis (PSGN) complicating scabies superinfection with Group A Streptococcus presents classically with which combination of findings? a) Nephrotic syndrome with heavy proteinuria, hypoalbuminemia, and edema b) Nephritic syndrome with hematuria, hypertension, oliguria, and mild proteinuria, occurring 1 to 3 weeks after streptococcal skin infection c) Rapidly progressive renal failure with ANCA-positive vasculitis d) Renal tubular acidosis with electrolyte disturbance (Correct Answer: b)

Crusted (Norwegian) scabies differs from ordinary scabies most importantly in that: a) It is caused by a different species of Sarcoptes b) It produces generalized hyperkeratotic crusts containing millions of mites and is highly contagious, requiring immediate community-level response c) It causes systemic organ involvement including hepatitis and nephritis d) It requires surgical treatment rather than pharmacological management (Correct Answer: b)

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The Ridley-Jopling classification of leprosy is based primarily on: a) The number of skin lesions b) The immunological spectrum reflecting the balance between cell-mediated immunity and bacillary load c) The drug susceptibility pattern of Mycobacterium leprae d) The clinical severity of peripheral nerve damage (Correct Answer: b)

Pellagra classically presents with dermatitis distributed on which body surfaces? a) Flexural surfaces (axillae, groin, antecubital fossae) b) Sun-exposed surfaces (dorsum of hands, face, neck, forearms) c) Mucosal surfaces (oral cavity, genitalia) d) Truncal surfaces without sun-exposure correlation (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A CHT upazila health complex physician encounters a 38-year-old Tripura man with a painless, indurated skin ulcer with a raised, undermined edge on the right forearm, persisting for four months despite local wound care. He lives in a border community adjacent to Chin State, Myanmar, and works in forest product collection. No sandfly history is obtained. Slit-skin smear from the ulcer edge reveals ovoid intracellular bodies in macrophages approximately 2 to 4 microns in diameter. The differential diagnosis and immediate management priorities should include: a) Presumptive tropical ulcer; prescribe metronidazole and penicillin without further investigation b) The smear findings are consistent with Leishman-Donovan bodies (amastigotes of Leishmania species); cutaneous leishmaniasis is the most likely diagnosis given the clinical and epidemiological context; management should include Giemsa confirmation of the LD body morphology, referral for systemic treatment consideration with sodium stibogluconate or miltefosine, IEDCR notification as a potential border zone Leishmania introduction, and differential diagnosis exclusion of Buruli ulcer and Mycobacterium ulcerans by referral smear and biopsy for histopathology where available c) Squamous cell carcinoma; refer directly to oncology d) Chromoblastomycosis; treat with itraconazole empirically (Correct Answer: b)

A 4-year-old Mro girl presents with symmetrically distributed periorificial and acral erythematous, scaly skin lesions with vesicle formation, poor growth, and recurrent diarrhea. Her diet consists almost entirely of polished rice with minimal animal protein. The most likely diagnosis and appropriate immediate management is: a) Scabies superinfected with impetigo; prescribe permethrin and oral cefalexin b) Zinc deficiency dermatitis (acrodermatitis enteropathica pattern); zinc supplementation with elemental zinc 10 mg daily for infants and 20 mg daily for older children for 10 to 14 days, combined with dietary counseling for zinc-rich food introduction and referral for comprehensive nutritional rehabilitation c) Contact dermatitis from plant exposure; prescribe topical corticosteroid d) Infantile seborrhoeic dermatitis; reassure and prescribe emollient (Correct Answer: b)

CHAPTER TWO: NEUROLOGICAL DISORDERS, EPILEPSY, AND NEUROTOXICOLOGICAL MEDICINE IN THE CHITTAGONG HILL TRACTS

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2.1 The CHT Neuroepidemiological Framework

Neurology in the CHT presents the clinician with a disease landscape that diverges substantially from the neurological epidemiology of Bangladesh's urban medical centers, because the spectrum of neurological conditions encountered in the CHT reflects the territory's specific infectious disease burden, nutritional profile, toxic exposures, altitude physiology, and structural trauma history in ways that collectively constitute what this textbook defines as the CHT Neuroepidemiological Framework. This framework holds that neurological diseases in the CHT must be understood across four intersecting causal planes: the infectious neurological plane (encompassing the neurological complications of malaria, including cerebral malaria with its acute neurological syndrome; bacterial meningitis; viral encephalitides including Nipah, Japanese encephalitis, and enteroviruses; tuberculosis meningitis and tuberculoma; neurocysticercosis from Taenia solium; and neurobrucellosis), the nutritional neurological plane (encompassing the neurological consequences of thiamine deficiency, B12 deficiency, pellagra-related encephalopathy, iodine deficiency, and the neurotoxic complications of severe protein-energy malnutrition), the toxic neurological plane (encompassing neurotoxic exposures specific to the CHT including organophosphate pesticide-associated chronic neurotoxicity, traditional plant-derived neurotoxins from some CHT botanical preparations, alcohol-related neurological disease, and the neurological consequences of snakebite envenomation), and the structural-psychosocial neurological plane (encompassing the neurological and neuropsychiatric manifestations of the CHT's political trauma history, including post-traumatic neurological sequelae of conflict-period violence, stress-related neurological syndromes, and the complex overlap between somatoform neurological presentations and the genuine structural brain injury that may coexist in the same patient). Understanding neurological disease in the CHT through this four-plane framework produces a diagnostic approach that is simultaneously more comprehensive and more clinically accurate than a framework that considers any single plane in isolation.

2.2 Cerebral Malaria: The CHT's Most Urgent Neurological Emergency

Cerebral malaria (CM), defined by the WHO as a Plasmodium falciparum infection presenting with unarousable coma (Glasgow Coma Scale score below 11 in adults, or Blantyre Coma Scale score below 3 in children, after exclusion of other causes of coma) in a patient with parasitemia, is the most life-threatening neurological emergency encountered in the CHT and accounts for the majority of malaria-related deaths in the territory. The pathophysiology of cerebral malaria, which has been refined substantially by research conducted since 2020, involves a convergence of at least five interactive mechanisms: sequestration of P. falciparum-parasitized erythrocytes (PRBCs) in cerebral microvascular endothelium through cytoadherence mediated by the PfEMP1 antigen to endothelial receptors including ICAM-1, CD36, and EPCR (endothelial protein C receptor); endothelial activation and disruption of the blood-brain barrier through PRBC-released parasite products including hemozoin, glycosylphosphatidylinositol (GPI) anchors, and extracellular vesicles; neuroinflammation mediated by cytokines including TNF-alpha, IFN-gamma, and IL-1 beta that are released by activated macrophages and neutrophils in response to sequestered PRBCs; systemic metabolic derangements including hypoglycemia (from increased glucose consumption by the parasite and the inhibition of hepatic gluconeogenesis by quinine, a

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drug still used in some CHT settings), lactic acidosis (from the anaerobic glycolysis of sequestered parasites and impaired hepatic lactate clearance), and severe anemia (producing cerebral hypoxia that amplifies the ischemic injury from vascular sequestration); and inducible nitric oxide synthase (iNOS) dysregulation (with early studies suggesting that excessive NO production may contribute to cerebral dysfunction by disrupting neurotransmission, while more recent 2024 data from the Mekong region suggest that insufficient NO bioavailability in the cerebral microcirculation may actually worsen microvascular occlusion). The clinical syndrome of cerebral malaria in the CHT follows a pattern that has been documented in multiple studies from the Chittagong Medical College Hospital series: fever preceding coma by two to five days (though some patients develop coma more rapidly), generalized convulsions (occurring in the majority of pediatric CM and approximately 20 percent of adult CM cases), features of brainstem dysfunction (abnormal posturing, respiratory irregularities, oculomotor abnormalities including conjugate eye deviation, "pingpong" gaze, and absent corneal reflexes in severe cases), and the specific finding of retinal changes of cerebral malaria (retinal whitening, retinal hemorrhages, and vessel color changes visible on fundoscopic examination in approximately 50 to 80 percent of CM cases, with the presence of these changes constituting one of the most specific adjunctive diagnostic features of CM in the differential diagnosis of tropical coma).

The emergency management of cerebral malaria in the CHT requires the immediate application of a systematic protocol that addresses simultaneously the antimalarial treatment (parenteral artesunate at a dose of 2.4 mg/kg IV at 0, 12, and 24 hours, then every 24 hours until the patient can tolerate oral treatment, or if parenteral artesunate is unavailable, artesunate rectal suppository 10 mg/kg as a pre-referral measure), the metabolic emergencies (blood glucose monitoring every one to two hours with immediate IV dextrose correction of any hypoglycemia less than 2.2 mmol/L; correction of severe anemia with packed red blood cell transfusion for hemoglobin below 5 g/dL in children or below 7 g/dL in adults with cardiac compromise; correction of lactic acidosis through adequate fluid resuscitation and treatment of the underlying parasitemia), the neurological management (seizure control with IV diazepam for active seizures; phenobarbital for prophylactic seizure control in pediatric CM where seizure prophylaxis has been studied, though a pivotal trial showed that high-dose phenobarbital increased mortality despite reducing seizures, so the current recommendation is treatment of active seizures only, not routine prophylaxis; careful patient positioning in the lateral decubitus or semi-prone position to prevent aspiration; airway protection with nasopharyngeal airway or endotracheal intubation in patients with Glasgow Coma Scale score below 8 and aspiration risk), and the complications surveillance (for acute respiratory distress syndrome from fluid overload, acute kidney injury, disseminated intravascular coagulation, and secondary bacterial sepsis, all of which may complicate the course of severe CM and each of which requires specific management). The management of post-CM neurological sequelae, which occur in approximately 10 to 30 percent of survivors of cerebral malaria (particularly in children), including cognitive impairment, behavioral disorders, epilepsy, cerebral palsy, and vision problems from cortical visual impairment, requires rehabilitation planning, family counseling, and long-term follow-up that is rarely available in the CHT context but represents an important unmet need for CM survivors.

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2.3 Bacterial Meningitis in the CHT

Bacterial meningitis, the acute infection of the meninges and subarachnoid space by bacterial pathogens, is a neurological emergency with a case fatality ratio of 20 to 30 percent even with appropriate antibiotic treatment and a neurological sequelae rate of 15 to 30 percent in survivors in resource-limited settings, producing the "meningitis triangle" of high mortality, high morbidity, and high treatment cost even when the condition is correctly diagnosed. The bacterial pathogens responsible for meningitis in the CHT context reflect the age and immune status of the affected individual: neonatal meningitis is caused primarily by Group B Streptococcus, E. coli, Klebsiella pneumoniae, and Listeria monocytogenes from the maternal birth canal and hospital environment; infant and childhood meningitis is caused primarily by Streptococcus pneumoniae and Neisseria meningitidis (with Haemophilus influenzae type b contributing in inadequately immunized children); adult meningitis is caused primarily by Streptococcus pneumoniae, Neisseria meningitidis, and Listeria monocytogenes (in the elderly and immunocompromised); and in the CHT's specific context, Mycobacterium tuberculosis meningitis is the most important subacute-chronic meningitis presentation that must always be excluded in a CHT patient with a prolonged febrile meningeal syndrome, given the territory's high TB burden. The clinical presentation of acute bacterial meningitis follows the classic triad of fever, severe headache, and neck stiffness (meningismus), with the Kernig's sign (inability to extend the knee when the hip is flexed to 90 degrees) and Brudzinski's sign (involuntary hip and knee flexion when the neck is passively flexed) providing bedside evidence of meningeal irritation. However, the clinical diagnosis of meningitis in the CHT is complicated by the high pretest probability of malaria (which itself produces meningeal signs in some cases, particularly when malaria-induced hypoglycemia or metabolic acidosis contribute to the altered sensorium), and by the limited availability of lumbar puncture and CSF analysis at most CHT health facilities. The lumbar puncture, which provides the definitive diagnostic information for bacterial meningitis (CSF opening pressure, appearance, cell count with differential, protein, glucose with simultaneous blood glucose, and Gram stain and culture), should be performed in all suspected meningitis cases where it is safe to do so (contraindications including severe coagulopathy, thrombocytopenia below 50,000/microL, suspected raised intracranial pressure with focal neurological signs or papilledema, and certain skin overlying the lumbar puncture site infections). When lumbar puncture is not immediately possible in a CHT setting, empirical antibiotic treatment for bacterial meningitis must not be delayed: the empirical regimen for adult community-acquired bacterial meningitis is ceftriaxone 2 g IV every 12 hours (providing excellent CSF penetration and broad-spectrum activity against the most likely pathogens), and in settings where Listeria is a concern (in elderly, pregnant, or immunocompromised patients), ampicillin 2 g IV every four hours should be added to the ceftriaxone. The addition of dexamethasone 0.15 mg/kg IV every six hours for four days (initiated before or simultaneously with the first antibiotic dose) reduces mortality and neurological sequelae in adult pneumococcal meningitis and should be used in all CHT settings where it is available.

2.4 Tuberculosis Meningitis: The CHT's Most Devastating Subacute Neurological Syndrome

Tuberculosis meningitis (TBM), caused by Mycobacterium tuberculosis seeding the meninges through hematogenous dissemination from a primary pulmonary or extrapulmonary focus (often

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through the rupture of a parameningeal Rich focus into the subarachnoid space), is the most severe form of extra-pulmonary tuberculosis and one of the most diagnostically challenging and prognostically devastating neurological conditions encountered in the CHT. TBM presents subacutely over days to weeks, typically with prodromal features of malaise, low-grade fever, and headache, progressing to meningeal signs (neck stiffness, photophobia, phonophobia), cranial nerve palsies (particularly of cranial nerves III, VI, and VII, from the exudative basilar meningitis that is the pathological hallmark of TBM), altered consciousness, and hydrocephalus (from obstruction of CSF flow by the thick basal exudate). The diagnostic challenge of TBM in the CHT context is formidable: the CSF findings (lymphocytic pleocytosis with typically 100 to 500 cells/microL, elevated protein above 100 mg/dL, low glucose with CSF:serum glucose ratio below 0.5, and typically negative Gram stain and no bacterial growth on routine culture) are characteristic but non-specific, and the Ziehl-Neelsen smear for acid-fast bacilli in CSF has a sensitivity of only 10 to 40 percent even with large volumes of CSF examined. GeneXpert MTB/RIF on CSF has revolutionized TBM diagnosis in settings where it is available, providing sensitivity of approximately 60 to 80 percent and rifampicin resistance information within two hours; this is the recommended diagnostic test for TBM at CHT district hospital level. Where GeneXpert is unavailable, the clinical diagnosis of TBM must be based on a combination of the clinical syndrome, CSF findings, evidence of tuberculosis elsewhere (pulmonary TB on chest X-ray, positive sputum smear or GeneXpert in the same patient), contact history with TB, and epidemiological context. The treatment of TBM follows the standard anti-tuberculosis treatment regimen with an intensified initial phase: 2HRZE/10HR (isoniazid H, rifampicin R, pyrazinamide Z, and ethambutol E for two months, followed by isoniazid and rifampicin for ten months, for a total of twelve months of treatment). High-dose adjunctive corticosteroids (dexamethasone 0.4 mg/kg/day IV for the first four weeks, then tapered over the subsequent four weeks) are strongly recommended by the WHO based on the pivotal Lancet 2004 trial by Thwaites and colleagues, which demonstrated a significant reduction in mortality in TBM patients receiving adjunctive dexamethasone compared with placebo, though the benefit on neurological disability in survivors was less clear. The management of hydrocephalus complicating TBM, when it develops in CHT patients, presents a particularly difficult clinical challenge because the neurosurgical intervention required for communicating hydrocephalus (ventriculoperitoneal shunt) or obstructive hydrocephalus (endoscopic third ventriculostomy) is available only in Dhaka or at most Chittagong Medical College Hospital, and the transport of a critically ill TBM patient with hydrocephalus from a remote CHT community to such a center carries enormous logistical and clinical risk.

2.5 Epilepsy in the CHT: Causes, Stigma, and the Treatment Gap

Epilepsy, defined as the enduring tendency to generate epileptic seizures arising from the brain's abnormal neuronal activity, with its associated neurobiological, cognitive, psychological, and social consequences, affects approximately 50 million people globally and constitutes one of the world's most common serious neurological disorders, with an estimated 80 percent of affected individuals living in low- and middle-income countries where the treatment gap (the proportion of people with epilepsy who do not receive appropriate treatment) reaches 75 to 90 percent. In the CHT, the epilepsy treatment gap is likely at the upper end of this range, driven by multiple converging barriers: the difficulty of reaching neurological specialist services in Chittagong or

Dhaka from remote CHT communities; the profound social stigma of epilepsy in CHT communities (which drives concealment, traditional healing seeking, and community exclusion of affected individuals); the unavailability of first-line antiepileptic drugs at many CHT peripheral health facilities; and the clinical complexity of epilepsy management in a setting where the multiple causative pathologies (neurocysticercosis from Taenia solium in pork-consuming CHT communities, cerebral malaria sequelae, TBM sequelae, perinatal brain injury from birth complications, head trauma from falls in agricultural and forest work, and idiopathic epilepsy) require different management strategies that demand correct causative diagnosis before appropriate treatment can be selected. Neurocysticercosis (NCC), caused by the encephalic larval stage (cysticercus) of the pork tapeworm Taenia solium, is the most common parasitic cause of epilepsy globally and is particularly relevant in CHT communities where pork consumption is common (Chakma, Marma, Bawm, and several other CHT communities are traditional pork consumers), where inadequate latrine use allows fecal contamination of the environment with T. solium eggs, and where human cysticercosis can develop from inadvertent ingestion of T. solium eggs (not from pork consumption, but from fecal-oral transmission of eggs shed by a human tapeworm carrier in the same community). The first-line antiepileptic drugs recommended by the WHO Essential Medicines List and appropriate for CHT use are phenobarbital (highly effective, inexpensive, widely available, and recommended as the priority antiepileptic in resource-limited settings by multiple international guidelines, with the important caveat that it is a controlled substance in many systems and requires careful prescribing protocols to prevent diversion), carbamazepine (for focal epilepsies and secondarily generalized seizures, available in Bangladesh but requiring monitoring for the rare but severe adverse effect of Stevens-Johnson syndrome, which has a higher incidence in carriers of the HLA-B*1502 allele that is more prevalent in populations of Southeast Asian ancestry than in populations of European ancestry, a pharmacogenetic consideration directly relevant to CHT's Southeast Asian indigenous communities), and sodium valproate (for generalized epilepsies including absence and myoclonic syndromes, with mandatory monitoring for teratogenicity in women of childbearing age and for hepatotoxicity in children under two years on polytherapy). The integration of epilepsy care into the CHT community health worker framework, including the training of BRAC Shasthya Shebikas and other community health workers to recognize seizures, to support medication adherence, to provide first aid for convulsive seizures (lateral positioning, airway protection, timing the seizure, not restraining the patient), and to reduce stigma through community education about the neurological nature of epilepsy, is the most practical pathway for expanding the epilepsy treatment reach in the CHT's remote communities.

MODEL EXAMINATION QUESTIONS: CHAPTER TWO (PART FIVE)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The WHO definition of cerebral malaria requires which minimum criterion for diagnosis? a) Plasmodium falciparum parasitemia with any fever b) Unarousable coma (GCS below 11 in adults) with P. falciparum parasitemia after exclusion of other causes of coma c) Seizures with malaria parasitemia d) Retinal changes on fundoscopy in a malaria patient (Correct Answer: b)

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The adjunctive treatment for adult bacterial meningitis (particularly pneumococcal) that has been shown to reduce mortality and neurological sequelae is: a) Intravenous immunoglobulin (IVIG) b) Dexamethasone 0.15 mg/kg IV every six hours for four days, initiated before or with the first antibiotic dose c) Mannitol IV for cerebral edema management d) Aspirin for anti-inflammatory effect (Correct Answer: b)

Neurocysticercosis, the most common parasitic cause of epilepsy globally, develops in humans through: a) Consumption of undercooked pork containing cysticerci b) Fecal-oral transmission of Taenia solium eggs shed by a human tapeworm carrier c) Penetration of skin by Taenia solium larvae in soil d) Inhalation of Taenia solium spores from infected pig feces (Correct Answer: b)

The HLA-B*1502 allele, which is associated with a substantially higher risk of Stevens-Johnson syndrome from carbamazepine, is more prevalent in which population group particularly relevant to CHT clinical practice? a) Populations of European ancestry b) Populations of African ancestry c) Populations of Southeast Asian ancestry d) Populations of Middle Eastern ancestry (Correct Answer: c)

Tuberculosis meningitis pathologically produces its distinctive clinical picture of cranial nerve palsies and hydrocephalus primarily through: a) Direct parenchymal invasion of the brain by mycobacteria b) Thick exudative basilar meningitis with CSF flow obstruction and cranial nerve entrapment within the exudate c) Demyelination of cranial nerve sheaths by mycobacterial toxins d) Vasculitis of cerebral blood vessels causing ischemic cranial nerve lesions (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A CHT community health worker reports to the Alikadam Upazila Health Complex that a 9-year-old Bawm boy has had three episodes of loss of consciousness with jerking movements in the past four months. The family has been treating him with prayers and herbal preparations from the village Ojha. The boy's family keeps pigs. On evaluation at the UHC, the boy is neurologically normal between episodes. No fever is documented. Serum cysticercus antibody ELISA sent to Chittagong returns positive. What is the most appropriate diagnostic and management approach? a) Diagnose idiopathic generalized epilepsy; prescribe sodium valproate b) The epidemiological context (pork-consuming community, pig keeping, positive cysticercus serology, afebrile focal-pattern seizures) is highly consistent with neurocysticercosis; the standard of care requires CT scan or MRI of the brain to characterize lesion number, stage, and location (parenchymal viable cysts, parenchymal calcified lesions, subarachnoid or ventricular disease), which should be arranged at Chittagong Medical College Hospital; management decisions including whether to use cysticidal therapy (albendazole) and adjunctive corticosteroids depend on the CT/MRI findings (cysticidal therapy is appropriate for parenchymal viable cysts but may worsen disease in some subarachnoid or ventricular forms); antiepileptic therapy with carbamazepine or valproate should be initiated while awaiting neuroimaging; screening of household members for intestinal taeniasis should also be arranged c) Prescribe anti-malarial treatment empirically d) Arrange EEG only and prescribe phenobarbital based on EEG result (Correct Answer: b)

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CHAPTER THREE: CHRONIC RESPIRATORY DISEASE AND PULMONARY MEDICINE IN THE CHITTAGONG HILL TRACTS

3.1 The Respiratory Disease Burden: A Compound Environmental and Infectious Crisis

The pulmonary health of the CHT's population is shaped by the most intense compound respiratory exposure environment in Bangladesh, at the intersection of three major respiratory hazard categories operating simultaneously and synergistically in the same communities and frequently in the same individual bodies. The first hazard category is biological: the CHT's forest ecology supports the transmission of multiple respiratory pathogens including Mycobacterium tuberculosis (which is transmitted by airborne droplet nuclei and is therefore promoted by any setting that increases respiratory exposure between infectious and susceptible individuals), measles virus (an airborne pathogen whose epidemic in 2025 decimated the Mro community), respiratory syncytial virus and other community respiratory viruses, and the environmental fungi and molds (including Aspergillus species, Histoplasma capsulatum, and Cryptococcus neoformans) that produce pulmonary disease in immunocompromised CHT patients including those with TB-associated immune suppression or undetected HIV. The second hazard category is chemical and particulate: the indoor air quality crisis from biomass combustion in poorly ventilated bamboo households, described in depth in Part One, produces chronic exposure to PM2.5, carbon monoxide, nitrogen dioxide, and polyaromatic hydrocarbons at concentrations that, when measured by direct monitoring in comparable South Asian rural households, routinely exceed WHO air quality guidelines by factors of 10 to 50 during cooking periods. The third hazard category is occupational: jhum burning creates seasonal acute outdoor air quality crises, forest work involves exposure to wood dust (a known Group 1 carcinogen for nasopharyngeal and paranasal sinus cancer), and rice paddy work in some CHT communities involves the aspiration of rice dust and endotoxin that have been associated with agricultural occupational lung disease globally. The CHT Respiratory Disease Compound Burden Doctrine holds that no single respiratory disease encountered in the CHT can be fully understood, effectively treated, or sustainably prevented without simultaneous engagement with all three hazard categories, because the exposure reduction and immune support that come from addressing the biological, chemical, and occupational respiratory hazard environments are each necessary conditions for long-term respiratory health, and none is individually sufficient.

3.2 COPD in the CHT: The Invisible Epidemic of the Cooking Fire

Chronic obstructive pulmonary disease (COPD), defined as a persistent, progressive airflow limitation associated with an enhanced inflammatory response of the airways and lung to noxious particles or gases, and characterized by the combination of chronic bronchitis (productive cough on most days for at least three months per year in two consecutive years) and emphysema (permanent enlargement of the air spaces distal to the terminal bronchioles with destruction of their walls), is one of the most globally significant non-communicable diseases, causing approximately 3.3 million deaths per year according to the WHO Global Burden of Disease 2024 estimates. In the CHT, COPD is driven not primarily by cigarette smoking (the

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dominant COPD risk factor in high-income countries) but by indoor biomass smoke exposure (COPD associated with biomass fuel exposure differs pathologically from tobacco-COPD and has been termed Biomass Fuel-associated COPD or BF-COPD), and by the occupational respiratory hazards described above. BF-COPD has a gender and social distribution in the CHT that directly reflects the gendered allocation of cooking labor: women, who spend far more time in the proximity of cooking fires than men in most CHT indigenous households, bear a disproportionately higher burden of BF-COPD, and the relationship between women's COPD burden and the social structure that allocates cooking labor exclusively to women is a clinical manifestation of the gendered pathology of household energy injustice in the CHT. The diagnosis of COPD in CHT health settings faces the challenge that spirometry, the gold standard diagnostic investigation (demonstrating post-bronchodilator FEV1/FVC ratio below 0.7, where FEV1 is the forced expiratory volume in the first second and FVC is the forced vital capacity), is not available at upazila health complex level and is limited even at district hospital level in the CHT. The clinical diagnosis of COPD in CHT patients must therefore rely on the combination of the characteristic history (progressive exertional dyspnea worsening over years, chronic productive cough, frequent respiratory infections, progressive reduction in exercise tolerance) and physical examination findings (barrel chest, use of accessory muscles of respiration, reduced air entry with prolonged expiration and wheeze on auscultation, and signs of cor pulmonale including elevated jugular venous pressure, peripheral edema, and a loud P2 in advanced disease) in the context of the appropriate exposure history (years of solid fuel cooking exposure and/or tobacco smoking). The management of COPD in the CHT setting includes bronchodilator therapy (salbutamol metered-dose inhaler for acute symptom relief, and ipratropium bromide as a longer-acting bronchodilator where available), smoking and cooking fuel exposure reduction counseling, pulmonary rehabilitation (breathing exercises, walking programs, and nutritional support to reverse the muscle wasting that contributes to the exercise limitation of COPD), and management of acute exacerbations (which are the most clinically dangerous events in COPD, characterized by acute worsening of dyspnea, increased sputum production, and altered sputum color, requiring short-acting bronchodilator intensification, systemic corticosteroids, antibiotics when bacterial exacerbation is suspected, and oxygen therapy for hypoxic patients, with early identification of patients requiring referral for ventilatory support).

3.3 Asthma in the CHT: Underdiagnosed, Undertreated, and Underappreciated

Asthma, a heterogeneous disease characterized by chronic airway inflammation, airway hyperresponsiveness, and variable airflow obstruction that typically produces recurrent episodes of wheezing, breathlessness, chest tightness, and cough, particularly at night or early morning, and that characteristically improves with bronchodilator treatment or resolves spontaneously, is substantially underdiagnosed and undertreated in the CHT. The underdiagnosis of asthma in CHT communities reflects several intersecting factors: the limited availability of diagnostic tools (peak flow meters and spirometry), the cultural attribution of wheezing episodes to supernatural causes or to "weakness" rather than to a treatable chronic disease, the linguistic barriers that prevent accurate symptom description in clinical encounters, the overlap of asthma symptoms with those of other common CHT respiratory conditions (particularly COPD, acute lower respiratory infection, and cardiac failure with pulmonary edema), and the absence of asthma education programs in the CHT's indigenous languages. The triggers of asthma exacerbation in

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CHT communities include those common globally (viral upper respiratory infections, exercise, cold air, strong odors) and those specifically prevalent in the CHT: indoor biomass smoke (both from cooking fires in the home and from jhum burning during the February to April burning season), dust mites in bamboo floor sleeping arrangements, mold spores from the humid bamboo walls and thatch roofs of CHT housing, and allergens from domestically kept animals including chickens, pigs, and goats. The treatment of asthma in CHT settings follows the Global Initiative for Asthma (GINA) 2024 step-wise management framework, adapted to the CHT's formulary realities: at the primary care level, a short-acting beta-2 agonist (SABA, preferably salbutamol metered-dose inhaler) should be available for all CHT asthma patients for acute symptom relief; for patients with persistent asthma requiring regular preventive treatment, inhaled corticosteroid (ICS) therapy (beclomethasone dipropionate pMDI as the most cost-effective option) should be initiated and maintained with spacer device use (which dramatically improves drug deposition efficiency in patients who cannot master the coordination required for direct pMDI use, a particularly important consideration in the CHT where patient education about MDI technique is often inadequate due to language barriers and limited health worker training time). A critical principle of asthma management in the CHT is that SABA-only treatment for persistent asthma, without ICS, represents suboptimal care that increases the risk of severe and fatal asthma attacks, and this principle must be communicated through the health system to all prescribers at CHT facilities.

3.4 Pneumonia in the CHT: From Neonatal to Geriatric, From Community to Nosocomial

Pneumonia, the acute infection of the pulmonary parenchyma producing alveolar consolidation, remains the leading infectious cause of death among children globally and a major cause of mortality across all age groups in the CHT. The epidemiology, microbiology, clinical presentation, and management of pneumonia in the CHT varies substantially across age groups and between community-acquired and healthcare-associated forms, requiring a clinically stratified approach to diagnosis and treatment that this section provides. Community-acquired pneumonia (CAP) in adults in the CHT is caused most commonly by Streptococcus pneumoniae (accounting for approximately 20 to 30 percent of CAP requiring hospitalization globally), Haemophilus influenzae (particularly in COPD patients and in those with inadequately vaccinated immunization histories), Klebsiella pneumoniae (more prevalent in malnourished, diabetic, and alcoholic patients, and in the CHT context in patients with severe protein-energy malnutrition), and Mycobacterium tuberculosis (which must always be considered in any CHT patient with subacute or chronic pneumonic illness, given the territory's high TB burden). Atypical pneumonia pathogens (Mycoplasma pneumoniae, Chlamydophila pneumoniae, Legionella pneumophila) cause a smaller but clinically significant proportion of CAP in CHT adults, with Legionella requiring specific consideration in community water systems where water temperature and stagnation conditions in some CHT institutional settings might support Legionella proliferation. The clinical severity assessment of CAP in CHT settings should use a validated and pragmatic severity score: the CURB-65 score (Confusion: 1 point; Urea greater than 7 mmol/L: 1 point; Respiratory rate greater than or equal to 30 per minute: 1 point; Blood pressure below 90 systolic or 60 diastolic: 1 point; Age 65 or older: 1 point) provides a simple, widely validated tool for deciding between outpatient management (CURB-65 score 0 to 1), inpatient management (CURB-65 score 2), and urgent hospitalization with ICU consideration

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(CURB-65 score 3 to 5). The first-line antibiotic for non-severe CAP in Bangladesh is amoxicillin (replacing cotrimoxazole, to which S. pneumoniae resistance rates in Bangladesh have reached levels that make it clinically unreliable), with the addition of a macrolide (azithromycin or clarithromycin) for atypical cover in moderate-to-severe CAP managed as an inpatient. For severe CAP requiring hospitalization, IV ceftriaxone plus azithromycin provides the recommended spectrum, with empirical anti-staphylococcal cover (cloxacillin or vancomycin if MRSA is suspected) added for post-influenza or aspiration-associated pneumonia presentations.

MODEL EXAMINATION QUESTIONS: CHAPTER THREE (PART FIVE)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

COPD associated primarily with indoor biomass fuel exposure rather than tobacco smoking is termed: a) Occupational asthma b) Hypersensitivity pneumonitis c) Biomass Fuel-associated COPD (BF-COPD) d) Simple chronic bronchitis (Correct Answer: c)

The CURB-65 severity score for community-acquired pneumonia assigns points for which five parameters? a) Cough severity, urinary symptoms, respiratory rate, blood pressure, and age above 65 b) Confusion, elevated urea (above 7 mmol/L), respiratory rate 30 or more per minute, low blood pressure (systolic below 90 or diastolic below 60 mmHg), and age 65 or older c) Chest X-ray severity, urea, rash, blood pressure, and age d) Cyanosis, urea, respiratory failure, blood pressure, and age above 65 (Correct Answer: b)

The diagnostic gold standard for COPD is based on: a) Chest X-ray findings of hyperinflation b) Post-bronchodilator FEV1/FVC ratio below 0.7 on spirometry c) Arterial blood gas analysis showing hypercapnia d) CT scan of the chest showing emphysematous changes (Correct Answer: b)

The GINA 2024 guidelines emphasize that for persistent asthma, SABA-only treatment without inhaled corticosteroid therapy: a) Is acceptable for mild asthma and should be continued indefinitely b) Represents suboptimal care that increases the risk of severe and fatal asthma attacks c) Is preferred in resource-limited settings to maximize cost-effectiveness d) Is recommended as a step-down strategy in well-controlled asthma (Correct Answer: b)

Aspiration pneumonia in CHT elderly patients most commonly causes infection in which lung zone due to gravitational dependency in the supine position? a) Left upper lobe b) Right middle lobe c) Right lower lobe (posterior segment) and left lower lobe d) Right upper lobe (Correct Answer: c)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 52-year-old Chakma woman who has cooked over open wood fires for 30 years presents to Rangamati District Hospital with a three-year history of progressive exertional dyspnea, productive morning cough, and two hospitalizations for respiratory infections in the past year.

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Spirometry shows FEV1 48% predicted and FVC 69% predicted (post-bronchodilator FEV1/FVC 0.62). CURB-65 is 1 on today's presentation with mild worsening of dyspnea. The most appropriate diagnosis and management plan is: a) Diagnose asthma; prescribe SABA inhaler alone b) Diagnose moderate BF-COPD (GOLD Stage 2, FEV1 50-80% predicted) based on the post-bronchodilator FEV1/FVC below 0.7 and the 30-year biomass fuel exposure history; initiate LAMA (tiotropium or ipratropium) as preferred maintenance bronchodilator; prescribe SABA (salbutamol) for rescue use; advise on cooking fuel exposure reduction (improved cookstove, kitchen ventilation); arrange pulmonary rehabilitation; vaccinate against pneumococcal disease and influenza; educate on exacerbation recognition and management; arrange follow-up spirometry in three months; no acute exacerbation management required today (CURB-65 of 1 does not indicate hospital admission) c) Refer immediately to Chittagong Medical College Hospital for thoracic surgery d) Diagnose heart failure and start diuretic therapy (Correct Answer: b)

CHAPTER FOUR: RENAL MEDICINE, HYDROLOGICAL NEPHROTOXICOLOGY, AND UROLOGICAL HEALTH IN THE CHITTAGONG HILL TRACTS

4.1 The CHT Renal Disease Paradigm: Water, Infection, and Terrain

The kidneys of CHT indigenous community members are subjected to a sustained and compound nephrotoxicological assault that arises from the convergence of the territory's specific infectious disease burden, its environmental chemical exposures, its chronic dehydration risk (physically demanding outdoor labor in high-temperature months with limited access to clean drinking water), its nutritional vulnerabilities (which impair renal protective mechanisms), and the toxic exposures from both traditional botanical preparations and improperly used agricultural chemicals. The CHT Renal Disease Paradigm, as articulated in this chapter, frames renal pathology in the CHT as the product of terrain-mediated nephrotoxicological accumulation rather than as isolated organ disease, in which multiple simultaneous and sequential renal insults combine to produce a burden of chronic and acute kidney disease that is substantially greater than the sum of its identifiable individual causes. This paradigm has five component doctrines. The Infectious Nephrology Doctrine holds that in the CHT, infectious diseases are the primary drivers of both acute and chronic kidney disease, operating through mechanisms including post-streptococcal glomerulonephritis (from GAS skin and throat infections), malaria-associated nephropathy (from the immune complex deposition and glomerular endothelial injury produced by P. falciparum and P. vivax infections), leptospirosis-associated acute tubular necrosis and interstitial nephritis (the most severe renal complication of Weil's disease, potentially requiring renal replacement therapy), and TB-associated nephritis (from direct mycobacterial renal invasion and immune complex deposition). The Hydrological Nephrotoxicology Doctrine holds that the chemical quality of CHT drinking water, particularly in areas where naturally occurring trace elements in hill springs or anthropogenic contaminants from agricultural or military chemical use exceed safe limits, produces chronic low-grade nephrotoxic exposure that accelerates the decline in renal function in individuals also experiencing infectious renal insults. The Botanical Nephrotoxicology Doctrine holds that some traditional CHT plant preparations

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contain nephrotoxic compounds (including pyrrolizidine alkaloids, which can cause chronic progressive veno-occlusive disease affecting both the hepatic and renal vasculature, and aristolochic acid, found in species of Aristolochia used in some Asian traditional medicine systems, which causes a specific, irreversible, rapidly progressive interstitial nephritis known as aristolochic acid nephropathy that progresses to end-stage renal disease in a high proportion of those exposed). The Dehydration Nephropathy Doctrine holds that the physically demanding subsistence agriculture and forest labor of CHT communities, performed in high-temperature months (March to June) with limited access to safe drinking water, creates a pattern of recurrent acute dehydration-induced acute kidney injury (AKI) that, when repeated across years and decades, may contribute to the development of chronic kidney disease (CKD) through a mechanism analogous to the chronic interstitial nephritis associated with repeated heat stress and dehydration documented in agricultural worker populations in Sri Lanka (Chronic Kidney Disease of Unknown Etiology, CKDu), Central America (Mesoamerican nephropathy), and Sri Lanka. The Malnutrition-Renal Synergy Doctrine holds that protein-energy malnutrition, which is prevalent among CHT indigenous communities, produces both direct renal functional impairment (through reduced glomerular filtration from decreased effective renal plasma flow and reduced protein-driven tubular function) and indirect renal vulnerability (through impaired immune function that increases susceptibility to the infectious nephropathies described above), creating a synergistic relationship between malnutrition and renal disease that amplifies the impact of each individual risk factor.

4.2 Malaria-Associated Nephropathy in the CHT

Malaria-associated nephropathy (MAN) encompasses the spectrum of renal diseases caused directly or indirectly by Plasmodium infection, and its clinical manifestations differ substantially between P. falciparum and P. vivax malaria, between acute and chronic presentations, and between pediatric and adult patients. In P. falciparum malaria, the most clinically urgent renal manifestation is the acute kidney injury (AKI) of severe malaria, which occurs in approximately 30 to 40 percent of adults with severe P. falciparum malaria (but is less common in children, where severe anemia and cerebral malaria predominate) and is primarily caused by acute tubular necrosis from the combined effects of reduced renal perfusion (from the microvascular obstruction of PRBC sequestration), direct tubular toxicity from free hemoglobin (released by hemolysis) and heme, and the proinflammatory cytokine cascade of severe falciparum infection. The AKI of severe malaria classically presents with oliguria (urine output below 0.5 mL/kg/hour), rising serum creatinine (with a characteristic rise of more than 44 micromol/L per day in rapidly progressive cases), elevated serum potassium (hyperkalemia from the combination of hemolytic potassium release, metabolic acidosis-driven transcellular potassium shift, and reduced renal potassium excretion), and metabolic acidosis (from renal failure combined with the lactic acidosis of severe malaria). The management of malaria-associated AKI requires specific attention to fluid balance in the CHT clinical context: aggressive fluid resuscitation that is appropriate for dengue shock syndrome (where the therapeutic goal is rapid volume restoration) may precipitate pulmonary edema in severe malaria AKI (where the disrupted pulmonary endothelium from TNF-alpha activation is already vulnerable to fluid overload), and the WHO guidelines for severe malaria specifically recommend cautious fluid administration (not exceeding 3.5 mL/kg/hour of isotonic saline for adults) rather than aggressive fluid loading.

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When AKI from malaria requires renal replacement therapy (in patients with severe hyperkalemia, refractory acidosis, pulmonary edema from fluid overload, uremic pericarditis, or anuric AKI beyond 24 hours), continuous renal replacement therapy (CRRT) or peritoneal dialysis (PD) is the recommended modality, both because intermittent hemodialysis produces hemodynamic instability in the critically ill malaria patient and because CRRT (if available) or PD (more feasible in CHT district hospital settings) provides gentler, sustained fluid and solute removal. The renal outcomes of malaria-associated AKI are generally favorable when adequate supportive care is provided and the underlying malaria is effectively treated: the majority of patients recover renal function to near-baseline within two to eight weeks, but approximately 10 to 20 percent of survivors of severe malaria AKI develop residual CKD, and these individuals require long-term follow-up of renal function, blood pressure, and proteinuria.

4.3 Snake Envenomation and Renal Failure in the CHT

Snakebite, a neglected tropical disease that the WHO added to its priority NTD list in 2017, is a significant cause of morbidity and mortality in the CHT, where jhum agricultural work, forest product collection, and the peridomestic habitat of several venomous species create frequent human-snake encounters that result in approximately 600 to 800 snakebite deaths annually in Bangladesh (national estimate), with a significant proportion occurring in the CHT and adjacent Chittagong division. The venomous snake species of clinical significance in the CHT include the Russell's viper (Daboia russelii), the cobra (Naja naja and Naja kaouthia), the krait species (Bungarus caeruleus, the common krait; and Bungarus fasciatus, the banded krait), and the green pit viper (Trimeresurus species), each of which produces a distinct clinical envenomation syndrome requiring specific recognition and management. Russell's viper envenomation is the most clinically complex and systemically dangerous snakebite in Bangladesh, producing a multisystem envenomation syndrome that specifically includes acute kidney injury of sufficient severity to require dialysis in approximately 20 to 30 percent of cases, systemic bleeding from venom-induced consumption coagulopathy (disseminated intravascular coagulation from the venom's procoagulant and anticoagulant factor activators), local tissue necrosis at the bite site (from cytotoxic phospholipase A2 components of the venom), and, in some cases, bilateral acute cortical necrosis (the most severe renal manifestation of Russell's viper envenomation, where bilateral renal cortical infarction from microvascular thrombosis produces irreversible renal failure requiring permanent dialysis, a clinical catastrophe in the CHT where long-term renal replacement therapy is not available outside Chittagong or Dhaka). The 20-minute whole blood clotting test (20WBCT), in which 2 mL of venous blood is placed in a clean glass test tube and observed for clot formation at 20 minutes, is the most practically feasible coagulopathy screening test in resource-limited CHT settings: if the blood fails to clot at 20 minutes, this indicates consumption coagulopathy from viperid (Russell's viper or pit viper) envenomation and is an indication for antivenom administration. The polyvalent snake antivenom (PSAV) produced in India and Pakistan and used in Bangladesh is effective against the major viper and elapid species of the region, but its availability at CHT upazila health complexes is inconsistently maintained, and the logistical management of cold-chain antivenom storage at remote facilities with unreliable electricity is a persistent challenge. The snakebite management protocol for CHT facilities must include immediate immobilization of the bitten limb (which reduces venom absorption by limiting lymphatic flow), IV access establishment, 20WBCT at 20 minutes,

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antivenom administration when indicated (for systemic envenomation signs: coagulopathy, neurotoxicity, hemolysis, or renal compromise) at the recommended initial dose (10 vials of PSAV in 250 to 500 mL normal saline over 30 to 60 minutes), and urgent referral to a facility with renal replacement capability for patients showing evidence of Russell's viper-associated coagulopathy and AKI.

4.4 Nephrolithiasis in the CHT: The Stone Disease of the Hills

Nephrolithiasis (kidney stones, urolithiasis) is a condition whose CHT-specific epidemiology reflects the territory's distinctive hydrology, diet, and climate in ways that produce stone risk profiles different from those of Bangladesh's plains population. The most important CHT-specific risk factors for stone formation are: chronic mild dehydration from physically demanding outdoor labor in hot months with limited clean water access (which concentrates urinary solutes and reduces protective urinary flow rates); the dietary pattern of high-oxalate foods in some CHT communities (including spinach, cassava leaves, and some traditional plant foods that are rich in oxalate); the high protein content of the traditional diet in communities with access to bushmeat and fish (which increases urinary uric acid and calcium excretion); and the naturally elevated fluoride content in some CHT hill spring waters (which, while more classically associated with dental and skeletal fluorosis than with nephrolithiasis, is being increasingly studied for its potential interaction with crystal nucleation in the renal tubule). The most common stone type in Bangladesh is calcium oxalate (as in most global populations), but uric acid stones may be more prevalent in communities with high purine intake from bushmeat and fish. The clinical presentation of renal colic in CHT patients (sudden onset severe flank pain radiating to the groin, often with nausea and vomiting, hematuria on urine dipstick, and costovertebral angle tenderness) is a recognizable clinical syndrome that should trigger initial management including diclofenac or ketorolac IM for analgesia (preferred over opioids for renal colic), alpha-1 adrenergic blocker therapy (tamsulosin 0.4 mg daily) as medical expulsive therapy for stones up to 10 mm in the lower ureter (which increases the spontaneous passage rate from approximately 50 percent to approximately 75 percent), adequate hydration, and urine straining to collect passed stones for composition analysis. Stones larger than 10 mm, stones associated with obstruction and infection (a urological emergency requiring immediate decompression by ureteric stent or percutaneous nephrostomy and urgent antibiotics for the infected obstructed urinary system), and stones that fail to pass spontaneously after four to six weeks require urological intervention (shock wave lithotripsy or ureteroscopy) at a specialist urological facility in Chittagong.

MODEL EXAMINATION QUESTIONS: CHAPTER FOUR (PART FIVE)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The 20-minute whole blood clotting test (20WBCT) is used in snakebite management to detect: a) The specific snake species responsible for the bite b) Venom-induced consumption coagulopathy from viperid envenomation c) Neurotoxic venom components from krait or cobra bites d) Infection risk from the bite wound (Correct Answer: b)

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Bilateral acute cortical necrosis, the most severe renal complication of Russell's viper envenomation, produces: a) Reversible AKI that resolves with antivenom treatment b) Irreversible renal failure requiring permanent renal replacement therapy c) Partial renal impairment that stabilizes over weeks d) Isolated tubular dysfunction without glomerular involvement (Correct Answer: b)

Aristolochic acid nephropathy, relevant to CHT botanical medicine safety, is characterized pathologically by: a) Mesangial IgA deposition b) Rapidly progressive, irreversible interstitial nephritis with progression to end-stage renal disease c) Membranous nephropathy with heavy proteinuria d) Granulomatous renal inflammation (Correct Answer: b)

The initial recommended fluid administration rate for an adult with severe P. falciparum malaria and AKI, according to WHO severe malaria guidelines, is: a) Aggressive fluid resuscitation at 30 mL/kg in 30 minutes b) Cautious administration not exceeding 3.5 mL/kg/hour of isotonic saline c) Fluid restriction to 500 mL per 24 hours d) Normal saline 1 liter over 1 hour as routine initial management (Correct Answer: b)

Medical expulsive therapy for ureteric stones up to 10 mm in the lower ureter uses which drug class? a) Beta-2 adrenergic agonists b) Alpha-1 adrenergic blockers (tamsulosin 0.4 mg daily) c) Calcium channel blockers d) Non-steroidal anti-inflammatory drugs (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 33-year-old Chakma jhum farmer is brought to Khagrachhari District Hospital following a snake bite to the right leg sustained while clearing a jhum field. Physical examination shows two fang marks on the right lower leg with local swelling. At 20 minutes, the 20WBCT blood sample shows no clot formation. Blood pressure is 90/60 mmHg, pulse 110 per minute, and the patient reports dark urine. Urine dipstick shows 3+ blood. Serum creatinine is 280 micromol/L. The snake was killed and brought in: it has a flattened, triangular head and a distinctive chain-like dorsal pattern. The most appropriate immediate management sequence is: a) Antivenom administration only; no further investigations needed b) Identify the snake morphology as consistent with Russell's viper (Daboia russelii); the clinical picture (coagulopathy on 20WBCT, hemolysis with hematuria, hypotension, and AKI) represents systemic Russell's viper envenomation requiring: (i) immediate administration of polyvalent snake antivenom (10 vials in 250 mL normal saline over 30 to 60 minutes) with adrenaline 0.5 mL of 1:1000 IM drawn up and ready for anaphylaxis management during antivenom infusion; (ii) cautious IV fluid therapy for hemodynamic support while monitoring for fluid overload; (iii) urgent coagulation screen (PT, APTT, fibrinogen) to quantify coagulopathy; (iv) repeat 20WBCT at 6 hours to assess antivenom response (if still unclotted, repeat antivenom dose); (v) urological monitoring with hourly urine output; (vi) urgent referral planning to Chittagong Medical College Hospital for renal replacement therapy given the AKI severity and hemodynamic compromise, which indicates high risk for bilateral acute cortical necrosis c) Apply tourniquet to the bitten limb and inject antivenom locally around the bite site d) Observe for 24 hours before deciding on antivenom (Correct Answer: b)

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CHAPTER FIVE: MUSCULOSKELETAL, RHEUMATOLOGICAL, AND OCCUPATIONAL INJURY MEDICINE IN THE CHITTAGONG HILL TRACTS

5.1 The Occupational Musculoskeletal Burden: Terrain, Labor, and the Body Under Load

The musculoskeletal health of CHT indigenous communities is shaped by the physical demands of subsistence agriculture on steep, difficult terrain, the occupational hazards of forest work and river labor, the nutritional deficiencies that compromise bone density and muscle integrity, the injury risks of a physically demanding life without modern mechanical assistance, and the virtual absence of occupational health surveillance or ergonomic intervention in any CHT workplace. The CHT Occupational Musculoskeletal Doctrine holds that musculoskeletal injury and disease in the CHT is primarily an occupational and ecological phenomenon rather than a primarily degenerative or idiopathic one, and that its prevention and management require engagement with the specific occupational and environmental determinants of each condition rather than simply applying diagnostic and treatment algorithms designed for sedentary, well-nourished urban patients to a population whose musculoskeletal problems are rooted in the physical realities of their working life on the hill terrain. The primary occupational musculoskeletal conditions of the CHT include: acute traumatic injuries (fractures, dislocations, lacerations, and crush injuries from falls on steep terrain, from falling timber during forest work, from agricultural tool injuries, and from falls into rivers during fishing); acute overload injuries (muscle tears, ligament sprains, and acute disc prolapse from the carrying of heavy loads on steep slopes, which is the primary means of freight transport in parts of the CHT where roads do not reach); chronic overuse injuries (tendinopathies, stress fractures, and chronic back pain from years of repetitive heavy labor in non-ergonomic postures); and degenerative joint disease (osteoarthritis, which is accelerated by both the mechanical loading of heavy agricultural labor and the nutritional risk factors of vitamin D deficiency and protein-energy malnutrition that impair cartilage health and repair).

5.2 Fracture Management in the CHT: The Terrain of Trauma

The management of fractures in the CHT presents a set of clinical challenges that arise from the convergence of geographic isolation (which creates long transport times between injury site and surgical facility), resource limitations (which restrict the available fixation methods, imaging modalities, and anesthetic options), nutritional vulnerability (which impairs fracture healing and increases the risk of wound infection after open fractures), and the specific injury mechanisms of the CHT (which produce fracture patterns reflecting the forces of falls on steep terrain, falling timber impact, and agricultural trauma). The initial management of suspected fractures in the CHT, at the community or primary care level, should follow the RICE principle (Rest, Immobilization, Cold application, Elevation) combined with analgesia (diclofenac or paracetamol for mild to moderate pain, with tramadol or morphine where available for severe pain, following the WHO analgesic ladder principles adapted to CHT formulary constraints), splinting with improvised materials (bamboo splints padded with clothing material can provide adequate immobilization for transportation of limb fractures when formal plaster of Paris

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equipment is unavailable), and urgent referral to a facility with X-ray capability and orthopedic management capacity. The specific fractures deserving priority management attention in the CHT context are: femoral neck fractures in the elderly (where the combination of osteoporosis from vitamin D deficiency and calcium inadequacy, and the fall risk from living and working on steep terrain, creates a high risk of the hip fracture that, without surgical intervention, carries a mortality of approximately 25 to 30 percent at one year from thromboembolic and other complications), open fractures (requiring urgent antibiotics and wound management to prevent the osteomyelitis that is devastating in a patient without access to long-term specialist orthopedic care), and spine fractures from falls on steep terrain (requiring immobilization and urgent referral with specific attention to neurological monitoring, since delayed recognition of spinal cord compression produces preventable permanent paralysis). The management of osteoporosis risk in CHT elderly communities requires population-level attention to vitamin D supplementation (vitamin D deficiency is prevalent in CHT communities from a combination of dietary inadequacy and, paradoxically in a sun-rich environment, skin coverage practices and the limited direct solar exposure of individuals who work under forest canopy cover), calcium intake improvement through dietary diversification, and fall prevention through home hazard assessment and community exercise programs for balance and strength.

5.3 Rheumatological Disease in the CHT: The Overlooked Articular Burden

Rheumatological diseases, encompassing the spectrum of inflammatory, autoimmune, crystal arthropathy, and degenerative joint and connective tissue diseases, have received essentially no systematic epidemiological attention in the CHT despite their likely significant prevalence and impact. The CHT-specific rheumatological conditions of priority clinical importance include: rheumatic fever and rheumatic heart disease (RHD), which remain highly prevalent in Bangladesh (significantly above the global average) and in the CHT specifically, because the environmental and social conditions that drive Group A Streptococcal pharyngitis (overcrowding, poverty, malnutrition) are maximally present in CHT indigenous communities, and because the secondary prophylaxis with benzathine penicillin G injections that is the only established method for preventing recurrent rheumatic fever and the progressive valvular damage of RHD requires monthly injections for five to ten years, a treatment duration and visit frequency that the geography and poverty of the CHT make extremely difficult to sustain; reactive arthritis (formerly Reiter's syndrome) following the enteric infections (Shigella, Salmonella, Campylobacter, Yersinia) and sexually transmitted infections (Chlamydia trachomatis) that are prevalent in the CHT, producing the clinical triad of arthritis, urethritis, and conjunctivitis (or uveitis) and requiring distinction from septic arthritis and gout; gout and hyperuricemia, which may be more prevalent in CHT communities with high purine intake from traditional protein sources (organ meats, bushmeat, and fish) and from alcohol consumption (particularly fermented rice beer, which raises serum uric acid through both alcohol-induced urate production increase and lactate-mediated urate excretion decrease), presenting as the acute monoarthritis of classic gouty arthritis most commonly affecting the first metatarsophalangeal joint (podagra), with the distinction from septic arthritis requiring urgent joint aspiration for synovial fluid analysis; and septic arthritis (bacterial joint infection), which in the CHT context may arise from hematogenous seeding of a joint during bacteremia from untreated skin or soft tissue infections (Staphylococcus aureus and Streptococcus pyogenes are the most common causative organisms,

with Gram-negative organisms including Klebsiella pneumoniae and E. coli causing septic arthritis in immunocompromised patients), and which represents a true orthopedic emergency requiring immediate joint aspiration both for diagnostic confirmation and for therapeutic joint decompression, followed by antibiotic therapy selected based on the Gram stain and culture of the aspirated synovial fluid. The destruction of joint cartilage in septic arthritis occurs within 48 to 72 hours of infection, making early diagnosis and treatment a clinical urgency that must not be subordinated to the delays inherent in CHT healthcare access.

MODEL EXAMINATION QUESTIONS: CHAPTER FIVE (PART FIVE)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The RICE principle of initial musculoskeletal injury management stands for: a) Rest, Ice, Compression, Elevation b) Rest, Immobilization, Cold application, Elevation c) Reduction, Immobilization, Cast, Elevation d) Rest, Irrigation, Compression, Elevation (Correct Answer: b)

The clinical triad of reactive arthritis (formerly Reiter's syndrome) consists of: a) Fever, rash, and lymphadenopathy b) Arthritis, urethritis, and conjunctivitis (or uveitis) c) Joint pain, muscle weakness, and skin tightening d) Splenomegaly, hepatomegaly, and arthritis (Correct Answer: b)

Secondary prophylaxis for rheumatic fever, which prevents recurrent streptococcal infection and progressive valvular damage, is most effectively delivered as: a) Daily oral penicillin V for one year only b) Monthly benzathine penicillin G IM injections for five to ten years (duration depending on the presence and severity of rheumatic heart disease) c) Amoxicillin-clavulanate for three months d) Aspirin for anti-inflammatory prophylaxis (Correct Answer: b)

Septic arthritis represents a clinical urgency because: a) It causes systemic sepsis within hours b) Joint cartilage destruction occurs within 48 to 72 hours of infection c) It is highly contagious and requires isolation d) It causes permanent nerve damage in the adjacent joint capsule (Correct Answer: b)

The acute monoarthritis of classic gout most classically affects which joint? a) Knee joint b) First metatarsophalangeal joint (podagra) c) Wrist joint d) Hip joint (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 45-year-old Marma woman presents to Bandarban District Hospital with a four-day history of severe pain, swelling, warmth, and redness of the right knee with inability to bear weight. She has had two previous similar episodes over three years, both affecting different joints, with each episode resolving spontaneously. She has no fever today. Serum uric acid is 9.2 mg/dL. WBC is 11,000 with mild neutrophilia. CRP is elevated at 45 mg/L. Knee aspiration yields 15 mL of turbid yellow fluid with WBC 35,000/microL (90% neutrophils), glucose low relative to serum, no organisms on Gram stain, and crystals not yet analyzed. The most clinically urgent consideration in the differential diagnosis and management is: a) Diagnose gout immediately based on elevated serum uric acid and treat with colchicine b) Prescribe NSAIDs empirically and

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discharge c) While gout is a reasonable differential given the elevated uric acid and episodic monoarthritis history, the synovial fluid findings (WBC 35,000/microL with 90% neutrophils, turbid fluid) are within the range seen in both gout (inflammatory arthritis) and septic arthritis, and septic arthritis cannot be excluded on clinical and basic laboratory grounds; the absence of fever and negative Gram stain do not exclude septic arthritis; synovial fluid must be sent for crystal analysis under polarized light (negatively birefringent needle-shaped monosodium urate crystals confirm gout) and for culture; while awaiting results, the patient should be admitted; if clinical deterioration suggests septic arthritis (worsening fever, rising WBC, positive culture), IV antibiotics (cloxacillin plus ceftriaxone empirically) should be initiated; the critical error is to treat as gout alone and miss septic arthritis, which would result in joint destruction within 48 to 72 hours d) Perform MRI before any other management (Correct Answer: c)

CHAPTER SIX: GASTROINTESTINAL AND HEPATOLOGICAL MEDICINE IN THE CHITTAGONG HILL TRACTS: THE BURDEN ON THE DIGESTIVE SYSTEM

6.1 The CHT Gastroenterological Burden: A Unified Framework

Gastrointestinal and liver disease in the CHT constitutes one of the most clinically significant and most comprehensively undermanaged disease burdens in the territory. The gastrointestinal system of CHT indigenous community members is subjected to what this textbook terms the CHT Digestive Assault Matrix, a composite of microbial, parasitic, nutritional, chemical, and mechanical insults that act simultaneously and sequentially to produce a pattern of chronic gastrointestinal disease (tropical enteropathy, with villous atrophy, crypt hyperplasia, and impaired nutrient absorption as the persistent baseline state), episodic acute gastroenteric illness (diarrheal disease from the enteropathogens documented in Part Four), and the secondary hepatic and nutritional consequences of sustained gut dysfunction (malabsorption syndromes, protein-calorie malnutrition from impaired absorption even when dietary intake is adequate, micronutrient deficiencies from specific absorptive pathway impairment, and non-alcoholic fatty liver disease in individuals whose metabolism is altered by the combination of episodic malnutrition and emerging dietary transition). The CHT Digestive Assault Matrix operates through five component pathways: the microbial pathway (chronic exposure to diverse enteropathogens that maintain the gut in a state of chronic low-grade inflammation); the parasitic pathway (helminthic intestinal parasites, giardiasis, cryptosporidiosis, and amoebiasis that cause direct mucosal injury and impaired nutrient absorption); the nutritional pathway (protein-energy malnutrition, zinc deficiency, and vitamin A deficiency that all impair intestinal mucosal integrity and repair capacity); the toxic pathway (alcohol consumption, traditional plant preparation hepatotoxins, and agricultural chemical exposures that damage the hepatocyte); and the mechanical pathway (the physical demands of subsistence labor that impair blood flow to the gut during intense exercise periods, combined with the frequent Valsalva maneuvers of heavy lifting that may contribute to the high prevalence of hernia in CHT agricultural workers).

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6.2 Amoebic Liver Abscess: The CHT's Dominant Hepatic Emergency

Amoebic liver abscess (ALA), caused by the invasive protozoan pathogen Entamoeba histolytica following its penetration of the colonic mucosa and hematogenous seeding of the liver via the portal circulation, is the most common hepatic emergency in the CHT and represents the most significant complication of amoebic colitis. Entamoeba histolytica is transmitted by the fecal-oral route through ingestion of cysts from contaminated food and water, and the CHT's severe WASH infrastructure deficit creates conditions of intense endemic transmission. The clinical presentation of ALA in CHT patients follows a characteristic pattern: high fever (above 38.5 degrees Celsius, present in over 90 percent of cases), right upper quadrant abdominal pain (often described as a constant, dull ache that worsens with movement and deep breathing), hepatomegaly with right lobe tenderness (the liver edge palpable two to four finger-breadths below the right costal margin, exquisitely tender on percussion), and a history of recent or current diarrhea in only approximately 30 to 50 percent of cases (contrary to common clinical expectation, the majority of ALA patients have no concurrent amoebiasis and no diarrheal history at the time of abscess presentation). Laboratory findings include elevated ESR and CRP, leukocytosis with neutrophilia, and frequently elevated alkaline phosphatase and bilirubin (reflecting the hepatic inflammation and biliary compression from the expanding abscess). The diagnostic imaging of choice for ALA is ultrasound of the right upper quadrant (demonstrating the characteristic round or oval hypoechoic lesion, typically in the right hepatic lobe, with a well-defined wall), which is available at most CHT district hospitals and provides excellent diagnostic accuracy when performed by experienced operators. The treatment of uncomplicated ALA is metronidazole 750 mg three times daily for ten days (or tinidazole 2 g daily for five days), followed by a luminal amoebicide (diloxanide furoate 500 mg three times daily for ten days, or paromomycin 500 mg three times daily for ten days) to eliminate intestinal colonization and prevent relapse. Percutaneous aspiration of the abscess under ultrasound guidance is indicated for: large abscesses (greater than five to six centimeters diameter) that are at high risk of spontaneous rupture into the pleural space or peritoneum; abscesses in the left lobe (which carry a higher rupture risk into the pericardium); and abscesses that fail to respond to metronidazole therapy within 72 hours.

6.3 Viral Hepatitis in the CHT: The Silent Liver Disease Burden

Viral hepatitis, encompassing the hepatic infections caused by hepatitis A virus (HAV), hepatitis B virus (HBV), hepatitis C virus (HCV), hepatitis D virus (HDV), and hepatitis E virus (HEV), constitutes a major but poorly characterized burden of liver disease in the CHT. Hepatitis A, transmitted by the fecal-oral route through contaminated water and food, is hyperendemic in Bangladesh and in the CHT specifically, with most CHT indigenous children acquiring natural HAV immunity through childhood infection (the most important epidemiological consequence being the shift from universal childhood infection under conditions of very poor sanitation to infection of older adolescents and adults under conditions of partially improved sanitation, producing more severe hepatitis in older-infected individuals, since HAV causes more severe illness with age). Hepatitis E, transmitted by the fecal-oral route and associated specifically with consumption of HEV-contaminated water during flooding events, is the most dangerous viral hepatitis for pregnant CHT women, because the genotype 1 HEV (the strain predominant in

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South Asia) produces fulminant hepatic failure (FHF) in approximately 20 to 25 percent of pregnant women who are infected in the third trimester, with FHF associated with acute liver failure, coagulopathy, hepatic encephalopathy, and a case fatality ratio in pregnant women exceeding 25 percent even with intensive supportive care. The management of HEV-associated FHF in a pregnant CHT woman at a district hospital or upazila health complex represents one of the most challenging clinical scenarios in CHT obstetric medicine, requiring simultaneous management of the hepatic failure (with lactulose for encephalopathy, vitamin K for coagulopathy, fresh frozen plasma when hemorrhage risk is immediate), the obstetric risk (with urgent delivery of the fetus when the gestational age permits, since delivery may improve the mother's hepatic recovery and reduces the risk of intrauterine fetal demise from the placental dysfunction of FHF), and the renal function (HEV-associated FHF can produce the hepatorenal syndrome requiring careful fluid management), all in a setting where intensive hepatology and obstetric specialist expertise is at least several hours away. Hepatitis B virus infection, transmitted primarily through perinatal mother-to-child transmission (vertical transmission) and through sexual contact, blood exposure, and injection drug use, is endemic in Bangladesh at a prevalence of approximately 5 to 7 percent HBsAg positivity in the general population. CHT-specific HBV prevalence data are not available, but the inadequacy of the hepatitis B birth dose immunization (ideally given within 24 hours of birth, but essentially impossible to administer in the majority of CHT deliveries occurring outside health facilities, as documented in Chapter Nine of Part One) means that the prevention of perinatal HBV transmission through timely birth dose vaccination is a systematically failing prevention strategy in the CHT, potentially sustaining higher rates of chronic HBV infection in CHT indigenous communities than the national average.

6.4 Non-Alcoholic Fatty Liver Disease and the CHT Metabolic Transition

Non-alcoholic fatty liver disease (NAFLD), defined as hepatic steatosis (fat accumulation in more than 5 percent of hepatocytes) in the absence of significant alcohol consumption and in the absence of secondary causes of hepatic steatosis (certain medications, Wilson's disease, hepatitis C), is now recognized as the most common liver disease globally, affecting approximately 25 percent of the world's adult population and rising rapidly with the global obesity and metabolic syndrome epidemic. In the CHT, NAFLD represents an emerging but underrecognized component of the NCD transition documented in Part Four, because the metabolic risk factors for NAFLD (including insulin resistance, type 2 diabetes, dyslipidemia, and abdominal obesity) are increasingly prevalent in CHT communities undergoing the dietary transition away from traditional plant-based diets toward processed foods, refined carbohydrates, and cooking oils high in saturated fat. The convergence of the traditional CHT metabolic risk factor of protein-energy malnutrition in early life (which, through the Barker-DOHaD mechanism discussed in Part Four, programs metabolic syndrome risk in adult life) with the dietary transition risk factors of increasing refined carbohydrate and saturated fat intake, is creating in CHT communities a particularly virulent form of NAFLD risk that does not fit the stereotypical image of the obese, sedentary NAFLD patient of high-income countries. CHT NAFLD patients may present with normal or even reduced body weight (in communities where overall caloric inadequacy persists despite dietary quality deterioration) but with significant hepatic steatosis on ultrasound, elevated liver enzymes, insulin resistance (as measured by HOMA-IR), and dyslipidemia (elevated

triglycerides and reduced HDL-cholesterol), constituting the metabolic syndrome pattern even without obesity. The clinical significance of NAFLD is its potential progression from simple steatosis (generally benign and reversible) to non-alcoholic steatohepatitis (NASH, characterized by steatosis plus hepatocellular injury and inflammation on biopsy), to NASH-related cirrhosis, and ultimately to hepatocellular carcinoma (HCC), which may develop on a NASH-cirrhotic background even in the absence of viral hepatitis. The management of NAFLD in the CHT requires a lifestyle intervention framework: caloric restriction and dietary quality improvement (reducing processed carbohydrates and saturated fat, increasing vegetables, legumes, and whole grains), physical activity increase (while recognizing that most CHT agricultural workers are already highly physically active, and that the relevant dietary quality intervention is the primary modifiable target), treatment of coexisting diabetes and dyslipidemia with appropriate medications (metformin and statins being the most relevant in this context), and avoidance of hepatotoxic exposures (particularly alcohol, which dramatically accelerates NAFLD progression, and hepatotoxic traditional plant preparations).

MODEL EXAMINATION QUESTIONS: CHAPTER SIX (PART FIVE)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The clinical presentation of amoebic liver abscess (ALA) includes concurrent diarrheal disease in approximately what proportion of cases? a) 90% of cases b) 30 to 50% of cases c) 5% of cases d) 100% of cases (Correct Answer: b)

Hepatitis E virus (HEV) genotype 1 infection in pregnant women in the third trimester carries a fulminant hepatic failure risk of approximately: a) 2 to 5% b) 20 to 25% c) 50 to 60% d) Less than 1% (Correct Answer: b)

Non-alcoholic fatty liver disease (NAFLD) is defined histologically as hepatic steatosis affecting more than what percentage of hepatocytes? a) 1% b) 5% c) 10% d) 25% (Correct Answer: b)

The treatment regimen for uncomplicated amoebic liver abscess is: a) Oral metronidazole 500 mg twice daily for 5 days, then no follow-up needed b) Metronidazole 750 mg three times daily for 10 days followed by a luminal amoebicide (diloxanide furoate or paromomycin) c) Intravenous ceftriaxone plus metronidazole for all cases d) Percutaneous aspiration without antibiotics for all cases (Correct Answer: b)

The hepatitis B birth dose, ideally given within 24 hours of birth, prevents which primary mechanism of HBV transmission? a) Waterborne HBV transmission in infancy b) Perinatal mother-to-child (vertical) HBV transmission during delivery c) Sexual transmission in adolescence d) Blood transfusion-associated transmission (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 28-year-old Mro woman at 34 weeks gestation is brought to Alikadam UHC with a two-day history of jaundice, abdominal pain, confusion, and bleeding from the gum line. She lives

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adjacent to the Sangu river and the community experienced flooding two weeks ago. Her blood pressure is 130/80 mmHg (ruling out severe pre-eclampsia as the primary diagnosis). Liver enzymes show ALT 1,890 U/L, total bilirubin 18.4 mg/dL. PT is prolonged at 38 seconds (control 12 seconds). Urine is deep tea-colored. HBsAg is negative. The most likely diagnosis and most critical immediate management decisions are: a) Diagnose pre-eclampsia with HELLP syndrome; deliver urgently b) The clinical picture of acute liver failure with coagulopathy, hepatic encephalopathy (confusion), and jaundice following flood water exposure in a third-trimester pregnancy in the CHT context is highly consistent with HEV-associated fulminant hepatic failure; HBsAg is negative, reducing HBV as the cause; immediate management priorities are: (i) notify CMCH obstetricians and arrange emergency transfer by the fastest available means; (ii) lactulose 30 mL three times daily and consider low-protein diet for hepatic encephalopathy management during transfer; (iii) IV vitamin K 10 mg for coagulopathy; (iv) do not give fresh frozen plasma prophylactically (reserve for active bleeding); (v) monitor urine output for hepatorenal syndrome; (vi) given 34 weeks gestation, delivery may be considered at the receiving hospital after specialist review, since delivery may improve maternal hepatic recovery; (vii) send HEV IgM serology, HAV IgM serology, and viral panel to differentiate; (viii) treat seizures if they develop with IV magnesium sulfate (first-line for eclampsia) while simultaneously managing the hepatic failure c) Prescribe metronidazole for amoebic hepatitis d) Reassure and monitor; hepatitis in pregnancy is self-limiting (Correct Answer: b)

CHAPTER SEVEN: OPHTHALMOLOGICAL AND OTOLARYNGOLOGICAL MEDICINE IN THE CHITTAGONG HILL TRACTS: THE SENSORY DISEASE BURDEN

7.1 The CHT Sensory Health Crisis: Eyes and Ears at the Ecological Frontier

Visual and auditory health in the CHT is compromised by a combination of preventable disease, nutritional deficiency, occupational exposure, and access failure that produces rates of avoidable blindness and hearing impairment substantially exceeding national averages. The World Health Organization's 2024 World Report on Vision estimated that globally 43 million people are blind and 295 million have moderate or severe visual impairment, with approximately 90 percent of visual impairment occurring in low- and middle-income countries. The CHT's specific contributors to preventable blindness and visual impairment include: cataract (the leading cause of blindness globally, accounting for approximately 50 percent of all blindness in low-income countries, with its risk accelerated in the CHT by ultraviolet radiation exposure from outdoor agricultural and forest work at the high altitude and forest-clearance areas of the territory, nutritional deficiency including vitamin C and vitamin E which are antioxidant protectors of the lens, and dehydration from outdoor labor that may accelerate lens protein denaturation); vitamin A deficiency-related corneal disease (xerophthalmia, including the progression from night blindness to Bitot's spots to corneal ulceration to keratomalacia and corneal scar-mediated blindness, which is particularly devastating in CHT children because it is entirely preventable through vitamin A supplementation and diet diversification, and it clusters precisely in communities like the Mro and Khumi where food insecurity and dietary diversity deficits are

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most extreme); measles-related corneal disease (the 2025 measles outbreak in the Mro community produced cases of keratoconjunctivitis in vitamin A-deficient children, with the risk of corneal ulceration and permanent blindness documented in post-measles surveys as a preventable complication of both the measles infection and the concurrent vitamin A deficiency); trachoma (a chronic ocular infection caused by Chlamydia trachomatis, which causes recurrent conjunctivitis leading to trichiasis, corneal abrasion, and ultimately corneal opacity and blindness, and which is associated with inadequate face hygiene and water scarcity, both conditions prevalent in CHT communities); diabetic retinopathy (emerging as a cause of visual impairment with the NCD transition, in CHT patients with type 2 diabetes who are undetected or untreated); and trauma-related visual loss (from agricultural tool injuries, forest debris, and the chemical eye injuries from forest plant sap exposure).

7.2 Cataract Surgery Delivery in the CHT: The Challenge of Eye Camp Medicine

Cataract, the opacity of the crystalline lens that progressively impairs visual acuity from blurred vision to light perception only, is the leading cause of treatable blindness in the CHT, and its treatment (surgical lens extraction with or without intraocular lens implantation) is one of the most cost-effective surgical interventions in global health, with an estimated cost per disability-adjusted life year (DALY) averted in the range of USD 15 to 100 in South Asian contexts. The challenge in the CHT is not the technical complexity of cataract surgery but the access to surgical services: the tertiary ophthalmology facility at Chittagong Medical College Hospital (the primary surgical cataract service for the CHT) is effectively unreachable for the majority of visually impaired CHT residents from remote communities, not only because of the transport cost and difficulty but because the social and economic structure of CHT communities makes extended absence for recovery from surgical procedures extremely difficult for the primary agricultural workers and caregivers who constitute most of the visually impaired population. The mobile eye camp model, in which an ophthalmological surgical team travels to a centrally accessible community location in the CHT to conduct screening, operate on cataract patients, and provide follow-up, has been demonstrated in Bangladesh and globally to be a highly effective modality for increasing cataract surgical coverage in remote areas. The adaptation of the mobile eye camp model to the CHT requires attention to several context-specific factors: language (examination and counseling must be conducted in indigenous languages with trained interpreters), community mobilization (the karbari and village headman network must be engaged to identify and refer visually impaired community members well in advance of the camp), post-operative follow-up (which must be structured around community health workers who can manage the immediate post-operative period, recognizing that patients may not be able to travel back to the camp for routine follow-up), and quality assurance (the visual outcome of cataract surgery at mobile eye camps must be systematically monitored against the WHO target of good visual outcome of 6/18 or better in 85 percent of operated eyes, to ensure that community trust in surgical eye care is maintained through demonstrated outcomes quality).

7.3 Otolaryngological Disease in the CHT: Ear, Nose, and Throat Burden

The otolaryngological disease burden of the CHT is dominated by conditions that reflect the territory's specific environmental exposures, infectious disease ecology, and occupational hazard

profile. Chronic suppurative otitis media (CSOM, defined as a persistent discharge from the middle ear through a tympanic membrane perforation lasting more than two weeks), is prevalent in CHT children because of the high rate of recurrent acute otitis media (AOM, the acute middle ear infection that is a common complication of the respiratory viral infections endemic in CHT communities), the nutritional vulnerability that impairs immune response and promotes bacterial superinfection of the middle ear, and the delayed treatment of AOM that allows perforation and progression to chronicity. CSOM produces conductive hearing loss that impairs language acquisition and educational progress in affected CHT children, compounding the educational disadvantage already produced by poverty, geographic isolation, and language barriers. The management of CSOM in CHT settings requires the topical antibiotic treatment of the discharging ear (ciprofloxacin ear drops have the best evidence base for CSOM and are appropriate as primary treatment for CHT peripheral facilities), combined with aggressive management of the underlying risk factors (nutritional rehabilitation, pneumococcal vaccination to reduce recurrent AOM, management of adenoid hypertrophy where it is identified as a contributing factor). Surgical management of CSOM (tympanoplasty for tympanic membrane closure) is available at tertiary level and should be offered to CHT patients where CSOM fails to resolve with medical management and where the hearing loss is functionally significant. Noise-induced hearing loss (NIHL) is a significant occupational health concern in CHT communities that use chainsaws, diesel-powered rice mills, and portable generators without hearing protection, and it represents a preventable cause of permanent sensorineural hearing loss that receives essentially no preventive attention in the CHT's occupational health (non-) framework. The screening for hearing impairment in CHT communities, using the simple finger rub test (generating a high-frequency friction sound adjacent to each ear canal) for community-level screening and pure tone audiometry (available at district hospital ENT clinics) for formal assessment, is a priority that should be integrated into the routine health assessment activities of CHT community health workers.

MODEL EXAMINATION QUESTIONS: CHAPTER SEVEN (PART FIVE)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Xerophthalmia, the ocular complication of vitamin A deficiency, progresses through which sequence? a) Cataract to glaucoma to blindness b) Night blindness to Bitot's spots to corneal ulceration to keratomalacia and corneal scar blindness c) Conjunctivitis to uveitis to optic atrophy d) Retinal detachment to vitreous hemorrhage to blindness (Correct Answer: b)

Trachoma, a cause of preventable blindness in resource-limited settings, is caused by which pathogen? a) Herpes simplex virus type 1 b) Chlamydia trachomatis c) Neisseria gonorrhoeae d) Adenovirus (Correct Answer: b)

The WHO target for good visual outcome (visual acuity of 6/18 or better) after cataract surgery in quality-assured programs is: a) 50% of operated eyes b) 70% of operated eyes c) 85% or more of operated eyes d) 100% of operated eyes (Correct Answer: c)

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Chronic suppurative otitis media (CSOM) is defined by the presence of: a) Acute otalgia with fever b) Persistent ear discharge through a tympanic membrane perforation lasting more than 2 weeks c) Bilateral sensorineural hearing loss d) Tinnitus and vertigo (Correct Answer: b)

The first-line topical antibiotic treatment for CSOM with the best evidence base is: a) Gentamicin ear drops b) Ciprofloxacin ear drops c) Neomycin-polymyxin ear drops d) Chloramphenicol ear drops (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A mobile eye camp is being planned for a remote Tanchangya community in Khagrachhari. The ophthalmology team leader asks the CHT District Health Officer for a comprehensive pre-camp quality planning framework. Based on the principles in this chapter, the framework should address: a) Drug procurement for malaria only; cataract surgery planning is not a public health priority b) The following simultaneous elements: (i) community mobilization through karbari and headman networks to identify and refer visually impaired patients in advance; (ii) examination and counseling protocols in the Tanchangya language using trained interpreters; (iii) pre-operative patient assessment including comorbidity screening (hypertension, diabetes management for surgical safety); (iv) quality surgical protocols targeting WHO cataract surgical outcome standards of 6/18 or better in 85% of operated eyes; (v) training of community health workers in immediate post-operative care and follow-up for the recovery period; (vi) systematic recording of all screening and surgical outcomes for quality monitoring and reporting; (vii) advance arrangement of emergency transport for any surgical complications requiring tertiary facility management c) Surgery on all screened patients regardless of indication to maximize output d) Vitamin A supplementation as the only intervention; surgery is not appropriate in remote settings (Correct Answer: b)

CHAPTER EIGHT: CANCER EPIDEMIOLOGY, ONCOLOGICAL EMERGENCY MANAGEMENT, AND PALLIATIVE CARE IN THE CHITTAGONG HILL TRACTS

8.1 The CHT Cancer Burden: A Landscape of Invisible Malignancy

Cancer in the CHT is an invisible epidemic, invisible not because it is absent (the epidemiological risk factors for multiple cancer types are powerfully present in the CHT population) but because the detection, diagnosis, and registration of cancer in the territory is so inadequate that the CHT cancer burden exists outside the data systems that would make it visible to policymakers, program planners, and the medical community. The National Cancer Registry of Bangladesh, which records cancer diagnoses from major cancer hospitals and pathology centers, captures essentially none of the CHT indigenous population's cancer burden, because CHT patients almost never reach the tertiary cancer facilities whose registrations constitute the data sources of the national registry. This systematic data invisibility of CHT cancer creates what this textbook terms the CHT Cancer Invisibility Paradox: the communities with the highest concentration of cancer risk factors (tobacco and betel nut use, persistent viral infections,

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nutritional deficiency impairing immune cancer surveillance, occupational carcinogen exposures, and limited cancer screening access) are simultaneously the communities least represented in the cancer data that determine where cancer control resources are allocated. The CHT Cancer Invisibility Paradox is not a technical data problem. It is a structural injustice that produces material harm by allowing the CHT cancer burden to remain unaddressed by the national cancer control program. The cancer types of highest epidemiological priority in the CHT, based on the convergence of risk factor prevalence and biological plausibility, are: oral and oropharyngeal cancer (from the areca nut-tobacco-betel leaf chewing practice documented across multiple CHT communities); lung cancer (from indoor biomass smoke exposure, with established epidemiological links between solid fuel cooking smoke and non-small cell lung cancer in never-smoking women documented in multiple large cohort studies from Asia); cervical cancer (caused by high-risk human papillomavirus types 16 and 18, transmitted sexually, with Bangladesh among the countries with the highest cervical cancer burden globally, and with cervical cancer screening coverage in the CHT essentially zero); hepatocellular carcinoma (arising on the background of chronic HBV infection and increasingly on NAFLD-related cirrhosis); colorectal cancer (with an emerging risk from the dietary transition toward processed food and reduced fiber intake); and skin squamous cell carcinoma (from cumulative ultraviolet radiation exposure in outdoor agricultural and forest workers, and from the chronic inflammatory skin changes of jute-processing and other occupational exposures).

8.2 Oral Cancer in the CHT: The Most Preventable Malignancy

Oral cancer, encompassing squamous cell carcinoma of the oral cavity (lips, anterior tongue, floor of mouth, buccal mucosa, gingiva, and hard palate), oropharynx (soft palate, tonsils, posterior tongue), and hypopharynx, is the cancer type with the highest direct epidemiological link to specific and modifiable CHT behavioral risk factors, making it simultaneously the most preventable cancer in the territory and, given the absence of prevention programs, one of the most catastrophically managed. Oral squamous cell carcinoma in South and Southeast Asia is causally linked to the chewing of areca nut (Areca catechu, betel nut), tobacco, and betel leaf (Piper betle) in various combinations, with areca nut serving as the primary carcinogen and tobacco dramatically amplifying the risk. The biologically active carcinogens in areca nut include arecoline, arecaidine, and the areca nut alkaloids that are metabolized to nitrosamines (powerful carcinogens) in the oral cavity, with the alkaline environment created by the addition of slaked lime (calcium hydroxide) to the betel quid dramatically accelerating this nitrosamine formation. The clinical sequence from areca nut exposure to oral cancer proceeds through the premalignant lesions of oral submucous fibrosis (OSF, a progressive fibrotic disease of the oral submucosa characterized by burning sensation, reduced mouth opening, and blanching and stiffness of the oral mucosa), oral leukoplakia (white non-removable plaques that cannot be classified clinically or pathologically as any other condition, with approximately 2 to 6 percent annual malignant transformation rate), and erythroplakia (red mucosal patches with a substantially higher malignant transformation rate of approximately 14 to 50 percent). The early detection of oral premalignant lesions and early-stage oral cancers, when they are entirely curable by local surgical excision or radiotherapy with five-year survival rates exceeding 80 percent, is the most clinically impactful intervention available for reducing CHT oral cancer mortality. The visual inspection with acetic acid (VIA) method, widely validated for cervical

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cancer screening, has been adapted for oral cancer screening as the Oral Cancer Screening with Visual Inspection (OCSVI) method, in which a trained health worker applies a 3 to 5 percent acetic acid solution to the oral cavity and visually inspects the mucosa under good lighting for acetowhite lesions (which represent the acetowhite staining of dysplastic epithelium) for immediate clinical action or referral. The deployment of community health workers trained in OCSVI for opportunistic oral cancer screening during household health visits in CHT communities with high areca nut-tobacco use prevalence represents the most operationally feasible strategy for improving early oral cancer detection in the territory.

8.3 Palliative Care in the CHT: The Ethics and Practice of Comfort at the End of the World's Edge

Palliative care, defined by the WHO as the approach that improves the quality of life of patients and their families facing the problems associated with life-threatening illness, through the prevention and relief of suffering by means of early identification and impeccable assessment and treatment of pain and other problems, physical, psychosocial, and spiritual, is perhaps the most underresourced and least developed component of the CHT health system, despite being arguably the most universally needed. Cancer patients in the CHT, who virtually universally present with late-stage disease due to the absence of early detection programs and the barriers to timely specialist care, require palliative care services that address not only their physical pain (which is the most immediately visible and most universally experienced dimension of advanced cancer) but their psychological suffering, their spiritual distress, their family's burden of care, and their practical needs for symptom management in a resource-limited, geographically isolated setting. The CHT Palliative Care Framework proposed in this chapter is grounded in four principles: the Dignity Principle (that every CHT patient with life-threatening illness deserves to be treated with respect and compassion that honors their personhood, their cultural identity, and their right to die with dignity in a setting that is meaningful to them); the Access Principle (that palliative care for CHT patients must be delivered where patients actually are, which is predominantly in their villages and homes rather than in distant hospitals, requiring a community-based palliative care model that integrates trained community health workers, family caregivers, and traditional healers as components of the palliative care team); the Pharmacological Access Principle (that oral morphine, the cornerstone of cancer pain management globally and recommended by the WHO as an essential medicine, must be made available at CHT district hospital level and ideally at upazila health complex level through a regulated, access-monitored supply chain that addresses the legitimate opioid regulation concerns without creating the access barriers that deny palliative care patients the analgesia they need); and the Cultural Integration Principle (that palliative care in the CHT must be adapted to the specific spiritual and cultural frameworks of CHT patients' communities, integrating Buddhist healing rituals, traditional community mourning practices, and indigenous concepts of a good death into the care approach, rather than imposing a Western biomedical model of clinical dying that is alienating and inappropriate in the CHT's sociocultural context). The CHT community health worker trained in basic palliative care (symptom recognition, oral morphine dose titration within a supervised protocol, family caregiver training, and psychological support for the dying patient and grieving family) is the most important single personnel resource for

expanding palliative care reach in the CHT, and their training and support must be a priority of any CHT cancer control or palliative care development initiative.

MODEL EXAMINATION QUESTIONS: CHAPTER EIGHT (PART FIVE)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The premalignant oral lesion with the highest malignant transformation rate (approximately 14 to 50 percent) is: a) Oral submucous fibrosis b) Oral leukoplakia c) Erythroplakia d) Geographic tongue (Correct Answer: c)

The carcinogen primarily responsible for the oral cancer risk of areca nut chewing is generated through: a) Direct DNA alkylation by arecoline b) Nitrosamine formation from areca nut alkaloids metabolized in the alkaline oral environment created by slaked lime c) Free radical generation from betel leaf essential oils d) Inflammatory prostaglandin production from tobacco-induced tissue damage (Correct Answer: b)

The five-year survival rate for early-stage oral cancer detected at stage I or II and treated with curative intent (surgery or radiotherapy) is approximately: a) 20 to 30% b) 50 to 60% c) More than 80% d) Less than 10% (Correct Answer: c)

The WHO Essential Medicines List includes oral morphine as the cornerstone of: a) Antibiotic treatment for oral infections b) Cancer pain management in palliative care c) Anaesthesia for minor surgical procedures d) Opioid substitution therapy for heroin dependence (Correct Answer: b)

The CHT Cancer Invisibility Paradox refers to: a) The fact that cancer is invisible to the naked eye until advanced stages b) The structural inequity whereby communities with the highest cancer risk factor burden are least represented in the cancer data that determine resource allocation c) The inability of cancer cells to be detected by standard blood tests d) The invisibility of cancer symptoms until the patient reaches hospital (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A district health officer in Bandarban conducts a rapid oral health assessment of 300 adults in three indigenous communities. The assessment finds that 78 percent of adults over 40 years are habitual areca nut and tobacco chewers. Examination by a trained nurse using visual inspection reveals 23 adults with white or red mucosal patches and 8 with restricted mouth opening consistent with oral submucous fibrosis. No individual in any of the three communities has ever had a formal oral health examination. Which program design elements are most critical for an immediate and sustained oral cancer control response to these findings? a) Distribute antiseptic mouthwash to all identified cases b) The following elements are essential: (i) urgent dental or surgical officer review of the 31 cases with mucosal abnormalities for histopathological biopsy assessment (leukoplakia requires biopsy to grade dysplasia; erythroplakia requires urgent biopsy; OSF should be biopsied from areas of maximum restriction); (ii) referral of any biopsy-proven

malignancy or high-grade dysplasia to CMCH surgical oncology for definitive treatment; (iii) behavioral cessation counseling for all betel quid-tobacco users in the communities using indigenous-language materials and community influencer engagement (karbaris, monks); (iv) establishment of annual oral mucosal screening as part of the routine health assessment for all adults in the communities; (v) community-level health education on recognizing early symptoms (non-healing oral sores, white or red patches, restricted mouth opening, unexplained pain) and the importance of early presentation; (vi) advocacy for CHT inclusion in the national cancer registry to ensure that CHT cancer burden becomes visible in national data c) Prescribe vitamin A supplements to all identified cases d) Refer all cases to the National Institute of Cancer Research and Hospital (NICRH) in Dhaka (Correct Answer: b)

CHAPTER NINE: EMERGENCY MEDICINE, TRAUMA SURGERY, AND CRITICAL CARE IN THE CHITTAGONG HILL TRACTS

9.1 The Emergency Medicine Void: Terrain, Time, and the Golden Hour in the CHT

Emergency medicine in the CHT operates under conditions that represent the most extreme version of the resource, terrain, and access constraints documented throughout this textbook, because emergency conditions by definition require rapid intervention and the CHT's terrain systematically denies rapidity of clinical response. The golden hour concept of trauma management (the observation that the probability of survival from severe trauma is substantially higher when definitive care is delivered within 60 minutes of injury) and the analogous time-critical windows for other emergency conditions (the 4.5-hour window for intravenous thrombolysis in ischemic stroke, the one-to-two-hour window for antivenom in severe snakebite, the minutes-to-hours window for fluid resuscitation in severe cholera, and the hours-to-day window for antibiotics in bacterial meningitis) are all systematically compromised in the CHT, where the geography of the territory means that the transport time from injury or illness onset to a facility capable of delivering definitive care routinely exceeds these critical windows by hours to days. The CHT Emergency Medicine Void Doctrine holds that the systematic denial of time-sensitive emergency care to CHT communities by the terrain and resource conditions of the territory is not merely a clinical problem but a public health emergency and a structural injustice that contributes to a preventable burden of emergency mortality and morbidity that is both measurable and morally unacceptable. This doctrine has three operational corollaries for emergency care system design in the CHT: the Pre-hospital Stabilization Corollary (which holds that in the CHT, the most impactful emergency medicine intervention is not the hospital emergency department but the community-level pre-hospital stabilization training and equipment that can keep a patient alive during the extended transport time to hospital), the Targeted Intervention Corollary (which holds that the small number of emergency conditions that are both highly prevalent in the CHT and most sensitive to time-critical intervention must be prioritized for specific emergency care pathway development, including: severe malaria, obstetric emergencies, snakebite, acute surgical abdomen, trauma, and severe respiratory failure), and the Communication Infrastructure Corollary (which holds that access to emergency medical advice via telemedicine is the most immediately achievable technology-based emergency care

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improvement available in the CHT context, and that the establishment of a 24-hour medical emergency advice hotline accessible to community health workers and peripheral health facility staff across the CHT is a health system investment that would save lives within weeks of implementation).

9.2 Trauma Management in the CHT: The ABCDE of a Resource-Limited Approach

Trauma, encompassing the physical injuries arising from the multiple high-risk activities of CHT daily life (agricultural falls on steep terrain, falls from trees during forest product collection, river accidents, tool injuries, traffic accidents on narrow hill roads, and the rare but serious injuries of landslide events), is a major contributor to emergency healthcare utilization at CHT health facilities and a leading cause of disability and mortality, particularly among young adult males who are the primary forest and agricultural workers. The management of major trauma in the CHT, whether at the community level, the upazila health complex, or the district hospital, must follow the ABCDE approach of the Advanced Trauma Life Support (ATLS) protocol (Airway with cervical spine protection, Breathing and ventilation, Circulation with hemorrhage control, Disability and neurological assessment, and Exposure and environmental control) adapted to the specific resource constraints and clinical epidemiology of the CHT setting. The most critical CHT-specific modifications of the ATLS approach are as follows. Airway management in a patient with an obstructed airway from maxillofacial trauma, blood, vomit, or foreign body aspiration must be managed with the available tools: jaw thrust and chin lift (preferred over head tilt-chin lift when cervical spine injury is suspected), oropharyngeal and nasopharyngeal airways, and endotracheal intubation when a trained clinician and appropriate equipment are available. Where endotracheal intubation is not possible and the airway is completely obstructed, surgical cricothyrotomy (incision through the cricothyroid membrane to create an emergency airway) is a life-saving procedure that can be performed with a scalpel and a suitable improvised tube or commercially available cricothyrotomy kit, and every CHT medical officer should be trained in this emergency airway procedure. Circulation management must prioritize hemorrhage control: external bleeding should be controlled by direct firm pressure; penetrating truncal trauma with suspected internal hemorrhage requires urgent surgical consultation and preparation for laparotomy (at district hospital level) or urgent transfer to Chittagong Medical College Hospital (for cases where CMCH is the nearest facility with surgical capacity); the permissive hypotension principle (maintaining systolic blood pressure of 80 to 90 mmHg rather than attempting normalization of blood pressure in penetrating trauma with active internal hemorrhage, to avoid the dilution of clotting factors and acceleration of hypothermia-coagulopathy-acidosis that occurs with aggressive early fluid resuscitation before hemorrhage control) has been validated in trauma centers globally but requires clinical judgment to apply in CHT settings where the tools for blood product resuscitation are unavailable. The management of traumatic brain injury (TBI) in the CHT requires the immediate identification of features indicating intracranial mass effect requiring neurosurgical evacuation: the "talk and die" phenomenon (a patient who initially communicates but then progressively deteriorates in GCS) indicates an expanding intracranial hematoma (most commonly an acute epidural hematoma from middle meningeal artery injury), and the clinical recognition of this trajectory is the most critical skill for CHT emergency physicians, because the window for surgical decompression

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before irreversible brainstem herniation is hours, and the transport time to CMCH's neurosurgical unit may consume this entire window.

9.3 The Acute Surgical Abdomen in the CHT: Diagnosis Without Imaging

The acute surgical abdomen, encompassing the spectrum of abdominal emergencies requiring surgical intervention within hours to days (including acute appendicitis, perforated hollow viscus, acute cholecystitis with empyema, bowel obstruction, strangulated hernia, ruptured ectopic pregnancy, ruptured amoebic liver abscess, and peritonitis from any cause), represents a major emergency surgical burden at CHT district hospitals and a diagnostic challenge of the highest order at the lower levels of the health system where imaging is unavailable. The acute abdomen diagnostic framework for the CHT without imaging relies entirely on the history and physical examination, and its accuracy depends on the clinician's mastery of the classic clinical features of each condition in their most recognizable presentation. Acute appendicitis presents classically with periumbilical pain migrating to the right iliac fossa, low-grade fever, anorexia, nausea, localized tenderness over McBurney's point (one-third of the distance from the anterior superior iliac spine to the umbilicus on the right side), and the presence of Rovsing's sign (right iliac fossa pain on palpation of the left iliac fossa), rebound tenderness, and guarding in the right iliac fossa. Bowel obstruction presents with colicky abdominal pain, absolute constipation (absence of both flatus and stool, distinguishing complete from partial obstruction), abdominal distension, and high-pitched tinkling bowel sounds on auscultation. The recognition of strangulation (vascular compromise of obstructed bowel, producing continuous severe pain rather than colicky pain, fever, peritoneal signs, and hemodynamic compromise) as a surgical emergency requiring immediate operation is the most critical distinction in bowel obstruction management. Ruptured ectopic pregnancy presents with lower abdominal pain of sudden onset (often the rupture is abrupt and dramatic, with sudden peritoneal irritation from the blood and trophoblastic tissue released into the peritoneum), shoulder tip pain (from diaphragmatic irritation by intraperitoneal blood), hemodynamic shock (tachycardia, hypotension, cold peripheries), and a positive urine pregnancy test (which should be performed in every CHT woman of reproductive age presenting with unexplained abdominal pain and hemodynamic instability, because ruptured ectopic pregnancy is invariably fatal without surgical intervention and the urine HCG test is the most important single diagnostic test in this context). The management of confirmed or suspected major abdominal surgical emergencies in CHT upazila health complexes should be: initial resuscitation (IV access, fluid resuscitation for hemodynamic compromise, analgesia for pain), and urgent transfer to Chittagong Medical College Hospital or Bandarban/Rangamati/Khagrachhari district hospitals (depending on proximity) where surgical management is available, with early notification to the receiving facility to prepare for emergency surgical reception.

9.4 Landslide Medicine: The CHT's Geophysical Trauma Emergency

Landslides are a recurrent and devastating source of mass casualty trauma in the CHT, driven by the combination of the territory's steep terrain, the geology of Miocene-Pliocene sedimentary rocks (which have low shear strength when saturated), and the rainfall intensity of the CHT monsoon that is among the highest in Bangladesh. Major landslide events in the CHT have

caused mass casualties with dozens to hundreds of deaths in single events: the June 13, 2017, landslides across the three CHT districts killed at least 160 people and injured hundreds more, displacing thousands. The mass casualty management challenge of a major CHT landslide event is compounded by the simultaneous destruction of the road infrastructure that links affected communities to health facilities (landslides typically also damage or block the roads that would provide the route for casualty evacuation), the collapse of community health worker networks in affected areas (since community health workers themselves may be casualties), and the communication blackout from damaged telecommunications infrastructure. The medical management of landslide casualties encompasses the spectrum from crush injury (with the rhabdomyolysis, acute kidney injury, and electrolyte disturbances of crush syndrome requiring urgent fluid resuscitation to prevent renal failure from myoglobin tubular toxicity), to the airway management of patients with earth and debris inhalation, to the orthopedic emergencies of multiple fractures and traumatic amputations, to the mass casualty triage challenge of allocating limited resources among multiple severely injured patients. The START (Simple Triage and Rapid Treatment) triage system, which classifies casualties into immediate (red), delayed (yellow), minimal (green), and expectant (black) categories based on the 30-second assessment of respiratory rate, perfusion, and mental status, provides the most practical mass casualty triage framework for CHT emergency responders and should be a required component of emergency training for all CHT district hospital and upazila health complex clinical staff, including community health workers who may be the first trained responders at a remote landslide scene.

MODEL EXAMINATION QUESTIONS: CHAPTER NINE (PART FIVE)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The four START triage categories for mass casualty events are: a) Critical, Serious, Fair, and Dead b) Immediate (red), Delayed (yellow), Minimal (green), and Expectant (black) c) Priority 1, Priority 2, Priority 3, and Priority 4 d) Resuscitate, Operate, Observe, and Discharge (Correct Answer: b)

The "talk and die" clinical phenomenon in traumatic brain injury indicates which intracranial pathology? a) Subarachnoid hemorrhage from aneurysm rupture b) Expanding intracranial hematoma (most commonly acute epidural hematoma) causing progressive brainstem compression c) Diffuse axonal injury d) Cerebral contusion without mass effect (Correct Answer: b)

The permissive hypotension principle in penetrating trauma management targets systolic blood pressure at approximately: a) Normal systolic pressure of 120 mmHg b) 80 to 90 mmHg, to prevent dilution of clotting factors before hemorrhage control c) 60 mmHg (the lowest tolerated by the brain) d) 100 to 110 mmHg (Correct Answer: b)

Ruptured ectopic pregnancy produces shoulder tip pain through which mechanism? a) Direct pressure on the brachial plexus from the ruptured tube b) Diaphragmatic irritation by intraperitoneal blood, referred to the C4 dermatome innervating the shoulder tip c) Cardiac

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tamponade from intraperitoneal blood d) Rib fracture from the expansion of the peritoneal cavity (Correct Answer: b)

Surgical cricothyrotomy is indicated in which clinical emergency? a) Stridor from epiglottitis b) Complete airway obstruction that cannot be managed by less invasive airway maneuvers in a patient facing imminent death from asphyxia c) Tracheal intubation before elective surgery d) Bronchospasm in severe asthma (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A landslide at 03:00 AM during heavy monsoon rain buries approximately 25 inhabitants of a remote Mro village in Bandarban. Seven survivors are pulled from the debris and brought to the nearest collection point by local residents. You are the medical officer at Alikadam UHC, notified by radio at 04:30 AM. Your facility has one emergency doctor, two nurses, limited IV supplies, no blood bank, no CT scanner, and road access to the village is blocked by the landslide debris. Your resources include one ambulance, portable suction, basic airway equipment, IV crystalloid, morphine, and a satellite phone for communication with CMCH. Applying the emergency management principles of this chapter, describe the immediate priority actions: a) Wait for CMCH to arrive before initiating any management b) The priority actions are: (i) activate the mass casualty protocol immediately, notifying CMCH by satellite phone and requesting air or water evacuation support and emergency surgical team dispatch; (ii) dispatch available community health workers and lay volunteer teams to the scene with basic first aid supplies, with telephone guidance on START triage; (iii) request that the seven survivors brought to the collection point be assessed using START triage and transported to UHC in priority order (red tags first, then yellow); (iv) at UHC, establish airway management, IV fluid resuscitation (for hemodynamic compromise and crush syndrome management, targeting urine output of 200 to 300 mL per hour to prevent renal failure from myoglobin toxicity), and analgesia (morphine IV titrated for severe pain), as the primary resuscitative interventions; (v) document and communicate the number and triage status of casualties to CMCH to guide the caliber of the emergency response; (vi) coordinate with local administration for road clearing or alternative water/air route to facilitate transfer of critically injured patients to CMCH for definitive surgical management; (vii) maintain the UHC as the stabilization point and transfer hub, not the definitive care site, for all patients requiring surgery, blood products, or intensive care c) Refer all patients to CMCH by phone without initiating treatment d) Treat with antibiotics prophylactically and discharge patients to home to reduce UHC crowding (Correct Answer: b)

CHAPTER TEN: HEALTH SYSTEM REFORM, HEALTH POLICY ARCHITECTURE, AND THE PHILOSOPHICAL FUTURE OF CHT MEDICINE

10.1 The Philosophy of CHT Health System Reform: Justice, Complexity, and the Long Game

Health system reform in the CHT, in the fullest sense of a structural transformation sufficient to produce equitable health outcomes for the territory's indigenous communities, is not a technical

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project that can be accomplished by deploying additional resources and personnel within the existing system architecture. It is a political and philosophical project that requires rethinking the fundamental premises upon which the CHT health system is designed, managed, financed, and evaluated. The CHT Health System Reform Philosophy articulated in this chapter rests on three foundational premises. The first premise is the Equity-as-Foundation Premise, which holds that a health system designed to serve multiple populations with profoundly unequal starting conditions (the extreme geographic isolation, political marginalization, and historical trauma of remote CHT indigenous communities on one hand; the relative infrastructure and institutional advantage of CHT district towns and Bengali-majority areas on the other) cannot achieve equity by applying the same program designs, the same performance metrics, and the same resource allocation formulas to all populations simultaneously. Achieving equity in health outcomes requires inequity in health system investment, with substantially greater per capita resources, culturally adapted program designs, and affirmatively determined outreach efforts directed toward the communities whose baseline disadvantage is greatest. The second premise is the Community Sovereignty Premise, which holds that the health needs, health priorities, and health system designs of CHT indigenous communities cannot be determined by external actors (including national government agencies, international organizations, and academic researchers) without the genuine, substantive, and documented free, prior, and informed consent (FPIC) of the affected communities themselves, and that health programs designed without FPIC produce not only ethical failures but practical failures, because communities whose values, priorities, and practical constraints have not been understood and incorporated into program design will not engage with programs that do not serve their actual needs in culturally appropriate ways. The third premise is the Structural Causation Premise, which holds that the CHT health system's most important reform is not a health system reform at all but a structural justice reform: the protection of land rights (which provides the economic and ecological foundation for nutritional security, livelihoods, and physical safety), the restoration of political participation (which provides communities with voice in the decisions that determine their lives), the elimination of institutional discrimination (which would ensure that government health services are delivered with the same quality and the same respect to indigenous communities as to Bengali communities in the same administrative area), and the genuine implementation of the CHT Peace Accord's provisions for indigenous governance of health services (which would create the institutional conditions for culturally appropriate, community-accountable health program delivery). None of these structural reforms is a health system intervention in the conventional sense. All of them are prerequisites for a health system reform that achieves genuinely equitable health outcomes rather than merely improving average health indicators while leaving the most disadvantaged communities behind.

10.2 The CHT Health System Reform Doctrine: Fifteen Operational Principles

The CHT Health System Reform Doctrine, developed in this textbook through the synthesis of the analytical frameworks, empirical evidence, and theoretical developments of all preceding chapters, is organized as fifteen operational principles that collectively constitute a comprehensive reform agenda for the CHT health system. The first principle is Equity-Weighted Resource Allocation: health financing for the CHT must implement a needs-adjusted, equity-weighted formula that allocates substantially greater per capita resources to the most

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geographically remote and epidemiologically disadvantaged communities, with the formula explicitly accounting for the cost of reaching these communities (which is dramatically higher than the average cost of service delivery in accessible areas) and the severity of their health disadvantage. The second principle is Indigenous Language Health Services: all government health services in the CHT must be delivered in the indigenous languages of the communities being served, requiring a systematic program of indigenous language training for health workers posted to CHT facilities and the production of all health communication materials (including prescription instructions, disease education materials, and health promotion messages) in the eleven indigenous languages of the CHT communities. The third principle is Community Health Worker Primacy: the community health worker (CHW) must be recognized as the primary healthcare provider for remote CHT communities where facility-based care is inaccessible, and CHWs must be adequately trained, compensated, equipped, supervised, and empowered to provide a comprehensive package of preventive and curative health services that extends well beyond the currently narrow scope of the CHW role in Bangladesh's national health program. The fourth principle is Traditional Medicine Integration: the CHT ethnomedicinal complex must be formally recognized as a component of the CHT health system, with Baiddya practitioners registered and supported, ethnomedicinal plant knowledge documented and conserved, and the integration of botanical and biomedical approaches to health care developed through collaborative research and practice protocols. The fifth principle is Governance Accountability: the health service delivery mandate of the CHT Regional Council and the three District Hill Councils under the 1997 Peace Accord must be genuinely implemented, with adequate financial resources transferred to these governance bodies and with accountability mechanisms that ensure indigenous community oversight of health service quality and equity. The sixth principle is Data Justice: the CHT health information system must be reformed to capture the health status, healthcare utilization, and health outcomes of all CHT communities disaggregated by ethnicity and geographic sub-district, ending the statistical invisibility that perpetuates health inequity by preventing its quantification. The seventh principle is Emergency Access Infrastructure: the physical and communication infrastructure required for time-sensitive emergency care access must be treated as a life-saving health investment, including permanent road improvement and monsoon-season maintenance, bridge construction at key river crossings, community boat and vehicle ownership for medical evacuation, and satellite telephone or radio communication at all upazila and union health facilities. The eighth principle is Nutrition as Health Investment: the CHT nutritional crisis must be addressed through a comprehensive strategy that integrates food system support (agricultural extension for jhum productivity improvement and dietary diversification, market access improvement, and post-harvest food storage technology), direct nutrition supplementation for the highest-risk groups (children under five, pregnant and lactating women), and universal micronutrient supplementation (vitamin A, iron, iodine, zinc) for CHT indigenous communities through health facility and community channels. The ninth principle is One Health Integration: the CHT health system must develop and maintain the integrated human-animal-environmental health surveillance and response capacity described in Part Four, with formal One Health coordination mechanisms engaging the Ministry of Health, Ministry of Fisheries and Livestock, Ministry of Environment and Forest, and CHT governance bodies. The tenth principle is Mental Health Mainstreaming: mental health services must be integrated into all levels of the CHT health system rather than remaining a specialist-only service inaccessible to the vast majority of CHT community members, with trained community health workers

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providing basic mental health support, psychological first aid, and referral pathways for complex mental health needs. The eleventh principle is Gender-Transformative Programming: every CHT health program must incorporate an explicit gender analysis and gender-transformative components that address the structural gender inequalities (in healthcare-seeking autonomy, decision-making power, exposure to occupational hazards, and nutritional allocation) that produce the gender-specific health disparities documented throughout this textbook. The twelfth principle is Climate Adaptation: CHT health program design must incorporate climate change adaptation as a cross-cutting consideration, with specific strategies for managing the health consequences of changing rainfall patterns, increasing temperatures, more severe flooding, and the shifting epidemiology of vector-borne diseases that climate change is producing in the CHT. The thirteenth principle is Research Justice: the CHT must be recognized as a research priority area for Bangladeshi and international health research institutions, with a commitment to research agenda setting that is led by the health priorities identified by CHT communities themselves rather than by the research interests of external institutions, and with genuine community benefit from research activities including capacity building, data sharing, and implementation of research findings. The fourteenth principle is Dignity in Healthcare: every contact between a CHT patient and a health system provider must be characterized by the respect, non-discrimination, cultural humility, and genuine therapeutic engagement that constitutes dignified healthcare, and the systematic disrespect, linguistic dismissal, and cultural condescension documented in qualitative health research from the CHT must be addressed through transformative training of health workers that goes beyond clinical skills to encompass the attitudes and behaviors of equitable care. The fifteenth principle is Long-Term Commitment: the CHT health system crisis has been created by centuries of colonial exploitation, decades of conflict, and a generation of structural marginalization, and its resolution requires a long-term commitment from Bangladesh's health system and political leadership that extends across election cycles and government changes, sustained by a legally binding health equity framework for the CHT that ensures institutional continuity of the reform agenda.

10.3 The Medical Student in the CHT: What It Means to Practice Medicine at the Frontier

This textbook has been written with a specific reader in mind: the medical student who will one day work in the CHT, or who may never set foot there but who should understand what medicine in the CHT demands of those who do. That student deserves an honest accounting of what it means to practice medicine at the geographic, social, and political frontier of Bangladesh. It means practicing with incomplete information and limited tools, and finding within those limitations not an excuse for passivity but an imperative for clinical ingenuity. It means treating patients who do not speak your language, who interpret their illness through a cosmological framework that you may never fully understand, and who have every reason to distrust the institution you represent, and finding within that encounter not the frustration of failed communication but the obligation of deeper listening. It means prescribing within an essential medicines list that does not include the drug you know your patient needs, and finding within that constraint not resignation but the motivation to advocate for the drug policy change that your patient's need demands. It means witnessing preventable deaths from preventable diseases and carrying the moral weight of that witnessing without becoming numbed by it, because it is the feeling of that weight that makes the physician an advocate rather than merely a technician. It

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means working in a health system whose structural failings are not your individual fault but are your collective professional responsibility, and finding within that responsibility not the paralysis of overwhelming complexity but the purpose of incremental, persistent, and principled engagement with the conditions that produce those failings. It means understanding that the best medicine you can practice in the CHT is not merely the best clinical medicine (though that is necessary) but the best citizenship: the medicine that connects the individual patient in front of you with the social structure that shaped their illness, and that speaks to both the biological and the political dimensions of their suffering with equal clarity and equal courage. The Chittagong Hill Tracts will demand the best of the clinician who chooses to serve there. It will also give that clinician the most profound professional experience available anywhere in Bangladesh: the experience of medicine practiced at the edge of what is possible, in service of people who have been waiting too long for someone to try.

10.4 A New Philosophy for CHT Public Health: The Geomedical Justice Doctrine

The concluding philosophical contribution of this textbook is the Geomedical Justice Doctrine, which represents a synthesis of the geomedicinal, ecological, social, and political frameworks developed across all five parts of this work into a unified philosophical foundation for CHT medicine and public health. The Geomedical Justice Doctrine holds that health equity in geographically complex, politically marginalized, and ecologically challenged territories like the CHT cannot be achieved through the application of health programs designed for homogeneous populations in accessible settings, but requires a framework that simultaneously addresses the ecological determinants of health (the terrain, the forest, the water, and the climate that shape disease risk), the social determinants of health (the poverty, the political exclusion, the gender inequality, and the ethnic discrimination that multiply that risk), the structural determinants of health (the land rights, the governance institutions, the economic systems, and the historical legacies that produce those social conditions), and the cultural determinants of health (the indigenous knowledge systems, the healing traditions, the cosmological frameworks, and the community governance structures that both determine health behavior and constitute resources for health promotion). The Geomedical Justice Doctrine insists on all four simultaneously, because each alone is insufficient: ecological interventions that improve water quality or vector control without addressing poverty cannot prevent diarrheal disease in communities that cannot afford the fuel to boil water or the materials to maintain a latrine; social interventions that reduce poverty without addressing the ecological determinants of disease cannot prevent malaria in communities whose terrain and forest create irreducible vector exposure; structural interventions that protect land rights without addressing the health system's cultural misalignment cannot ensure that communities use the health services that their improved economic security theoretically makes accessible; and cultural respect for indigenous medicine without the structural and social conditions that allow communities to thrive cannot compensate for the preventable deaths produced by treatable infections and inadequate nutrition. The Geomedical Justice Doctrine is simultaneously a scientific framework, a clinical ethic, and a political commitment: a claim that health science in the CHT is inseparable from health justice, and that the practice of medicine in this territory is inherently and irreducibly a moral and political act, as well as a biological and clinical one.

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MODEL EXAMINATION QUESTIONS: CHAPTER TEN (PART FIVE)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Free, Prior, and Informed Consent (FPIC), as applied to health program design in indigenous communities, refers to: a) The clinical consent process for individual surgical procedures b) The collective right of indigenous communities to be consulted and to consent before programs affecting them are designed and implemented, based on full information provided in advance c) The requirement for written consent forms in clinical research only d) The financial consent process for government health spending (Correct Answer: b)

The CHT Health System Reform Doctrine principle of Data Justice specifically addresses: a) The right of patients to access their individual medical records b) The reform of the CHT health information system to capture disaggregated data by ethnicity and geographic sub-district, ending the statistical invisibility that perpetuates health inequity c) The justice system's role in health worker accountability d) The fair distribution of research funding between CHT districts (Correct Answer: b)

The Geomedical Justice Doctrine holds that health equity in the CHT requires simultaneous engagement with how many categories of health determinants? a) One (the ecological determinants) b) Two (the ecological and social determinants) c) Three (the ecological, social, and structural determinants) d) Four (the ecological, social, structural, and cultural determinants) (Correct Answer: d)

The Community Sovereignty Premise in CHT health system reform philosophy holds that: a) Individual patients have sovereignty over their treatment decisions b) Health needs and health system designs of CHT communities cannot be determined without genuine FPIC of the affected communities c) District government authorities have sovereign authority over CHT health programs d) International organizations have sovereignty over health aid programs in the CHT (Correct Answer: b)

The fifteen operational principles of the CHT Health System Reform Doctrine include which of the following as the first principle? a) Digital health infrastructure b) Equity-Weighted Resource Allocation c) Mental health mainstreaming d) Research justice (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A new Bangladesh national health policy is being developed for the 2026 to 2031 period. A coalition of CHT health advocates argues that the standard national health policy framework, which allocates health resources per capita equally across all districts, fails to address the structural health inequities of the CHT. They request a needs-adjusted, equity-weighted allocation formula specifically for the CHT. The planning division asks for a technical justification for this request. Based on the Geomedical Justice Doctrine and the CHT Health System Reform Doctrine articulated in this textbook, which argument most comprehensively justifies the equity-weighted allocation request? a) The CHT has higher malaria incidence, which

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requires additional resources b) The CHT's combination of extreme geographic remoteness (which makes the cost of service delivery per patient substantially higher than the national average), the historical structural underfunding and neglect of CHT indigenous communities by successive national governments (producing a cumulative health infrastructure deficit far exceeding what equal per capita allocation could redress), the ecological complexity of the terrain (which requires adapted program designs more expensive than standard programs), the cultural and linguistic diversity (which requires additional health worker training investment and material production in eleven indigenous languages), the documented severity of health disparities (with CHT indigenous communities consistently exhibiting health indicators substantially worse than national averages across multiple dimensions), and the explicit mandate of the 1997 CHT Peace Accord for special attention to CHT indigenous community welfare, together constitute an overwhelming technical and ethical case for an equity-weighted allocation formula that provides substantially greater per capita resources to CHT indigenous communities than the national average, with the magnitude of the weighting determined by the measured gap in health outcomes and health infrastructure rather than by political negotiation c) The CHT deserves equity-weighted allocation because it is the largest district in Bangladesh by area d) The CHT has a unique flora and fauna that requires special environmental health investment (Correct Answer: b)

A medical student from CMCH completes a two-week clinical rotation at Bandarban District Hospital and observes that most indigenous patients wait until advanced disease stages before presenting, receive consultations of less than three minutes in Bangla that they clearly do not fully understand, are rarely given written prescription instructions (and could not read them if they were), and are never asked about their concurrent use of traditional medicine. Reflecting on this observation through the framework of this textbook, which analysis and recommendation most appropriately captures the professional responsibility implied by the student's observation? a) The situation is regrettable but unavoidable given the workload of the district hospital b) The observed patterns constitute simultaneously a clinical failure (incomplete medical histories producing diagnostic errors), a communicative failure (instructions not understood by patients reducing treatment adherence), a cultural failure (non-engagement with traditional medicine producing drug interaction risks and missed delays to care), and a structural failure (the health system's design assumptions regarding language competence and health literacy do not match the reality of its patient population); the student's professional responsibility includes: documenting and reporting these observations to the medical college's department of preventive and social medicine for academic analysis; advocating through the student and professional medical associations for mandatory indigenous language training and cultural competency components in clinical postings at CHT facilities; engaging with CHT civil society organizations working on health equity to understand how students can contribute to advocacy; committing personally to a clinical practice that, wherever in Bangladesh they eventually work, prioritizes patient comprehension, cultural respect, and honest engagement with the full determinants of the patient's health c) The student should not comment on institutional practices during a clinical rotation d) The observed patterns are culturally appropriate and reflect the different communication styles of CHT communities (Correct Answer: b)

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EPILOGUE TO PART FIVE: THE SYNTHESIS OF ADVANCED CLINICAL SCIENCE AND THE CHT'S UNFINISHED STORY

Part Five has traversed the specialist clinical territory of the CHT's health landscape with the same foundational commitment that has defined every preceding chapter: to see the CHT patient not as an abstraction from a clinical algorithm but as a person embedded in a specific ecological, historical, social, and political reality that determines both the nature of their illness and the conditions of their healing. The dermatological chapter opened the territory of the skin as an ecological register, inscribed by the parasites, fungi, bacteria, nutritional deficiencies, and solar exposures of a life lived on the land. The neurological chapter navigated the most urgent and the most complex emergency presentations of a territory where cerebral malaria, bacterial meningitis, tuberculosis meningitis, epilepsy, and neurocysticercosis create a neuroepidemiological landscape unlike anything in the Bangladesh plains. The respiratory chapter confronted the compound environmental assault on the lungs of people who cook over open fires, breathe burning jhum smoke, work in forests of dust and mold, and live in crowded bamboo houses without ventilation, and who present with COPD, asthma, and pneumonia as the biological registrations of a lifetime of environmental injustice. The renal chapter illuminated the kidneys as the final filter of the CHT's water, infection, snake venom, and botanical toxin, and documented the ways in which terrain-conditioned nephrotoxicological accumulation produces kidney failure in populations that have no renal replacement therapy within reach. The musculoskeletal chapter honored the physical dignity and the physical cost of a life built on manual labor, steep slopes, and the carrying of loads that most of the world has long assigned to machines. The gastrointestinal and hepatological chapter engaged the gut and the liver as the battleground where food security and water security are tested daily, where the amoeba and the hepatitis virus compete for the body's resilience, and where the emerging fatty liver disease of dietary transition signals the next wave of chronic disease burden to come. The ophthalmological and otolaryngological chapter gave clinical form to the preventable blindness of the cataract, the xerophthalmia, and the measles complication, and to the silent hearing loss of the cooking fire, the chainsaw, and the undertreated ear infection. The oncological chapter named the invisible cancer epidemic of the CHT and provided the palliative care philosophy that insists that every dying CHT patient deserves to die with dignity, with their pain managed, and in a setting that honors their cosmological and cultural identity. The emergency medicine chapter confronted the golden hour in a territory where the golden hour is always already lost, and proposed that pre-hospital stabilization, community first response, and telemedicine emergency advice can partially bridge the gap that geography has imposed. The health system reform chapter concluded with the Geomedical Justice Doctrine: the philosophical synthesis that positions CHT medicine not as a technical specialty of tropical medicine but as a practice of justice, as inseparable from the political struggle for CHT indigenous rights as it is from the biological science of infectious disease, nutrition, and pharmacology.

The story of health in the Chittagong Hill Tracts is not finished. It is not close to finished. The children of the Mro community who died of measles in 2025 died preventable deaths in a preventable epidemic that will be repeated in some form unless the structural conditions that produced it are changed. The Chakma farmers who develop COPD from a lifetime of cooking smoke will continue to do so until the energy transition that replaces their biomass fires with

clean fuels reaches the remotest CHT valleys. The Marma women who die in childbirth from postpartum hemorrhage because they are three hours from the nearest blood bank will continue to do so until the obstetric emergency care system is reformed with the geographic intelligence and the adequate resource commitment that equity demands. The Bawm children with undiagnosed epilepsy who are hidden from the community and denied education and social participation because of seizure stigma will continue to suffer avoidable exclusion until the mental health literacy program reaches their village. Each of these ongoing stories is a call to clinical action, a call to research, and a call to advocacy. This textbook has tried to equip the reader with the clinical science, the epidemiological framework, the sociological insight, and the philosophical orientation to answer those calls with knowledge, courage, and the deep commitment to justice that every patient in the Chittagong Hill Tracts deserves from the physician who chooses to serve them.

PART FIVE COMPREHENSIVE ASSESSMENT: INTEGRATIVE EXAMINATION QUESTIONS

For Postgraduate Entrance, FCPS, MD, and MPH:

Integrative Case 1: A 17-year-old Bawm adolescent girl from a remote village in Bandarban is brought to the district hospital by her father after three years of progressive difficulty opening her mouth, burning sensation in the oral cavity, and whitish discoloration of the inner cheeks. On examination, her interincisal distance is reduced to 28 mm (normal above 40 mm). The buccal mucosa shows blanching, fibrosis, and stiffness on palpation. She has been chewing betel nut mixed with tobacco since age 12. A single area of mixed red and white lesion (erythroleukoplakia) approximately 12 mm in diameter is noted on the right buccal mucosa. Which of the following describes the most appropriate immediate management approach? a) Prescribe oral antifungal medication for presumed candidiasis b) The clinical picture is consistent with oral submucous fibrosis (OSF) from long-term areca nut-tobacco use, with a lesion pattern (erythroleukoplakia) carrying a high malignant transformation risk; immediate priorities are: (i) urgent referral to a dental/oral surgery specialist at CMCH for biopsy of the erythroleukoplakia lesion to establish the histological diagnosis and dysplasia grade; (ii) complete betel quid cessation counseling with family and patient engagement (noting that cessation will not reverse OSF but prevents progression and malignant transformation); (iii) physiotherapy for the restricted mouth opening (if pre-cancerous pathology is excluded on biopsy); (iv) if biopsy shows severe dysplasia or carcinoma in situ, surgical excision and follow-up; (v) community-level reporting to the CHT health officer for aggregate data collection to characterize the community-level oral cancer risk burden c) Reassure and prescribe vitamin B complex d) Extract all teeth to improve mouth access (Correct Answer: b)

Integrative Case 2: A public health team conducting an assessment of three Tripura communities in Khagrachhari documents the following in a single one-week field visit: (i) household biomass fuel use in 96% of homes; (ii) open defecation in 45% of households; (iii) malaria RDT positivity rate of 28% in a febrile illness clinic; (iv) two children with xerophthalmia (Bitot's

spots); (v) one adult with a hypopigmented anesthetic skin patch on the forearm; (vi) 60% of women over 40 years reporting productive cough of more than three months; (vii) one family with a child having recurrent seizures attributed to spirit possession; (viii) one elder with advanced oral submucous fibrosis. Prioritize these findings by urgency of public health response and specify the first response action for each of the top three priorities: a) Prioritize the malaria positivity only; all other findings are social issues b) The prioritization and first response actions are: Priority 1 (Immediate): The two children with xerophthalmia (Bitot's spots) require immediate high-dose vitamin A supplementation (200,000 IU for children over one year) to prevent corneal ulceration and blindness, community-wide vitamin A deficiency assessment, and emergency vitamin A supplementation for all children under five years in the community who are not already on supplementation programs. Priority 2 (Urgent): The 28% malaria RDT positivity rate requires immediate deployment of a malaria treatment team and universal RDT testing of the febrile illness clinic, artemether-lumefantrine treatment for all confirmed P. falciparum positive cases, primaquine (after G6PD testing) for confirmed P. vivax cases, and active case finding in the community. Priority 3 (Urgent): The leprosy suspect (hypopigmented anesthetic skin patch) requires formal three-cardinal-sign assessment and referral to the district leprosy officer for WHO MDT initiation if confirmed, combined with household and close contact examination for additional cases. The COPD-suggestive productive cough finding in 60% of women over 40 years requires systematic spirometry referral planning (non-urgent but high-priority population health intervention). The epileptic child requires clinical assessment and antiepileptic initiation (non-emergency unless status epilepticus is occurring). The oral submucous fibrosis elder requires referral for biopsy assessment (non-emergency but clinically important). The household biomass fuel use and open defecation findings require long-term WASH and clean energy programs (structural interventions not amenable to immediate field response) c) Prioritize the open defecation finding; all other findings are secondary d) Prioritize the elder with oral submucous fibrosis for immediate hospital transfer (Correct Answer: b)

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PART SIX: HEMATOLOGICAL MEDICINE, CARDIOVASCULAR AND METABOLIC DISEASE, IMMUNOLOGICAL SCIENCE, PEDIATRIC CLINICAL MEDICINE, AND APPLIED PHARMACOLOGY IN THE CHITTAGONG HILL TRACTS

Foreword to Part Six

The first five parts of this textbook established the ecological, historical, social, and clinical foundations for understanding health and disease in the Chittagong Hill Tracts. They demonstrated that the terrain is not a backdrop but a biological actor; that the social and political history of the territory is not merely context but pathology; that the indigenous medical traditions of the CHT are not folklore but pharmacopoeia; and that the gap between the health of CHT indigenous communities and the health of the general population of Bangladesh is not a statistical artifact but a structural injustice produced by centuries of conquest, decades of conflict, and a generation of inadequate post-conflict repair. Part Six enters the molecular interior of these realities. It examines the blood, the heart, the endocrine glands, the immune system, the developing bodies of children, the aging bodies of elders, the pharmacological landscape of the CHT's medicines and herb-drug interactions, the methodologies by which clinical knowledge of

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the CHT is generated and validated, and the epidemiological surveillance systems by which outbreaks are detected and controlled. Each of these domains opens onto the same fundamental truth: that in the CHT, clinical science is never value-neutral, never purely technical, and never fully comprehensible without the ecological, social, and political framework that determines why specific people, in specific places, at specific moments in history, fall ill in the specific ways they do. Part Six brings the full apparatus of modern biomedical science to bear on the health of the hill peoples of Bangladesh, while insisting that this science be grounded in respect for the persons it serves, in solidarity with the communities whose health it seeks to understand, and in the intellectual honesty to name the structural causes of preventable suffering wherever they are found.

CHAPTER ONE: HEMATOLOGICAL DISORDERS IN THE CHITTAGONG HILL TRACTS: BLOOD, ANEMIA, AND THE MOLECULAR LANDSCAPE OF THE ERYTHROCYTE

1.1 The CHT Hematological Burden Doctrine

The hematological health of CHT indigenous communities is characterized by what this textbook terms the CHT Hematological Burden Doctrine, which holds that blood disorders in the CHT operate as both primary diseases and as downstream amplifiers of every other disease category in the territory, functioning in a bidirectional causation network in which anemia impairs immunity, reduces cognitive performance, degrades physical work capacity, increases maternal and perinatal mortality risk, and deepens poverty, while infections, malnutrition, and parasitism simultaneously deplete red cell mass, impair erythropoiesis, and degrade hemoglobin function in ways that make recovery from any acute illness more difficult and more dangerous. The CHT Hematological Burden Doctrine is grounded in four foundational observations drawn from the convergence of the latest epidemiological data, molecular biology research, and field clinical experience from the territory. The first observation is that the CHT sits at the intersection of the highest burden of hemolytic and parasitic anemia in Bangladesh (from Plasmodium-driven hemolysis, hookworm-driven iron loss, and helminthic competition for absorptive iron), the highest burden of nutritional iron, folate, and vitamin B12 deficiency anemia (from the dietary inadequacy documented in Part Five), and a significant inherited hemoglobin disorder burden (from the genetically isolated indigenous populations of the CHT whose founder effects and endogamy have produced significant prevalences of hemoglobinopathies). The second observation is that the compounding of hemolytic, nutritional, and inherited anemia in the same individual patient, which is not uncommon in CHT clinical practice, produces anemia of extraordinary severity (hemoglobin levels below 5 g/dL are documented in CHT hospital series of severe malaria patients, and levels below 3 g/dL are reported in cases of complicated coexistent malaria and severe nutritional anemia in children) that carries a mortality risk far exceeding that of any single anemia etiology in isolation. The third observation is that the management of complex, multi-etiological anemia in the CHT is complicated by the limited diagnostic infrastructure of the territory, where complete blood count capability may be the only hematological investigation available, and the differential diagnosis of anemia must therefore

rely heavily on clinical assessment and epidemiological probability rather than on peripheral blood morphology, reticulocyte counts, iron studies, hemoglobin electrophoresis, and other investigations that are standard in resource-adequate settings. The fourth observation is that the inherited hemoglobin disorders of CHT indigenous populations have received almost no systematic study from Bangladeshi researchers, representing a major knowledge gap in the national hematology literature that leaves a substantial population without accurate diagnosis, appropriate genetic counseling, or optimized clinical management. The CHT Hematological Burden Doctrine insists that hematology in the CHT is not a specialist concern separate from primary care and public health but is woven into the fabric of every clinical encounter and every community health intervention in the territory, because the state of the blood is the state of the whole person.

The epidemiology of anemia in the CHT reflects the multi-etiological character of the CHT hematological burden. A household survey of CHT indigenous children and women of reproductive age conducted in Bandarban and Rangamati districts and published in 2024 found that the prevalence of anemia (defined by WHO standards as hemoglobin below 11 g/dL in children under five years, below 11 g/dL in pregnant women, and below 12 g/dL in non-pregnant women) was 68 percent in children under five years, 72 percent in pregnant women, and 54 percent in non-pregnant women of reproductive age, compared with national Bangladesh averages of approximately 36 percent, 42 percent, and 32 percent respectively. These figures are not merely alarming in their absolute magnitude. They represent a systematic failure of the national nutrition and health programs to reach the most vulnerable segment of the CHT population at a level of coverage and effectiveness comparable to what has been achieved in the Bangladesh plains. The severity distribution of anemia in the CHT survey was also striking: a significant proportion of cases were classified as moderate or severe anemia (hemoglobin below 8 g/dL in non-pregnant women or below 7 g/dL in children), indicating that the hematological compromise in affected individuals was clinically severe rather than a mild biochemical abnormality with limited functional consequences. The functional consequences of the documented anemia prevalence are, in the CHT context, directly and measurably pathological: maternal anemia at this prevalence and severity is a major driver of low birth weight (through placental dysfunction), preterm birth, maternal mortality from hemorrhage (anemia dramatically reduces the physiological reserve available to survive obstetric blood loss), and neonatal anemia (from iron-deficient erythropoiesis in the iron-depleted neonate). Child anemia at this prevalence is a major driver of impaired cognitive development (the causal link between iron deficiency anemia and impaired neurocognitive performance in children, operating through the iron-dependence of myelinogenesis, neurotransmitter synthesis, and mitochondrial energy production in the developing brain, is one of the most robustly established findings in nutritional neuroscience), school performance failure, physical stunting amplification, and vulnerability to infectious illness. The CHT anemia crisis is therefore not a hematological abstraction but a direct cause of the educational disadvantage, the intergenerational poverty transmission, and the maternal mortality that are the defining characteristics of the CHT indigenous health crisis.

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1.2 Iron Deficiency Anemia: Pathophysiology, Clinical Recognition, and Management in the CHT

Iron deficiency anemia (IDA) is the most common single etiology of anemia in the CHT, attributable to the convergence of inadequate dietary iron intake (the traditional CHT diet, which is predominantly plant-based with limited consumption of red meat and organ meats, the highest-iron dietary sources), impaired iron absorption (from phytate-rich staple foods including rice and sesame that inhibit non-heme iron absorption, and from the chronic intestinal inflammation of tropical enteropathy that damages the duodenal iron absorptive mucosa), increased iron demand (during pregnancy, rapid childhood growth, and recovery from acute illness), and excess iron loss (from hookworm intestinal blood loss, heavy menstrual bleeding in iron-deficient women whose uterine integrity is compromised, and the chronic inflammatory state of repeated infections that redistributes iron into storage compartments through the hepcidin-mediated mechanism, creating the functional iron deficiency of anemia of chronic inflammation). The pathophysiology of IDA proceeds through three stages of progressive iron depletion. The first stage is iron depletion, in which body iron stores (primarily ferritin-bound iron in the liver, spleen, and bone marrow macrophages) are depleted without measurable effect on hemoglobin concentration, red cell morphology, or serum iron. The second stage is iron-deficient erythropoiesis, in which depleted iron stores can no longer support normal hemoglobin synthesis, producing a fall in serum iron, a rise in total iron binding capacity (TIBC), a fall in transferrin saturation below 16 percent, and early microcytosis and hypochromia on peripheral blood film, while hemoglobin may still be in the lower range of normal or only mildly reduced. The third stage is overt IDA, with frank anemia (hemoglobin below the age-sex-specific threshold), significant microcytosis and hypochromia on peripheral blood film, elevated red cell distribution width (RDW), and the clinical symptoms of anemia.

The clinical recognition of IDA in the CHT setting, where laboratory capability may be limited to hemoglobin measurement by hemoglobinometer and microscopy of a hand-stained peripheral blood film, requires a combination of clinical assessment and peripheral film interpretation. The clinical signs of IDA in moderately severe disease include pallor (assessed by examining the conjunctivae, the palms, and the nail beds for pallor, with the comparison of a pale conjunctiva against the vivid pink of a healthy conjunctiva being the most sensitive clinical sign), angular stomatitis (cracking and inflammation at the corners of the mouth, which is a non-specific sign of multiple nutritional deficiencies including iron and riboflavin but common in severe IDA), koilonychia (spoon-shaped nails with a flat or concave contour replacing the normal convex curvature, which is a specific sign of advanced IDA), glossitis (a smooth, red, atrophic tongue from papillary atrophy in severe IDA), and Plummer-Vinson syndrome (the triad of dysphagia from pharyngeal web formation, glossitis, and iron deficiency anemia, which is a rare but premalignant condition associated with very long-standing severe IDA in women and deserves mention here because it is documented in South Asian populations including those with dietary patterns similar to CHT communities). The peripheral blood film in IDA shows hypochromic microcytic erythrocytes (small, pale red cells with an enlarged area of central pallor occupying more than one-third of the cell diameter), anisocytosis (variation in red cell size, reflected in elevated RDW), poikilocytosis (variation in red cell shape, including pencil cells or elliptocytes), and reduced mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH) on

automated CBC if available. The treatment of IDA in CHT patients requires both the correction of the hemoglobin deficit (by iron supplementation) and the identification and management of the underlying cause of iron depletion (dietary deficiency, hookworm, excessive blood loss). Oral ferrous sulfate (200 mg tablets, each containing 65 mg elemental iron, given three times daily in adults, corresponding to a daily elemental iron dose of 195 mg) is the mainstay of outpatient IDA treatment and should be given on an empty stomach (between meals) for maximum absorption, though its gastric side effects (nausea, epigastric discomfort, constipation) frequently limit compliance in this schedule and taking it with a small amount of food is an acceptable compromise that slightly reduces but does not eliminate absorption. Vitamin C co-administration (50 to 200 mg alongside each iron dose) enhances non-heme iron absorption through reduction of ferric to the more absorbable ferrous form and is a practical dietary advice that can be given to all CHT patients on oral iron therapy. The duration of iron therapy should continue for three months after hemoglobin normalization to fully replenish iron stores, a principle that is frequently violated in clinical practice where therapy is discontinued as soon as hemoglobin improves, leaving patients with depleted stores and rapid relapse of IDA.

1.3 Malaria-Associated Anemia: The Hemolytic Engine of CHT Hematological Pathology

Malaria-associated anemia (MAA) is the dominant form of acute severe anemia in the CHT and is the hematological emergency most likely to require blood transfusion in CHT clinical settings. The pathophysiology of MAA in P. falciparum infection is complex and multifactorial, involving more than the simple destruction of parasitized erythrocytes that is the most widely taught mechanism. The complete pathophysiological accounting of MAA encompasses four distinct mechanisms: hemolysis of parasitized erythrocytes (the merozoite invasion, intracellular development, and schizont rupture sequence causes direct mechanical and metabolic destruction of the parasitized red cell, releasing parasites and erythrocyte debris into the bloodstream), bystander hemolysis of non-parasitized erythrocytes (the oxidative stress generated by the malaria infection and the generation of hemozoin-mediated reactive oxygen species damages even non-parasitized erythrocytes in the circulation, reducing their deformability and accelerating their clearance by the reticuloendothelial system at rates far exceeding the direct loss from parasitized cell rupture), dyserythropoiesis (malaria infection profoundly suppresses the bone marrow's erythropoietic response to anemia, through cytokine-mediated inhibition of erythroid progenitor differentiation in the bone marrow that is disproportionate to the degree of anemia and results in a reticulocyte response far lower than would be expected for the degree of hemoglobin fall), and hypersplenism (the spleen becomes massively enlarged in chronic and hyperreactive malaria exposure, developing an increased capacity to sequester and destroy erythrocytes, including non-parasitized ones, contributing to chronic MAA in populations with high endemic malaria exposure).

The clinical assessment of MAA severity in CHT patients requires integration of the hemoglobin measurement with the assessment of clinical signs of hemodynamic compensation and decompensation. Hemoglobin below 5 g/dL in adults or below 6 g/dL in children constitutes severe malarial anemia by WHO criteria and requires consideration of blood transfusion, though the decision to transfuse must balance the clinical need for oxygen-carrying capacity restoration against the risks of transfusion in the CHT context, where blood banking capacity is limited

primarily to district hospitals, blood product safety (HIV, HBV, HCV, and other transfusion-transmissible infection screening) may not meet the highest standards possible, and volume overload from transfusion in patients with chronic compensated severe anemia can precipitate pulmonary edema. The WHO guidelines for severe malaria recommend blood transfusion in children with severe malarial anemia (hemoglobin below 5 g/dL or hematocrit below 15 percent) who also show evidence of respiratory distress, impaired consciousness, or clinical signs of hemodynamic compromise (tachycardia, poor peripheral perfusion, low blood pressure). In adults with severe malarial anemia, the transfusion threshold is somewhat less well defined, but hemoglobin below 5 g/dL with clinical signs of impaired tissue oxygenation (angina, severe tachycardia, altered consciousness) in the context of severe malaria justifies urgent transfusion. The transfusion itself should use packed red cells (if available) rather than whole blood to minimize volume load, and should be given slowly (over four to six hours per unit) with careful monitoring for the development of pulmonary edema, which is an especially dangerous complication in patients with concurrent parasitemia who may have malaria-associated acute lung injury.

1.4 Hemoglobinopathies in CHT Indigenous Populations: The Underinvestigated Molecular Epidemiology

The hemoglobinopathies, a group of inherited disorders of hemoglobin structure or synthesis, represent one of the most important and most neglected dimensions of hematological medicine in the CHT. The two major categories of hemoglobinopathy are the structural hemoglobin variants (of which the clinically most significant is sickle cell hemoglobin, HbS, though various other clinically important structural variants are present in Asian populations) and the thalassemias (disorders of globin chain synthesis, divided into alpha-thalassemia from alpha-globin gene deletions on chromosome 16, and beta-thalassemia from beta-globin gene mutations on chromosome 11). The molecular epidemiology of hemoglobinopathies in CHT indigenous populations is essentially unknown. The genetic isolation, the ethnolinguistic distinctiveness, and the documented endogamy of the CHT's eleven indigenous communities provide the classic conditions for the accumulation of genetic polymorphisms through founder effect and genetic drift, and the known prevalence of alpha-thalassemia and HbE (hemoglobin E, a structural variant produced by a point mutation in the beta-globin gene at codon 26) in the populations of the Greater Mekong Subregion and Southeast Asia, whose ethnic composition overlaps substantially with that of the Tibeto-Burman and Austro-Asiatic speaking communities of the CHT, strongly suggests that these disorders are present at epidemiologically significant prevalence in the CHT's indigenous communities.

Hemoglobin E (HbE) deserves particular attention in the CHT context. HbE is the most common structural hemoglobin variant in South and Southeast Asia, with carrier prevalence ranging from 5 to 30 percent in certain ethnic populations of Southeast Asia and Northeast India. The heterozygous state (HbAE) produces mild microcytosis without significant anemia and is clinically benign. However, the coinheritance of HbE with beta-thalassemia (HbE/beta-thalassemia) produces HbE beta-thalassemia, one of the most common and most clinically variable severe hemoglobinopathies in Asia, ranging from a thalassemia intermedia phenotype (moderate anemia manageable without regular transfusion) to a thalassemia major phenotype

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(severe transfusion-dependent anemia indistinguishable clinically from beta-thalassemia major). Given the documented prevalence of both HbE and beta-thalassemia in the ethnic populations genetically related to CHT indigenous communities, HbE beta-thalassemia is likely to be present in CHT communities at a prevalence that is clinically significant but entirely undiagnosed, because hemoglobin electrophoresis (the investigation required to identify HbE) is not available in the CHT below district hospital level, and even at district hospital level, the clinical impetus to perform hemoglobin electrophoresis in a child with chronic anemia is often absent due to the clinician's assumption that the anemia is nutritional or malarial in origin. The consequences of missed HbE beta-thalassemia diagnosis in the CHT include: misattribution of chronic anemia to malaria or nutritional deficiency with ineffective iron supplementation (iron supplementation does not improve thalassemia anemia and can cause iron overload in thalassemia patients, which is itself harmful), failure of appropriate genetic counseling for affected families (which would inform reproductive decisions in a context where the risk of producing a severely affected HbE beta-thalassemia child can be significantly reduced by partner testing and prenatal diagnosis), and the unnecessary suffering of patients with undertreated severe thalassemia who could benefit from hydroxyurea treatment (which increases fetal hemoglobin production and reduces the severity of HbE beta-thalassemia in many patients) or, in the most severe cases, from hematopoietic stem cell transplantation.

Alpha-thalassemia, produced by deletions of the alpha-globin genes on chromosome 16, is highly prevalent across South and Southeast Asia and is present in significant proportions of the ethnic populations ancestrally related to CHT indigenous communities. The two alpha-globin gene deletions on each chromosome 16 mean that individuals can carry between zero and four dysfunctional alpha-globin genes in their genome. The single-gene deletion carrier state (alpha-plus thalassemia trait, genotype -alpha/alpha-alpha) is clinically silent. The two-gene deletion state (genotype -alpha/-alpha or --/alpha-alpha) produces alpha-thalassemia trait with mild microcytosis and mild anemia. The three-gene deletion state (HbH disease, genotype --/-alpha) produces moderately severe hemolytic anemia with inclusions in the red cells (HbH bodies) visible on supravital staining, splenomegaly, and chronic hemolytic jaundice. The four-gene deletion state (hydrops fetalis, genotype --/--) produces lethal fetal anemia incompatible with extrauterine life, manifesting as stillbirth or neonatal death from severe hemolytic anemia. In the CHT, the alpha-thalassemia trait is likely to be prevalent in the indigenous population and may account for a proportion of the chronic microcytic anemia that is attributed to iron deficiency, with the clinical distinction between iron deficiency and alpha-thalassemia trait requiring iron studies and hemoglobin electrophoresis that are rarely performed. The practical implication is that CHT children and adults with microcytic anemia who do not respond to adequate iron supplementation over an adequate treatment period should be considered for investigation of alpha-thalassemia and other hemoglobinopathies when this investigation becomes available. The advocacy for the development of hemoglobin electrophoresis capacity at CHT district hospitals is a clinical priority of significant importance for the accurate diagnosis and management of the CHT's hematological burden.

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1.5 Glucose-6-Phosphate Dehydrogenase Deficiency in the CHT: The Pharmacogenomic Imperative

Glucose-6-phosphate dehydrogenase (G6PD) deficiency, introduced in Part One and Part Five in the context of primaquine therapy for Plasmodium vivax malaria, deserves a dedicated and more extensive treatment in the context of CHT hematology because it is the most clinically prevalent inherited erythrocyte enzyme defect in the territory and has implications extending far beyond malaria treatment to encompass the management of multiple other conditions and the administration of a wide range of drugs. G6PD deficiency is an X-linked recessive condition (the gene encoding G6PD is located on the X chromosome), meaning that hemizygous males (with a single X chromosome carrying the deficient allele) and homozygous females (with two X chromosomes both carrying the deficient allele) express the full clinical phenotype, while heterozygous females (with one normal and one deficient X chromosome) have intermediate G6PD activity and variable clinical expression. The clinical significance of G6PD deficiency lies in the enzyme's critical role in the hexose monophosphate shunt (also called the pentose phosphate pathway), the only metabolic pathway by which erythrocytes can generate reduced glutathione (GSH) for protection against oxidative stress. Erythrocytes, unlike most other cells, have no nucleus, no mitochondria, and no alternative energy metabolism pathways for antioxidant defense; they are entirely dependent on the G6PD-catalyzed generation of NADPH and subsequently GSH for protection against the oxidative denaturation of hemoglobin to methemoglobin and the oxidative damage to the erythrocyte membrane. When G6PD-deficient erythrocytes are exposed to oxidant drugs (primaquine, dapsone, methylene blue), oxidant foods (particularly fava beans, known as broad beans or Vicia faba, which contain vicine and convicine that generate oxidative stress on erythrocyte membranes), infections (which generate endogenous oxidants as part of the immune response, explaining the triggered hemolysis that occurs in G6PD-deficient patients during acute infections), or acidosis (metabolic acidosis increases oxidant stress on erythrocytes), the lack of adequate NADPH and GSH production allows oxidative damage to hemoglobin and the erythrocyte membrane to proceed unchecked, resulting in the denaturation of hemoglobin to Heinz bodies (insoluble precipitates of denatured hemoglobin visible on special staining of the peripheral blood film), the rigidification and destruction of affected erythrocytes in the spleen and through intravascular hemolysis, and the clinical syndrome of acute hemolytic anemia, manifesting as sudden onset of pallor, jaundice, hemoglobinuria (dark tea-colored or port wine-colored urine from free hemoglobin filtered by the kidneys), fatigue, abdominal pain, and in severe cases acute kidney injury from hemoglobin-mediated renal tubular toxicity.

The prevalence of G6PD deficiency in CHT indigenous populations has not been systematically measured in any population-based study in Bangladesh. The available evidence from surrogate populations, including the ethnic populations of Northeast India (particularly the Naga and other Tibeto-Burman ethnic groups closely related to the CHT's Bawm, Pangkhua, Khumi, and Lushai communities), Myanmar, and the Greater Mekong Subregion, suggests prevalence rates in hemizygous males of 10 to 25 percent, with significant variation between ethnic groups. G6PD deficiency prevalence in some Southeast Asian ethnic populations (particularly those in Cambodia, Laos, and Thailand, where certain ancestrally related groups share genetic heritage with CHT communities) reaches 25 to 30 percent in males. At these prevalence levels, one in

four to one in ten male CHT patients receiving a drug such as primaquine (for P. vivax malaria radical cure), dapsone (for leprosy treatment), or methylene blue (which is used in some CHT traditional medicine preparations as a dye and has oxidant activity) would be at risk of triggering acute hemolytic anemia. The pharmacogenomic imperative in the CHT is therefore urgent and practical: G6PD testing must become a standard of care before prescribing drugs with oxidant hemolytic potential in the CHT, particularly primaquine for P. vivax radical cure. The WHO has recommended point-of-care G6PD testing before primaquine administration as the global standard, and the CareStart G6PD rapid diagnostic test (which provides a semi-quantitative assessment of G6PD activity using a lateral flow format, without the need for specialized equipment, in approximately ten minutes) is now available and has been validated in multiple field settings in Southeast Asia and South Asia. Advocacy for the universal availability of point-of-care G6PD testing at all CHT health facilities providing malaria treatment is one of the most immediate and most impactful clinical quality improvement initiatives available for the CHT.

MODEL EXAMINATION QUESTIONS: CHAPTER ONE

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The most common inherited hemoglobin structural variant in South and Southeast Asia, likely to be present in CHT indigenous populations but systematically undiagnosed, is: a) Hemoglobin S (sickle cell hemoglobin) b) Hemoglobin C c) Hemoglobin E (HbE) d) Hemoglobin D Punjab (Correct Answer: c)

G6PD deficiency produces acute hemolytic anemia primarily through which pathophysiological mechanism? a) Direct complement-mediated erythrocyte destruction b) Inadequate NADPH and reduced glutathione production, leaving erythrocytes unable to defend against oxidative stress c) Autoimmune erythrocyte destruction from anti-erythrocyte antibodies d) Intrinsic erythrocyte membrane defects producing spherocytosis (Correct Answer: b)

The clinical sign of koilonychia (spoon-shaped nails) is specifically associated with: a) Vitamin B12 deficiency anemia b) Hemolytic anemia c) Advanced iron deficiency anemia d) Folate deficiency anemia (Correct Answer: c)

The four distinct pathophysiological mechanisms of malaria-associated anemia include all of the following EXCEPT: a) Hemolysis of parasitized erythrocytes during schizont rupture b) Bystander hemolysis of non-parasitized erythrocytes c) Dyserythropoiesis from bone marrow erythropoietic suppression d) Autoimmune destruction of erythrocytes by anti-RBC antibodies (Correct Answer: d)

The stage of iron deficiency in which iron stores are depleted but hemoglobin remains normal is called: a) Iron depletion b) Iron-deficient erythropoiesis c) Overt iron deficiency anemia d) Functional iron deficiency (Correct Answer: a)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

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A 6-year-old Bawm child in Bandarban presents with chronic severe anemia (hemoglobin 5.8 g/dL), marked splenomegaly, mild jaundice, and very pronounced microcytosis and hypochromia on peripheral blood film. The mother confirms the child has had this degree of anemia "since birth." Iron supplementation for the past three months has produced no improvement in hemoglobin. The most important next diagnostic step and its clinical rationale are: a) Repeat iron supplementation at higher dose b) Hemoglobin electrophoresis to investigate for HbE beta-thalassemia or other hemoglobinopathy, because the combination of congenital chronic hemolytic anemia, splenomegaly, jaundice, extreme microcytosis without response to iron therapy, and the patient's ethnic background (which overlaps with Southeast Asian populations with high HbE prevalence) makes a hemoglobinopathy the most likely diagnosis; further iron therapy in an iron-sufficient thalassemia patient risks iron overload c) Bone marrow biopsy d) Blood transfusion without further diagnostic workup (Correct Answer: b)

A CHT upazila health complex physician is about to prescribe primaquine for P. vivax radical cure to a 28-year-old Marma male patient. The facility does not have a G6PD rapid diagnostic test. Which of the following management approaches is most clinically appropriate given this constraint? a) Proceed with primaquine at standard dose (15 mg daily for 14 days) because the risk of not treating the hypnozoites outweighs the G6PD risk b) Omit primaquine entirely and only treat with blood schizonticidal therapy c) Prescribe a low-dose, slow-treatment primaquine regimen (0.75 mg/kg once weekly for eight weeks, which is the WHO-endorsed alternative regimen that significantly reduces but does not eliminate hemolytic risk in patients with intermediate G6PD deficiency), warn the patient and family to return immediately with any dark urine, pallor, or jaundice; simultaneously advocate to the district health officer for urgent G6PD RDT procurement; advise the patient to avoid fava beans and other oxidant foods d) Substitute dapsone for primaquine (Correct Answer: c)

CHAPTER TWO: CARDIOVASCULAR MEDICINE IN THE CHITTAGONG HILL TRACTS: THE NON-COMMUNICABLE DISEASE TRANSITION AT THE ECOLOGICAL FRONTIER

2.1 The CHT Cardiovascular Epidemiological Transition: A New Understanding

Cardiovascular disease in the Chittagong Hill Tracts is simultaneously an ancient and a modern phenomenon. It is ancient in the sense that the physiological foundations of cardiovascular pathology, including hypertension, cardiac hypertrophy, valvular heart disease, and the arterial wall changes of chronic inflammatory disease, have been present in CHT communities for as long as those communities have existed, driven by the infection, malnutrition, and physical stress of a life on the ecological frontier. It is modern in the sense that the specific phenotypic expression of cardiovascular disease in the CHT is rapidly changing, driven by the dietary and lifestyle transitions of the NCD epidemiological shift documented in Part Five. The CHT Cardiovascular Epidemiological Transition Framework, as articulated in this chapter, distinguishes three temporal phases of cardiovascular disease evolution in the CHT. The first phase is the Pre-Transition Phase, characterized by the dominance of rheumatic heart disease

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(from streptococcal pharyngitis and acute rheumatic fever in children living in overcrowded, nutritionally compromised conditions), infective endocarditis (from the high burden of bacteremic infections in immunocompromised individuals with pre-existing valvular lesions), cardiac complications of malaria (including malaria-associated myocarditis and the cardiac consequences of severe malarial anemia, including high-output cardiac failure from the compensatory tachycardia and increased cardiac output demanded by chronic severe anemia), and hypertensive heart disease (from salt-rich preserved food consumption, psychological stress of chronic political marginalization, and chronic kidney disease from the renal insults documented in Part Five). The second phase is the Early Transition Phase, currently underway in accessible CHT communities with greater market integration and dietary change, characterized by the emergence of type 2 diabetes-driven cardiovascular risk, dyslipidemia from saturated fat consumption increases in transitioning communities, hypertension with increasing incidence above and beyond the pre-transition drivers, and the beginning of coronary artery disease emergence in communities where it was previously rare. The third phase is the Advanced Transition Phase, not yet reached in the CHT but visible in the trajectory of other South Asian and Southeast Asian transitional populations, in which coronary artery disease, ischemic stroke, and heart failure from cardiomyopathy dominate the cardiovascular burden alongside the persistent rheumatic and infectious cardiac diseases of the pre-transition phase.

The CHT Cardiovascular Epidemiological Transition Framework has important clinical implications that distinguish cardiovascular medicine in the CHT from both the cardiovascular medicine of South Asian urban populations (where the advanced transition phase is already dominant) and from the cardiovascular medicine of sub-Saharan Africa (where rheumatic and hypertensive heart disease remain predominant). In the CHT, the clinician must be simultaneously competent in the recognition and management of rheumatic heart disease mitral stenosis (which remains an important cause of cardiac morbidity in middle-aged CHT indigenous women who had untreated streptococcal pharyngitis and acute rheumatic fever in childhood), the acute management of malaria-associated high-output cardiac failure, the management of hypertensive urgency and emergency in patients with no prior diagnosis or treatment, and the early recognition and management of emerging type 2 diabetes-driven cardiovascular risk in CHT community members undergoing dietary transition. This broad cardiovascular competency requirement, spanning multiple phases of the epidemiological transition, is unique to the transitional medical geography of territories like the CHT and demands a clinical education framework that does not privilege either the infectious-cardiac or the chronic-NCD dimension of cardiovascular medicine but integrates both within a coherent and ecologically grounded framework.

2.2 Rheumatic Heart Disease in the CHT: The Preventable Legacy of Streptococcal Infection

Rheumatic heart disease (RHD) represents the most important preventable cause of cardiovascular morbidity and mortality among the young adult population of the CHT. The pathophysiological chain leading from acute rheumatic fever (ARF) to RHD begins with Group A streptococcal (GAS, Streptococcus pyogenes) pharyngitis in a susceptible child, producing an immune response that through molecular mimicry (the structural similarity between certain GAS surface antigens, particularly the M protein and the N-acetyl-beta-D-glucosamine component of

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GAS carbohydrate, and cardiac tissue proteins including myosin, laminin, and valve collagen) generates cross-reactive T lymphocytes and antibodies that attack the heart valves, myocardium, and pericardium. ARF typically occurs two to four weeks after streptococcal pharyngitis and manifests with the Jones criteria features: carditis (inflammation of the heart, which may involve the endocardium, myocardium, and pericardium), migratory polyarthritis (typically affecting the large joints of the limbs in a migratory pattern), chorea (Sydenham's chorea, a neurological manifestation of rheumatic fever producing involuntary movements, emotional lability, and decreased muscle tone), erythema marginatum (a characteristic skin rash), and subcutaneous nodules. The cardiac involvement in ARF, particularly the valvular endocarditis, can produce permanent valve damage through the scarring and fibrosis of the healing process. Repeated episodes of ARF (in children who do not receive secondary prophylaxis against recurrent streptococcal infection) accumulate valve damage progressively, ultimately producing the chronic valve lesions of RHD: mitral regurgitation (in early disease, from the acute carditis) and mitral stenosis (in later disease, from progressive leaflet thickening, fusion of commissures, and calcification of the subvalvular apparatus), aortic valve involvement, and occasionally tricuspid and pulmonary valve lesions.

The epidemiological conditions that favor ARF and RHD in the CHT are precisely those that characterize the territory: household overcrowding that facilitates GAS transmission through respiratory droplets, inadequate access to antibiotic treatment that allows streptococcal pharyngitis to proceed without eradication of the causative organism and without interruption of the ARF-triggering immune response, and malnutrition that impairs the immune response to GAS in ways that may both increase susceptibility to recurrent streptococcal pharyngitis and alter the immune dysregulation that drives the rheumatic cross-reactive response. The 2023 data from the Global Burden of Disease study estimated that approximately 40 million people globally are living with RHD and that it causes approximately 300,000 deaths per year, with 80 percent of the burden concentrated in low- and middle-income countries. The CHT, with its combination of overcrowded bamboo housing, high streptococcal pharyngitis incidence, antibiotic access barriers, nutritional compromise, and endemic household poverty, is an environment that should produce one of the highest RHD prevalence rates in Bangladesh, yet CHT-specific RHD prevalence data do not exist. The clinical importance of this knowledge gap is that a CHT woman presenting at age 35 with dyspnea, orthopnea, hemoptysis, and a characteristic low-pitched mid-diastolic murmur at the cardiac apex heard best with the bell of the stethoscope in the left lateral decubitus position (the classic auscultatory features of mitral stenosis) is presenting with the end-stage consequence of an entirely preventable childhood disease process, and that this presentation is a signal for reflection on the failure of primary and secondary prevention of ARF in the CHT, not merely a clinical problem to be managed in isolation. The secondary prophylaxis of ARF, through monthly intramuscular benzathine penicillin injections (1.2 million units IM monthly for at least ten years from the last episode of ARF and until at least age 25 years in patients without carditis, or lifelong in patients with established RHD), is the most evidence-based intervention for preventing progression of ARF to severe RHD, and its consistent delivery to CHT children and adolescents with confirmed ARF represents a major clinical gap that must be addressed by the CHT health system.

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2.3 Hypertension in the CHT: Epidemiology, Determinants, and the Paradox of Low Diagnosis

Hypertension (blood pressure persistently at or above 140/90 mmHg by conventional threshold, though the 2023 ESC guidelines and other recent guidelines have moved toward risk-stratified rather than fixed-threshold diagnosis) is increasingly recognized as a major component of the NCD burden in the CHT, though its epidemiology in CHT indigenous populations is substantially less well characterized than in the general Bangladesh population. A 2024 cross-sectional survey of hypertension prevalence in four CHT indigenous communities (two Chakma and two Marma communities in Rangamati and Bandarban) found a crude hypertension prevalence of 29.4 percent in adults over 30 years, with diagnosis rates of only 38 percent of hypertensives (meaning that 62 percent of hypertensive individuals had not been told they had high blood pressure), treatment rates of 26 percent of diagnosed individuals, and control rates of only 19 percent of those receiving treatment. These figures, while preliminary and from a limited sample, illustrate what this textbook terms the CHT Hypertension Triple Gap: the gap between hypertension prevalence and diagnosis (the detection gap), the gap between diagnosis and treatment initiation (the treatment gap), and the gap between treatment initiation and blood pressure control (the control gap). Each of these gaps has distinct causes in the CHT context. The detection gap arises from the absence of routine opportunistic blood pressure measurement at community health worker and primary care levels, the absence of annual health check-up programs for adults over 30 years in CHT communities, and the absence of symptoms in most individuals with uncomplicated hypertension (which means that patients do not self-present for blood pressure evaluation). The treatment gap arises from financial barriers to purchasing antihypertensive medications (which must typically be taken indefinitely), physician hesitancy to initiate treatment based on a single blood pressure measurement in a poorly equipped facility, and patient reluctance to accept a long-term treatment commitment for an asymptomatic condition. The control gap arises from medication non-adherence (driven by cost, side effects, pill burden, and the absence of refill services in remote communities), dietary non-modification (the high sodium intake from preserved fish and fermented condiments common in CHT diets is a major hypertension driver that is difficult to modify), and inadequate follow-up and treatment titration. The clinical management of hypertension in the CHT requires addressing all three gaps simultaneously, with community-based blood pressure screening as the entry point, single-pill combination therapy where possible (to reduce pill burden and improve adherence), and community health worker-based follow-up to support adherence and early recognition of treatment failure.

The specific determinants of hypertension in CHT indigenous communities deserve attention because they include both the universal determinants of hypertension globally (age, obesity, sedentary lifestyle, high sodium intake, excessive alcohol consumption, genetic susceptibility, chronic kidney disease) and several CHT-specific determinants. Chronic psychological stress, rooted in the political history of the CHT, land insecurity, and the experience of ethnic discrimination, is increasingly recognized in the psychoneuroimmunological and cardiovascular literature as an independent risk factor for hypertension, operating through sustained activation of the hypothalamic-pituitary-adrenal axis and the sympathetic nervous system that produces chronic elevation of cortisol and catecholamines, resulting in vasoconstriction, sodium retention,

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and vascular remodeling. The indigenous fermented fish products (including shidal in Chakma cuisine, ngapi preparations in Marma cooking, and other community-specific fermented condiments) that form major flavor components of CHT traditional diets have very high sodium content and contribute substantially to dietary sodium excess in regular consumers. The chronic kidney disease documented in Part Five (from repeated malaria-associated nephritis, snake venom nephrotoxicity, traditional nephrotoxic plant preparation exposure, and other CHT-specific renal insults) drives secondary hypertension through the loss of renal sodium excretory capacity and the activation of the renin-angiotensin-aldosterone system (RAAS) that occurs in the context of renal parenchymal damage. The clinical implication is that first-line antihypertensive selection in CHT patients should specifically address these dominant pathophysiological drivers: ACE inhibitors or angiotensin receptor blockers (ARBs) as preferred agents in the substantial proportion of CHT hypertensive patients with underlying CKD or diabetes (where their renoprotective properties beyond blood pressure lowering are of particular benefit), combined with dietary sodium counseling that engages respectfully with the cultural role of fermented fish in CHT cuisine (proposing reduction rather than elimination, and exploring lower-sodium preparation methods).

2.4 Cardiac Arrhythmias, Heart Failure, and Echocardiography Access in the CHT

Cardiac arrhythmias, including atrial fibrillation (AF), ventricular arrhythmias, and conduction system disease, occur in the CHT in the context of the cardiac structural diseases documented in this chapter (particularly rheumatic mitral stenosis, which is a major cause of AF through atrial enlargement and fibrosis) and as complications of metabolic diseases (hypokalemia from diarrheal disease and diuretic use, hypomagnesemia, and thyroid disease). Atrial fibrillation in the context of rheumatic mitral stenosis is particularly dangerous because the loss of coordinated atrial contraction reduces the already impaired mitral diastolic filling, dramatically worsening cardiac output, and because the stasis of blood in the dilated, fibrillating left atrium creates a high risk of left atrial thrombus formation and systemic embolism (particularly cerebral embolism causing cardioembolic stroke, which produces some of the most devastating neurological outcomes in the CHT where cerebrovascular rehabilitation is entirely unavailable). The recognition of AF on clinical examination (an irregularly irregular pulse with pulse deficit when comparing the apical and radial rates simultaneously) is a core clinical skill that requires no technology and should be performed routinely in all CHT adult patients with cardiac symptoms or with known rheumatic heart disease. Echocardiography, the gold standard for cardiac structural assessment and the definitive investigation for all forms of valvular heart disease, cardiomyopathy, pericardial disease, and cardiac thrombus, is available at CHT district hospitals in some cases and at Chittagong Medical College Hospital for referral. The development of hand-held point-of-care ultrasound (POCUS) technology, which is now available in devices such as the Butterfly iQ and the Vscan Extend at costs that are becoming accessible for district-level deployment, offers the possibility of basic echocardiographic assessment (identifying significant valvular disease, pericardial effusion, and left ventricular dysfunction) at the district hospital level in the CHT without requiring the capital investment and technical infrastructure of a full echocardiography service. Advocacy for the deployment of POCUS technology at CHT district hospitals, combined with the training of district hospital physicians in basic echocardiographic assessment, represents an achievable technology-based improvement in cardiovascular

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diagnostic capability that could significantly improve the early detection and appropriate management of the rheumatic and hypertensive cardiac disease documented in the territory.

MODEL EXAMINATION QUESTIONS: CHAPTER TWO

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Rheumatic heart disease is initiated by which pathophysiological mechanism linking streptococcal pharyngitis to cardiac valve damage? a) Direct bacterial invasion of heart valves by Group A Streptococcus b) Molecular mimicry between GAS surface antigens and cardiac tissue proteins, producing cross-reactive T lymphocytes and antibodies that attack the heart c) Viral co-infection with cardiotropic viruses triggered by streptococcal pharyngitis d) Toxin-mediated direct cardiac damage from streptococcal exotoxins (Correct Answer: b)

The secondary prophylaxis of acute rheumatic fever to prevent recurrence and RHD progression uses: a) Daily oral amoxicillin for two years only b) Monthly intramuscular benzathine penicillin 1.2 million units for at least ten years and until at least age 25 c) Daily oral azithromycin for twelve months d) Single-dose intramuscular ceftriaxone once annually (Correct Answer: b)

Atrial fibrillation in the context of rheumatic mitral stenosis causes stroke primarily through which mechanism? a) Paradoxical embolism through a patent foramen ovale b) Hyperperfusion of the cerebral circulation from uncontrolled tachycardia c) Left atrial thrombus formation from blood stasis in the dilated fibrillating left atrium, with subsequent embolism to the cerebral circulation d) Bacterial endocarditis seeding the cerebral vessels (Correct Answer: c)

The CHT Hypertension Triple Gap refers to: a) The gap between systolic, diastolic, and mean arterial pressure measurements b) The detection gap, the treatment gap, and the control gap between hypertension prevalence, diagnosis, treatment, and control c) The three-district gap in hypertension services between Rangamati, Bandarban, and Khagrachhari d) The gap between traditional, biomedical, and community-based hypertension management (Correct Answer: b)

Which first-line antihypertensive drug class is specifically preferred in CHT hypertensive patients with underlying chronic kidney disease or diabetes? a) Beta-blockers (metoprolol or atenolol) b) Calcium channel blockers (amlodipine) only c) ACE inhibitors or ARBs, due to their renoprotective properties beyond blood pressure lowering d) Centrally acting agents (methyldopa) (Correct Answer: c)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 38-year-old Chakma woman presents to Rangamati District Hospital with progressive dyspnea over six months, two episodes of hemoptysis, and palpitations. She reports a childhood illness with joint pains and fever that resolved spontaneously without treatment at age 12. Examination reveals an irregularly irregular pulse of 92 beats per minute, a low-pitched rumbling mid-diastolic murmur with presystolic accentuation at the cardiac apex in the left lateral decubitus position, a loud first heart sound, and a palpable diastolic thrill at the apex. The most likely

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diagnosis, its pathophysiological basis in CHT context, and the most critical immediate investigation and management decision are: a) Hypertensive heart disease; treat with antihypertensives b) The clinical picture is classic for rheumatic mitral stenosis (MS) with atrial fibrillation (AF), based on the following elements: the history of childhood febrile illness with joint pains consistent with undiagnosed acute rheumatic fever at age 12; the current atrial fibrillation (irregularly irregular pulse); the characteristic low-pitched mid-diastolic murmur with presystolic accentuation, loud S1, and apical diastolic thrill of MS; and the symptoms of pulmonary venous congestion (dyspnea, hemoptysis); immediate priorities are: (i) ECG to confirm AF; (ii) echocardiography (at CMCH if district hospital lacks capacity) to characterize the valve lesion severity (MVA, mean pressure gradient, valve score for suitability of PTMC), assess for left atrial thrombus (which contraindicates immediate cardioversion), and assess left ventricular function; (iii) rate control of AF with digoxin or beta-blocker to reduce tachycardia and improve diastolic filling; (iv) anticoagulation with warfarin (vitamin K antagonist) to prevent left atrial thrombus and cardioembolic stroke, targeting INR 2 to 3; (v) referral to CMCH cardiology for expert management and assessment for percutaneous transvalvular mitral commissurotomy (PTMC) or surgical valve replacement as definitive treatment for severe MS c) Pulmonary tuberculosis; sputum AFB d) Viral myocarditis; prescribe bed rest (Correct Answer: b)

CHAPTER THREE: ENDOCRINOLOGY AND METABOLIC DISEASE IN THE CHT: DIABETES, THYROID DISORDERS, AND THE METABOLIC SYNDROME AT THE FRONTIER

3.1 The CHT Metabolic Transition Doctrine

The CHT Metabolic Transition Doctrine, as articulated in this chapter, holds that the metabolic diseases emerging in CHT indigenous communities are not simple importations of the lifestyle-driven metabolic epidemics of urban South Asia, but are qualitatively distinct metabolic disturbances that emerge from the specific intersection of the CHT's pre-transition biology (including the programming effects of early life malnutrition through the Developmental Origins of Health and Disease, DOHaD, pathway, the unique insulin sensitivity and adipokine profiles of genetically isolated indigenous populations, and the legacy of chronic infection-driven immune dysregulation on glucose homeostasis) with the dietary and lifestyle changes of the NCD transition. The pre-transition biology of CHT indigenous populations creates a metabolic risk profile that is not adequately captured by the standard BMI-based obesity and metabolic syndrome frameworks developed primarily for populations in high-income countries with different genetic backgrounds, different birth weight distributions, and different histories of nutritional experience. The DOHaD pathway, grounded in the work of David Barker and developed subsequently through the concept of thrifty phenotype programming, holds that intrauterine and early postnatal nutritional adversity programs persistent epigenetic changes in the metabolic control systems of the developing organism, reducing insulin secretory capacity, reducing insulin sensitivity in peripheral tissues, and increasing the adipogenic response to caloric excess, in ways that optimize survival under conditions of continued caloric scarcity but

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create a metabolic syndrome phenotype when the individual subsequently encounters caloric abundance. In CHT indigenous communities with high rates of low birth weight (from the placental malaria and maternal malnutrition documented in Part One and Part Six Chapter One), the prevalence of thrifty phenotype programming is substantial, and this programming creates a population-level metabolic risk that is biologically embedded in the bodies of people who may appear by conventional BMI criteria to be normal weight or even underweight. The clinical implication is that type 2 diabetes and the metabolic syndrome in CHT indigenous communities may present at lower BMI thresholds than those used in standard clinical guidelines, and that a CHT patient with a BMI of 23 (which would not trigger metabolic screening in most national guidelines) may already have significant insulin resistance, dyslipidemia, and early type 2 diabetes that requires evaluation.

Type 2 diabetes mellitus (T2DM) is increasingly recognized in CHT clinical practice as a significant and growing health problem, though precise prevalence data for CHT indigenous communities are not available from any population-based study published to date. The clinical recognition of T2DM in the CHT is complicated by several factors. The classic presenting symptoms of T2DM (polyuria, polydipsia, polyphagia, weight loss) are frequently absent or attributed by patients to other causes (polyuria may be attributed to diarrheal illness, weight loss to malnutrition or tuberculosis, fatigue to malaria or anemia). Many CHT patients with T2DM present for the first time with a diabetic complication: diabetic foot infection (a major cause of surgical admission and lower limb amputation at CHT district hospitals, as documented in the Part Five chapters on emergency and surgical medicine), visual impairment from diabetic retinopathy, peripheral neuropathy producing burning foot pain and numbness (which may be attributed to nutritional neuropathy in the CHT context), or acute metabolic decompensation in the form of hyperosmolar hyperglycemic state (HHS) triggered by infection (which is the most common precipitant of diabetic emergencies in tropical settings). The management of T2DM in the CHT context requires adaptation of the standard glycemic management guidelines to the specific constraints and considerations of the territory. Metformin remains the recommended first-line pharmacological treatment for T2DM, and its use in the CHT is appropriate, affordable (it is on the WHO Essential Medicines List and generally available at district hospital pharmacies), and effective. Its gastrointestinal side effects (nausea, diarrhea, abdominal discomfort) are relevant in the CHT, where diarrheal illness is endemic and the addition of drug-related gastrointestinal symptoms may be attributed to infection rather than metformin, but starting at low dose (500 mg once daily with the largest meal, titrating over four to eight weeks to the target dose of 1,000 mg twice daily) minimizes these side effects significantly.

3.2 Thyroid Disorders in the CHT: Iodine, Mountains, and the Invisible Gland

Thyroid disease in the CHT presents a pattern that reflects the dual influence of iodine deficiency (historically endemic in mountainous regions of South Asia and a classical geomedicinal determinant of thyroid pathology) and the autoimmune and structural thyroid diseases increasingly recognized as the CHT dietary transition exposes previously iodine-restricted populations to variable iodine intakes. Iodine deficiency disorders (IDD), encompassing the spectrum of hypothyroidism, goiter, cretinism (congenital severe hypothyroidism from maternal iodine deficiency during pregnancy), and subclinical cognitive impairment from mild-to-

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moderate iodine deficiency in childhood, have historically been documented in Bangladesh's hill districts, and the CHT's geographic position as a mountainous territory with rainfall-leached soils (the geological processes of the monsoon-fed erosion in the CHT hills leach iodine from the surface soils into rivers and ultimately to the sea, leaving the CHT's agricultural soils iodine-depleted) creates the conditions for endemic iodine deficiency unless adequately compensated through the use of iodized salt or other dietary iodine sources. The Bangladesh national iodized salt program has substantially reduced IDD nationally, but the program's coverage in the remote CHT communities most dependent on locally produced salt or salt obtained through informal border trade channels (including non-iodized salt from Myanmar) is imperfect, and pockets of IDD may persist in the most remote CHT communities despite national program improvements. The clinical recognition of hypothyroidism in CHT patients requires awareness of its diverse and non-specific presentation, which in the adult patient includes cold intolerance (of limited diagnostic value in a mountain territory where cold is normal), fatigue and lethargy (common to multiple conditions prevalent in the CHT), weight gain (relevant in a community where weight gain is generally unusual and may be attributed to recovery from malnutrition), constipation (common from multiple causes), dry skin, bradycardia, and in severe cases myxedema, pericardial effusion, and cardiac failure. Neonatal hypothyroidism (congenital hypothyroidism, from maternal iodine deficiency or thyroid dysgenesis), which presents with prolonged neonatal jaundice, feeding difficulty, large tongue, large fontanelles, umbilical hernia, hypothermia, and hypotonia in the newborn period, is an endocrine emergency requiring urgent thyroid hormone replacement to prevent permanent intellectual disability, and neonatal screening for congenital hypothyroidism (through heel prick TSH measurement) is currently absent from CHT clinical practice despite the availability of the test in Bangladesh's major tertiary centers.

Thyroid cancer, though less common than other cancer types discussed in Part Five, deserves mention in the CHT context because differentiated thyroid cancer (papillary and follicular thyroid carcinoma) has a relatively favorable prognosis when detected at early stage and treated with total thyroidectomy and radioiodine ablation, but the extreme limitation of thyroid surgery and radioiodine therapy availability for CHT patients (concentrated exclusively at Chittagong Medical College Hospital and national referral centers in Dhaka) means that the majority of CHT thyroid cancer patients who are diagnosed are diagnosed late. Nodular goiter, which is endemic in iodine-deficient areas, requires a structured clinical approach in the CHT: solitary thyroid nodules and rapidly growing goiters must be investigated for malignancy (through fine needle aspiration cytology where available) rather than uniformly attributed to iodine deficiency and left untreated. The clinical approach to thyroid nodule assessment in the CHT context should use the ATA (American Thyroid Association) or BTA (British Thyroid Association) risk stratification framework to identify nodules requiring FNAC based on ultrasound features (solid composition, hypoechogenicity, irregular margins, microcalcifications, taller-than-wide shape, and lymph node abnormalities each independently increase malignancy risk), with those CHT patients in whom FNAC is not locally available requiring referral to Chittagong Medical College Hospital for ultrasound-guided FNAC if their clinical or ultrasound risk features suggest malignancy.

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3.3 The Metabolic Syndrome in CHT Indigenous Populations: A New Phenotypic Understanding

The metabolic syndrome, defined conventionally as the clustering of central obesity, elevated triglycerides, reduced HDL-cholesterol, elevated fasting glucose, and hypertension, has been operationally defined by multiple sets of criteria (IDF, ATP III, WHO, and the harmonized NCEP/AHA criteria) that differ primarily in their waist circumference thresholds and their required components. All definitions use waist circumference as a measure of central (visceral) adiposity, which is the mechanistically primary component of the metabolic syndrome because visceral adipose tissue is metabolically active in distinct ways from subcutaneous fat, secreting pro-inflammatory adipokines (including TNF-alpha, IL-6, and resistin) that impair insulin signaling in peripheral tissues and the liver, and releasing free fatty acids directly into the portal circulation where they drive hepatic insulin resistance and de novo lipogenesis. The appropriate waist circumference thresholds for CHT indigenous populations are not established, because no population-specific anthropometric studies of adequate quality have been conducted in the CHT, but the evidence from comparable Asian populations (Japanese, Korean, Chinese, and South Asian studies) consistently shows that Asian populations develop metabolic syndrome at substantially lower BMI and waist circumference thresholds than European populations, necessitating lower cut-off values. For South Asian populations, the IDF recommends waist circumference thresholds of 90 cm in men and 80 cm in women (compared with 102 cm and 88 cm for European populations), and these South Asian thresholds are the most appropriate available proxy for CHT indigenous populations pending population-specific data. The practical implication for CHT clinical screening is that a CHT indigenous man with a waist circumference of 85 cm (which would be classified as normal using European cut-offs) should be screened for other metabolic syndrome components and for early type 2 diabetes, because his ethnic-specific metabolic risk at this waist circumference is substantially higher than a European man's risk at the same measurement.

MODEL EXAMINATION QUESTIONS: CHAPTER THREE

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The Developmental Origins of Health and Disease (DOHaD) hypothesis, as applied to CHT indigenous communities, predicts that: a) Children born in the CHT develop better metabolic adaptation to caloric excess due to exercise b) Intrauterine and early postnatal malnutrition programs epigenetic changes that reduce insulin secretory capacity and increase adipogenic response, creating metabolic syndrome risk when the individual encounters caloric excess c) Malaria-associated intrauterine growth restriction has no long-term metabolic consequences d) Indigenous populations have inherently better insulin sensitivity than non-indigenous populations (Correct Answer: b)

The classic presentation of congenital hypothyroidism in the neonate includes all of the following EXCEPT: a) Prolonged neonatal jaundice b) Large tongue (macroglossia) c) Tachycardia and sweating d) Umbilical hernia and hypothermia (Correct Answer: c)

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The most appropriate first-line pharmacological treatment for newly diagnosed type 2 diabetes in a CHT adult patient with no renal or hepatic contraindications is: a) Insulin (basal or premixed) b) Sulfonylurea (glibenclamide) c) Metformin d) DPP-4 inhibitor (Correct Answer: c)

Visceral adipose tissue is metabolically distinct from subcutaneous fat in that it: a) Stores more energy per gram than subcutaneous fat b) Secretes pro-inflammatory adipokines and releases free fatty acids directly into the portal circulation, driving hepatic insulin resistance and dyslipidemia c) Has a lower blood supply and less metabolic activity d) Is not related to cardiovascular risk in Asian populations (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A community health worker in a CHT Marma community conducts metabolic syndrome screening. She identifies a 45-year-old woman with waist circumference 82 cm, fasting blood glucose 6.4 mmol/L, triglycerides 1.9 mmol/L, HDL-cholesterol 0.9 mmol/L, and blood pressure 138/86 mmHg (two readings). Applying the IDF criteria for South Asian populations, this patient meets criteria for metabolic syndrome. Which element of her management plan is most critical for cardiovascular risk reduction? a) Weight loss through caloric restriction to below 1,200 calories per day b) A comprehensive and individualized risk reduction plan addressing all components of the metabolic syndrome simultaneously: (i) lifestyle intervention targeting dietary sodium reduction (relevant to blood pressure), dietary refined carbohydrate reduction (relevant to triglycerides and glucose), increased physical activity in CHT-appropriate forms (agricultural work may already be high, but targeted aerobic activity adds further benefit), (ii) metformin initiation for impaired fasting glucose with lifestyle counseling, (iii) blood pressure management with ACE inhibitor or ARB if blood pressure does not normalize with lifestyle intervention over three months, (iv) statin therapy assessment (calculation of 10-year ASCVD risk using pooled cohort equations or Framingham risk score, with moderate-intensity statin initiation for high-risk patients), (v) repeat metabolic panel in three months with monitoring of glucose, lipids, and blood pressure, (vi) family member screening for metabolic syndrome c) Prescribe aspirin 75 mg daily as primary prevention d) Refer immediately to CMCH endocrinology (Correct Answer: b)

CHAPTER FOUR: IMMUNOLOGICAL SCIENCE, VACCINE PROGRAM ARCHITECTURE, AND THE CHT IMMUNE LANDSCAPE

4.1 The CHT Immunological Identity: A Convergence of Infection, Malnutrition, and Genetic Isolation

The immunological health of CHT indigenous communities is shaped by a convergence of factors that produce an immune system with distinct characteristics from the general Bangladesh population: a high historical pathogen exposure load (from endemic malaria, chronic intestinal parasitism, repeated diarrheal infections, tuberculosis exposure, and the diverse vector-borne and zoonotic infections of the CHT forest zone) that has over generations shaped the adaptive immune repertoire of CHT populations through natural selection; the nutritional deficiency state

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documented throughout this textbook that impairs multiple arms of both the innate and adaptive immune systems in profoundly specific ways (protein-energy malnutrition reduces T-lymphocyte proliferative capacity and cytokine production, zinc deficiency impairs NK cell activity and neutrophil function, vitamin A deficiency impairs mucosal barrier integrity and the differentiation of innate lymphoid cells, and iron deficiency impairs neutrophil oxidative burst, lymphocyte proliferation, and NK cell cytotoxicity); the genetic isolation and endogamy of CHT indigenous communities that have produced unique HLA (Human Leukocyte Antigen) allele distributions (the HLA system governs the presentation of antigenic peptides to T lymphocytes and is the primary genetic determinant of adaptive immune response specificity and magnitude, so differences in HLA allele distribution between CHT populations and other populations may produce differences in vaccine response, susceptibility to autoimmune disease, and susceptibility to specific infectious diseases); and the legacy of chronic helminthic and other parasitic infections that chronically shift the immune response toward a Th2 cytokine profile (dominated by IL-4, IL-5, IL-13, and IgE), potentially impairing the Th1-dominated cellular immunity that is critical for control of intracellular pathogens such as Mycobacterium tuberculosis, Plasmodium species, and Leishmania. The immunological consequence of this Th2 skew in chronically helminth-infected CHT communities is the documented paradox of immune hypo-responsiveness to pathogens (potentially increasing susceptibility to TB, malaria, and other intracellular infections) coexisting with immune hyper-responsiveness in other domains (the elevated IgE levels in helminth-infected individuals paradoxically reduce atopic disease through competitive occupation of mast cell IgE receptors, providing a partial explanation for the low prevalence of atopic asthma and eczema in the most helminth-burdened CHT communities, in contrast to the paradoxical increase in these conditions in communities undergoing helminth elimination without adequate Th1 immune environment restoration).

The vaccine immunology of CHT indigenous communities is a practically critical and scientifically underinvestigated area. Vaccine response is determined by the interaction between the antigen delivered by the vaccine and the immune system of the vaccinee, and the immunological characteristics of CHT populations (altered HLA allele distributions, Th2 skew from chronic helminthic infection, nutritional immune compromise) have the potential to modify the magnitude and durability of the vaccine-specific immune response in ways that may affect both the individual-level protection conferred by vaccination and the community-level herd immunity threshold that must be achieved for epidemic prevention. The most important practically documented concern in the CHT vaccine context is the reduced immunogenicity of oral poliovirus vaccine (OPV) and oral rotavirus vaccine in malnourished children with tropical enteropathy, a finding that has been replicated across multiple studies from South and Southeast Asian settings with similar enteric disease burdens to the CHT. The proposed mechanisms for this reduced oral vaccine immunogenicity include the degradation of the vaccine virus by the intestinal proteolytic environment of the enteropathy-affected gut, the competition of vaccine-virus-specific immune responses with the concurrent immune activation from ongoing enteropathogen exposures, and the impaired mucosal secretory IgA response in malnourished children. The practical implication is that CHT children with clinical or subclinical tropical enteropathy and malnutrition may require additional doses of oral vaccines to achieve adequate seroconversion compared with the standard EPI schedule, and that the monitoring of post-vaccination seroconversion rates in CHT communities is a public health priority that has not

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been implemented. The 2025 measles outbreak, while primarily attributable to vaccine program access failure rather than vaccine immunogenicity failure, underscores the urgency of understanding and addressing all factors that may reduce the effectiveness of the immunization program in the CHT.

4.2 The Expanded Programme on Immunization in the CHT: Coverage, Gaps, and the Architecture of Failure

The Expanded Programme on Immunization (EPI) of Bangladesh administers vaccines against ten diseases: tuberculosis (BCG), diphtheria, tetanus, pertussis (DTP), hepatitis B, Haemophilus influenzae type b (Hib, through the pentavalent DTP-HB-Hib combination vaccine), polio (IPV and OPV), measles-rubella (MR), and pneumococcal disease (PCV10, introduced nationally from 2015). The EPI schedule in Bangladesh delivers these vaccines through a combination of outreach vaccination sessions (in which health workers travel to community-level sites to deliver vaccines), facility-based vaccination services (at union health and family welfare centers and upazila health complexes), and national immunization days (for polio and other selected antigens). The national immunization coverage for most antigens in Bangladesh has improved dramatically since the 1990s, reaching above 90 percent for several antigens in the national DHS data. However, this national average conceals massive geographic and demographic heterogeneity, and the CHT, particularly the remote indigenous communities of Bandarban, is documented as one of the most under-covered areas in Bangladesh for virtually every vaccine antigen.

The architecture of EPI failure in remote CHT communities has been analyzed from multiple angles, and the analysis consistently identifies the same convergent factors. The geographic architecture of outreach immunization service delivery assumes a maximum travel distance from the health facility to the outreach site that is simply not achievable in the extreme terrain of remote CHT communities, where the distance from a health facility to communities like Kurukpata in Alikadam is a multiple-hour journey requiring boat transport and foot travel, well beyond the operational range of routine outreach sessions that are constrained by the work hours and transport resources of the health worker. The cold chain architecture of the EPI assumes that vaccines can be maintained at 2 to 8 degrees Celsius from the vaccine store to the point of injection, and this requirement becomes increasingly difficult to meet with each additional hour of transport time and terrain complexity, creating a vaccine potency risk for the fraction of doses that do reach remote CHT communities. The communication architecture of the EPI assumes that communities receive and understand immunization schedule information and will present at the appropriate time and location for vaccination, an assumption that breaks down completely in communities whose primary language is not Bangla and who have no access to Bangla-medium mass media. The registration architecture of the EPI assumes that children are captured in birth registration and health facility records that allow tracking of immunization status and identification of missed doses, an assumption that is systematically violated in CHT communities where birth registration rates are low and health record systems do not adequately extend into the most remote settlements.

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4.3 Autoimmunity and Immune-Mediated Disease in the CHT: The Emerging Dimension

Autoimmune diseases and other immune-mediated conditions represent an emerging and poorly characterized dimension of CHT medical burden. The global epidemiology of autoimmune diseases demonstrates a consistent inverse relationship between pathogen exposure (and specifically helminthic infection) and autoimmune disease prevalence, producing the hygiene hypothesis and its refinement in the old friends hypothesis (Rook, 2003, updated in subsequent work through 2024): that the organisms with which humans co-evolved over millennia of pre-industrial living, including helminths, saprophytic mycobacteria, and other non-pathogenic microorganisms encountered through soil and water exposure, were essential regulators of the immune system's inflammatory set-point, and their elimination through sanitation improvement and antibiotic treatment has left the immune system without its evolutionary calibrators, resulting in the dysregulated inflammation of autoimmune and allergic disease. In the CHT, the coexistence of populations with high helminthic infection burden (and possibly lower autoimmune disease risk) alongside populations undergoing rapid WASH improvements and antibiotic exposure (potentially experiencing the immunological dysregulation of the hygiene hypothesis) creates a natural laboratory for investigating the old friends hypothesis in a South Asian context. The clinical implication is that as CHT communities undergo sanitation improvements and reduce their helminthic infection burden, the clinician should anticipate an emerging burden of atopic and autoimmune disease that does not currently present prominently in the CHT clinical picture. Rheumatoid arthritis, systemic lupus erythematosus (SLE), inflammatory bowel disease, and type 1 diabetes are all conditions whose prevalence has historically been low in tropical settings with high pathogen burden and that may increase as these settings undergo epidemiological transition, requiring the CHT health system to develop clinical capacity in immunorheumatological diagnosis and management that does not currently exist.

MODEL EXAMINATION QUESTIONS: CHAPTER FOUR

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The Th2 cytokine skew produced by chronic helminthic infection is primarily driven by which cytokines? a) IFN-gamma, TNF-alpha, IL-2, and IL-12 b) IL-4, IL-5, IL-13, and IgE c) IL-17, IL-22, and IL-23 d) IL-6, IL-10, and TGF-beta (Correct Answer: b)

The old friends hypothesis proposes that autoimmune and allergic disease is caused by: a) Increased exposure to environmental allergens from industrial pollution b) The elimination through sanitation and antibiotic use of organisms with which humans co-evolved, which historically regulated the immune system's inflammatory set-point c) Genetic mutations in immune regulatory genes caused by environmental toxins d) Increased viral exposures from international travel and urbanization (Correct Answer: b)

Reduced immunogenicity of oral poliovirus vaccine (OPV) in malnourished CHT children is attributed to: a) Anti-vaccine community resistance b) Cold chain failure during transport c) Degradation of vaccine virus by intestinal proteolytic environment, competition from concurrent

enteropathogen immune activation, and impaired mucosal secretory IgA response d) Interference from simultaneous BCG vaccination (Correct Answer: c)

The HLA (Human Leukocyte Antigen) system is most fundamentally relevant to vaccine immunology because: a) HLA molecules determine ABO blood group compatibility b) HLA allele distribution governs the presentation of antigenic peptides to T lymphocytes, determining the specificity and magnitude of adaptive immune responses to vaccine antigens c) HLA typing determines which vaccines are safe to administer d) HLA molecules transport vaccine antigens across the intestinal mucosa (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A district EPI officer in Bandarban reviews immunization coverage data from a recent coverage survey and finds that MR (measles-rubella) vaccine coverage in Alikadam upazila's three most remote unions is 12 percent, compared with 91 percent in the district town. She is designing an equity-focused immunization intensification strategy for these unions. Based on the immunization architecture failure analysis in this chapter, which combination of interventions addresses the most critical structural barriers? a) Increase the frequency of standard outreach sessions by the existing health worker team b) The strategy must simultaneously address: (i) geographic access by establishing permanent community-level immunization posts in each remote union, staffed by a locally recruited and specifically trained indigenous community health worker who is resident in the community and can deliver vaccinations without the extended travel of external outreach teams; (ii) cold chain access by deploying solar-powered vaccine refrigerators at each permanent community post; (iii) communication barriers by producing indigenous-language immunization communication materials in Mro, Bawm, and other local languages and deploying them through the trusted channels of karbaris, Buddhist monks, and village elders; (iv) registration gaps by initiating community-based birth registration and immunization status tracking through the indigenous CHW network; (v) demand generation through FPIC-based community engagement meetings that address vaccine hesitancy with factual, culturally appropriate information; (vi) program monitoring through quarterly coverage surveys disaggregated by ethnic community and geographic sub-district c) Conduct a single national immunization day and move on d) Withhold immunization from communities with hesitancy until they formally request services (Correct Answer: b)

CHAPTER FIVE: PEDIATRIC CLINICAL MEDICINE IN THE CHT: DISEASES OF CHILDHOOD IN A GEOMEDICINAL FRONTIER

5.1 The CHT Pediatric Epidemiological Framework: The Vulnerable Child at the Ecological Margin

Childhood in the Chittagong Hill Tracts is, for a significant proportion of indigenous children, a medical emergency that unfolds in slow motion. The combination of undernutrition that begins in utero (from placental malaria and maternal malnutrition), accelerates in the first two years of

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life (from suboptimal breastfeeding practices, early introduction of nutritionally inadequate complementary foods, repeated diarrheal illnesses, and the malarial infections that suppress appetite and disrupt nutrient absorption), and settles into a persistent chronic state of stunting and wasting that impairs every biological system simultaneously; the infectious disease burden that includes malaria, diarrheal diseases, respiratory infections, vaccine-preventable diseases, and endemic parasitism; the absence of consistent access to skilled healthcare; and the environmental insults of household air pollution, contaminated water, and agrochemical exposure together constitute what this textbook terms the CHT Pediatric Adversity Matrix, a structured and systemic patterning of biological, environmental, and social threats to child health that is not random, not natural, and not inevitable, but is produced by the specific ecological, political, and economic conditions of the CHT's indigenous communities. The CHT Pediatric Adversity Matrix is not simply a list of risk factors. It is an integrated system in which each component amplifies the pathological impact of every other component: malnutrition impairs the immune response to every infectious challenge; infections deplete nutritional reserves and suppress appetite, deepening malnutrition; household air pollution impairs respiratory mucosal defenses, increasing susceptibility to respiratory infections; contaminated water creates diarrheal illness that impairs nutrient absorption; and the social marginalization of the family limits access to the healthcare that could interrupt each of these vicious cycles before it produces permanent harm.

The under-five mortality rate (U5MR) in the CHT is not precisely quantified due to the absence of adequate vital registration, but triangulation of available data from community surveys, facility records, and the partial census data available for CHT indigenous communities suggests that U5MR in the most remote CHT communities is substantially higher than the national Bangladesh average of approximately 31 per 1,000 live births (DHS 2017-2018). The principal causes of under-five mortality in the CHT, as estimated from the available data, are neonatal causes (approximately 35 to 40 percent of all under-five deaths), pneumonia and acute lower respiratory infections (approximately 20 to 25 percent), diarrheal diseases (approximately 15 to 20 percent), malaria (approximately 10 to 15 percent), and malnutrition as an underlying cause contributing to deaths in all categories (documented in studies from similar settings to contribute to approximately 45 percent of all under-five deaths as an underlying cause of impaired immune defense against the proximate infectious killer). The clinical management of severe illness in under-five children in the CHT setting requires the application of the Integrated Management of Childhood Illness (IMCI) framework, adapted to the specific epidemiological and resource context of the CHT, and expanded to address the CHT-specific clinical challenges that the standard IMCI algorithm does not fully capture.

5.2 Acute Respiratory Infections in Children: The Pneumonia Burden

Pneumonia, the inflammation of the lower respiratory tract parenchyma (alveoli and supporting structures) produced by infection with bacterial, viral, or atypical organisms, is the single largest infectious cause of under-five mortality globally and is a leading cause of child death in the CHT. The etiological landscape of childhood pneumonia in the CHT is shaped by the dominant respiratory pathogens documented in similar settings in South and Southeast Asia, including Streptococcus pneumoniae (the leading bacterial cause of severe pneumonia in children under five globally, responsible for a substantial proportion of pneumonia deaths, and preventable

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through the PCV10 vaccine now included in the Bangladesh EPI), Haemophilus influenzae type b (also targeted by the Hib-containing pentavalent vaccine), Respiratory Syncytial Virus (RSV, the dominant viral cause of severe lower respiratory infection in infants and toddlers globally, responsible for approximately 3.2 million hospital admissions and 120,000 deaths annually in children under five in low- and middle-income countries according to 2023 estimates, and not yet preventable by vaccine in the Bangladesh EPI schedule as of 2025 despite the regulatory approval of the first maternal RSV vaccine and infant RSV monoclonal antibody in high-income countries from 2023), Staphylococcus aureus (a particularly dangerous cause of rapidly progressive necrotizing pneumonia and empyema in children, requiring broad-spectrum antibiotic coverage including anti-staphylococcal coverage, and a pathogen of concern given the documented methicillin-resistant Staphylococcus aureus, MRSA, burden in the Mekong subregion), and Mycobacterium tuberculosis (causing primary pulmonary tuberculosis in children, which presents differently from adult pulmonary TB, typically with hilar lymphadenopathy, patchy infiltrates without cavitation, and a lymphocytic pleural effusion rather than the upper lobe cavitating disease of adult TB).

The clinical assessment of pneumonia severity in a child presenting to a CHT health facility uses the WHO IMCI classification framework. Chest-indrawing pneumonia (the retraction of the lower chest wall with inspiration, indicating increased work of breathing from significant lower airway or alveolar disease) classifies the child as having chest-indrawing pneumonia requiring in-patient treatment. Fast breathing alone (respiratory rate above 60 per minute in infants under 2 months, above 50 per minute in infants 2 to 12 months, or above 40 per minute in children 12 months to five years) without chest indrawing classifies the child as having non-severe pneumonia requiring oral amoxicillin and home-based observation. Danger signs (central cyanosis, inability to drink or breastfeed, lethargy or reduced consciousness, convulsions, stridor in a calm child) classify the child as having very severe pneumonia requiring urgent parenteral antibiotic treatment and immediate referral. The antibiotic management of severe chest-indrawing pneumonia in children in CHT district hospitals and upazila health complexes uses ampicillin (50 mg/kg IM or IV every six hours) plus gentamicin (7.5 mg/kg IM or IV once daily) as the first-line regimen, which provides effective coverage for S. pneumoniae, H. influenzae type b, and neonatal-spectrum gram-negative organisms, is recommended by the WHO IMCI guidelines, and is available at government facility pharmacies. The 2023 WHO updated guidelines recommend three days of ampicillin-gentamicin for severe pneumonia without very severe signs in children over six months, which reduces the duration of hospital admission, a practically important consideration in the CHT where prolonged hospitalization creates major household economic burdens.

5.3 Severe Acute Malnutrition: Recognition, Management, and the F-75/F-100 Protocol

Severe acute malnutrition (SAM), defined as weight-for-height Z-score below -3 (severe wasting) or mid-upper-arm circumference (MUAC) below 115 mm in children 6 to 59 months of age, or the presence of bilateral pitting nutritional edema (kwashiorkor), is the nutritional emergency most frequently requiring hospitalization and most directly life-threatening of the malnutrition presentations in the CHT. A child with SAM has a case fatality rate of 20 to 30 percent without treatment, reduced to approximately 5 to 10 percent with standardized in-patient

management, and to approximately 1 to 5 percent with comprehensive community-based management using ready-to-use therapeutic food (RUTF) for cases without complications. The two principal clinical presentations of SAM are marasmus (severe wasting with minimal subcutaneous fat and muscle, producing the characteristic visible ribs, protuberant abdomen from distended bowel gas and hepatomegaly, old man's face appearance from loss of buccal fat pads, and hair changes) and kwashiorkor (primarily characterized by bilateral symmetrical pitting edema beginning from the feet and extending upward in severity, accompanied by hair changes (depigmentation, easy pluckability, flag sign from alternating bands of normal and depigmented hair), skin changes (flaky paint dermatitis with areas of hyperpigmentation and peeling), hepatomegaly from fatty infiltration, and marked misery and apathy). The metabolic characteristics of kwashiorkor, which includes significant electrolyte disturbances (hypokalemia, hypomagnesemia, and hypophosphatemia), impaired hepatic protein synthesis (low albumin, impaired clotting factor production), and immune compromise from protein deficiency, make the management of kwashiorkor more complex than marasmus and require specific attention to electrolyte repletion, the avoidance of high-energy feeding during the acute phase (which risks the refeeding syndrome from phosphate redistribution), and the management of secondary infections that almost invariably accompany kwashiorkor. The WHO ten-step protocol for in-patient SAM management, which guides the management through the acute stabilization phase (days one to seven, using the F-75 starter formula at restricted caloric delivery to avoid refeeding syndrome), the transition phase, and the rehabilitation phase (using the F-100 catch-up formula at higher caloric delivery to drive rapid weight gain), is the evidence-based standard for CHT district hospital SAM management, and every CHT district hospital must maintain the capacity to implement this protocol.

5.4 Neonatal Care in the CHT: The Most Critical 28 Days

Neonatal mortality (deaths in the first 28 days of life) accounts for approximately 40 percent of all under-five mortality globally and an estimated similar or higher proportion in the CHT, where the combination of high rates of deliveries without skilled birth attendance, high rates of low birth weight, high rates of infection from non-hygienic delivery practices, and limited newborn resuscitation capability at health facilities creates a particularly dangerous neonatal period. The major causes of neonatal death in the CHT are birth asphyxia (failure to establish normal breathing at delivery, producing hypoxic-ischemic encephalopathy with its spectrum from mild neurodevelopmental impairment to neonatal death), neonatal sepsis (infection entering through the umbilical cord from a contaminated delivery environment, through the skin from neonatal skin infections, or through aspiration of infected amniotic fluid), prematurity and its complications (particularly respiratory distress syndrome from surfactant deficiency in lungs less than 34 weeks gestation, hypothermia from the inadequate thermoregulation of the preterm newborn, and neonatal hypoglycemia from limited glycogen stores), and neonatal tetanus (from delivery onto contaminated surfaces or cord cutting with non-sterile instruments, a cause of neonatal death that is preventable through maternal immunization with tetanus toxoid, which the Bangladesh EPI has made widely available but whose coverage in remote CHT indigenous women remains incomplete). The most impactful single intervention for reducing neonatal mortality at the community level in the CHT is the Helping Babies Breathe (HBB) protocol, which teaches traditional birth attendants, community health workers, and peripheral health

facility staff the essential skills of immediate newborn assessment, drying and stimulation (which is effective in establishing breathing in the majority of birth asphyxia cases), suction of the airway, and bag-mask ventilation (which provides positive pressure ventilation to the non-breathing neonate using simple equipment that is available at district and upazila level), with evidence from multiple large randomized trials showing that these simple interventions, when consistently applied by trained birth attendants in community settings, reduce early neonatal mortality from birth asphyxia by 30 to 50 percent. Kangaroo Mother Care (KMC), the practice of providing continuous skin-to-skin contact between the preterm or low birth weight neonate and its mother (or a family member), is the most evidence-based intervention for reducing preterm mortality and morbidity and is entirely resource-independent, requiring no equipment beyond the human body and a fabric wrap to secure the infant in the kangaroo position. KMC has been shown in numerous trials and a 2021 Cochrane review to reduce preterm mortality by approximately 40 percent and reduce hypothermia, hypoglycemia, and infection in low birth weight neonates. Its deployment through trained CHT community health workers and traditional birth attendants, with appropriate cultural adaptation for each CHT community, represents the highest-priority technology-independent neonatal intervention available in the territory.

MODEL EXAMINATION QUESTIONS: CHAPTER FIVE

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The WHO IMCI criterion for fast breathing in a child aged 12 months to 5 years is a respiratory rate above: a) 30 breaths per minute b) 40 breaths per minute c) 50 breaths per minute d) 60 breaths per minute (Correct Answer: b)

Severe acute malnutrition with bilateral pitting nutritional edema is classified as: a) Marasmus b) Kwashiorkor c) Marasmic-kwashiorkor d) Nutritional dwarfism (Correct Answer: b)

The F-75 starter formula in WHO SAM management protocol is used in the stabilization phase primarily to: a) Maximize caloric intake for rapid catch-up growth b) Provide restricted caloric delivery to avoid the refeeding syndrome from phosphate redistribution c) Supply antibiotic therapy through a fortified formula d) Correct dehydration through oral rehydration (Correct Answer: b)

Kangaroo Mother Care reduces preterm infant mortality primarily through: a) Antibiotic properties of maternal skin secretions b) Prevention of hypothermia, hypoglycemia, and infection through continuous skin-to-skin contact c) Stimulation of surfactant production in immature lungs d) Provision of immunoglobulins through colostrum only (Correct Answer: b)

The pathological process producing respiratory distress syndrome in preterm neonates below 34 weeks gestation is: a) Neonatal pneumonia from aspiration of amniotic fluid b) Surfactant deficiency in the immature lung producing alveolar collapse and impaired gas exchange c) Congenital diaphragmatic hernia from structural defect d) Respiratory muscle weakness from prematurity (Correct Answer: b)

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For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 14-month-old Khumi infant is brought to the Bandarban District Hospital with a 3-day history of fever, cough, and difficulty breathing. On examination: weight 6.2 kg (significantly below the expected 10 kg, indicating severe wasting), temperature 38.9 degrees, RR 56 breaths per minute, HR 148 BPM, SpO2 84% on room air, severe chest indrawing, nasal flaring, grunting, and bilateral basal crepitations on auscultation. MUAC measures 108 mm. The child has bilateral pitting edema of both feet. Applying the principles of integrated pediatric clinical management from this chapter, the complete assessment and initial management priorities are: a) Oral amoxicillin and home management b) The child meets multiple concurrent emergency criteria: (i) Very severe pneumonia (SpO2 84%, severe chest indrawing, grunting, nasal flaring, age-appropriate fast breathing) requiring immediate oxygen therapy (target SpO2 above 94%), IM ampicillin 50 mg/kg plus gentamicin 7.5 mg/kg once daily as parenteral first-line antibiotics, careful fluid management (avoid excessive IV fluid in severe pneumonia as it worsens pulmonary edema, prioritize oral hydration unless the child cannot take fluids); (ii) SAM with kwashiorkor (severe wasting from MUAC 108 mm AND bilateral pitting edema), requiring management on the WHO ten-step SAM protocol: treat hypoglycemia if present (check blood glucose immediately), prevent hypothermia (keep the child warm), treat and prevent dehydration with cautious ORS (never IV fluids for rehydration in SAM unless the child is in shock, as the immunocompromised heart is vulnerable to fluid overload), begin empirical broad-spectrum antibiotics for presumed sepsis (amoxicillin-clavulanate or ampicillin-gentamicin as already prescribed for pneumonia), give vitamin A 100,000 IU (for age 12-59 months with SAM and suspected deficiency), folic acid, zinc, and B-complex vitamins; begin F-75 starter formula at 100 kcal/kg/day by nasogastric tube if the child is too ill to suck; (iii) daily reassessment for treatment response c) Diagnose malaria only and treat with artemether-lumefantrine d) Discharge with nutritional supplementation and review in one week (Correct Answer: b)

CHAPTER SIX: APPLIED PHARMACOLOGY IN THE CHT: DRUG USE, HERB-DRUG INTERACTIONS, RATIONAL PRESCRIBING, AND THE PHARMACEUTICAL LANDSCAPE

6.1 The CHT Pharmacological Reality: A Landscape Between the Forest and the Pharmacy

The pharmacological reality of the CHT is the product of four simultaneous pharmaceutical systems operating in the same geographic and clinical space: the formal biomedical pharmacopoeia of the Bangladesh national health system (dominated by the WHO Essential Medicines List and the Bangladesh National Formulary, available through government supply chains to public facilities and through commercial channels in pharmacies); the traditional botanical pharmacopoeia of the CHT ethnomedicinal complex (the plant medicines of the Baiddya tradition described in Part One, Part Four, and referenced throughout this textbook); the unregulated informal pharmaceutical sector (including the rural medical practitioners, unlicensed drug dispensers, and village pharmacies that provide a majority of first-contact pharmaceutical access in remote CHT communities with the limited knowledge base and variable product

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quality that characterize informal pharmaceutical systems globally); and the cross-border pharmaceutical trade (including medicines imported informally from Myanmar and India across the CHT's porous border, which may include counterfeit antimalarials, sub-standard antibiotics, traditional medicinal preparations of uncertain composition, and drugs not licensed in Bangladesh). The interaction of these four pharmaceutical systems creates a pharmacological landscape of extraordinary complexity, in which the same patient may simultaneously be taking a biomedical antimalarial from a government clinic, a botanical preparation from a Baiddya healer, an antibiotic dispensed by a rural pharmacist without prescription, and a traditional preparation obtained from the Myanmar border market, with no healthcare provider having a complete picture of the patient's complete pharmaceutical exposure and no system in place to prevent the clinically significant drug-drug and herb-drug interactions that this polypharmacy inevitably generates.

The CHT Rational Prescribing Doctrine, articulated in this chapter, holds that pharmacological practice in the CHT must be governed by five principles simultaneously. The Completeness Principle requires that every CHT clinical encounter include a systematic inquiry into the patient's complete pharmaceutical exposure, encompassing prescribed biomedical medications, over-the-counter pharmaceuticals, informal sector preparations, and traditional botanical medicines, because the interactions between these systems can be clinically significant and potentially dangerous. The Appropriateness Principle requires that every prescription in the CHT be based on an accurate diagnosis and an evidence-based assessment of the benefit-to-risk ratio of the proposed treatment in the specific patient context, with particular attention to the CHT-specific contraindications (G6PD deficiency for primaquine and other oxidant drugs), pharmacokinetic modifications (the reduced drug metabolism from severe malnutrition, which reduces cytochrome P450 enzyme activity and can produce drug accumulation at standard doses), and the limited follow-up capacity that requires selection of short-course, simple regimens over complex multi-drug, multi-dose regimens wherever clinical evidence supports equivalence. The Accessibility Principle requires that prescribing in the CHT take into account the actual availability of the prescribed drug at the patient's geographic location, because prescribing a drug that is unavailable at the nearest pharmacy or facility serves the clinician's professional conscience while failing the patient's actual need. The Safety Principle requires that the identification and management of adverse drug reactions receive specific attention in the CHT context, because the delayed presentation of adverse drug reactions (from limited healthcare access), the misattribution of drug adverse effects to disease progression or new illness, and the absence of pharmacovigilance systems in the CHT create conditions where drug-related harm goes unrecognized and unaddressed. The Conservation Principle requires that antibiotic prescribing in the CHT be governed by antibiotic stewardship principles, with antibiotics prescribed only when there is a clinical indication for bacterial infection, at the appropriate dose and for the appropriate duration, and with avoidance of the broad-spectrum, empirical antibiotic prescribing that drives antimicrobial resistance, because the CHT's proximity to Myanmar, which is a documented hotspot for antimicrobial resistance development, makes resistance containment a particular priority.

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6.2 Herb-Drug Interactions of Clinical Significance in the CHT

Herb-drug interactions represent a clinically underrecognized and potentially dangerous dimension of pharmacological practice in the CHT, where the concurrent use of traditional botanical medicines and biomedical pharmaceuticals is common but almost never systematically evaluated. The mechanisms of herb-drug interaction are the same as those of drug-drug interactions: pharmacokinetic interactions (in which the plant medicine alters the absorption, distribution, metabolism, or elimination of the pharmaceutical drug) and pharmacodynamic interactions (in which the plant medicine has additive, synergistic, or antagonistic pharmacological effects with the pharmaceutical drug). The pharmacokinetic interactions of greatest clinical importance in the CHT context involve the cytochrome P450 (CYP) enzyme system, the major metabolic pathway for most pharmaceutical drugs. CHT ethnomedicinal plants known to have CYP enzyme modulatory effects include several species from the families most heavily represented in the Baiddya pharmacopoeia. St. John's Wort (Hypericum perforatum), widely known as a potent CYP3A4 and P-glycoprotein inducer that reduces the plasma concentrations of numerous drugs including antiretrovirals, ciclosporin, and warfarin, is not a CHT-specific plant, but the principle of CYP induction by plant components is directly relevant because several CHT botanical preparations have been shown in in vitro studies to have CYP modulatory activity, including Andrographis paniculata (Kalmegh, widely used in CHT traditional medicine for fever and gastrointestinal conditions, and shown to have CYP3A4 inhibitory activity in multiple studies), Piper longum (Long pepper, used in Ayurvedic and CHT traditional medicine, shown to inhibit CYP3A4 and CYP1A2), and Curcuma longa (turmeric, used across CHT communities as both a food spice and a traditional medicine, and shown to inhibit multiple CYP isoforms at pharmacological concentrations). The clinical significance of these CYP interactions in the CHT context relates primarily to the drugs most commonly co-prescribed with traditional medicines in CHT clinical practice: artemether-lumefantrine (which is metabolized primarily through CYP3A4, meaning that CYP3A4 inhibitors can increase artemether and lumefantrine plasma concentrations with potential toxicity consequences, while CYP3A4 inducers can reduce plasma concentrations and potentially contribute to treatment failure), warfarin (which is metabolized through CYP2C9 and is highly sensitive to CYP modulatory interactions, with narrow therapeutic index), and rifampicin (which is itself a potent CYP inducer and can be influenced by concurrent CYP-active botanical preparations). The clinical management of potential herb-drug interactions in the CHT requires a combination of systematic inquiry about traditional medicine use (which must be conducted respectfully and without judgment, because patients who anticipate disapproval will not disclose their traditional medicine use), clinical monitoring for signs of drug toxicity or treatment failure that might indicate a pharmacokinetic interaction, and where clinically possible, the suggestion of a temporal separation between botanical and pharmaceutical administration to reduce the duration of concurrent absorption.

6.3 Antibiotic Stewardship in the CHT: The Resistance Crisis at the Ecological Frontier

Antimicrobial resistance (AMR) is recognized globally as one of the most serious threats to human health in the twenty-first century, with the 2022 Lancet analysis estimating that AMR directly caused 1.27 million deaths globally in 2019 and was associated with 4.95 million deaths.

The CHT's geographic position at the border of Myanmar, a country with documented high rates of antimicrobial resistance across multiple pathogen-antibiotic combinations (including multidrug-resistant tuberculosis, artemisinin-resistant Plasmodium falciparum, and extensively drug-resistant gram-negative bacterial infections), and its large informal pharmaceutical sector in which antibiotics are dispensed without prescription and frequently without accurate diagnosis, creates conditions for accelerated AMR development and spread that demand specific attention. The CHT Antibiotic Stewardship Framework articulated in this chapter operates at three levels. At the prescriber level, the framework requires adherence to the WHO AWaRe (Access, Watch, Reserve) antibiotic classification in antibiotic selection: Access antibiotics (amoxicillin, cotrimoxazole, benzylpenicillin, metronidazole, gentamicin) should be the first-line agents for common infections where their spectrum of activity is appropriate, and Watch and Reserve antibiotics should be reserved for second-line indications and microbiologically confirmed resistant infections respectively. At the facility level, the framework requires the maintenance of an antibiotic formulary based on locally available resistance data (however limited), the monitoring of antibiotic consumption and antibiotic expenditure as proxies for prescribing practice, and the provision of antibiogram data from clinical isolates to inform empirical antibiotic selection for hospitalized patients. At the community level, the framework requires engagement with the informal pharmaceutical sector (particularly rural pharmacies and drug dispensers) to reduce the over-the-counter dispensing of antibiotics without clinical indication, an intervention that is politically and logistically challenging but epidemiologically essential for resistance containment.

MODEL EXAMINATION QUESTIONS: CHAPTER SIX

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The WHO AWaRe antibiotic classification categorizes antibiotics into three groups. The Access category contains antibiotics that should: a) Be reserved exclusively for resistant infections b) Be first-line agents for common infections where their spectrum is appropriate, and be prioritized for availability in all healthcare settings c) Be restricted to hospital use only d) Not be used in children under 12 years (Correct Answer: b)

Andrographis paniculata (Kalmegh), a commonly used CHT ethnomedicinal plant, is pharmacokinetically significant because it has documented: a) Anticoagulant activity equivalent to warfarin b) CYP3A4 inhibitory activity that can increase plasma concentrations of co-administered drugs metabolized by this pathway c) Potassium-wasting diuretic effects d) Acetylcholinesterase inhibitory activity (Correct Answer: b)

The refeeding syndrome, a dangerous complication of re-feeding severely malnourished patients too rapidly, is caused by: a) Hyperglycemia from excessive carbohydrate delivery b) Rapid intracellular shift of phosphate from the circulation during glucose-driven cellular energy metabolism, producing hypophosphatemia with cardiac, respiratory, and neurological consequences c) Fluid overload from enteral nutrition delivery d) Bacterial contamination of therapeutic food preparations (Correct Answer: b)

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For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 35-year-old Marma woman with confirmed Plasmodium falciparum malaria is prescribed artemether-lumefantrine (AL) by the district hospital physician. During the systematic traditional medicine inquiry, she discloses that she has been taking a preparation from the local Baiddya containing Andrographis paniculata and Piper longum twice daily for the past two weeks for fever management. What pharmacokinetic concern does this raise, and what is the clinically appropriate response? a) No concern; traditional medicines do not interact with biomedical pharmaceuticals b) Both Andrographis paniculata and Piper longum have CYP3A4 inhibitory activity, and since lumefantrine is primarily metabolized through CYP3A4, their concurrent administration may increase plasma lumefantrine concentrations, potentially increasing the risk of QT-interval prolongation and lumefantrine-associated cardiotoxicity; the clinically appropriate responses are: (i) obtain a 12-lead ECG to assess baseline QTc interval before initiating AL treatment; (ii) advise the patient to temporarily discontinue the Baiddya preparation for the six-day duration of AL treatment; (iii) explain the reason for this advice respectfully and without dismissing the value of the Baiddya preparation; (iv) monitor the patient clinically during treatment for symptoms of QT prolongation (palpitations, syncope, presyncope); (v) if clinically feasible, advise the patient to avoid other QT-prolonging medications (including azithromycin and fluoroquinolones) during AL treatment; (vi) document the herb-drug interaction concern in the patient's record c) Switch from artemether-lumefantrine to quinine monotherapy d) Increase the artemether-lumefantrine dose to compensate for CYP induction (Correct Answer: b)

CHAPTER SEVEN: COMMUNICABLE DISEASE SURVEILLANCE, EPIDEMIOLOGICAL INVESTIGATION, AND OUTBREAK RESPONSE IN THE CHT

7.1 The CHT Epidemiological Surveillance Architecture: A Doctrine of Structured Vigilance

Epidemiological surveillance, defined as the ongoing systematic collection, analysis, interpretation, and dissemination of health data for the purpose of planning, implementing, and evaluating public health practice, is the operational nervous system of any functioning public health system. In the CHT, the epidemiological surveillance system faces challenges that go beyond the technical limitations of any specific data collection method and extend into the fundamental questions of what can be known, by whom, through what means, and with what accountability in a geographically complex, politically sensitive, and institutionally fragmented territory. The CHT Epidemiological Surveillance Doctrine, articulated in this chapter, holds that effective surveillance in the CHT requires the simultaneous development of five mutually reinforcing surveillance capacities: passiveclinical surveillance (through the routine recording and reporting of disease cases from health facilities at all levels of the CHT health system), active community surveillance (through trained community health workers conducting systematic morbidity and mortality monitoring in their assigned communities and reporting to health facilities through established communication channels), sentinel surveillance (through the designation of specific health facilities and community sites as sentinel sites providing more detailed epidemiological and microbiological data than the routine passive system), event-based

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surveillance (through informal information networks including community leaders, religious figures, traditional healers, and media that can rapidly signal unusual health events requiring formal investigation), and environmental surveillance (through the systematic monitoring of vector density, water microbiological quality, and other environmental health indicators that provide early warning of epidemic potential before cases occur).

The CHT passive surveillance system, based on the routine recording and reporting of cases through the Integrated Management of Health Information System (iMHIS) of Bangladesh, captures only a fraction of the actual disease burden of the CHT for multiple well-documented reasons. The most remote communities, where disease burden is highest, have the least access to health facilities from which cases would be reported. Health workers at peripheral facilities frequently lack the time, the tools, or the training to complete case recording forms accurately and consistently. The IT infrastructure required for digital reporting is absent at most CHT peripheral facilities. The aggregated district-level data that emerge from the passive system are profoundly uninformative about the specific geographic and ethnic distribution of disease within the district, because they do not capture the sub-district geographic or ethnic identity of reported cases. The result is a surveillance system that systematically underrepresents the communities with the highest disease burden and provides data that are too aggregated to guide the targeted, community-specific interventions that CHT epidemiology demands. The reform of the CHT surveillance system, which is a prerequisite for meaningful epidemic preparedness and health program monitoring, requires specific investment in the training and equipping of community health workers as surveillance agents, the development of paper-based or mobile phone-based (where network coverage exists) case reporting tools adapted to the literacy levels and language capabilities of CHT health workers, and the establishment of a CHT-specific disease surveillance dashboard accessible to district and upazila health authorities for real-time situational awareness.

7.2 The Epidemiological Investigation of an Outbreak: A CHT Field Guide

The investigation of an infectious disease outbreak in the CHT follows the standard epidemiological investigation framework (establish that an outbreak exists, confirm the diagnosis, define the case, count cases and develop epidemic curves, determine the affected population and place, identify the exposure or source, develop and test hypotheses, implement control measures, and communicate findings) but requires CHT-specific adaptations at every step. The confirmation of an outbreak in the CHT is frequently delayed compared with accessible settings because the initial cases may be seen by traditional healers, rural drug dispensers, or BRAC community health workers rather than by facility-based clinicians who would trigger formal reporting. The communication of an unusual disease cluster from a remote CHT community to the district health authorities typically requires the active initiative of a community health worker or traditional healer who recognizes the cluster's significance, because passive surveillance systems do not capture clusters in communities where facility utilization is minimal. The rapid identification of the causative pathogen in a CHT outbreak requires field laboratory capability that currently does not exist in the CHT: most outbreaks in the territory are investigated initially with clinical and epidemiological tools alone, without microbiological confirmation, and the diagnosis is established by sending specimens to district hospital laboratories or (for novel pathogens or complex diagnostic questions) to the Institute of

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Epidemiology Disease Control and Research (IEDCR) in Dhaka, with turnaround times of days to weeks that are epidemiologically unhelpful for guiding the initial response.

The 2025 measles outbreak in Kurukpata provides the definitive recent case study for outbreak investigation in the CHT. The initial recognition of the outbreak occurred not through the formal surveillance system but through informal channels: community members and the council head of Kurukpata reported the unusual cluster of febrile rash illness in children to the local karbari network, which communicated with BRAC community health workers, who escalated to the Alikadam UHC. The time from outbreak onset (estimated early March 2025) to first formal response (the establishment of a temporary medical camp at Kurukpata primary school) was approximately two to three weeks, during which the outbreak expanded to involve multiple villages and accumulate the deaths that made it a national news story. The clinical confirmation of measles was established by the clinical presentation (prodromal fever, cough, coryza, conjunctivitis, followed by Koplik spots and centrifugally spreading maculopapular rash) in multiple cases, and laboratory confirmation through measles-specific IgM serology (requiring blood specimen collection and shipment to the national laboratory) was achieved for representative cases. The case-count epidemiology of the outbreak revealed the expected age distribution of unimmunized population outbreak, with the overwhelming majority of cases in children under five years, a high secondary attack rate within households (consistent with the extremely high measles R0 of 12 to 18 in fully susceptible populations), and a case fatality ratio elevated above the expected level for measles in adequately nourished populations, consistent with the documented severe malnutrition and vitamin A deficiency in Mro children that amplified measles severity. The outbreak control response included isolation of confirmed cases where possible, ring vaccination of contacts and community members who could be reached, vitamin A supplementation for all confirmed and suspected cases, nutritional supplementation for severe cases, and surveillance expansion to identify the full geographic extent of the outbreak. Lessons from the investigation regarding the surveillance architecture failure, the immunization program coverage gap, and the need for culturally adapted health communication were documented in post-outbreak review reports, though the translation of these lessons into sustained programmatic change remains, as documented earlier in this textbook, imperfectly achieved.

7.3 Foodborne Disease Surveillance and Outbreaks in the CHT

Foodborne disease, encompassing the illnesses produced by the ingestion of food or water contaminated with pathogenic microorganisms (bacteria, viruses, parasites) or their toxins, is a major but underrecognized component of the CHT's diarrheal disease burden. The specific ecological and food practices of the CHT create several pathways for foodborne disease that are distinct from the foodborne disease risks of urban Bangladesh. The consumption of fermented foods (including fermented fish, fermented bamboo shoots, fermented rice and millets, and fermented soybean preparations) is a central component of the cuisine of multiple CHT ethnic communities, and fermented foods, while generally safe when prepared according to traditional protocols maintained over centuries, can harbor pathogenic organisms when fermentation conditions are inadequate (insufficient salt concentration, improper temperature control, or contamination from unclean utensils or water). Bacillus cereus food poisoning, which produces

either an emetic syndrome (from the heat-stable emetic toxin of B. cereus that survives cooking in incompletely stored cooked rice, with symptoms of nausea and vomiting beginning within one to five hours of ingestion) or a diarrheal syndrome (from the heat-labile enterotoxin of B. cereus in various foods, with symptoms of abdominal cramps and diarrhea beginning eight to sixteen hours after ingestion), is likely to be prevalent in CHT communities where cooked rice is stored at ambient temperature for extended periods before consumption (a common practice in remote communities where refrigeration is absent) and then reheated (which does not destroy the preformed heat-stable emetic toxin). Botulism, from Clostridium botulinum toxin in improperly prepared preserved or fermented foods, is a rare but potentially fatal foodborne illness that should be in the differential diagnosis of any CHT patient presenting with descending flaccid paralysis (the hallmark neurological presentation of botulism toxin-mediated blockade of acetylcholine release at the neuromuscular junction) following ingestion of preserved or fermented food preparations. Mushroom poisoning, from the inadvertent consumption of toxic mushroom species during wild food foraging in the CHT forest (wild mushroom collection is practiced in multiple CHT indigenous communities as a dietary supplement), can produce a range of clinical presentations from self-limiting gastrointestinal toxicity to fatal hepatic failure from amatoxin poisoning (from Amanita phalloides and related species, whose amatoxins irreversibly inhibit RNA polymerase II in hepatocytes, producing a characteristic clinical course of initial gastrointestinal symptoms, a false recovery period, and then progressive fatal hepatic failure occurring three to ten days after ingestion). The recognition of amatoxin mushroom poisoning in the CHT is a clinical emergency that requires knowledge of the characteristic delayed hepatotoxic presentation and the management principle of early silibinin or N-acetylcysteine administration (as antidotes with evidence for reducing hepatic amatoxin toxicity), activated charcoal to reduce gastrointestinal amatoxin absorption in early presentations, and consideration of liver transplantation referral (to Dhaka) for the most severe cases.

MODEL EXAMINATION QUESTIONS: CHAPTER SEVEN

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Event-based surveillance in the CHT epidemiological surveillance system relies primarily on: a) Electronic health records from district hospital computers b) Informal information networks including community leaders, religious figures, traditional healers, and media signaling unusual health events c) Monthly facility report submissions to the district health office d) Annual demographic and health surveys (Correct Answer: b)

Amatoxin poisoning from ingestion of Amanita phalloides mushrooms produces fatal hepatic failure through which mechanism? a) Direct viral hepatitis by a mushroom-associated hepatotropic virus b) Irreversible inhibition of RNA polymerase II in hepatocytes, blocking mRNA synthesis and hepatocyte protein production c) Aflatoxin B1-mediated hepatocellular carcinoma d) Immune-mediated hepatitis from mushroom antigen cross-reactivity (Correct Answer: b)

The characteristic clinical course of severe amatoxin mushroom poisoning is: a) Immediate onset of flaccid paralysis b) Initial gastrointestinal symptoms, followed by a false recovery period of

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one to three days, then progressive fatal hepatic failure c) Immediate anaphylaxis and bronchospasm d) Subacute development of renal failure without hepatic involvement (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A district epidemiologist in Khagrachhari receives a report from a BRAC shasthya shebika of a cluster of children in a remote Tripura village presenting with acute onset of nausea, profuse vomiting, and abdominal pain within two hours of a shared meal of reheated rice from the previous evening's cooking. No fever is reported. This clinical and epidemiological picture is most consistent with which foodborne pathogen, and what is the public health investigation approach? a) Salmonella typhi food poisoning from inadequately cooked meat b) The presentation of multiple individuals simultaneously developing nausea and vomiting within one to five hours of consuming reheated stored rice, without fever, is consistent with Bacillus cereus emetic toxin syndrome, in which the heat-stable emetic toxin is produced during storage of cooked rice at ambient temperature and survives reheating; the public health investigation approach includes: (i) collecting stool specimens from affected individuals and a food sample from the remaining rice if available for microbiological analysis; (ii) conducting a structured epidemiological questionnaire (attack rate calculation by food item consumed to confirm the rice association, exact timing of rice preparation and storage to document the storage interval, temperature at storage); (iii) implementing immediate hygiene education for the community regarding safe rice storage (refrigeration or complete disposal of uneaten cooked rice within two hours of cooking); (iv) clinical management is supportive as the illness is self-limiting (oral rehydration, antiemetics if needed, monitoring for severe dehydration), with antibiotics not indicated for preformed toxin syndromes c) Contaminated water from a cholera outbreak d) Botulism from fermented bamboo shoots (Correct Answer: b)

CHAPTER EIGHT: ALLERGY, DERMATOLOGICAL IMMUNOLOGY, AND PARASITIC-IMMUNE INTERACTIONS IN THE CHT

8.1 The CHT Allergy Paradox: The Inverse Relationship Between Parasitism and Atopy

The relationship between parasitic infection and allergic disease in the CHT indigenous communities illustrates one of the most scientifically fascinating and clinically important immunological phenomena in tropical medicine: the inverse relationship between helminth infection prevalence and atopic disease prevalence, which forms the empirical foundation of the hygiene hypothesis and its more sophisticated successor theories. In CHT communities with high helminth infection burden (as documented in Part Five and Part One), the Th2 cytokine skew produced by helminthic infection creates an immunological milieu that is simultaneously elevated in total IgE (from the global immune shift toward IgE-heavy responses) and reduced in allergen-specific IgE-mediated atopic responses (through the competitive occupation of mast cell IgE receptors by non-specific IgE and the regulatory mechanisms that limit effector cell activation). The practical clinical correlate of this immunological paradox is that CHT

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communities with high helminth burden appear clinically to have lower rates of classic atopic asthma, allergic rhinitis, and atopic eczema than comparable populations in low-helminth environments, despite having elevated total IgE levels that would predict high atopic risk in the standard immunological framework. This divergence between total IgE elevation and atopic disease prevalence in the CHT is a real clinical observation that must be incorporated into the clinical assessment of allergic disease in the territory: an elevated total IgE in a CHT indigenous patient should not be reflexively interpreted as evidence of atopy, because it may primarily reflect helminth-driven polyclonal IgE production, and the distinction between helminth-associated IgE elevation and allergen-specific IgE elevation (assessed through RAST or skin prick testing) is clinically important for management decisions.

The transition from high helminth burden to lower helminth burden in CHT communities undergoing sanitation improvement creates what immunologists call a deheliminthization immunological transition, in which the Th2/Treg dominance maintained by helminthic infection recedes, allowing the Th1/Th17 axis to become relatively more active. This immunological transition has been hypothesized to produce, on a population level, a biphasic immune health consequence: in the short to medium term, the reduction in helminthic immune suppression improves the Th1 cellular immunity that contains intracellular pathogens (potentially improving TB resistance and malaria severity control), but in the longer term, as the old friends immunological regulation is lost without alternative regulatory input, the risk of atopic and autoimmune disease may increase. For CHT health system planning, this suggests that sanitation improvement programs (which are unconditionally beneficial from the perspective of diarrheal disease control and nutritional status) should be accompanied by monitoring of atopic disease trends in the communities where the programs are implemented, to detect and clinically manage the anticipated increase in atopic disease prevalence that may follow deheliminthization.

8.2 Contact Dermatitis and Occupational Skin Disease in the CHT

Contact dermatitis, the inflammatory skin condition produced by direct contact of the skin with exogenous substances, is a prevalent and clinically significant occupational and environmental skin disease in the CHT, given the extensive and diversified skin exposures of CHT agricultural, forest, and domestic workers. Contact dermatitis is clinically divided into irritant contact dermatitis (ICD, produced by the direct cytotoxic effects of irritants on the skin, without immunological mediation) and allergic contact dermatitis (ACD, produced by a type IV delayed-type hypersensitivity reaction mediated by allergen-specific T lymphocytes, requiring prior sensitization and producing a more intense and reproducible response to the specific allergen than ICD). The distinction between ICD and ACD has therapeutic implications: ICD is managed by identifying and eliminating the irritant and providing emollient barrier repair, while ACD requires both allergen avoidance and, in acute phases, topical or systemic corticosteroid anti-inflammatory treatment. In the CHT occupational and environmental context, the most important irritant contactants include alkalis from lime (calcium hydroxide) used in construction, slash-and-burn ash deposits during jhum cultivation (which contain wood ash alkalis), and the sap of certain forest plants with cytotoxic properties. Important allergen contactants producing ACD in the CHT include Toxicodendron species (the urushiol-producing plants including poison ivy, poison oak, and related Asian species such as Rhus verniciflua, the lacquer tree, and Semecarpus

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anacardium, the marking nut tree, which is used in CHT communities for ink marking and has documented urushiol-related allergens), nickel (from jewelry and agricultural tool handles), rubber chemicals (from rubber gloves used in rubber plantation work), and multiple plant allergens from the sesquiterpene lactone-containing Compositae family plants used in CHT jhum cultivation. The clinical management of occupational contact dermatitis in the CHT must address both the acute treatment phase and the long-term occupational modification required, which in the CHT context may require creative adaptations: if a jhum farmer has developed ACD to Compositae plant allergens in jhum fields, complete avoidance is not feasible without abandoning their livelihood, and management must focus on protective barrier methods (gloves, long-sleeved clothing, post-exposure washing protocols) rather than complete allergen elimination.

8.3 Scabies, Head Lice, and the Social Biology of Ectoparasitic Infection in the CHT

Scabies, produced by the burrowing of the human itch mite Sarcoptes scabiei var. hominis into the stratum corneum of the skin, is a highly prevalent and socially patterned parasitic skin disease in CHT indigenous communities. The transmission of scabies requires direct skin-to-skin contact of sufficient duration for mite transfer, and the social patterns of CHT indigenous communities (close bodily contact during communal work and ceremonial activities, shared sleeping arrangements within family groups, and extended contact between children in overcrowded housing) create exactly the transmission conditions that produce high scabies prevalence. The clinical presentation of scabies is dominated by intense pruritus that is characteristically worse at night (when the mite's burrowing activity increases with body temperature) and that is disproportionately severe compared with the sparse visible skin findings of early infestation. The classical scabies lesions are linear burrows (the tracks of the female mite in the stratum corneum) typically found in the interdigital web spaces, the flexor aspects of the wrists, the anterior axillary folds, the areolae (in women), the genitalia (in men), and the umbilical region, accompanied by secondary papules, vesicles, and the impetiginous changes of secondary bacterial superinfection (which is extremely common in CHT scabies, given the Staphylococcus aureus and Streptococcus pyogenes skin colonization that occurs in nutritionally compromised and immunologically impaired children). Crusted scabies (Norwegian scabies), the hyperinfested form of scabies occurring in immunocompromised individuals (including those with severe protein-energy malnutrition, HIV, or prolonged corticosteroid use), is characterized by the presence of thousands to millions of mites within thick, hyperkeratotic crusted plaques on the skin, and represents a highly contagious reservoir for community transmission that requires aggressive management with oral ivermectin in addition to topical treatment. The standard treatment for scabies in the CHT context is topical permethrin 5 percent cream (applied to the entire body surface from the neck downward, left overnight, and repeated in one week), which is highly effective and widely available. The management of scabies in CHT communities requires a community-based approach: treating only the index patient while leaving untreated infested household contacts and close-contact community members creates the conditions for immediate re-infestation of the treated patient, and mass treatment of all household members and close contacts simultaneously (regardless of symptom status, since asymptomatic infestation is common) is the operationally appropriate approach for achieving scabies control in high-prevalence CHT communities. Oral ivermectin (200 micrograms per kilogram body weight as a

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single dose, repeated in one week) is an alternative to topical permethrin that offers the practical advantage of a simpler administration protocol, particularly for community-level mass drug administration programs.

MODEL EXAMINATION QUESTIONS: CHAPTER EIGHT

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The inverse relationship between helminth infection prevalence and atopic disease prevalence is explained by which immunological mechanism? a) Helminths destroy IgE-producing B lymphocytes b) Helminth-driven Th2 cytokine skew and competitive occupation of mast cell IgE receptors by non-specific IgE, combined with regulatory mechanisms limiting effector cell activation, paradoxically reduce allergen-specific IgE-mediated atopic responses despite elevated total IgE c) Helminths produce antihistamines that suppress allergic reactions d) Protein-energy malnutrition from helminthic competition prevents IgE production (Correct Answer: b)

Crusted (Norwegian) scabies is distinguished from ordinary scabies by: a) The presence of normal total IgE b) Hyperinfestation with thousands to millions of mites within thick hyperkeratotic crusted plaques, occurring in immunocompromised individuals c) The presence of burrows on the face and scalp only d) Bacterial superinfection without the primary mite infestation (Correct Answer: b)

Allergic contact dermatitis is mediated by which immunological mechanism? a) IgE-mediated type I immediate hypersensitivity b) Type IV delayed-type hypersensitivity mediated by allergen-specific T lymphocytes c) Complement-mediated type II cytotoxic hypersensitivity d) Immune complex-mediated type III hypersensitivity (Correct Answer: b)

The urushiol-producing plant genus responsible for producing allergic contact dermatitis in CHT forest workers is: a) Andrographis b) Toxicodendron (including related Semecarpus and Rhus species) c) Bryophyllum d) Oroxylum (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A CHT upazila health complex physician observes an unusual number of patients from the same Mro village presenting with intensely pruritic skin disease in the same week, including several children with thick, crusted hyperkeratotic plaques on the hands and feet, arms, and trunk. Some of these children have signs of protein-energy malnutrition. Others in the household have milder itching. The physician suspects a mixed outbreak of ordinary and crusted scabies in a malnourished community. Applying the community management principles from this chapter, the most comprehensive response is: a) Treat only the patients presenting at the clinic with topical permethrin b) The community management approach requires: (i) confirmation of crusted scabies diagnosis in the hyperkeratotic cases (the mites are visible in scrapings from the crusts on light microscopy, and the mite count per gram of skin scraping is diagnostic); (ii) treatment of all crusted scabies cases with oral ivermectin 200 micrograms/kg on days one and two (minimum two doses, with additional doses for cases that do not respond), plus topical permethrin 5%

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applied to the entire body including the scalp and under fingernails in crusted scabies; (iii) simultaneous treatment of all household members and close contacts with topical permethrin regardless of symptom status (community-level mass treatment); (iv) secondary bacterial infection treatment with oral cefalexin or topical mupirocin for all cases with impetigo; (v) nutritional rehabilitation of the malnourished children to address the underlying immune compromise that predisposed to crusted scabies; (vi) environmental decontamination (washing and hot-pressing all bedding, clothing, and fabric items that the crusted scabies patients have contacted, as the high mite load of crusted scabies contaminates the environment with viable mites that can survive off-host for several days); (vii) community education on scabies transmission and the importance of completing treatment c) Refer all cases to the dermatology unit at CMCH d) Prescribe oral antihistamines for all itching patients (Correct Answer: b)

CHAPTER NINE: GERIATRIC HEALTH AND AGING IN THE CHT INDIGENOUS POPULATION

9.1 The CHT Geriatric Health Crisis: Aging at the Margin of the Health System

The geriatric population (individuals aged 60 years and above) of the CHT indigenous communities faces a set of health challenges that is both continuous with the health challenges of earlier life (the accumulated consequences of decades of malnutrition, infection, physical labor, environmental exposure, and inadequate healthcare) and qualitatively distinct in the specific biology, the social context, and the healthcare needs of old age. The CHT elderly population is at once the repository of the community's most important cultural, linguistic, and medical knowledge (including the ethnomedicinal traditions of the Baiddya healers and the agricultural knowledge systems of the jhum farmers) and the most medically vulnerable and most healthcare-service-excluded segment of the CHT population. A qualitative study published in the peer-reviewed literature (referenced in Part One of this textbook) specifically identified elderly indigenous individuals' lack of knowledge about healthcare needs, geographical barriers, poor financial conditions, higher cost of medical services, scarcity of nearby hospitals, and communication barriers as the primary determinants of their inadequate healthcare access, producing a profile of geriatric health exclusion that is structural rather than individual in its causation and that demands structural responses rather than individual-level remediation alone.

The geriatric health of CHT indigenous communities is characterized by several disease patterns that reflect the aging of bodies that have experienced a lifetime of the CHT Pediatric Adversity Matrix. The musculoskeletal burden of elderly CHT individuals is disproportionate to their age by comparison with less physically stressed populations: decades of subsistence agriculture on steep terrain, carrying loads without mechanical assistance, and the biomechanical stresses of jhum clearing and processing produce patterns of osteoarthritis (particularly of the lumbar spine, hip, and knee), chronic musculoskeletal pain, and early functional decline in joint mobility and physical capacity. Chronic obstructive pulmonary disease (COPD), from decades of household solid fuel cooking smoke and jhum burning smoke exposure, likely reaches its highest prevalence and most functionally severe expression in the elderly CHT cohort who have the

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longest cumulative exposure histories. The cardiovascular consequences of decades of hypertension (much of it undetected and untreated), rheumatic heart disease, and the metabolic syndrome produce the cardiac and vascular morbidity that is the dominant cause of death in aging populations globally, increasingly so in the CHT as well. Cognitive impairment and dementia, including vascular dementia from the cumulative cerebrovascular disease of long-standing hypertension and the ischemic strokes that are documented in the CHT (from both atrial fibrillation in rheumatic heart disease and hypertensive cerebrovascular disease), and Alzheimer's disease dementia (whose prevalence in elderly CHT indigenous populations has not been studied), present particular challenges in the CHT, where the recognition of dementia in elderly community members may be attributed to supernatural causes, social withdrawal, or normal aging rather than to a medical condition amenable to assessment and management.

9.2 Falls, Fractures, and Osteoporosis in the Elderly CHT Population

Falls and fall-related fractures are a major cause of morbidity, disability, and mortality in elderly populations globally, and in the CHT context, they are both more likely to occur (because of the dangerous terrain that the elderly must navigate daily, including steep jhum field slopes, river banks, and uneven forest paths) and more likely to produce serious consequences (because of the severely limited fracture management capability at most CHT health facilities and the extreme difficulty of evacuating a fractured elderly person from a remote community to a district hospital). Hip fracture, the most clinically serious fall-related fracture in the elderly, carries a one-year mortality of approximately 20 to 30 percent in high-income countries with excellent orthopedic surgical management; in the CHT, where orthopedic surgical capacity is concentrated at CMCH and where the transport time from a remote community to CMCH may be 12 to 24 hours even in non-emergency transport circumstances, the mortality from hip fracture in elderly indigenous people is almost certainly substantially higher, because the immobility and the systemic consequences of a displaced hip fracture (deep vein thrombosis, pulmonary embolism, pressure ulcers, pneumonia from prolonged bed rest, urinary tract infection from urinary retention) accumulate rapidly during the transport delay. The clinical management of a CHT elderly patient with a suspected hip fracture (characterized by severe pain at the hip and groin, inability to bear weight, shortening and external rotation deformity of the affected limb) at the community or UHC level includes adequate analgesia (intramuscular morphine or tramadol for severe pain), immobilization of the limb in a position of comfort (with the knee slightly bent over a pillow), prevention of pressure ulcer development (with regular repositioning if possible), hydration (oral if possible, IV if the patient cannot drink), and urgent arrangement of transfer to the nearest facility with orthopedic surgical capability, while simultaneously contacting the receiving facility to arrange orthopedic surgical reception. Osteoporosis prevention in the elderly CHT population requires attention to the specific risk factors prevalent in the territory: chronic malnutrition-related calcium and vitamin D deficiency (calcium-rich foods including dairy are not traditional components of most CHT diets, and vitamin D synthesis from sun exposure is potentially impaired by consistent clothing coverage for cultural reasons and by the shading effect of dense forest canopy in some forest worker communities), the physical inactivity associated with disability in older age, and the bone-density-reducing effects of long-term tobacco and alcohol use.

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9.3 Palliative and End-of-Life Care for Elderly CHT Indigenous Patients

The end of life for elderly CHT indigenous community members is shaped by the convergence of the biomedical realities of their disease burden, the cultural and cosmological frameworks of their communities that determine how death is understood and prepared for, and the practical healthcare realities of a territory where palliative care infrastructure is essentially absent. The Part Five chapter on oncological medicine discussed the palliative care framework in the context of cancer patients, and those principles apply equally to the management of elderly patients with chronic and progressive conditions at the end of life. The cultural dimension of end-of-life care in CHT indigenous communities is particularly important. Chakma and Marma Buddhist traditions conceptualize death within a karmic framework: the quality of the dying process, including the mental state at the moment of death, is believed to influence the quality of the subsequent rebirth, creating a strong community motivation to ensure that the dying person is in a state of mental clarity, peace, and right awareness at the end of life. This has specific implications for pain management: the concern that opioid analgesics may cloud consciousness and impair the mental clarity required for a good Buddhist death creates resistance to morphine use in some CHT Buddhist communities, a resistance that must be engaged with respectfully and that may require specific conversation between the clinician, the patient, and Buddhist monastic figures about the compassionate and theologically defensible place of pain relief in enabling rather than obstructing the good death. The Tripura traditional concepts of a good death include the gathering of family and community members, the performance of specific rituals, the utterance of final instructions, and dying in the home rather than in a hospital, all of which are practically achievable in the CHT without hospital-based end-of-life care and which reinforce the argument for home-based palliative care delivery as the most culturally appropriate model for CHT elderly dying patients. The community health worker trained in basic palliative care, as advocated in Part Five, is the most important clinical resource for supporting CHT elderly patients and their families through the dying process in culturally appropriate, dignified, and symptom-controlled ways that honor both the biomedical obligation to relieve suffering and the community's right to shape the experience of death in accordance with their own values.

MODEL EXAMINATION QUESTIONS: CHAPTER NINE

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The most serious complication of hip fracture requiring urgent orthopedic surgical management is: a) Bruising and soft tissue swelling around the hip b) Displaced femoral neck fracture with interruption of the blood supply to the femoral head, risking avascular necrosis c) Superficial skin laceration at the site of impact d) Anxiety and psychological distress from pain (Correct Answer: b)

The one-year mortality following hip fracture in elderly patients in low-resource settings without timely orthopedic surgical management is approximately: a) 2 to 5 percent b) 8 to 12 percent c) 20 to 30 percent d) 50 to 60 percent (Correct Answer: c)

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Vascular dementia, the most common form of dementia in populations with high vascular risk, is caused by: a) Accumulation of amyloid beta plaques and tau neurofibrillary tangles b) Cumulative cerebrovascular disease from repeated ischemic brain injury (lacunar infarcts, watershed infarcts) producing progressive cognitive decline c) Chronic alcohol toxicity to the hippocampus d) Thiamine deficiency from malnutrition (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A CHT district geriatric health program designer is conducting a needs assessment in three elderly Chakma and Marma communities in Rangamati. The key findings are: (i) 48 percent of respondents over 65 years have not seen a healthcare worker in the past year; (ii) 35 percent report significant chronic pain (musculoskeletal); (iii) 22 percent have blood pressure readings above 160/100 on a single measurement; (iv) 15 percent have clinical features consistent with significant visual impairment (unable to count fingers at 3 meters); (v) several families describe elderly relatives who have become confused, lost their way home from the fields, and require supervision for daily activities. Based on the geriatric health framework of this chapter, the most comprehensive priority program design addresses: a) Blood pressure screening alone; all other findings are age-related and untreatable b) A comprehensive community geriatric health program addressing: (i) community health worker-based annual health assessment for all adults over 60 years covering blood pressure, visual acuity, cognitive screening (using the MMSE or the culturally adapted CHT indigenous language version), pain assessment, fall risk assessment, functional assessment, and nutritional status; (ii) blood pressure management with ACE inhibitor or ARB as preferred agents for newly identified hypertension; (iii) referral to the district mobile eye camp for visual acuity impairment assessment and cataract surgical evaluation; (iv) cognitive impairment assessment with referral to district hospital for specialist evaluation when cognitive impairment is identified, including neuroimaging (CT head) where available to exclude treatable causes (vascular lesions, subdural hematoma, normal pressure hydrocephalus) from degenerative dementia; (v) pain management with paracetamol (acetaminophen, safe first-line for musculoskeletal pain) as the preferred agent in elderly patients to avoid NSAID-related renal toxicity and gastrointestinal harm; (vi) community education on fall prevention through environmental modification (hand rails on steep paths, removal of indoor obstacles, appropriate footwear) c) Mass antihypertensive medication distribution without assessment d) Referral of all elderly patients to the national institute of geriatric medicine in Dhaka (Correct Answer: b)

CHAPTER TEN: CLINICAL RESEARCH METHODS, EVIDENCE GENERATION, AND KNOWLEDGE TRANSLATION IN THE CHT

10.1 The CHT Research Ethics and Epistemology Doctrine

Clinical and public health research in the CHT has a troubled history that informs its ethical future. The CHT has been, over its history of contact with the colonial and post-colonial scientific world, a site for research conducted primarily by outsiders for the benefit of audiences outside the territory, with the CHT communities serving as subjects of investigation rather than

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as agents of knowledge production. The extraction of biological samples (including blood, tissue, and genetic material) from CHT communities for research purposes without adequate explanation, genuine informed consent, or the return of results and benefits to the communities has occurred in the past and continues to represent a risk in the current research environment, where the global interest in the genetics, pharmacology, and epidemiology of tropical infections intersects with the vulnerability of remote indigenous communities who may have limited capacity to critically evaluate research proposals and assert their rights. The CHT Research Ethics and Epistemology Doctrine articulated in this chapter holds that research in the CHT must be governed by a framework that goes beyond the standard biomedical research ethics requirements (ethical committee approval, individual informed consent, confidentiality protection, equitable participant selection) to incorporate the specific ethical obligations arising from the CHT's history of research exploitation, the indigenous communities' rights to FPIC (free, prior, and informed consent) as stipulated in the UN Declaration on the Rights of Indigenous Peoples, and the epistemological principle that indigenous knowledge systems (including the Baiddya botanical medicine tradition, the indigenous ecological knowledge of CHT farming and forest communities, and the community's own narratives of health and disease) are legitimate forms of knowledge production whose contribution to the understanding of CHT health must be valued, preserved, and credited rather than appropriated without acknowledgment. The CHT Research Ethics and Epistemology Doctrine has four operational pillars. The first pillar is Community Benefit Primacy: research in the CHT must be designed to generate knowledge that primarily benefits the CHT communities whose participation makes the research possible, and the benefit pathway from research findings to community health improvement must be specified, realistic, and monitored. The second pillar is Indigenous Knowledge Respect: research designs must acknowledge and engage with indigenous knowledge systems as co-equal sources of hypothesis generation, not merely as cultural curiosities to be noted before the serious scientific work begins. The third pillar is Local Capacity Building: every research project in the CHT must include a component of local capacity building, training CHT community members and CHT health workers as research participants, data collectors, interpreters, and ultimately as co-investigators and independent researchers, building the CHT's own scientific capacity rather than perpetuating its dependence on external expertise. The fourth pillar is Data Sovereignty: the CHT communities from whom data are collected must have the right to access, review, and veto the publication of research findings that misrepresent their communities, violate their privacy, or could be used in ways harmful to their interests.

10.2 Epidemiological Study Designs for CHT Health Research: Selection, Application, and Interpretation

The selection of an appropriate epidemiological study design for research questions arising from CHT health practice requires an understanding of both the epistemological properties of different study designs and the practical constraints that the CHT context imposes on research methodology. The CHT's challenges for research include: the absence of population registers and vital registration (which undermines cohort studies and case-control studies that require defined source populations and accurate exposure and outcome ascertainment), the geographic fragmentation of communities (which makes random sampling and participant follow-up logistically complex), the linguistic diversity (which requires multi-language survey instruments

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and trained interpreters with the associated risk of measurement error), the inadequacy of laboratory infrastructure (which limits the biological measurement capability available to researchers), and the institutional complexity of research permissions (which require approval from both national ethics committees and CHT governance bodies, and which may require extensive community consultation processes before data collection begins). Within these constraints, several study designs are particularly well-suited to generating useful evidence for CHT health policy and practice. The cross-sectional survey, which measures exposure and outcome simultaneously in a defined population sample at a single point in time, is the most practicable design for CHT population health assessments, providing prevalence data on conditions, risk factors, and health service utilization. Its primary limitation is the inability to distinguish causation from association (the cross-sectional nature precludes the determination of whether exposure preceded outcome). The nested case-control study, which identifies cases of a disease and matched controls from within a defined cohort that has already been established, is more efficient than a prospective cohort study for rare disease outcomes and is feasible in the CHT when conducted within the patient registers of district hospitals or within the community databases of NGO health programs. The stepped wedge randomized trial, a design in which a new intervention is progressively rolled out to all sites or communities in a staggered, randomized sequence, offers the ethical advantage of eventually providing the intervention to all participants (unlike standard RCTs where some participants are permanently in the control group) and the practical advantage of building on the phased implementation that is operationally necessary in geographically complex territories anyway, making it particularly well-suited for evaluating the effects of complex health system interventions in the CHT.

10.3 The Practice of Evidence-Based Medicine in the CHT: Adapting Global Evidence to Local Realities

Evidence-based medicine (EBM), defined as the conscientious, explicit, and judicious integration of current best evidence with clinical expertise and patient values in the making of clinical decisions, is as important in the CHT as anywhere in the world, and its application in the CHT is more complex and more demanding than its application in the settings for which the majority of the world's clinical evidence has been generated. The three-component EBM model (best external evidence, clinical expertise, patient values) requires specific adaptations in the CHT. Best external evidence must be critically appraised for its generalizability to CHT populations: a randomized controlled trial conducted in a university hospital in a high-income country that demonstrates the efficacy of a specific treatment for a specific disease may not be applicable to a CHT patient whose disease is of different severity, whose nutritional status and immune function are different, whose G6PD status may contraindicate the study treatment, and whose access to follow-up is severely limited. The clinical guideline adapted to high-income settings may need modification for CHT application, and the CHT clinician needs the EBM skills to identify the most applicable evidence, to recognize the applicability limitations of existing evidence, and to design their clinical practice in a way that integrates the best available evidence with the specific biological, pharmacological, cultural, and resource realities of their patients. Clinical expertise in the CHT context specifically encompasses the mastery of clinical assessment without high-technology investigation (auscultatory diagnosis of heart disease, clinical diagnosis of malaria in the absence of RDT, palpation-based assessment of

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organomegaly and lymphadenopathy), the knowledge of CHT-specific disease manifestations and CHT-specific drug interactions, and the capacity to make sound clinical decisions under conditions of diagnostic uncertainty. Patient values in the CHT context encompasses the cosmological illness frameworks, the traditional treatment preferences, the household economic realities, the linguistic and cultural communication needs, and the historical experiences of institutional healthcare that shape how CHT patients understand and respond to the clinical decisions that are made with them and for them.

The knowledge translation challenge in the CHT, the process of transforming research findings into health policy changes and clinical practice improvements that actually improve the health of CHT communities, is perhaps more demanding than the knowledge generation challenge. The CHT health system has accumulated a substantial research literature (of variable quality and relevance) over the past several decades, documenting the disease burden, the health system failures, and in some cases the effective interventions applicable in the territory. The translation of this literature into policy change has been systematically impeded by the structural and political barriers documented throughout this textbook: the underfunding of the CHT health system, the bureaucratic resistance to meaningful decentralization of health authority to CHT governance bodies, the political sensitivity of CHT indigenous health advocacy in the context of ongoing land rights and self-determination disputes, and the absence of a systematic mechanism for converting research evidence into binding health policy commitments at the district and national level. The CHT Health Policy Translation Framework proposed in this chapter holds that knowledge translation in the CHT requires three complementary processes: systematic synthesis of available CHT evidence into clinical practice guidelines adapted to CHT conditions, advocacy processes that present this synthesized evidence to CHT governance bodies and national health policymakers in forms that are accessible, compelling, and politically actionable, and accountability mechanisms that track the implementation of evidence-based policy commitments and hold responsible actors accountable for failures of implementation. None of these processes can be effective in isolation, and all three require the active participation of CHT indigenous community organizations, CHT health workers, and national and international research and advocacy communities working in genuine partnership.

10.4 The Future of CHT Health Research: Priorities, Methods, and the Indigenous Researcher

The most important future development in CHT health research is the emergence of a generation of CHT indigenous researchers: scientists from Chakma, Marma, Tripura, Mro, and other indigenous communities who have received scientific training adequate to design, conduct, and publish independent research on the health of their own communities. The production of indigenous researchers from the CHT is not merely a matter of cultural symbolism or political correctness. It is an epistemological and methodological imperative. Research questions about CHT health are best formulated by people who understand the CHT from the inside; research methodologies that require deep community trust, cultural competence, and linguistic accuracy are best executed by researchers who are part of the community; and research findings that need to be translated into culturally appropriate health education and behavior change are best communicated by messengers who share the cosmological framework and the social context of

the audience. The creation of the conditions for CHT indigenous researchers to emerge requires investment at every stage of the educational and scientific pipeline: quality secondary education in the CHT (to enable CHT students to enter university-level science courses), financial support for indigenous students pursuing medical and public health education (including scholarships, stipends, and affirmative admission provisions in the national medical universities), mentorship programs connecting CHT students with established researchers from similar backgrounds in Bangladesh and internationally, and the development of CHT-based research institutions (whether university departments, public health institutes, or NGO research units) that can serve as intellectual homes for CHT indigenous researchers without requiring them to sever their community connections by relocating to Dhaka or abroad.

The priority research agenda for CHT health in the coming decade, as identified by the synthesis of evidence gaps documented throughout this textbook, encompasses the following domains. Genetic epidemiology of hemoglobinopathies and G6PD deficiency in the eleven CHT indigenous communities, providing the prevalence data that clinical practice guidelines for malaria treatment and blood transfusion require. Population-based NCD epidemiology, generating the diabetes, hypertension, cardiovascular disease, and metabolic syndrome prevalence estimates that are currently absent for CHT indigenous populations. Climate change health impact assessment, quantifying the effects of observed and projected climate changes on malaria epidemiology, diarrheal disease seasonality, heat-related illness, and food security in the CHT. Ethnopharmacological validation, conducting systematic pharmacological research on the most clinically used and most biologically plausible CHT Baiddya plant medicines to identify those with sufficient evidence for integration into the formal pharmaceutical system. Mental health epidemiology, generating the first population-based estimates of PTSD, depression, anxiety, and complex trauma prevalence in CHT communities, disaggregated by age, gender, conflict exposure, displacement history, and ethnic community. Health system intervention evaluation, conducting rigorous stepped wedge or cluster randomized evaluations of specific CHT health system interventions, including indigenous community health worker programs, mobile health clinic services, and traditional healer integration models, to generate the evidence base that health system reform proposals require for political credibility and optimal design. Nutritional intervention research, evaluating the effectiveness and feasibility of CHT-specific nutritional programs including diversified agricultural support, ready-to-use therapeutic food delivery systems adapted to CHT terrain constraints, and community-based management of acute malnutrition in the most remote communities.

MODEL EXAMINATION QUESTIONS: CHAPTER TEN

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The three components of the evidence-based medicine (EBM) model are: a) Diagnosis, treatment, and follow-up b) Best external evidence, clinical expertise, and patient values c) Randomized controlled trials, systematic reviews, and meta-analyses d) History, physical examination, and investigation (Correct Answer: b)

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The stepped wedge randomized trial design is particularly appropriate for CHT health system research because: a) It is cheaper than all other research designs b) It provides the intervention to all participants eventually, making it ethical in vulnerable populations, and builds on the phased implementation that is operationally necessary in geographically complex territories c) It requires no randomization d) It can be conducted without community consent (Correct Answer: b)

The UN Declaration on the Rights of Indigenous Peoples (UNDRIP) requires which standard for research involving indigenous communities that goes beyond standard biomedical ethics? a) Payment of participants at commercial market rates b) Free, Prior, and Informed Consent (FPIC) from the affected community as a collective right, not merely individual informed consent c) Publication in indigenous languages d) Restriction of research to health topics selected by national governments (Correct Answer: b)

The CHT Research Ethics and Epistemology Doctrine's principle of Data Sovereignty holds that: a) All CHT health data must be published in open-access journals b) CHT communities have the right to access, review, and veto publication of research findings that misrepresent their communities, violate their privacy, or could be used in ways harmful to their interests c) Government owns all data collected in its territory d) Researchers retain exclusive rights to all data collected in their studies (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A team of researchers from a Dhaka university proposes a blood sample collection study in three Mro communities in Alikadam to characterize hemoglobin variants and G6PD deficiency prevalence. They have national ethics committee approval but have not contacted the local CHT administration or community leaders. A BRAC field coordinator warns them that community engagement will be essential for the study's feasibility. Based on the CHT Research Ethics and Epistemology Doctrine in this chapter, which actions are ethically required before blood collection can commence? a) Begin collection immediately since national ethics committee approval is sufficient b) The following are ethically required: (i) engagement with the Alikadam UNO (Upazila Nirbahi Officer) and the District Hill Council of Bandarban for administrative authorization and research permission at the local governance level; (ii) community-level FPIC meetings with the karbaris and headmen of each Mro community to explain the research purpose, procedures, benefits, risks, and data handling in Mro language with trained interpreters, and to obtain documented collective community consent as well as individual informed consent for each participant; (iii) specification of the benefit return pathway from findings to community: specifically, how will the prevalence data generated by this study be used to improve G6PD-informed primaquine prescribing in Alikadam, and will the results be shared with the community in Mro language; (iv) local capacity building component: training of at least two Mro community health workers as community research assistants for the study, building local research capacity; (v) data sovereignty agreement specifying the community's right to review pre-publication findings; (vi) provision of clinical results to individual participants and their healthcare providers where clinically actionable c) Obtain written consent from the district health officer and begin d)

Conduct the research anonymously without community notification to avoid disruption (Correct Answer: b)

A CHT public health researcher reviews the available evidence for a community health worker-based integrated management of childhood illness (IMCI) program in remote Khagrachhari communities and finds the following: two randomized controlled trials conducted in Bangladesh (but in plains districts with very different infrastructure) showing significant reduction in under-five mortality, one qualitative study from Khagrachhari documenting acceptability barriers related to language and cultural practices, and no controlled evidence from the CHT specifically. She must advise the district health office on whether to implement the program. How should she apply the principles of evidence-based medicine in the CHT as described in this chapter? a) Withhold recommendation until a full RCT is conducted in the Khagrachhari context b) She should apply the following EBM principles in the CHT context: (i) the external evidence from Bangladesh RCTs is of high quality but has limited direct generalizability to the Khagrachhari indigenous community context, and this limitation should be explicitly stated; (ii) the qualitative evidence from Khagrachhari is directly relevant and should be weighted heavily in the assessment of implementation feasibility and required modifications; (iii) clinical expertise from CHT health workers and community members who have experience with similar programs should be solicited; (iv) patient values (community preferences for program design, language, and cultural appropriateness) are central to implementation success and should be incorporated through FPIC community engagement; (v) given the strength of the RCT evidence for IMCI effectiveness in comparable resource-limited settings and the documented severe under-five mortality burden in Khagrachhari, the weight of evidence supports implementation, but with the CHT-specific adaptations identified in the qualitative evidence (indigenous language training for CHWs, cultural competence training, engagement of traditional healers as referral partners); (vi) the implementation should be accompanied by a stepped-wedge evaluation to generate CHT-specific evidence while providing the intervention universally c) Accept the Bangladesh plains evidence as fully generalizable and implement without modification d) Reject the evidence entirely as non-applicable to the CHT (Correct Answer: b)

EPILOGUE TO PART SIX: THE MOLECULAR INTERIOR OF STRUCTURAL INEQUITY

Part Six has descended into the molecular, cellular, and systemic biological territories that underlie the epidemiological and clinical panoramas documented in the preceding five parts of this textbook. It has examined the blood of CHT indigenous people and found in its composition the fingerprints of generations of malnutrition, parasitism, and inadequate healthcare, expressed in the hypochromic microcytic erythrocytes of iron deficiency, the sickling red cells of genetic selection by malaria, the hemolysis of G6PD-deficient cells exposed to the drugs prescribed for the diseases that the same malaria pressure has generated. It has listened to the hearts of CHT adults and heard in the mitral murmur of rheumatic stenosis the echo of a childhood streptococcal infection that went untreated because the family could not reach the clinic, or could not afford the penicillin, or did not know that the child's sore throat was the beginning of a

cardiac disease that would disable them thirty years later. It has measured the blood pressure of middle-aged CHT farmers and found in the readings not merely a physiological deviation but the somatic expression of decades of stress, salt, poverty, and political exclusion. It has analyzed the pharmacological landscape of the CHT and found a complexity that neither the standard pharmacology textbook nor the national formulary prepares the clinician to navigate, where the same patient who takes artemether-lumefantrine for malaria may also be taking a Baiddya preparation of Andrographis paniculata that inhibits the CYP3A4 enzyme responsible for lumefantrine metabolism, creating an interaction that no one in the system has considered or will consider unless the clinician is specifically trained to ask.

Part Six has also explored the terrain of research and evidence in the CHT, insisting that the generation of knowledge about CHT health is itself a political and ethical act, that the extraction of biological data from indigenous communities without adequate consent, benefit return, or capacity building is a form of the same structural exploitation that has produced the health disparities being studied, and that the emergence of CHT indigenous researchers is not merely desirable but essential for the production of the kind of knowledge that can genuinely transform CHT health. The CHT's health research agenda is long, the gaps in evidence are profound, and the urgency of translating the available evidence into policy and practice change is absolute. But the most important insight of this chapter, and of this entire part of the textbook, is that the molecular and cellular pathology documented in CHT patients is not a biological given, not a natural consequence of living in a difficult terrain, and not an inevitable product of the disease ecology of the hill territory. It is a product of history, politics, and economics, operating through the specific biological pathways that epidemiology and clinical science allow us to trace, from the anemia in the blood of a Mro child to the political decision that left her community outside immunization coverage for a generation, from the hemolytic crisis of a Marma farmer's G6PD-deficient erythrocytes dissolving in the presence of primaquine to the absence of a diagnostic test that a five-dollar device could have provided, from the tight mitral valve of a Chakma woman to the streptococcal pharyngitis that went untreated in her childhood because the benzathine penicillin that would have cost less than a dollar was not available at her village health post. The science of Part Six is the science of accountability. Every molecular finding in this part points back to a structural failure that is the responsibility not of the patient, not of the clinician, and not of the disease, but of the systems, institutions, and power relations that have produced and perpetuated the conditions of health inequity in the Chittagong Hill Tracts. The obligation of the reader of this textbook, whatever their professional role, is to carry that accountability into their work.

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PART SEVEN: ADVANCED MENTAL HEALTH SCIENCE, CLIMATE AND ENVIRONMENTAL HEALTH MEDICINE, GENDER AND REPRODUCTIVE JUSTICE, HEALTH ECONOMICS, PARASITOLOGICAL INTELLIGENCE, AND THE POLITICAL ECOLOGY OF CARE IN THE CHITTAGONG HILL TRACTS

Preface to Part Seven

Part Seven of this textbook occupies a pivotal position in the intellectual architecture of the series, serving simultaneously as a convergent synthesis of the clinical, epidemiological, and philosophical themes introduced in Parts One through Six and as a bridge toward the advanced translational and systemic analyses that constitute Part Eight. The clinician who has absorbed the preceding six parts possesses a detailed and nuanced understanding of the major disease categories of the Chittagong Hill Tracts, the structural determinants of health inequity in the territory, the pharmacological and diagnostic landscape in which CHT practice operates, and the philosophical frameworks that give clinical work in this terrain its unique character. Part Seven deepens this understanding by entering domains that the preceding parts addressed either briefly or tangentially: the full neuropsychiatric architecture of mental illness in a trauma-saturated indigenous population; the physiology of climate-mediated disease and the emerging clinical science of climate health; the intersectional health consequences of gender inequality and gender-based violence; the economic architecture of CHT health systems and the financial geography of disease burden; the full parasitological spectrum beyond malaria; the molecular and genomic intelligence of CHT pathogen populations; the political ecology that frames all of the above; the medicine of disability and rehabilitation in a resource-constrained mountain context; and the formal science of clinical decision-making under conditions of maximal uncertainty. Each chapter in Part Seven is written in the tradition established by its predecessors: grounded in the most current available evidence, philosophically engaged, technically rigorous, clinically actionable, and consistently attentive to the historical, cultural, and structural context that makes CHT medicine one of the most intellectually demanding and ethically charged fields in contemporary South Asian public health.

CHAPTER ONE: ADVANCED MENTAL HEALTH SCIENCE IN THE CHITTAGONG HILL TRACTS: NEUROPSYCHIATRY, TRAUMA PSYCHIATRY, AND THE CLINICAL ARCHITECTURE OF PSYCHIATRIC DISEASE IN AN INDIGENOUS MOUNTAIN POPULATION

1.1 The Neuropsychiatric Landscape of the CHT: A Reconceptualization

The neuropsychiatric landscape of the Chittagong Hill Tracts constitutes one of the most complex and underexplored dimensions of the territory's health burden, and its adequate comprehension requires a theoretical framework that exceeds the boundaries of conventional clinical psychiatry as taught in the MBBS or MD curriculum of Bangladesh's standard medical

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colleges. The neuropsychiatric burden of the CHT is not simply a collection of individual psychiatric disorders occurring at measurable frequencies in a defined population. It is a terrain-conditioned, historically determined, structurally generated, and culturally mediated system of psychological suffering whose surface presentations are the visible manifestations of deep structural forces that operate at the level of community, politics, ecology, and intergenerational biology simultaneously. The Neuropsychiatric Terrain Burden Framework, introduced in this chapter as an original conceptual contribution of this textbook, holds that in geographically and politically marginalized territories such as the CHT, psychiatric morbidity is best understood not as a deviation of individual brain function from a normative baseline but as the biologically encoded response of human nervous systems to conditions of sustained adversity, threat, loss, and dispossession that are themselves the products of specific historical and political choices made by those with power over those without it. This reconceptualization has immediate clinical implications. It means that the treatment of psychiatric disease in the CHT that does not engage with its structural determinants is, at best, incomplete and, at worst, a form of complicity with the conditions that produce the disease it claims to treat. It does not mean that biological psychiatry is irrelevant in the CHT; neuro-chemical dysregulation is real, pharmacotherapy is often necessary, and neurobiological mechanisms of psychiatric disease operate in the CHT exactly as they do everywhere else. But it means that biological psychiatry must be embedded within a psychosocial, ecological, and structural framework that gives it the appropriate scope and context. The World Health Organization's Mental Health Action Plan 2013-2030, updated and extended in 2021, emphasizes the need for mental health services that are community-based, rights-oriented, and integrated with broader social protection systems, principles that have particular resonance in the CHT context. The 2024 Lancet Commission on Global Mental Health updated its analysis of the global mental health treatment gap, noting that low-and middle-income countries continue to face a treatment gap exceeding 75 percent for major psychiatric disorders, with rural and indigenous populations within these countries facing even larger gaps. In the CHT, the mental health treatment gap is almost certainly one of the widest in Bangladesh, given the combination of sparse psychiatric service infrastructure, linguistic and cultural barriers to mental health service engagement, the stigma associated with psychiatric diagnosis in CHT indigenous communities, and the absence of systematic mental health surveillance data at the community level in the territory.

The neurological and psychiatric consequences of malaria deserve specific attention in the CHT mental health context, as they represent a bridge between the territory's dominant infectious disease and its neuropsychiatric burden. Cerebral malaria, the most severe neurological complication of Plasmodium falciparum infection, produces its acute neurological manifestations through a complex pathophysiology that includes cytoadherence of parasitized erythrocytes to cerebral microvascular endothelium (mediated by PfEMP1 binding to endothelial receptors including ICAM-1, CD36, and EPCR), resulting in sequestration of parasitized red cells in cerebral capillaries and postcapillary venules; neuroinflammation driven by the release of pro-inflammatory cytokines (particularly TNF-alpha, IL-1-beta, and IL-6) by activated macrophages and monocytes responding to the parasite and its byproducts; disruption of the blood-brain barrier through inflammatory endothelial activation; cerebral edema from both cytotoxic and vasogenic mechanisms; and in some patients, hemoglobin-mediated neurotoxicity from the hemolysis that accompanies severe malarial anemia. The immediate neurological consequences

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of cerebral malaria are well-described in the clinical literature and include reduced consciousness, seizures, focal neurological deficits, and in fatal cases, transtentorial herniation. What is far less well-recognized, and what is of particular importance in the CHT context where malaria is endemic and recurrent cerebral malaria episodes are documented in high-transmission communities, are the post-malaria neurological syndromes (PMNS): a cluster of neurological and psychiatric sequelae that persist after parasitological cure and that have been documented in survivors of cerebral malaria in Africa, India, and Southeast Asia. Post-malaria neurological syndromes include acute post-malaria neurological syndrome (APMNS, which typically presents within two months of acute illness with psychosis, confusion, cerebellar ataxia, or extrapyramidal features) and the longer-term neurocognitive sequelae that include impaired memory, attention deficits, processing speed reduction, and behavioral changes that have been documented in children surviving cerebral malaria in African study populations and that are almost certainly operating in CHT children as well, constituting an invisible burden of acquired neurocognitive disability that compounds the developmental disadvantages of malnutrition and educational inequality. The CHT clinician who encounters a school-aged child with learning difficulties, attention problems, or behavioral disturbance should include a history of prior cerebral malaria in the differential explanation, recognizing that cerebral malaria sequelae are a preventable cause of acquired cognitive disability in this population.

The formal psychiatric diagnostic classifications applied to CHT patients require engagement with the culturally specific presentations of psychiatric illness in CHT communities, a process increasingly formalized in the field of cultural psychiatry and now required for comprehensive assessment by the DSM-5-TR (published in 2022) Cultural Formulation Interview and by the ICD-11's recognition of cultural variation in symptom expression. Post-traumatic stress disorder in CHT conflict survivors presents with both culturally universal features (intrusive re-experiencing, hyperarousal, avoidance, and negative alterations in cognition and mood, as defined by DSM-5 criteria) and CHT-specific clinical features that require cultural competence to recognize. CHT conflict survivors, particularly elderly Chakma and Marma individuals who experienced the most intensive periods of violence between 1975 and 1997, frequently express PTSD-related distress through somatic idioms (physical complaints including headaches, chest tightness, gastrointestinal pain, and fatigue that are not explained by concurrent organic disease), through the Chakma culturally specific distress category of "moner rog" (illness of the mind-heart, which conflates psychological and emotional suffering in a way that has no direct equivalent in the Western psychiatric binary of mental versus physical disease), and through behavioral withdrawal and community disengagement that may be misinterpreted as dementia or physical illness by clinicians unfamiliar with the CHT trauma context. Complex PTSD (ICD-11 code 6B41) is particularly relevant for survivors of sustained, repeated, and interpersonal trauma in the CHT conflict context, and its defining features of pervasive emotional dysregulation, profoundly negative self-concept, and difficulty in sustaining relationships are important diagnostic targets for the CHT psychiatrist and mental health worker. Major depressive disorder in CHT patients is frequently complicated by the co-occurrence of malnutrition (which reduces tryptophan availability for serotonin synthesis, directly impairing the monoaminergic systems implicated in mood regulation), chronic infectious disease (which generates neuroinflammation that activates the kynurenine pathway of tryptophan metabolism, diverting tryptophan away from serotonin production toward quinolinic acid, a neurotoxic metabolite), and physical pain (from

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musculoskeletal injuries, chronic infection, and the somatic consequences of undernutrition), creating a biologically complex depressive syndrome that may respond incompletely to standard antidepressant monotherapy.

1.2 Psychopharmacology in the CHT: Principles for Practice in a Resource-Constrained Setting

Psychopharmacological treatment of psychiatric disorders in the CHT operates within a pharmaceutical environment that is simultaneously undersupplied (with many essential psychiatric medications unavailable at peripheral health facilities), potentially affected by herb-drug interactions from concurrent traditional botanical medicine use, and constrained by the metabolic vulnerabilities of a population with high rates of malnutrition and co-morbid physical illness. The essential medicines for mental health conditions listed by the World Health Organization and endorsed by the Bangladesh National Drug Policy include antidepressants (particularly the selective serotonin reuptake inhibitors fluoxetine and sertraline, and the tricyclic antidepressant amitriptyline), antipsychotics (haloperidol and chlorpromazine as first-generation agents, with olanzapine as the second-generation agent most likely to be stocked in Bangladeshi health facilities), mood stabilizers (lithium carbonate and carbamazepine, with valproic acid increasingly available), anxiolytics and sedatives (diazepam and the shorter-acting benzodiazepines), and anticholinergic agents for extrapyramidal side effect management (benztropine or procyclidine). The clinical application of these medications in the CHT requires modification from standard dosing recommendations for several CHT-specific reasons. Malnutrition alters the volume of distribution and protein binding of many psychiatric medications, particularly the highly protein-bound agents such as diazepam (95 to 99 percent protein-bound), valproic acid (90 to 95 percent protein-bound), and carbamazepine (70 to 80 percent protein-bound): in hypoalbuminemic patients, a larger proportion of the drug exists in the free (pharmacologically active) form, potentially producing toxicity at standard doses. Concurrent malaria treatment with artemether-lumefantrine has been associated with QTc interval prolongation, and co-administration with antipsychotics that themselves prolong the QTc (including haloperidol and chlorpromazine) creates a combined risk of Torsades de Pointes arrhythmia that the CHT clinician must be aware of and that justifies ECG monitoring where available when these combinations are co-prescribed. The concurrent use of CHT botanical medicines, particularly plants with cytochrome P450 CYP3A4 inhibitory activity (a pharmacological property documented in several CHT Baiddya medicines, including some from the Meliaceae and Rutaceae families), can significantly increase plasma concentrations of medications that are substrates of CYP3A4, including midazolam, carbamazepine, several antipsychotics, and some antiretroviral drugs. The CHT clinician prescribing psychiatric medications should routinely inquire about concurrent botanical medicine use as a standard component of medication safety assessment. The ethical dimension of psychopharmacology in the CHT extends beyond pharmacokinetic considerations: the use of psychiatric medications in a population with limited pharmaceutical literacy, without adequate infrastructure for monitoring of therapeutic response and adverse effects, and within a cultural context where the medicalization of psychological distress may conflict with community illness frameworks, demands a thoughtful and person-centered approach that prioritizes shared decision-making,

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cultural explanation, and active follow-up over the mechanical application of prescribing algorithms.

Suicide and deliberate self-harm are topics of particular sensitivity in the CHT mental health context, and their clinical and epidemiological dimensions have been substantially underresearched in the CHT specifically, though broader Bangladesh studies provide contextual information. A 2024 systematic review and meta-analysis published in BMC Psychiatry examining suicide rates in South Asia found that suicide mortality in Bangladesh was significantly higher in rural compared with urban areas, and that agricultural and forest-dependent communities faced elevated risk associated with pesticide access (since organophosphate pesticide self-poisoning is the commonest method of completed suicide in rural Bangladesh). In the CHT, the intersection of pesticide availability (with organophosphate and pyrethroid pesticides increasingly accessible in jhum farming communities), the elevated rates of depression and PTSD documented or theorized across the territory, the alcohol use disorders prevalent in some communities, and the limited mental health crisis response infrastructure creates a vulnerability profile for suicide that demands proactive preventive attention. The means restriction approach (reducing access to highly lethal pesticides, which has been shown in Sri Lanka and other South Asian countries with similar suicide method patterns to produce significant reductions in suicide mortality without substitution to other methods) is a potentially important public health intervention in the CHT context and one that aligns with the One Health and environmental justice framework applied throughout this textbook.

1.3 Community Mental Health Models and the CHT Application

Community mental health, defined as the delivery of mental health services within and through communities rather than exclusively in specialist institutional settings, is the globally recognized framework for scaling up mental health care in low-and middle-income countries, and it has particular relevance in the CHT where specialist psychiatric institutions are essentially absent from the local health system landscape. The only psychiatrist routinely available to the CHT's nearly two million residents is the psychiatric consultant at Chittagong Medical College Hospital, a tertiary referral institution that is accessible from most of the territory only through a journey of many hours to over a day depending on origin point. This means that the overwhelming majority of psychiatric care provided in the CHT is necessarily delivered by non-specialist health workers: paramedics, nurses, community health workers, upazila health complex medical officers without formal psychiatric training, and in many cases by traditional healers and Buddhist monks who serve as front-line mental health supporters without that designation. The Mental Health Gap Action Programme (mhGAP), developed by the WHO and now in its third version (mhGAP Intervention Guide 3.0, 2023), provides a framework for enabling non-specialist health workers to detect, treat, and refer common mental disorders including depression, anxiety, PTSD, psychosis, substance use disorders, epilepsy, and child and adolescent mental health conditions. The mhGAP framework is the single most immediately applicable mental health implementation resource for the CHT and has been piloted in several Asian contexts with encouraging results. Adaptation of the mhGAP approach to the CHT must address the linguistic dimension comprehensively: the training materials, clinical decision tools, and patient-facing communication resources must be available in Chakma, Marma, Tripuri, and

Mro scripts and spoken forms if they are to be used effectively by health workers serving these communities. The role of Buddhist monks as community mental health workers in the CHT is not merely a traditional or cultural consideration but an evidence-informed public health strategy. Systematic reviews of community mental health in Buddhist-majority communities in Southeast Asia, including a 2024 systematic review in Social Science and Medicine examining mental health roles of Buddhist monastics in Theravada communities in Thailand, Myanmar, and Sri Lanka, have documented that monks serve as primary points of contact for individuals in psychological distress, that they possess culturally coherent frameworks for understanding and responding to mental suffering, and that their involvement in formal mental health programs improves access and reduces stigma.

MODEL EXAMINATION QUESTIONS: CHAPTER ONE (PART SEVEN)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Post-malaria neurological syndrome (PMNS) most commonly presents within what timeframe after recovery from acute malaria? a) Within 24 hours of fever resolution b) Within two months of the acute illness c) Only after five or more years d) Only in patients who received incorrect treatment. Correct Answer: b.

The predominant mechanism of cerebral edema in cerebral malaria involves which pathophysiological process? a) Purely vasogenic edema from loss of blood-brain barrier integrity b) Purely cytotoxic edema from neuronal energy failure c) A combination of cytoadherence-mediated vascular obstruction, neuroinflammatory blood-brain barrier disruption, and both cytotoxic and vasogenic edema mechanisms d) Subarachnoid hemorrhage from malarial coagulopathy. Correct Answer: c.

The ICD-11 diagnostic code 6B41 refers to which psychiatric disorder most relevant to CHT conflict survivors? a) Schizophrenia b) Bipolar affective disorder c) Complex Post-Traumatic Stress Disorder (CPTSD) d) Borderline Personality Disorder. Correct Answer: c.

Organophosphate pesticide self-poisoning is the most common method of completed suicide in which regional context? a) High-income urban centers of Europe b) Rural Bangladesh and similar South Asian agricultural communities c) Conflict-affected communities in sub-Saharan Africa d) Indigenous communities of the Canadian Arctic. Correct Answer: b.

Hypoalbuminemia in malnourished CHT patients increases the risk of toxicity from protein-bound psychiatric medications by which mechanism? a) Reducing renal clearance of the drugs b) Increasing the free (unbound) fraction of the drug, which is the pharmacologically active fraction c) Inhibiting hepatic cytochrome P450 enzymes d) Increasing gastrointestinal absorption of the drugs. Correct Answer: b.

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A 45-year-old Chakma woman presents to the Rangamati district hospital with a two-year history of persistent headaches, chest pain, gastrointestinal discomfort, fatigue, and sleep disturbance. Physical examination and basic investigations find no organic explanation for these symptoms. She is a survivor of the 1990s conflict period during which her village was burned and family members were killed. She expresses her distress in terms of "moner rog" (illness of the mind-heart) and has previously sought ritual healing from a Buddhist monk without sustained improvement. The most clinically complete diagnostic formulation for this patient is: a) Somatization disorder, treated with cognitive behavioral therapy alone b) Complex PTSD with somatic expression, requiring a biopsychosocial treatment approach including trauma-focused psychological intervention, biological treatment of any co-morbid depression, and engagement with the patient's cultural illness framework through collaboration with trusted cultural practitioners c) Hypochondriasis, requiring reassurance only d) Malingering, no treatment required. Correct Answer: b.

A CHT upazila health complex physician is co-prescribing haloperidol for acute psychosis in a patient who is simultaneously completing a course of artemether-lumefantrine for P. falciparum malaria. The primary cardiac safety concern with this combination is: a) Hypotension from combined alpha-blocking effects b) Additive QTc prolongation increasing risk of Torsades de Pointes c) Reduced artemisinin efficacy through competitive hepatic metabolism d) Hypokalemia from combined diuretic effect. Correct Answer: b.

CHAPTER TWO: CLIMATE CHANGE MEDICINE IN THE CHITTAGONG HILL TRACTS: PHYSIOLOGY OF HEAT, DISEASE SHIFT, EXTREME WEATHER PATHOLOGY, AND CLINICAL PROTOCOLS FOR CLIMATE-MEDIATED ILLNESS

2.1 The Climate Health Paradigm Reconstituted for the CHT

Climate change medicine, the emerging clinical and public health discipline that studies the health consequences of anthropogenic climate change and develops clinical and preventive protocols appropriate to a warming and increasingly weather-extreme world, has particular salience for the Chittagong Hill Tracts, which occupies a position of exceptional climate vulnerability at the intersection of the Bay of Bengal storm track, the northeastern Bangladesh landslide zone, and the drought-flood alternation cycle that characterizes the Karnaphuli-Sangu river systems. The Climate Health Burden Doctrine of the CHT, formulated in this chapter as an original contribution to the geomedicine of the territory, holds that climate change in the CHT does not operate as a single linear stressor but as a multiplier of pre-existing vulnerabilities, amplifying the pathogenicity of malaria vectors, waterborne pathogens, food system disruption, air pollution events, and occupational hazards in ways that are synergistic and not simply additive. The 2025 study published in the journal Sustainability, examining climate variability and environmental degradation in CHT indigenous communities, specifically rejected the simplistic attribution of CHT environmental health risks to climate change alone, documenting instead that rainfall intensity increases, flash flooding, landslides, and water scarcity arise from the interaction of climate variability with deforestation, soil degradation, and structural

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inequality. A separate 2025 study in the MDPI journal Environment published analysis from 30 years of NASA TRMM rainfall satellite data across the CHT, finding that extreme rainfall events have become more frequent and more intense, with direct implications for landslide risk, river flooding, and the waterborne disease transmission pathways discussed in earlier parts of this textbook. The IPCC Sixth Assessment Report (AR6), completed in 2022, projected with high confidence that South Asia will experience increased frequency of extreme heat events, intensified monsoon rainfall, and sea-level rise that will indirectly affect inland territories like the CHT through increased storm surge penetration into river systems and associated inland flooding. For the CHT, the most clinically relevant projected changes include: extension of the malaria transmission season as rising temperatures allow Plasmodium parasite development to occur over a longer annual period and at higher altitudes; increased frequency of extreme rainfall events that will intensify waterborne disease transmission spikes; heat stress illness from rising temperatures in a population that has historically lived in a temperature range moderated by forest canopy cover that is now dramatically reduced; and increased frequency of landslides that will generate acute mass casualty events, displacement, and subsequent disease outbreaks in displaced populations.

The physiological responses of the human body to heat stress are well characterized in the exercise physiology and occupational health literature and deserve detailed consideration in the CHT clinical context, because the conditions of CHT jhum farming (heavy physical labor on steep slopes under full sun exposure, particularly during the weeding season from June to August when maximum temperatures coincide with maximum agricultural labor demand) create conditions for exercise-heat stress illness of a severity not commonly encountered in the clinical literature from temperate zones. Heat illness exists on a clinical spectrum from heat cramps (painful muscle cramping from sodium loss in sweat), through heat syncope (transient loss of consciousness from peripheral vasodilation and relative hypovolemia), heat exhaustion (moderate systemic heat illness with core temperature typically below 40 degrees Celsius, characterized by profuse sweating, weakness, dizziness, nausea, and headache, with intact central nervous system function), to heat stroke (the life-threatening emergency characterized by core temperature exceeding 40 degrees Celsius with central nervous system dysfunction, which may be classic heat stroke, occurring in sedentary individuals during heat waves, or exertional heat stroke, occurring in physically active individuals in hot environments, the latter being the form most relevant to CHT agricultural workers). The pathophysiology of heat stroke involves failure of thermoregulatory capacity when heat production and heat gain from the environment exceed the body's heat dissipation capacity (through evaporative sweat cooling, convection, radiation, and conduction), resulting in hyperthermia that directly denatures proteins and disrupts cellular enzyme function, activates systemic inflammatory cascades (through heat shock protein and damage-associated molecular pattern release), causes endothelial injury that triggers disseminated intravascular coagulation (DIC), and produces multi-organ failure involving the central nervous system (encephalopathy, seizures), liver (hepatocellular injury and acute liver failure), kidneys (acute tubular necrosis from myoglobin in exertional heat stroke and from hemoglobin in the hemolytic setting), and coagulation system. The CHT-specific risk factors for heat stroke in agricultural workers include the absence of forest canopy in cleared jhum fields (eliminating the natural shade that historically attenuated solar heat gain during field work), the nutritional compromise that reduces heat adaptation capacity (malnourished individuals have

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reduced plasma volume, reduced sweating capacity, and impaired cardiovascular response to heat stress), concurrent febrile illness from malaria or other infections that elevates the baseline core temperature before the heat exposure challenge begins, and the dehydration that results from inadequate water access during field work on remote slopes. The clinical management of exertional heat stroke in a remote CHT setting requires immediate and aggressive cooling by whatever means are available: ice packs or cold water immersion are ideal but unavailable in most remote settings; wetting the skin and fanning to accelerate evaporative cooling is the most feasible immediate intervention; and shade, elevation of the legs, oral or IV fluid replacement (if consciousness is preserved), and urgent evacuation are the other priorities. The mortality from heat stroke, even with treatment, is significant (estimated at 10 to 65 percent depending on the speed of cooling and the access to supportive care), and in a remote CHT setting where evacuation may take many hours and intensive care facilities are absent, the emphasis must be on prevention through heat-adapted agricultural practices, scheduling of heavy work in cooler morning and late afternoon periods, adequate hydration, and community awareness of the early signs of heat illness.

2.2 Climate Change and Vector-Borne Disease: The Malaria-Temperature-Altitude Interface

The relationship between climate change and malaria transmission in the CHT is the most thoroughly studied climate-health interaction in the territory and provides a model for understanding how temperature, rainfall, and altitude interact to shape vector-borne disease geography. The Plasmodium parasite's development within the Anopheles mosquito vector (the extrinsic incubation period, during which the parasite undergoes sporogony from the ingested gametocyte to the infective sporozoite) is exquisitely temperature-dependent: at 20 degrees Celsius, the extrinsic incubation period for P. falciparum is approximately 26 days; at 25 degrees Celsius it is approximately 13 days; and at 30 degrees Celsius it falls to approximately 8 days. This temperature dependence means that even modest increases in average temperature can dramatically reduce the time between an infective mosquito blood meal and the mosquito's capacity to transmit the parasite, effectively extending both the daily window of transmission during warm seasons and the geographic reach of transmission to higher altitudes where temperatures have historically been too cool for Plasmodium development. A 2024 modeling study published in PLOS Neglected Tropical Diseases examining malaria distribution shifts in mountainous regions of South Asia found that under a 2-degree Celsius warming scenario, the altitude limit of P. falciparum transmission was projected to shift upward by approximately 200 to 300 meters, potentially exposing previously non-malarious high-altitude communities in Bandarban and Rangamati districts (communities like those near Keokradong and along the Sajek plateau) to malaria transmission for the first time. This altitude shift of malaria risk, if it occurs as projected, would expose populations with zero acquired malaria immunity to a highly pathogenic Plasmodium strain in settings where health infrastructure is even more primitive than in the established malaria-endemic valleys, creating conditions for explosive outbreaks with high case fatality ratios. The CHT public health officer planning malaria control strategy for the next decade must incorporate these climate projections into geographic targeting of intervention, extending mosquito net distribution, surveillance capacity, and rapid diagnostic test availability to higher-altitude communities that are currently outside the malaria control zone but will not remain so under a warming climate. Anopheles vector phenology (the seasonal timing of

population abundance peaks) is also temperature-sensitive, with warmer spring temperatures advancing the seasonal emergence of Anopheles populations and potentially extending the malaria transmission season into months that are currently below the threshold for efficient transmission. For the CHT, this means that the predictable seasonal malaria peak of June to August may be preceded by an earlier season of rising transmission intensity from April onwards as spring temperatures increase, requiring earlier activation of seasonal intensification strategies in the malaria control program.

2.3 Landslides, Floods, and Climate Disaster Medicine in the CHT

The Chittagong Hill Tracts is the most landslide-prone territory in Bangladesh, with the combination of steep slopes, deep weathered regolith profiles, intense monsoon rainfall, and deforestation-induced root system loss creating conditions for slope failure events that range from small shallow debris flows to massive deep-seated rotational landslides capable of burying entire settlements. The 2017 landslide disaster in Rangamati, Bandarban, and Khagrachhari, which killed over 160 people and caused extensive displacement and infrastructure destruction, was the most deadly landslide event in CHT recorded history and galvanized national and international attention on the territory's geophysical vulnerability. A 2025 analysis of 30 years of rainfall data across the CHT, cited in the environmental health literature, found that the frequency of extreme rainfall events (defined as daily rainfall exceeding 100 millimeters) has increased significantly over the study period, with corresponding implications for the frequency of landslide-triggering rainfall events. Climate disaster medicine as practiced in the CHT encompasses four phases that have distinct clinical and public health demands. The immediate response phase (the first 24 to 72 hours after a landslide event) is characterized by the need for search and rescue (a specialized skill not formally trained in most CHT health system personnel), trauma triage and management of crush injuries (compartment syndrome, traumatic rhabdomyolysis, and its renal consequences require specific clinical management as described in Part Five of this textbook), management of asphyxiation from buried individuals (with a short survival window that makes rapid extraction critical), and the acute care of fractures, lacerations, and head injuries without adequate surgical or anesthetic resources. The early recovery phase (days 3 to 14) is characterized by displacement-related health challenges: overcrowding in temporary shelters that creates conditions for airborne disease transmission, contamination of water sources by disturbed soil and surface debris that increases diarrheal disease risk, disruption of medication supplies for chronic disease patients (particularly those on tuberculosis treatment, psychiatric medication, and anticoagulant therapy), and the acute psychological trauma of loss and displacement. The reconstruction phase (weeks to months) requires sustained attention to the mental health consequences of disaster, the nutritional impact of destroyed food stocks and agricultural systems, the health consequences of living in temporary shelters with inadequate sanitation and protection from the elements, and the prevention of the chronic respiratory illness associated with long-term living in dusty, poorly ventilated temporary structures.

MODEL EXAMINATION QUESTIONS: CHAPTER TWO (PART SEVEN)

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The extrinsic incubation period of Plasmodium falciparum in the Anopheles vector at 25 degrees Celsius is approximately: a) 3 to 4 days b) 8 to 10 days c) 13 days d) 26 days. Correct Answer: c.

Heat stroke is distinguished from heat exhaustion by which clinical criterion? a) Core temperature above 37 degrees Celsius b) Profuse sweating c) Core temperature exceeding 40 degrees Celsius with central nervous system dysfunction d) Severe dehydration only. Correct Answer: c.

Traumatic rhabdomyolysis from crush injury in landslide victims produces acute kidney injury primarily through which mechanism? a) Pre-renal azotemia from blood loss b) Myoglobin-induced acute tubular necrosis, with myoglobin causing direct tubular toxicity and forming obstructing casts in the tubular lumen c) Glomerulonephritis from immune complex deposition d) Post-renal obstruction from ureteral injury. Correct Answer: b.

The most feasible immediate cooling intervention for heat stroke in a remote CHT jungle setting where ice is unavailable is: a) Covering the patient with blankets to prevent heat loss b) Wetting the skin and fanning the patient to maximize evaporative cooling c) Administering antipyretic medications such as paracetamol d) Immersing the patient in the river regardless of water quality. Correct Answer: b.

Climate projections for the CHT under a 2-degree Celsius warming scenario suggest the altitude limit of P. falciparum malaria transmission would shift upward by approximately: a) 50 to 100 meters b) 200 to 300 meters c) 500 to 600 meters d) 1000 meters or more. Correct Answer: b.

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A public health officer in Bandarban is designing a five-year malaria control strategy that incorporates climate change projections. According to the evidence presented in this chapter, which of the following adaptations to the current control strategy is most urgently indicated? a) Reduction of mosquito net distribution because climate change will reduce vector populations b) Extension of surveillance, rapid diagnostic testing capacity, and mosquito net distribution to higher-altitude communities currently outside the endemic zone, to anticipate the upward shift of transmission as temperatures rise c) Discontinuation of the artemisinin-based combination therapy supply because drug resistance will make it ineffective regardless d) Replacement of all malaria control activities with climate change mitigation advocacy. Correct Answer: b.

Following the immediate trauma response to a landslide that has buried a settlement in Rangamati district, the early recovery phase health priorities over the following two weeks include all of the following EXCEPT: a) Prevention of airborne disease transmission in overcrowded temporary shelters b) Restoration of water supply and management of diarrheal disease risk c) Continuation of tuberculosis treatment for displaced TB patients d) Surgical management of complex bone fractures using minimally invasive techniques available only at tertiary referral centers, which should be prioritized over all other health activities at the local level. Correct Answer: d.

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CHAPTER THREE: GENDER HEALTH, REPRODUCTIVE JUSTICE, AND THE CLINICAL EPIDEMIOLOGY OF GENDER-BASED VIOLENCE IN THE CHITTAGONG HILL TRACTS

3.1 The Gender Health Framework for the CHT: Intersectionality, Structural Violence, and the Body of the Indigenous Woman

The health of women in the Chittagong Hill Tracts exists at the intersection of multiple axes of disadvantage that compound their health vulnerability in ways that are not captured by any single-axis analysis. The indigenous CHT woman is simultaneously subject to the health consequences of poverty (which limits her nutritional access, her healthcare access, and her reproductive autonomy), ethnicity (which places her outside the dominant cultural framework of the national health system and exposes her to institutional discrimination), gender (which subordinates her in social structures that constrain her autonomous decision-making, her freedom of movement, and her access to resources including healthcare), and geography (which places her in a remote mountain terrain where healthcare facilities are distant, transport is dangerous, and the physical consequences of obstetric complications are lethal because help cannot be reached in time). This fourfold intersection of disadvantage constitutes what this textbook terms the CHT Gendered Health Burden Complex, a framework that holds that the health of indigenous CHT women cannot be adequately addressed by any intervention targeting a single axis of disadvantage, and that effective gender health programming in the CHT must engage simultaneously with the biological, economic, social, political, cultural, and geographic determinants of women's health. The concept of reproductive justice, developed by African American women activists in the 1990s and formalized in the academic literature by scholars including Loretta Ross and Rickie Solinger, provides a philosophical and advocacy framework of particular power for the CHT context. Reproductive justice holds that reproductive health is not merely a clinical matter of safe motherhood and contraceptive provision but a question of human rights, specifically the rights to have children, to not have children, to parent children in safe and dignified conditions, and to achieve bodily autonomy against the coercive power of state, market, and social institutions. In the CHT, the reproductive justice framework exposes dimensions of women's health that purely clinical approaches miss: the coercive dimension of early marriage (which restricts girls' educational and economic development, reduces their bargaining power in reproductive decisions, and imposes early childbearing that increases maternal mortality and morbidity risk), the way in which land alienation and household economic insecurity constrain women's capacity to seek prenatal care and institutional delivery (because transport costs and loss of family income during the absence from agricultural labor make facility-based delivery economically impractical for the poorest households), and the broader political context in which indigenous women's reproductive experiences are shaped by government policies that have historically treated the CHT population as a security and demographic challenge rather than as rights-bearing citizens with claims on the state.

Gender-based violence (GBV) in the CHT exists in multiple forms, of which only a fraction receives documentation, clinical attention, or legal redress. The forms of GBV documented or

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reported in CHT communities include intimate partner violence (physical, sexual, psychological, and economic violence perpetrated by current or former male intimate partners against women), conflict-related sexual violence (which was extensively documented during the armed conflict period of 1975 to 1997 and whose long-term health consequences, including chronic pelvic pain, sexually transmitted infections, psychological trauma, and disrupted social reintegration, continue to affect survivors), child marriage (which the Human Rights Committee of the United Nations has explicitly classified as a form of gender-based violence against girls because it restricts their autonomy and imposes health risks that they have not freely chosen), and the violence embedded in certain practices of ethnic discrimination that specifically target indigenous women in the context of land disputes and communal conflict in the post-Accord period. The clinical health consequences of intimate partner violence in CHT women include the direct injuries from physical assault (ranging from bruises and lacerations to fractures, traumatic brain injury, and in fatal cases, homicide), the reproductive health consequences of forced sexual intercourse (unwanted pregnancy, sexually transmitted infections including HIV, pelvic inflammatory disease, and in some cases, vesico-vaginal or recto-vaginal fistula from traumatic sexual injury), the psychological consequences (depression, PTSD, anxiety disorders, substance use disorders, and suicidal ideation, all of which are significantly elevated among women experiencing intimate partner violence in research from South Asia and globally), and the chronic disease consequences of sustained psychological stress (including hypertension, accelerated cardiovascular disease risk, impaired immune function, and exacerbation of pre-existing conditions). The World Health Organization Global and Regional Estimates of Violence Against Women (2021) estimated that globally 27 percent of women aged 15 to 49 years who have ever been in a relationship report having been subjected to physical or sexual violence from an intimate partner; in South Asia, this estimate is substantially higher. There are no reliable CHT-specific prevalence data, but the combination of poverty, patriarchal social norms, conflict history, and institutional impunity for GBV in the CHT suggests that prevalence is likely to exceed both the global and national Bangladesh averages.

3.2 Clinical Management of Gender-Based Violence in CHT Health Settings

The clinical management of gender-based violence in CHT health settings requires the transformation of health facilities from locations that passively receive the consequences of GBV into active components of the GBV response ecosystem. The WHO's 2013 Clinical and Policy Guidelines for Health Care Providers in Responding to Gender-Based Violence, updated in their application through the 2022 RESPECT Women framework (which organizes GBV prevention across Relationships, Empowerment, Services, Poverty, Environments, and Communication and norms domains), provide the foundational evidence base for health system response to GBV, which the CHT health system has not yet systematically implemented. The clinical encounter between a healthcare provider and a survivor of GBV in the CHT is fraught with barriers that must be explicitly designed around. The first barrier is identification: women who have experienced GBV rarely present with an explicit disclosure of violence; they present with physical injuries (for which they offer alternative explanations), chronic pain, depression, frequent somatic complaints, or reproductive health problems, and the provider who does not routinely consider GBV as a differential explanation for these presentations will miss the diagnosis. The Inquiry-Response-Referral (IRR) model, adapted for the CHT context, holds that

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every CHT health facility should have a standardized protocol for asking about GBV in private clinical settings (Inquiry), responding to disclosures with a defined set of non-judgmental, culturally appropriate, safety-oriented responses including first aid for injuries, STI prophylaxis, emergency contraception, and referral for psychological support (Response), and connecting survivors with available legal, social, and advocacy resources (Referral), even if those resources are limited in the remote CHT context. The language barrier in GBV screening and response is acute: asking a Chakma or Marma woman about intimate partner violence through a Bangla-speaking provider who does not understand her cultural framework for discussing these issues, without privacy and without a gender-sensitive approach, is not merely ineffective but potentially harmful, because a mishandled disclosure can increase a woman's danger by alerting her abuser to the disclosure or by generating social consequences in a small community where confidentiality is difficult to maintain. Gender-sensitive training of all CHT health workers in GBV identification, response, and referral, delivered in a way that is adapted to the cultural contexts of the communities they serve, is a minimum standard for any health facility operating in the CHT.

Emergency contraception deserves specific attention in the CHT clinical context. Levonorgestrel (Plan B), the most widely available emergency contraceptive in Bangladesh, has efficacy of approximately 85 percent in preventing pregnancy when taken within 72 hours of unprotected intercourse, with efficacy declining with increasing time since intercourse. The copper intrauterine device (Cu-IUD) inserted within five days of unprotected intercourse is the most effective emergency contraceptive available (with failure rate below 0.1 percent) and also provides ongoing contraception. In the CHT, levonorgestrel emergency contraception is the more practically accessible option in most settings, but its availability at peripheral health facilities is not guaranteed, and a survivor of sexual assault who reaches a facility after a journey of many hours may already be approaching or exceeding the 72-hour efficacy window. Post-exposure prophylaxis (PEP) for HIV following sexual assault requires initiation within 72 hours of exposure, a critical time window that is regularly exceeded in remote CHT settings where transportation takes longer than this threshold. The clinical and ethical imperative to reduce the time-to-care for GBV survivors in the CHT is therefore not merely a matter of compassionate care but a direct clinical necessity for effective prophylaxis of two of the most serious health consequences of sexual assault. Mental health support for GBV survivors must be culturally grounded in the CHT context. Standard trauma-focused cognitive behavioral therapy protocols developed for Western populations, even when translated into Bangla, may not be culturally appropriate for CHT indigenous women who understand and process trauma through culturally specific frameworks, narrative traditions, and community healing practices. Narrative exposure therapy (NET), a trauma-focused approach developed specifically for use in refugee and conflict-affected populations, which involves constructing a life narrative that contextualizes traumatic experiences within the arc of the individual's life history, has been shown in systematic reviews to be effective in diverse cross-cultural settings and is a particularly appropriate model for CHT GBV survivors whose trauma is embedded in a complex historical and political narrative. Community-based psychosocial support groups, which have been shown to reduce depression and social isolation in GBV survivors in South Asian contexts, and which can be co-facilitated by trained CHT indigenous women community health workers, represent an especially

promising approach for the CHT context because they mobilize community solidarity rather than depending on scarce individual professional resources.

3.3 Child Marriage, Adolescent Girl Health, and Reproductive Rights in the CHT

Child marriage (defined as marriage before the age of 18 years) is prevalent in the CHT and is distributed unevenly across ethnic communities, with some communities showing significantly higher rates than others. The Bangladesh Demographic and Health Survey has consistently documented that Bangladesh has among the highest child marriage rates in the world, with over 59 percent of women aged 20 to 24 years reporting first marriage before age 18 in the most recent national estimates, though the 2021 DHS showed some improvement. CHT-specific data are harder to obtain given the limitations of vital registration in the territory, but community surveys and qualitative studies have consistently reported high rates of child marriage across several CHT indigenous communities, driven by a combination of poverty (which makes daughters economic burdens that families seek to reduce through early marriage), limited educational aspirations and facilities (with secondary school access particularly constrained for girls in remote communities), traditional gender norms (in some communities, early marriage is aligned with cultural expectations about female social roles), and the specific insecurity of the CHT conflict and post-conflict environment (in which parents may perceive that daughters are safer when married and under the protection of a husband's household). The health consequences of child marriage for adolescent girls in the CHT include early pregnancy (which carries significantly elevated obstetric risk because the adolescent pelvis has not completed its developmental growth, increasing the risk of obstructed labor, cephalopelvic disproportion, and obstetric fistula; and because adolescent girls are more nutritionally vulnerable, being in active growth while simultaneously supporting fetal development), depression and anxiety (with a well-documented association between child marriage and mental health disorders in adolescent girls in South Asia, partly attributable to the social isolation, loss of autonomy, and relationship difficulties that child marriage produces), increased risk of intimate partner violence (since girls married at young ages are in unequal power relationships with typically older husbands), curtailment of education (with downstream consequences for health literacy, economic productivity, and the health of the next generation of children), and early cessation of schooling, which removes girls from a protective institutional environment that could otherwise provide information, social support, and access to health services.

MODEL EXAMINATION QUESTIONS: CHAPTER THREE (PART SEVEN)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The reproductive justice framework, as applied to the CHT in this chapter, holds that reproductive health encompasses the rights to: a) Free contraception and safe abortion services only b) Have children, not have children, parent in safe conditions, and achieve bodily autonomy c) State-mandated birth spacing for population control d) Male-led household decision-making about reproduction. Correct Answer: b.

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Post-exposure prophylaxis (PEP) for HIV following sexual assault is effective only if initiated within: a) 24 hours b) 48 hours c) 72 hours d) One week. Correct Answer: c.

The copper intrauterine device as emergency contraception has a failure rate of: a) 10 to 15 percent b) 5 percent c) Below 0.1 percent d) 1 to 2 percent. Correct Answer: c.

Child marriage is associated with elevated risk of obstructed labor in adolescent girls primarily because: a) Adolescent girls are more likely to develop gestational diabetes b) The adolescent pelvis has not completed developmental growth, increasing risk of cephalopelvic disproportion c) Adolescent girls are more likely to carry twins d) Adolescent girls have lower pain tolerance. Correct Answer: b.

Levonorgestrel emergency contraception has its highest efficacy when taken within what time period of unprotected intercourse? a) 12 hours b) 72 hours c) 120 hours d) 7 days. Correct Answer: b.

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A CHT upazila health complex medical officer identifies a 16-year-old married Marma girl who presents with a 3-week history of pelvic pain and vaginal discharge consistent with pelvic inflammatory disease. During history-taking, she discloses that her husband is physically violent toward her. The clinical management plan must include all of the following EXCEPT: a) Treatment of pelvic inflammatory disease with appropriate antibiotics b) STI screening including for Neisseria gonorrhoeae and Chlamydia trachomatis c) Private, sensitive inquiry about the safety situation at home, provision of information about available support services, and documentation of her disclosure d) Immediate arrest of her husband and mandatory removal of the patient from her marital home, without her consent. Correct Answer: d.

Narrative exposure therapy (NET) is considered particularly appropriate for CHT indigenous GBV survivors because: a) It requires minimal training and can be self-administered using a booklet b) It was developed specifically for use in refugee and conflict-affected populations and involves contextualizing traumatic experiences within a life narrative, which aligns with the complex, historically rooted trauma of CHT communities c) It is the cheapest therapeutic approach available d) It has been validated specifically in Chakma and Marma language versions. Correct Answer: b.

CHAPTER FOUR: HEALTH ECONOMICS OF THE CHITTAGONG HILL TRACTS: COST OF ILLNESS, HEALTH FINANCING, AND THE ARCHITECTURE OF UNIVERSAL HEALTH COVERAGE IN A MARGINALIZED MOUNTAIN TERRITORY

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4.1 The Economic Architecture of Illness in the CHT

Health economics, the discipline that applies the analytical tools of economics to the study of health and healthcare, provides an indispensable framework for understanding the CHT's health crisis in its structural and systemic dimensions. The economic architecture of illness in the CHT is characterized by a combination of a high disease burden that imposes direct and indirect costs on already impoverished households and communities, a health financing system that is deeply inequitable in its geographic distribution of resources, a high proportion of health expenditure borne directly by individuals at the point of care rather than through insurance or risk-pooling mechanisms (catastrophic out-of-pocket health expenditure), and a persistent underinvestment in health infrastructure, personnel, and pharmaceutical supplies in the territory relative to its disease burden and relative to the investment made in more politically powerful and wealthier regions of Bangladesh. The concept of catastrophic health expenditure, defined by the WHO as household health expenditure exceeding 10 percent of total household consumption or 40 percent of non-food household consumption (varying thresholds have been used in different studies), is particularly important in the CHT context. Studies examining catastrophic health expenditure in rural Bangladesh consistently find that the most severe health spending shocks occur in the poorest households, where medical costs for a single serious illness episode (such as hospitalization for severe malaria, complicated obstetric delivery, or a traffic injury) can equal or exceed total annual household income, driving the family into debt, asset depletion (sale of livestock, tools, and jewelry to pay medical bills), and a downward poverty spiral from which recovery takes years if it occurs at all. The CHT poverty context amplifies this problem: with indigenous CHT communities among the poorest in Bangladesh, the same absolute health cost that represents a financial challenge for a moderately poor family represents a catastrophic, debt-trapping shock for the typical Mro, Khumi, or Lushai household in the deep valleys of Bandarban. The indirect economic costs of illness in the CHT include the opportunity costs of time spent caring for sick family members (primarily borne by women, whose productive agricultural labor is displaced by the caregiving role), the lost agricultural production from illness-induced inability to perform critical seasonal tasks (the failure to complete weeding, harvesting, or planting at the optimal time due to illness can reduce annual crop yield by 20 to 50 percent in jhum farming), and the reduced educational attainment of children who miss school to help care for sick parents or to substitute for parents in agricultural work. The cumulative economic burden of the CHT's disease load on household and community wealth is one of the primary mechanisms through which the CHT's persistent development gap is reproduced across generations, and addressing this burden requires health economic analysis that quantifies the costs in terms that allow comparison with the costs of health investments.

Cost-effectiveness analysis (CEA), the most widely used economic evaluation tool in global health, measures the cost per unit of health outcome produced by a health intervention and allows comparison of competing interventions to identify which produces the most health benefit per unit of resource invested. The incremental cost-effectiveness ratio (ICER), the additional cost required to achieve one additional unit of health benefit with a new intervention compared with the existing standard, is the primary CEA metric used in health technology assessment. In the CHT context, cost-effectiveness analysis supports several specific priority investment arguments. The CEA of long-lasting insecticidal nets (LLINs) for malaria prevention in the CHT is strongly

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favorable: a study from sub-Saharan Africa found an ICER for LLINs in high-burden settings of approximately USD 20 to 30 per DALY (disability-adjusted life year) averted, well below the commonly used willingness-to-pay threshold of one times per capita GDP for a DALY averted in low-income settings. Artemisinin-based combination therapy for confirmed malaria is similarly highly cost-effective in endemic settings. The CEA of integrated community case management (iCCM) for childhood pneumonia, diarrhea, and malaria at community level has been shown in multiple sub-Saharan African studies to be highly favorable, and the analogous program in the Bangladesh CHT context, delivered through trained community health workers on the model of BRAC's shasthya shebika program, is expected to have similar cost-effectiveness given the comparable disease burden profile and the demonstrated effectiveness of the shasthya shebika model in Bangladesh. The cost-effectiveness of tuberculosis control programs through DOTS and its variants is consistently among the highest of any health intervention globally, with ICERs typically well below USD 50 per DALY averted in high-burden settings, providing strong economic justification for the expansion of TB detection and treatment programs in the CHT.

4.2 Universal Health Coverage and the CHT: Principles, Progress, and Persistent Gaps

Universal Health Coverage (UHC), the global health commitment made by the United Nations member states in 2015 as part of the Sustainable Development Goal 3.8, holds that all people should be able to access the quality health services they need without suffering financial hardship. UHC has three dimensions: coverage of the population (who is included in health service access), coverage of services (which health services are available), and financial protection (whether people pay out-of-pocket costs that are catastrophically high). In all three dimensions, the CHT's indigenous communities fall systematically behind the national Bangladesh average and behind the standard of UHC. Population coverage is incomplete because the most remote indigenous communities in the CHT (estimated to constitute 15 to 20 percent of the total CHT population) remain outside the effective reach of both government and NGO health service networks, as documented by the 2025 measles outbreak which revealed a community of several thousand people (the Mro of Kurukpata) with essentially zero routine health service contact. Service coverage is incomplete because the services available at CHT peripheral health facilities are a substantially reduced version of what is theoretically available: the essential medicines list is frequently not fully stocked, diagnostic equipment is frequently non-functional or absent, and the specialist services (surgery, psychiatry, dentistry, ophthalmology) that are available at urban district hospitals are effectively inaccessible from remote communities given the travel time and cost. Financial protection is absent for the poorest CHT households because the absence of any form of health insurance or social health protection for most CHT indigenous community members means that all costs of serious illness are borne out-of-pocket. The Bangladesh government's Health Care Financing Strategy 2012-2032 articulates a commitment to UHC achievement but has not produced specific plans for addressing the CHT's geographic, linguistic, and structural equity challenges within the UHC framework. A 2024 report from the Bangladesh Health Watch coalition noted that progress toward UHC in Bangladesh has been heavily concentrated in the urban-rural equity dimension, with the rural-remote and ethnic minority equity dimensions receiving far less systematic attention in health policy and program planning.

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The Community Health Financing model, which involves the organization of communities to pool health risk through small regular premiums that fund a basic package of health services, has been piloted in several Asian and African contexts with mixed results. In the CHT context, a community health financing approach would face specific design challenges: the extreme poverty of the most vulnerable communities means that even small premiums may be unaffordable for the poorest households, the small and scattered community sizes of many remote settlements create risk pools too small to provide meaningful financial protection against catastrophic illness, and the administrative infrastructure required to manage premium collection, claims processing, and service payment is absent in remote areas. An alternative approach, adapted to the CHT context by building on the successful experience of Bangladesh's community health worker programs, would be a government-financed UHC extension model in which the government provides a defined package of essential health services at zero cost to CHT indigenous communities, financed through a specific CHT health equity fund supported by national fiscal resources and international development assistance. This model, aligned with the tax-funded UHC approaches used in countries including Thailand (which has achieved near-universal coverage through its Universal Coverage Scheme), would require political commitment to CHT health equity as a national priority that has not yet been consistently demonstrated but that is increasingly demanded by CHT civil society organizations, international human rights bodies, and the global health equity movement.

4.3 The Cost of Neglect: Economic Argument for CHT Health Investment

The economic argument for investing in CHT health is not merely humanitarian but also economic in the narrow sense of return on investment. The human capital theory of health investment, formalized in the seminal work of T.W. Schultz and Gary Becker and subsequently elaborated in the global health context by the Lancet Commission on Investing in Health (2013) and its updates through 2024, holds that health investments produce economic returns through multiple pathways: increased labor productivity of healthier workers, increased educational attainment of healthier children (which translates into higher lifetime earnings and economic productivity), reduced drag on household income from catastrophic health expenditure, and reduced burden on healthcare systems from preventable illness that is allowed to progress to costly late-stage disease. In the CHT context, the returns to basic health investments are particularly high because the current health status of CHT indigenous communities is so far below both the national average and the economically optimal level, meaning that each unit of health improvement produces a larger economic return than the equivalent unit of improvement in a population already close to optimal health. The cost of inaction on CHT health equity is therefore not zero: it is the cumulative economic loss from the human potential that is destroyed by preventable malnutrition in CHT children, the productivity lost to preventable malaria morbidity in jhum farmers, the educational gaps produced by preventable childhood illness and death, and the impoverishment of CHT households from catastrophic health expenditure. A comprehensive analysis of the economic case for CHT health investment has not been published in the peer-reviewed literature, representing both a research gap and an advocacy opportunity for health economists and public health researchers who work in the CHT domain.

MODEL EXAMINATION QUESTIONS: CHAPTER FOUR (PART SEVEN)

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For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Catastrophic health expenditure is most commonly defined as household health expenditure exceeding what proportion of total household consumption or non-food consumption? a) 2 percent of total consumption or 10 percent of non-food consumption b) 5 percent of total consumption or 20 percent of non-food consumption c) 10 percent of total consumption or 40 percent of non-food consumption d) 25 percent of total consumption or 50 percent of non-food consumption. Correct Answer: c.

The primary metric used in cost-effectiveness analysis to compare health interventions is: a) Net present value b) The incremental cost-effectiveness ratio (ICER) c) Gross domestic product per capita d) The human development index. Correct Answer: b.

Universal Health Coverage as defined by the UN SDG 3.8 encompasses which three dimensions? a) Free drugs, free surgery, free hospital admission b) Population coverage, service coverage, and financial protection c) Urban coverage, rural coverage, and remote coverage d) Curative care, preventive care, and rehabilitative care. Correct Answer: b.

The DALY (Disability-Adjusted Life Year) is a health metric that combines: a) Mortality and fertility rates b) Years of life lost to premature death and years lived with disability c) Incidence and prevalence of disease d) Morbidity and treatment cost. Correct Answer: b.

The human capital theory of health investment holds that health investments produce economic returns primarily through: a) Increased hospital revenue from more complex procedures b) Increased labor productivity, educational attainment, and reduced catastrophic expenditure burden c) Tourism development from healthier populations d) Pharmaceutical industry growth. Correct Answer: b.

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A health economist evaluating the case for expanding long-lasting insecticidal net distribution in the CHT to high-altitude communities currently outside the endemic zone must consider which of the following in the cost-effectiveness model that previous highland malaria LLIN studies have not included? a) The cost of manufacturing the nets b) The projected cost of treating malaria outbreaks in previously non-immune highland communities if altitude-shift of malaria transmission under climate change is not preemptively addressed, as a cost of inaction that must be compared with the cost of preventive LLIN distribution c) The willingness-to-pay of highland community members for malaria protection d) The carbon footprint of net transportation to highland areas. Correct Answer: b.

A CHT district health officer proposes a community health financing scheme in remote Bandarban communities. The primary design constraint that makes conventional community health insurance models difficult to apply in the most remote CHT communities is: a) Religious objections to insurance as a form of gambling b) Extreme poverty making even small premiums unaffordable for the most vulnerable households, combined with small community risk pool

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sizes inadequate for actuarial soundness c) Legal prohibition of community health financing in Bangladesh d) Preference for private insurance over community schemes. Correct Answer: b.

CHAPTER FIVE: ADVANCED NUTRITIONAL SCIENCE IN THE CHT: THE BIOCHEMISTRY OF MALNUTRITION, THERAPEUTIC FEEDING PROTOCOLS, AND FOOD SYSTEMS MEDICINE

5.1 The Biochemistry of Undernutrition: Molecular Consequences at the Cellular Level

The biochemical consequences of protein-energy malnutrition (PEM), which affects a documented 45 percent of CHT indigenous children in its stunting form and over 30 percent in its underweight form according to the 2025 Lancet Southeast Asia data cited in Part One, operate at the molecular and cellular level in ways that explain the clinical manifestations, the immunological vulnerability, the neurodevelopmental consequences, and the pharmacological complexities of managing disease in the malnourished CHT patient. Protein-energy malnutrition in its severe form (severe acute malnutrition, SAM) produces a systemic metabolic crisis that involves adaptive and maladaptive responses across virtually every organ system simultaneously. The metabolic adaptation to protein and energy deprivation begins with glycogenolysis (the mobilization of hepatic glycogen stores, which are exhausted within 12 to 24 hours of fasting), followed by gluconeogenesis from amino acid precursors (primarily alanine from muscle protein catabolism) and from glycerol released by adipose tissue lipolysis. As fat stores are depleted and muscle protein becomes the primary substrate for gluconeogenesis, the progressive loss of skeletal muscle mass produces the clinical wasting that defines acute malnutrition, while the visceral protein compartment (serum albumin, transferrin, pre-albumin, and retinol-binding protein), which is the last protein compartment to be catabolized in survival-oriented metabolic adaptation, is depleted in severe and prolonged malnutrition, producing the hypoalbuminemia that drives the edema, ascites, and characteristic facial appearance of kwashiorkor. The distinction between kwashiorkor (predominantly protein deficiency with edematous malnutrition, characterized by bilateral pitting edema, hypoalbuminemia, fatty liver, skin changes, and hair depigmentation) and marasmus (predominantly energy deficiency with wasting, characterized by extreme wasting of fat and muscle mass without edema) is a clinical classification that has been challenged by more recent research suggesting that oxidative stress and aflatoxin exposure may contribute to the pathogenesis of kwashiorkor independent of the protein-energy ratio, a finding with potential relevance to the CHT where food storage in humid bamboo structures may favor aflatoxin-producing mold growth. The ICD-11 adopts a simplified clinical classification of acute malnutrition in children that focuses on mid-upper arm circumference (MUAC) and the presence of bilateral pitting edema as the primary diagnostic criteria, reflecting the operational feasibility of MUAC measurement and edema detection in resource-limited settings compared with the anthropometric calculation of weight-for-height Z-scores.

The immunological consequences of malnutrition in CHT children represent perhaps the most clinically significant dimension of the nutritional crisis, as they transform potentially survivable infectious exposures into lethal events. Malnutrition impairs virtually every component of the

immune system. The innate immune system is compromised through reduced neutrophil bactericidal activity (due to reduced production of reactive oxygen species from NADPH oxidase, an enzyme system that requires adequate zinc for function), impaired natural killer cell activity, disrupted mucosal barrier function (the intestinal epithelium, the respiratory epithelium, and the skin all depend on adequate protein, vitamin A, and zinc for structural integrity), and reduced complement component production. The adaptive immune system is compromised through reduced thymic development (protein malnutrition causes thymic involution, reducing the output of naive T cells into the peripheral immune system), impaired T-lymphocyte proliferative responses to antigen (due to inadequate precursor amino acids for the protein synthesis required for cell division), reduced antibody production (both primary and secondary antibody responses are impaired, reducing the effectiveness of immunization as well as natural immunity), and impaired cytokine production (particularly interleukin-2 and interferon-gamma, the primary T-helper 1 cytokines responsible for macrophage activation and intracellular pathogen killing). The result of this comprehensive immunological compromise is the dramatically elevated susceptibility to infectious disease that converts a diarrheal episode that would be self-limited in a well-nourished child into a life-threatening fluid and electrolyte catastrophe in a severely malnourished child, and that converts measles from a manageable childhood illness into the fatal epidemic of the CHT's 2025 catastrophe. The interaction between malnutrition and specific micronutrient deficiencies amplifies the immunological compromise: vitamin A deficiency (prevalent in many CHT communities) specifically impairs mucosal immunity and the differentiation of T cells into regulatory subsets that modulate the inflammatory response; zinc deficiency impairs neutrophil function, T-cell proliferation, and the development of antibody responses; and iron deficiency anemia (while its relationship to immunity is complex and context-specific, with mild iron deficiency potentially having some protective effect against intracellular pathogens but severe iron deficiency clearly impairing immune function) contributes to the overall vulnerability profile.

5.2 Therapeutic Feeding Protocols for Severe Acute Malnutrition in CHT Children

The WHO-recommended treatment protocol for severe acute malnutrition (SAM) in children without medical complications, which has been successfully implemented in community-based settings in South Asia and sub-Saharan Africa, consists of Ready-to-Use Therapeutic Food (RUTF) as the primary nutritional intervention, delivered as part of a Community-Based Management of Acute Malnutrition (CMAM) program that identifies SAM cases through community-level MUAC screening, treats uncomplicated cases in the community without hospitalization, and refers complicated cases (those with SAM plus bilateral edema, appetite failure, or severe medical illness) to inpatient therapeutic feeding centers for stabilization phase management. The WHO F-75 and F-100 milk formulas are the standard nutritional interventions for the two phases of inpatient SAM management: F-75 (a relatively low-energy, low-protein formula) is used in the stabilization phase (the first 1 to 2 weeks of treatment) to correct the metabolic abnormalities of SAM without overwhelming the child's compromised hepatic and cardiac capacity, specifically avoiding the refeeding syndrome that can occur with overly aggressive early refeeding (characterized by hypophosphatemia, hypokalemia, and hypomagnesemia from the rapid intracellular shift of these electrolytes during cellular anabolic recovery, which can trigger cardiac arrhythmias, respiratory failure, and cardiac arrest); F-100 is

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used in the rehabilitation phase, once metabolic stability is achieved, to drive rapid catch-up growth. RUTF, which is a high-energy, high-protein, mineral-and-vitamin-enriched peanut paste (approximately 500 kcal per 100 grams) that does not require water for preparation, refrigeration for storage, or cooking fuel, is ideally suited to the CHT community setting because it can be administered safely at home by mothers who have received basic training, it is microbiologically safe in the field conditions of remote CHT communities, and it has been shown in randomized trials to produce recovery rates in uncomplicated SAM comparable to inpatient RUTF-based treatment. The adaptation of the standard CMAM protocol to the CHT requires several CHT-specific considerations. The CHT's ethnic diversity means that the mothers managing RUTF at home speak diverse languages, and CMAM caregiver training must be delivered in the relevant indigenous languages by trained indigenous community health workers. The cultural acceptability of peanut-based RUTF must be assessed in each community, as dietary taboos or preferences in some CHT communities may affect acceptance. The supply chain for RUTF in remote CHT communities is a significant logistical challenge that must be addressed through pre-positioning of RUTF stocks at community-level distribution points, motorcycle or boat-based resupply to remote communities, and community health worker coordination with district-level supply management. The monitoring of treatment response through regular MUAC measurements and appetite testing must be standardized and consistently applied across all CHT CMAM program sites.

The food systems medicine approach to nutritional health in the CHT, introduced in this section as an extension of conventional clinical nutrition into the broader food systems and food environment context, holds that the nutritional status of CHT communities cannot be sustainably improved by therapeutic interventions alone, because therapeutic interventions address the individual-level consequences of systemic food system failures without addressing the systems themselves. Food systems medicine in the CHT encompasses the clinical application of evidence about food systems to patient care (advising patients on food diversification strategies using locally available species, seasonal food preservation techniques, and dietary practices that maximize micronutrient absorption), the advocacy role of health professionals in food systems policy (supporting indigenous land rights as a food security intervention, opposing agricultural policies that restrict jhum cultivation without providing sustainable alternatives, and advocating for market access infrastructure that allows CHT communities to purchase food when local production is insufficient), and the integration of food system analysis into public health planning for the CHT (designing nutritional interventions that strengthen local food systems rather than creating dependency on externally supplied therapeutic products). The 2025 Lancet Southeast Asia paper on nutritional disparities between CHT indigenous and Bengali children explicitly called for targeted, culturally sensitive, and structurally oriented nutrition interventions that address the specific food system determinants of malnutrition in CHT indigenous communities, recognizing that individual therapeutic feeding, while essential for managing existing severe malnutrition, cannot by itself prevent the regeneration of new severe malnutrition cases from the same food-insecure structural conditions.

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5.3 Micronutrient Deficiency Diseases in the CHT: An Advanced Clinical Survey

The micronutrient deficiency diseases of the CHT include iodine deficiency disorders, vitamin A deficiency, iron deficiency anemia, zinc deficiency, vitamin D deficiency, and the B-vitamin deficiencies (particularly riboflavin deficiency and niacin deficiency, which may be relevant given the maize-based diet of some CHT communities), of which several have been discussed in prior parts. This section focuses specifically on the micronutrient interactions and compounding effects that are unique to the CHT context. The iron-malaria interaction is among the most clinically important micronutrient-infection interactions in the CHT and is significantly more complex than is commonly taught in undergraduate medicine. Iron deficiency anemia impairs cognitive development, reduces physical work capacity, and (as discussed above) has complex effects on immune function. Iron supplementation in iron-deficient children in malaria-endemic areas has been associated in some studies with increased malaria morbidity, leading to a major controversy in the global health literature in the mid-2000s following a trial in Pemba, Tanzania, that found increased malaria-associated mortality in children receiving iron supplementation without concurrent malaria prophylaxis. The current WHO guidance (2022 updated recommendations) recommends that iron supplementation in malaria-endemic areas should be provided together with malaria prevention measures (LLIN use and prompt treatment of malaria) and appropriate malaria management, recognizing that iron supplementation is necessary for the management of iron deficiency anemia but that it should be delivered within a malaria-safe framework. In the CHT, this means that iron supplementation programs for children and pregnant women must be integrated with malaria control activities, not delivered as standalone vertical programs. The zinc-malaria interaction is less well-characterized in the CHT literature but has been studied in other malaria-endemic areas of Asia: zinc deficiency is associated with increased malaria susceptibility in some studies, and zinc supplementation has been shown in some trials to reduce malaria morbidity and mortality in children, potentially through its effects on neutrophil bactericidal activity and mucosal immunity. The iodine-brain interaction, mediated through thyroid hormone's critical role in neuronal migration, myelination, and synaptogenesis during fetal and early postnatal brain development, means that iodine deficiency in pregnant women produces irreversible fetal brain damage even before the infant has its own functioning thyroid gland, and the consequences (cretinism in severe deficiency, subtler cognitive deficits in moderate deficiency) are permanent and not reversible by post-natal iodine supplementation. The CHT's geological characteristics, including the paucity of iodine in the leached hill soils, create a natural iodine deficiency environment, and the relatively limited access of some CHT communities to iodized salt (the primary national iodine deficiency prevention strategy in Bangladesh) means that iodine deficiency disorders may persist in communities where iodized salt has not fully penetrated the food supply. Universal salt iodization (USI), the WHO-recommended strategy for iodine deficiency prevention, has been substantially implemented in Bangladesh but not uniformly across all CHT communities.

MODEL EXAMINATION QUESTIONS: CHAPTER FIVE (PART SEVEN)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

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The refeeding syndrome that can occur during the stabilization phase of severe acute malnutrition treatment is characterized primarily by: a) Hypernatremia and hyperchloremia from excessive salt intake b) Hypophosphatemia, hypokalemia, and hypomagnesemia from rapid intracellular electrolyte shift during cellular anabolic recovery c) Hyperglycemia from excessive carbohydrate delivery d) Hyperkalemia from tissue breakdown. Correct Answer: b.

The WHO-recommended therapeutic diet used in the stabilization phase of inpatient severe acute malnutrition management is: a) F-100 milk formula with high-energy and high-protein content b) F-75 milk formula with lower energy and protein designed to avoid overwhelming compromised hepatic and cardiac capacity c) Ready-to-Use Therapeutic Food from the first day of treatment d) Full breast milk supplemented with oral glucose solution. Correct Answer: b.

Kwashiorkor, the edematous form of severe acute malnutrition, is associated with bilateral pitting edema resulting primarily from: a) Hyperaldosteronism from adrenal gland activation b) Hypoalbuminemia reducing plasma oncotic pressure c) Cardiac failure from malnutrition-related cardiomyopathy d) Renal failure from protein deficiency. Correct Answer: b.

Mid-upper arm circumference (MUAC) is used in community-based acute malnutrition screening because: a) It is more accurate than weight-for-height Z-scores in all settings b) It is operationally feasible in resource-limited community settings without scales or height boards, while providing reliable identification of the most acutely malnourished children c) It detects stunting more reliably than weight-for-height d) It is the WHO's officially preferred method for all clinical and research settings. Correct Answer: b.

Vitamin A deficiency specifically impairs which components of the immune system? a) Neutrophil count only b) Mucosal immunity through disrupted epithelial barrier integrity and impaired T-cell differentiation into regulatory subsets c) Only the complement system d) Only B-cell antibody production. Correct Answer: b.

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A CHT CMAM program officer finds that RUTF distributed to Mro community mothers in Alikadam upazila has lower-than-expected utilization. Investigation reveals that many mothers are concerned about giving their children a peanut paste product that is unfamiliar in their community's food tradition, and some are sharing the RUTF with adult family members rather than giving it exclusively to the index child. The most appropriate programmatic response is: a) Discontinue the RUTF program and replace it with hospitalization-based SAM treatment b) Conduct culturally sensitive community education through trusted community health workers and community leaders in the Mro language, explaining the specific purpose of RUTF for the severely malnourished child's recovery, and assess whether RUTF acceptability requires adaptation of the product or the program d) Continue the program unchanged because WHO guidelines require RUTF use d) Replace RUTF with locally produced food supplements. Correct Answer: b.

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CHAPTER SIX: PARASITOLOGY BEYOND MALARIA: SOIL-TRANSMITTED HELMINTHS, PROTOZOA, NEGLECTED TROPICAL DISEASES, AND THE FULL PARASITOLOGICAL SPECTRUM OF THE CHT

6.1 The CHT as a Tropical Parasitology Theatre

The Chittagong Hill Tracts is, from a parasitological perspective, one of the richest and most diverse disease environments in South Asia, hosting a complex community of parasitic organisms that extends far beyond the malaria parasites that dominate the clinical and research literature. The full parasitological spectrum of the CHT includes intestinal helminths (soil-transmitted helminths, tapeworms, and flukes), blood and tissue helminths (including lymphatic filarial worms and potentially other tissue-invasive species), intestinal protozoa (including Entamoeba histolytica, Giardia lamblia, and Cryptosporidium parvum), blood protozoa (including the Leishmania species responsible for visceral and cutaneous leishmaniasis, documented in some CHT border areas), ectoparasites (including Sarcoptes scabiei, lice, and ticks, which serve as vectors for several bacterial diseases), and, at the speculative frontier of CHT parasitology, the possibility of Strongyloides stercoralis hyperinfection syndrome (a potentially lethal condition in immunocompromised individuals, particularly those on systemic corticosteroids) and of Toxoplasma gondii infection in communities with close contact with domestic cats and the consumption of undercooked or raw meat. The Parasitological Terrain Burden principle, introduced here as an extension of the Terrain-Conditioned Pathology framework of Part One, holds that the CHT's specific ecological and social environment creates a distinct community of parasites that reflects the convergence of the hill ecosystem's biological diversity, the sanitation deficit of CHT communities, the dietary practices of indigenous communities (including the consumption of raw or minimally cooked freshwater fish, undercooked pork, and forest products), and the human ecological relationships (including barefoot contact with soil, open-water swimming, and domestic animal proximity) that characterize daily life in the territory.

Soil-transmitted helminthiasis (STH), caused by the intestinal roundworm Ascaris lumbricoides, the whipworm Trichuris trichiura, and the hookworm species (Ancylostoma duodenale and Necator americanus), represents the highest-prevalence parasitic infection category in the CHT, with CHT community surveys conducted in the 1990s and 2000s documenting STH prevalence rates ranging from 30 to 70 percent in school-aged children, depending on the community surveyed and the diagnostic method used. The pathophysiological consequences of heavy STH infection in CHT children include nutritional competition (adult Ascaris worms can each consume up to 10 percent of the protein intake of a moderately infected child, with a child harboring 10 to 20 worms losing a nutritionally significant proportion of their dietary protein to the parasite burden), intestinal obstruction (Ascaris bolus obstruction is a well-documented pediatric emergency in high-burden settings, causing acute abdomen, vomiting, and in severe cases, intestinal perforation), bile duct and pancreatic duct obstruction by ectopic Ascaris migration (presenting as biliary colic, acute cholangitis, or acute pancreatitis), iron deficiency anemia from hookworm blood sucking (each adult hookworm consumes approximately 0.05 to 0.30 mL of blood per day; a child with 100 hookworms is losing up to 30 mL of blood per day, equivalent to a severe daily hemorrhage), and the protein-losing enteropathy that results from the

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intense mucosal inflammation that characterizes heavy Trichuris infection. The interaction between STH and malnutrition is synergistic and bidirectional: STH infection reduces nutritional status by competing for nutrients, damaging intestinal mucosa, and causing protein loss; and malnutrition impairs the immune response that normally limits STH infection intensity, allowing heavier worm burdens to develop. Deworming with benzimidazole anthelmintics (albendazole 400 mg as a single dose or mebendazole 500 mg as a single dose, the WHO-recommended treatment for STH in children) is among the most cost-effective health interventions available, with very low cost per treatment, high acceptability (the drugs are generally well-tolerated), and measurable short-term nutritional and hemoglobin benefits in heavily infected children. The Preventive Chemotherapy approach, which delivers mass drug administration (MDA) of albendazole to all children in endemic areas twice yearly without prior individual diagnostic testing, is the WHO-recommended strategy for STH control in high-burden settings and is currently implemented in Bangladesh through school-based deworming programs. The extension of this program to CHT communities, including pre-school-aged children and pregnant women (for whom iron and folate supplementation is combined with deworming), is a high-priority, low-cost intervention that has not been consistently implemented across all remote CHT communities.

6.2 Protozoan Parasitic Disease: Amoebiasis, Giardiasis, and Cryptosporidiosis

The intestinal protozoa of the CHT cause a spectrum of disease ranging from asymptomatic carriage to life-threatening colitis and systemic infection. Entamoeba histolytica, the causative agent of amoebiasis, has a global prevalence of approximately 500 million infected individuals, with the highest burden in tropical regions with poor sanitation, fitting the CHT profile precisely. The majority of E. histolytica infections (approximately 90 percent) are asymptomatic, but the remainder produce a clinical spectrum that includes amoebic colitis (presenting as bloody diarrhea, tenesmus, and cramping abdominal pain, distinguished from bacterial dysentery by the absence of fever and systemic toxicity in uncomplicated cases), amoebic dysentery (more severe colitis with high fever, profuse bloody stool, and systemic illness), and extra-intestinal amoebiasis, most commonly amoebic liver abscess (ALA). Amoebic liver abscess, the most feared complication of E. histolytica infection, results from haematogenous spread of trophozoites from the colon to the liver via the portal venous system, producing a space-occupying necrotic lesion (the classic "anchovy sauce" pus of ALA is actually liquefied hepatic tissue rather than true pus) that presents with right upper quadrant pain, fever, hepatomegaly, and in some cases, diaphragmatic irritation producing right shoulder tip pain and right basal pleural effusion. The diagnosis of ALA is supported by serology (amoebic antibody titers are positive in over 90 percent of ALA cases), ultrasound imaging (which shows a hypoechoic right-lobe lesion in most cases), and the clinical context (a febrile patient from a CHT community with right upper quadrant pain has a high pre-test probability of ALA given the endemic context). Treatment is with metronidazole (750 mg three times daily for 10 days, the standard adult dose) followed by a luminal amoebicide such as diloxanide furoate (500 mg three times daily for 10 days) to eliminate intestinal carriage and prevent relapse; aspiration of the abscess is reserved for very large abscesses, those at risk of rupture, those not responding to metronidazole within 72 hours, and left-lobe abscesses (which carry higher risk of rupture into the pericardium). Giardia lamblia (also known as Giardia intestinalis or Giardia duodenalis) produces a spectrum of intestinal

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disease including asymptomatic carriage, acute self-limited diarrhea, and chronic malabsorption syndrome (with fatty stools, bloating, weight loss, and micronutrient malabsorption) in those with heavier infections or altered immunity. Giardia is particularly important in the CHT context because it thrives in the surface water sources (hill streams and spring water) used for drinking by many CHT communities, and because its cysts are resistant to standard chlorination at the doses typically applied in community water treatment. Cryptosporidium parvum, an obligate intracellular apicomplexan parasite closely related phylogenetically to Plasmodium, causes a self-limited watery diarrhea in immunocompetent individuals but a severe, potentially fatal, uncontrollable diarrheal illness (cryptosporidiosis) in immunocompromised individuals, particularly those with CD4 T-cell counts below 100 cells per microliter from HIV infection, and severely malnourished children in whom T-cell function is profoundly compromised. The absence of specific anti-cryptosporidial therapy with consistent efficacy in immunocompromised patients (nitazoxanide reduces symptoms in immunocompetent individuals but has limited efficacy in severe immunocompromise) means that prevention through water treatment (specifically UV irradiation or filtration, since Cryptosporidium oocysts are chlorine-resistant) is the primary public health tool.

6.3 Neglected Tropical Diseases in the CHT: The Invisible Burden

The World Health Organization's list of Neglected Tropical Diseases (NTDs) includes 20 conditions that are endemic in tropical and subtropical environments, predominantly affecting the poorest and most marginalized populations, and that have received historically inadequate research, drug development, and control investment relative to their burden. Several NTDs are present or likely present in the CHT and deserve specific clinical attention. Visceral leishmaniasis (kala-azar), caused by Leishmania donovani and transmitted by the phlebotomine sandfly (Phlebotomus argentipes), is a major NTD in South Asia with an estimated 100,000 to 200,000 new cases annually globally. Bangladesh is one of the three most affected countries in South Asia. The CHT's proximity to known kala-azar endemic districts in the Sylhet and Mymensingh regions of Bangladesh and to kala-azar-endemic areas of Myanmar creates the conditions for transmission in the border areas of the CHT, though systematic surveillance data specifically documenting kala-azar in the CHT are limited. The clinical presentation of visceral leishmaniasis (prolonged fever of more than two weeks, progressive splenomegaly, hepatomegaly, weight loss, weakness, and the characteristic progressive darkening of the skin of the face, hands, feet, and abdomen that gives the disease its Hindi name meaning "black fever") should prompt specific diagnostic consideration in CHT patients with this clinical picture, particularly those from communities near the Bangladesh-India-Myanmar border areas. Cutaneous leishmaniasis (CL), caused by other Leishmania species transmitted by different sandfly species, may also be present in the CHT given the diverse forest sandfly fauna of the territory, but the evidence base is absent. Lymphatic filariasis (LF), caused by the filarial nematodes Wuchereria bancrofti (transmitted by Culex mosquitoes) and Brugia species (transmitted by Mansonia and Anopheles mosquitoes), is endemic in parts of Bangladesh including areas adjacent to the CHT. The chronic manifestations of LF (lymphedema and elephantiasis of the lower limbs and genitalia, and hydrocele in men) result from the obstruction of lymphatic drainage by adult filarial worms and the inflammatory response to their death, producing severely disfiguring and disabling conditions that impair economic productivity,

social participation, and dignity. The treatment of active LF infection (diethylcarbamazine combined with albendazole, or ivermectin combined with albendazole, the WHO-recommended combinations) is effective in eliminating microfilaremia and reducing adult worm burden, while morbidity management of established lymphedema requires ongoing limb hygiene, elevation, exercise, and in some cases surgical management of hydrocele.

Scabies, caused by infestation with the mite Sarcoptes scabiei, is highly prevalent in CHT communities where overcrowding in bamboo households, limited bathing access, and shared sleeping arrangements facilitate the close skin-to-skin contact required for transmission. Scabies produces intensely pruritic papular, vesicular, and crusted lesions concentrated in the finger webs, wrists, periumbilical areas, buttocks, and genitalia, with nocturnal pruritus exacerbation (when the female mite is most active) being a characteristic feature. Secondary bacterial infection of scabies lesions with Streptococcus pyogenes (Group A Streptococcus) and Staphylococcus aureus is common in the CHT setting, where scratching of pruritic lesions introduces skin flora into broken skin, and it can lead to impetigo, cellulitis, ecthyma, and in some cases glomerulonephritis from streptococcal nephritogenic strains or septicemia from secondary bacteremia. The Norwegian (crusted) scabies variant, in which the hyperkeratotic skin lesions harbor millions of mites (compared with the typical 10 to 15 mites in ordinary scabies), occurs in severely immunocompromised individuals including those with malnutrition, HIV, and prolonged corticosteroid use, and represents a highly contagious and difficult-to-treat form of the disease requiring systemic ivermectin (which is now available in Bangladesh) combined with topical keratolytics and scabicide. Permethrin 5% cream (applied topically to the entire skin surface from neck to toe and left on for 8 to 12 hours before washing off) is the first-line treatment for ordinary scabies, with oral ivermectin (200 micrograms per kilogram as a single dose, repeated in two weeks) as an equally effective alternative preferred in mass treatment settings. Community-level treatment of scabies (treating all household members and close contacts simultaneously) is essential to prevent re-infestation, and MDA campaigns in high-burden CHT communities, using oral ivermectin because of its logistical convenience compared with topical permethrin application to all household members, represent the most effective approach to scabies control.

MODEL EXAMINATION QUESTIONS: CHAPTER SIX (PART SEVEN)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The classic pus aspirated from an amoebic liver abscess is described as "anchovy sauce" because: a) It contains actual anchovy proteins from the patient's diet b) It consists of liquefied hepatic tissue rather than true pus, producing the characteristic reddish-brown color and smooth texture c) It has the same pH as anchovy paste d) It is produced by a secondary Staphylococcal infection. Correct Answer: b.

The primary mechanism by which hookworm causes iron deficiency anemia is: a) Destruction of erythrocytes in the intestinal lumen b) Blood sucking by adult hookworms in the intestinal lumen, with each adult worm consuming up to 0.30 mL of blood per day c) Inhibition of iron

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absorption by secreted hookworm products d) Redistribution of iron from the blood to the hookworm's intestinal tissue. Correct Answer: b.

Norwegian (crusted) scabies differs from ordinary scabies primarily in: a) The species of mite involved b) The dramatically higher mite burden (millions versus 10 to 15 mites) and the associated higher contagiousness, occurring in immunocompromised individuals c) The body distribution of lesions d) Its transmission route, which is airborne rather than contact. Correct Answer: b.

The phlebotomine sandfly responsible for Leishmania donovani transmission in South Asia is: a) Lutzomyia longipalpis b) Phlebotomus argentipes c) Phlebotomus papatasi d) Sergentomyia babu. Correct Answer: b.

Cryptosporidium oocysts are resistant to standard chlorination used in water treatment. The water treatment method that effectively kills Cryptosporidium oocysts is: a) Chlorination alone at standard doses b) UV irradiation or filtration through membranes with pore size less than 1 micron c) Boiling for only 30 seconds d) Sodium hypochlorite addition at any concentration. Correct Answer: b.

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 35-year-old Marma man from a forest valley community near the Bangladesh-Myanmar border in Bandarban district presents with four weeks of progressively worsening fever, weight loss, progressive weakness, and marked abdominal distension. Examination reveals marked splenomegaly (spleen palpable 8 cm below the left costal margin), hepatomegaly, and hyperpigmentation of the skin of his face and forearms. CBC shows pancytopenia. The most important diagnostic consideration in the CHT border context is: a) Acute lymphoblastic leukemia b) Visceral leishmaniasis (kala-azar), with rK39 rapid antigen serology and bone marrow aspiration for Leishmania amastigotes being the appropriate diagnostic investigations c) Typhoid fever with complications d) Falciparum malaria with severe anemia. Correct Answer: b.

A community health worker finds that 45 percent of children in a remote Khagrachhari community test positive for soil-transmitted helminths during a school survey. The most cost-effective and immediately implementable intervention to reduce this prevalence is: a) Individual stool microscopy for all affected children before treatment b) Construction of flush toilets in all households as the first priority before any pharmacological intervention c) Mass drug administration of albendazole 400 mg to all school-aged children in the community, combined with deworming of pre-school children and pregnant women as part of a preventive chemotherapy program d) Referral of all positive cases to the district hospital for inpatient management. Correct Answer: c.

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CHAPTER SEVEN: INFECTIOUS DISEASE INTELLIGENCE: MOLECULAR EPIDEMIOLOGY, SURVEILLANCE SCIENCE, GENOMIC PATHOGEN TRACKING, AND OUTBREAK INVESTIGATION IN THE CHT

7.1 The Infectious Disease Intelligence Framework for the CHT

Infectious disease intelligence, defined in this chapter as the systematic collection, analysis, interpretation, and communication of data about infectious disease threats in order to support timely and effective public health response, represents a critical but underdeveloped capacity in the CHT's health system architecture. The CHT's unique epidemiological and ecological characteristics (its position at a biogeographical frontier between South and Southeast Asia, its extensive border with the disease-emergent zone of Myanmar and northeastern India, its dense and ecologically rich forest zone that harbors diverse mammalian and avian disease reservoirs, its mobile and cross-border human population, and its structurally compromised health system that produces delayed detection of disease events) create a confluence of factors that makes the territory both a high-priority site for infectious disease surveillance and a location where adequate surveillance is particularly difficult to establish and sustain. The Integrated Disease Surveillance and Response (IDSR) framework, adopted by WHO SEARO as the regional approach to epidemic intelligence in South and Southeast Asia, provides the organizational architecture for a strengthened CHT infectious disease surveillance system, but its implementation in the CHT requires adaptation to the territory's specific constraints, including the fragmentation of administrative authority between national and district-level health governance structures, the language barriers that complicate reporting from indigenous community levels, and the limited diagnostic capacity at peripheral facilities that reduces the sensitivity of passive case surveillance. The Active versus Passive Surveillance distinction is fundamental to CHT surveillance design. Passive surveillance (waiting for clinicians to report cases of notifiable diseases through the standard government reporting chain) systematically underdetects disease in the CHT because the conditions for passive surveillance (clinicians who recognize notifiable conditions, complete reporting forms, and transmit them up the health system hierarchy in a timely manner) are precisely the conditions most degraded in the remote CHT context. Active surveillance (proactively seeking cases through community-level screening, household surveys, sentinel site monitoring, and outbreak investigation) is required to supplement and calibrate the passive system, particularly for high-priority conditions including malaria, tuberculosis, cholera, measles, and any novel respiratory illness pattern.

The molecular epidemiology revolution, which has transformed the capacity to understand the transmission dynamics, geographic spread, evolutionary history, and drug resistance profiles of infectious pathogens through the application of whole-genome sequencing (WGS) and phylogenomic analysis, has reached the CHT context primarily through its application to malaria parasite genomics and to a lesser extent tuberculosis genotyping. Whole-genome sequencing of P. falciparum isolates from CHT communities has been conducted in studies examining genetic diversity, artemisinin resistance markers (the kelch13 propeller domain mutations associated with partial artemisinin resistance in the Greater Mekong Subregion, particularly C580Y, which is the predominant resistance allele in the Mekong and which has now been found in some South Asian isolates), and drug resistance markers including chloroquine resistance (mediated by

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mutations in the pfcrt gene, particularly K76T), and sulfadoxine-pyrimethamine resistance (mediated by mutations in pfdhfr and pfdhps genes). The CHT malaria parasite population is genetically complex, reflecting both local evolution and importation of parasite strains through human movement across the Myanmar border. The 2024 WHO World Malaria Report updated the monitoring of kelch13 mutations in parasite populations globally and specifically called for enhanced molecular surveillance in the Indian subcontinent, where artemisinin resistance spread from the Mekong represents the most urgent pharmacological threat to malaria control. Establishing a routine CHT malaria parasite genomic surveillance program, linking district-level malaria control programs with the molecular diagnostic capacity of the Infectious Disease Hospital in Chittagong and the genomics facilities at academic institutions in Dhaka, represents a feasible and urgently needed investment in CHT infectious disease intelligence. Mycobacterium tuberculosis genotyping, through whole-genome sequencing or targeted molecular typing methods, provides critical information on transmission clusters (identifying which patients acquired their TB from whom, enabling targeted contact tracing), drug resistance profiles (supporting early identification of MDR-TB cases before clinical drug resistance manifests), and importation of drug-resistant strains (through phylogenomic comparison with databases of TB genomes from Myanmar and other neighboring territories). The Bangladesh National Tuberculosis Reference Laboratory in Dhaka has WGS capacity that has not yet been systematically applied to characterization of CHT-specific TB strains.

7.2 Outbreak Investigation Methodology for CHT Epidemiologists

Outbreak investigation in the CHT context requires both standard epidemiological methodology and CHT-specific adaptations that address the territory's geographic, linguistic, and systemic peculiarities. The classic six-step outbreak investigation process (verify the diagnosis and confirm the outbreak; establish a case definition; find cases systematically; describe the outbreak by time, place, and person; generate and test hypotheses; and implement control measures) must be executed with several CHT-specific modifications. The verification step requires particular attention to the diagnostic limitations of the CHT setting: in the 2025 measles outbreak, the initial weeks of the epidemic involved a mix of confirmed (laboratory-tested) and suspected (clinically diagnosed) cases, and the underestimation of the true case count from the earliest stages of the outbreak resulted partly from limited laboratory testing capacity in remote areas and partly from delayed recognition that a significant outbreak was underway. The CHT-adapted case definition must be operable at the community level by health workers with limited diagnostic resources, using clinical criteria that are sensitive enough to capture the majority of true cases without generating large numbers of false positives. The person-time-place description of a CHT outbreak must explicitly map the geographic distribution of cases against the terrain and transport network of the affected area, because the terrain-specific clustering of cases (for example, within a single valley accessible only by foot from the nearest road) provides diagnostic information about the mode of transmission and the boundaries of the at-risk population that is invisible in a standard map without terrain analysis. Hypothesis generation about the source and mode of transmission in a CHT outbreak benefits from the application of the CHT Ecological Epidemiology Doctrine (from Chapter Three of Part One), which adds the terrain axis to the epidemiological triad and prompts specific investigation of how the physical geography of the outbreak area may be facilitating transmission (for example, through the

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concentration of shared water sources in a valley, the seasonal use of shared agricultural water for human consumption, or the aggregation of a community at a seasonal festival where disease-spreading contact occurs). Control measure implementation in a CHT outbreak is constrained by the same terrain, transport, language, and institutional trust barriers that constrain routine health service delivery, and the outbreak response plan must explicitly address these barriers with CHT-specific solutions: helicopter or boat delivery of supplies and personnel to otherwise inaccessible areas, engagement of local chiefs and traditional healers as outbreak communication and response partners, delivery of public health messages in indigenous languages through locally trusted messengers, and pre-positioned stock of key outbreak response materials (vaccines, oral rehydration salts, rapid diagnostic tests, basic antibiotics, and personal protective equipment) at accessible community health posts.

7.3 Syndromic Surveillance and Early Warning Systems for CHT Outbreaks

Syndromic surveillance, the monitoring of clinical syndromes (rather than confirmed diagnoses) in real time to detect unusual clusters of illness that may indicate an emerging outbreak before laboratory confirmation is possible, offers particular advantages in the CHT context where laboratory confirmation of diagnoses is delayed and often unavailable at the community level. A CHT syndromic surveillance system, building on the existing community health worker networks (particularly the BRAC shasthya shebika network and the government community health workers at union health and family welfare centers), could monitor the weekly incidence of predefined clinical syndromes in community-level populations, using standardized simple reporting forms in indigenous languages submitted via mobile phone (where coverage exists) or via courier in areas without connectivity. The syndromes to be monitored in the CHT context, based on the territory's known disease burden and emerging threat profile, should include acute undifferentiated fever (with sub-categories for fever with rash, fever with bleeding, fever with altered consciousness, and fever with jaundice), acute watery diarrhea, acute bloody diarrhea (dysentery), acute respiratory illness (with sub-categories for pneumonia severity), neonatal illness, sudden unexpected deaths, and acute neurological syndrome. The digital health infrastructure required for a real-time CHT syndromic surveillance system has been partially established through the government health management information system (HMIS) and through BRAC's community health worker information systems, but significant gaps remain in remote areas without mobile phone connectivity, where paper-based weekly reporting with regular courier collection remains the most feasible approach. The One Health surveillance dimension of CHT infectious disease intelligence requires integration of the human health surveillance data with veterinary surveillance (monitoring disease in domestic animals including poultry, pigs, goats, and cattle, which serve as reservoir hosts or amplifying hosts for several zoonotic pathogens) and wildlife surveillance (monitoring disease and death events in wild animals in CHT forest areas, which could provide early warning of zoonotic spillover events). Establishing functioning interdisciplinary One Health surveillance committees at the district level in Rangamati, Bandarban, and Khagrachhari, with representation from the District Health Office, the District Livestock Office, the Forest Department, and indigenous community representatives, represents the minimum governance infrastructure for a One Health early warning system in the CHT.

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MODEL EXAMINATION QUESTIONS: CHAPTER SEVEN (PART SEVEN)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The kelch13 propeller domain mutation most strongly associated with partial artemisinin resistance in P. falciparum from the Greater Mekong Subregion is: a) K76T b) C580Y c) A623E d) S549T. Correct Answer: b.

Passive surveillance in the CHT systematically underdetects disease because: a) Indigenous communities deliberately conceal their illness from the government health system b) The conditions required for passive surveillance (clinician recognition, form completion, timely reporting) are precisely those most degraded in remote CHT settings c) The government has prohibited passive disease reporting in the CHT d) There are no notifiable diseases in the CHT. Correct Answer: b.

Syndromic surveillance monitors which of the following to detect emerging outbreaks? a) Confirmed laboratory-diagnosed cases only b) Clinical syndromes in real time, detecting unusual clusters before laboratory confirmation is available c) Administrative records of pharmacy dispensing d) Hospital admission data from tertiary centers only. Correct Answer: b.

The pfcrt K76T mutation in Plasmodium falciparum confers resistance to which antimalarial drug? a) Artemether b) Chloroquine c) Quinine d) Primaquine. Correct Answer: b.

In the classic six-step outbreak investigation, what is the primary purpose of establishing a case definition? a) To provide a legal basis for quarantine measures b) To create a standardized, consistently applied set of criteria for identifying true cases and distinguishing them from non-cases, enabling systematic case-finding and descriptive analysis c) To determine which treatment the patient should receive d) To exclude patients from treatment programs. Correct Answer: b.

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A district epidemiologist in Khagrachhari receives reports of an unusual cluster of acute watery diarrhea with rapid dehydration in a riverside community following severe flooding. The epidemiological investigation confirms 45 cases meeting the clinical case definition of severe acute watery diarrhea over the past 72 hours, with three deaths. Applying the CHT Ecological Epidemiology Doctrine, the investigation should specifically examine which terrain-specific factor as a priority hypothesis for the transmission source? a) Miasmatic air currents from the flooded land b) Contamination of shared drinking water sources by floodwater carrying fecal matter from upstream open defecation sites and latrines, disrupting the normally used spring sources and driving the community to consume turbid surface water c) Changes in the nutritional status of the community from flood-destroyed food stocks d) Stress-induced immune suppression from the psychological trauma of flooding. Correct Answer: b.

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CHAPTER EIGHT: THE POLITICAL ECOLOGY OF HEALTH: LAND, POWER, DISPOSSESSION, AND DISEASE IN THE CHITTAGONG HILL TRACTS

8.1 Political Ecology as Medical Science: Foundations and CHT Application

Political ecology of health, the intellectual tradition that examines how political and economic power structures shape the distribution of environmental health risks and health outcomes across populations, provides the theoretical framework most adequate to the systemic analysis of health inequity in the Chittagong Hill Tracts. The foundational insight of political ecology of health, articulated in the work of Paul Farmer (particularly his concept of structural violence and the application of biosocial analysis to health disparities), Merrill Singer (whose ecosyndemics framework examines how synergistic epidemics are produced by the interaction of social conditions and infectious disease burdens), and more recently the contributors to the Lancet Commission on Climate Change and Health (whose 2015 and subsequent reports documented that climate change operates as a "threat multiplier" for existing health inequities), is that health and disease are not distributed randomly across populations but are systematically structured by the distribution of power, resources, and risk in society, and that understanding the health of any population requires understanding the political economy of the society in which it lives. In the CHT, the political ecology of health framework demands that the analysis of the territory's disease burden begin not with the pathogen or the patient but with the political history that has produced the conditions in which the pathogens thrive and the patients are vulnerable. The CHT Regulation of 1900, the Kaptai Dam of 1962, the resettlement program of the 1970s to 1990s, the armed conflict of 1975 to 1997, and the post-Accord land disputes that continue to the present are not historical footnotes to a medical textbook. They are the primary etiological agents of the CHT's health crisis, operating through the pathways of poverty, displacement, nutritional insecurity, psychological trauma, and institutional distrust that this textbook has documented across its chapters. The political ecology framework is not an alternative to biological medicine; it is the necessary structural context within which biological medicine must operate in the CHT, and without which the biological interventions of the individual clinician, however skillfully applied, will be perpetually overwhelmed by the pathological forces that the political structures of the CHT continue to generate.

The land rights dimension of CHT health is the most fundamental axis of the political ecology of health in the territory. Land in the CHT is not merely an economic asset. It is the material foundation of food security (through jhum cultivation and forest foraging), the basis of cultural identity and cosmological relationship (the indigenous peoples of the CHT, like indigenous peoples globally, understand their relationship to specific territories as constitutive of their identity, their spirituality, and their social coherence), and the primary determinant of the economic capacity from which healthcare access and nutritional security flow. The ongoing land alienation in the CHT, through which indigenous communities continue to lose access to ancestral land through a combination of government-issued land grants to Bengali settlers, military reservation of land, commercial enterprise acquisition (particularly rubber plantation establishment), and conservation designation (Reserved Forest areas from which communities are excluded), directly drives the health outcomes documented in this textbook. When an indigenous household loses access to the jhum land on which it depends for food production, the

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nutritional status of its children declines, their immune function is compromised, their vulnerability to infectious disease increases, and the cycle of poverty and preventable illness that has characterized the CHT for generations deepens rather than resolves. The human rights framework for CHT land rights, grounded in the UN Declaration on the Rights of Indigenous Peoples (UNDRIP, adopted in 2007 with Bangladesh among the supporting states), the ILO Convention 169 on Indigenous and Tribal Peoples, and the CHT Peace Accord provisions that have not been fully implemented, provides the legal and moral basis for demanding land rights protection as a health intervention. The medical community's advocacy role in this domain, through public statements, research documentation, and policy engagement, is not an overreach beyond medicine's proper domain. It is the application of the medical profession's commitment to the health of its patients to the structural determinants of their health.

8.2 The CHT Conflict Health Legacy: Transitional Justice, Accountability, and Healing

The concept of transitional justice, the processes through which societies address serious human rights violations and mass atrocities committed by or during authoritarian regimes or armed conflicts, has direct and largely unrecognized relevance for the health of CHT indigenous communities. Transitional justice mechanisms include truth commissions (formal processes of documenting and acknowledging the events and their perpetrators), criminal accountability (prosecution of those responsible for human rights violations), reparations (material and symbolic compensation to victims and affected communities), and institutional reform (restructuring the institutions that enabled or perpetrated violence to prevent recurrence). In the CHT, the 1997 Peace Accord addressed some of the immediate political dimensions of the conflict but established no formal truth commission, provided no reparations program for conflict victims, and produced no criminal accountability for the human rights violations (including enforced disappearances, extrajudicial killings, sexual violence, and forced displacement) that are documented in reports by Amnesty International, Human Rights Watch, and the UN Human Rights Committee from the conflict period. The absence of transitional justice in the CHT context is not merely a political or legal failure. It is a health failure. The mental health literature on post-conflict populations consistently demonstrates that the acknowledgment of injustice, the validation of victims' experiences, and the experience of some form of accountability for perpetrators contribute significantly to psychological healing for both individual survivors and collective communities, while the silence and impunity that characterize the post-CHT conflict environment perpetuate the conditions of collective psychological injury that manifest as elevated rates of depression, PTSD, substance use disorders, and the somatic presentations of unresolved trauma that CHT clinicians encounter daily. The connection between transitional justice and population health is not only theoretical: a 2024 systematic review published in Global Health Action, examining health outcomes in post-conflict communities across Africa, Asia, and Latin America, found that communities that had undergone formal transitional justice processes showed significantly better mental health outcomes over a 10-year period compared with communities where armed conflict ended without accountability or acknowledgment.

The militarization of the CHT, specifically the ongoing presence of a large military force in the territory (Bangladesh has the highest ratio of military personnel to civilian population in the CHT

of any part of the country), has health dimensions that are rarely discussed in the public health literature. The military's control over land access, movement, and infrastructure development in significant parts of the CHT has direct consequences for healthcare access: military checkpoints and permit requirements that historically regulated movement in the CHT (and that in various forms continue to affect civilian movement in some areas) create barriers to the timely transport of sick patients to health facilities. Military occupation of land that indigenous communities have relied on for agricultural production reduces the food security of affected households. The psychological impact of living under military surveillance and control, particularly for communities whose experience of the military includes the violence of the conflict period, contributes to the chronic stress that operates as a health risk through psychoneuroimmunological mechanisms. These dimensions of the militarization-health relationship in the CHT are not discussed in the standard public health literature on Bangladesh, representing a significant gap that is maintained partly by the political sensitivity of the subject and partly by the access difficulties that prevent researchers from conducting independent studies in military-controlled areas of the CHT. The political ecology of health framework requires acknowledgment of this gap and advocacy for research access and transparency as preconditions for evidence-based health policy in the CHT.

8.3 The Settler-Indigenous Health Differential: Documenting and Addressing Health Inequity

The health differential between indigenous communities and Bengali settler communities within the CHT is one of the most systematically documented dimensions of CHT health inequity and one of the most morally significant. Available data consistently show that indigenous CHT communities have worse health outcomes than their Bengali neighbors living in the same geographic territory, including higher rates of malnutrition, higher under-five mortality, lower immunization coverage, lower access to skilled birth attendance, and lower utilization of formal health services. This differential cannot be explained by genetics or culture alone, and the attempt to explain it through culture (implying that indigenous practices are responsible for indigenous health disadvantage) is a form of victim-blaming that obscures the structural causes. The structural causes of the health differential between indigenous and Bengali populations in the CHT include the historical and ongoing land alienation that has impoverished indigenous communities while some Bengali settlers have accessed more productive land; the government's investment priorities in CHT infrastructure (including roads, markets, and health facilities) that have historically been more responsive to the needs of Bengali settler communities in district towns than to the needs of indigenous communities in remote areas; the language of health service delivery (Bengali) that serves Bengali settlers but not indigenous patients effectively; and the cultural framework of government health services (which is oriented toward the dominant Bengali population) that aligns better with Bengali settler health-seeking norms than with indigenous community health beliefs and practices. Documenting this health differential through rigorous research, including ethnicity-disaggregated health statistics that Bangladesh's health information system does not currently generate routinely, is a prerequisite for policy response. The CHT public health research agenda must prioritize the collection and analysis of ethnicity-specific health data, not as an abstract academic exercise, but as the evidentiary foundation for equity-focused health policy that directs resources to the communities with the greatest unmet need.

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MODEL EXAMINATION QUESTIONS: CHAPTER EIGHT (PART SEVEN)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Paul Farmer's concept of structural violence refers to harm caused to people by: a) Organized physical violence during armed conflict b) Social structures and institutions characterized by poverty, racism, political exclusion, and inequality that systematically disadvantage specific populations c) Violence perpetrated by military structures d) Natural disasters and extreme weather events. Correct Answer: b.

The UN Declaration on the Rights of Indigenous Peoples (UNDRIP) was adopted in which year? a) 1997 b) 2000 c) 2007 d) 2015. Correct Answer: c.

Merrill Singer's "ecosyndemics" framework examines: a) The impact of environmental pollution on ecosystem health b) How synergistic epidemics are produced by the interaction of social conditions and infectious disease burdens c) The carbon cycle and its relationship to respiratory disease d) The genetic ecology of pathogen evolution. Correct Answer: b.

Transitional justice mechanisms include all of the following EXCEPT: a) Truth commissions b) Criminal accountability for perpetrators c) Reparations for victims d) Mandatory resettlement of affected populations to new locations. Correct Answer: d.

The systemic collection, analysis, interpretation, and communication of data about infectious disease threats to support timely public health response is the definition of: a) Clinical microbiology b) Infectious disease intelligence c) Epidemic containment d) Passive surveillance. Correct Answer: b.

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 2024 systematic review examining health outcomes in post-conflict communities found that communities that underwent formal transitional justice processes showed significantly better outcomes in which specific health domain compared with communities where conflict ended without accountability? a) Physical injury recovery rates b) Mental health outcomes over a 10-year period c) Infectious disease incidence d) Maternal mortality rates. Correct Answer: b.

A CHT district health officer is designing a proposal for health system equity improvement, presenting it to the Ministry of Health and Family Welfare in Dhaka. To make the strongest evidence-based case for redirecting resources toward indigenous CHT communities, the most critical data element that is currently absent and that the proposal must call for generating is: a) Genetic mapping of the CHT indigenous population b) Routine collection and public reporting of ethnicity-disaggregated health statistics across all standard health indicators in the CHT c) A comprehensive history of traditional medicine in the CHT d) A pharmaceutical needs assessment for Bengali-language drug labels. Correct Answer: b.

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CHAPTER NINE: REHABILITATION MEDICINE, DISABILITY, AND FUNCTIONAL RESTORATION IN THE CHITTAGONG HILL TRACTS

9.1 The Disability Landscape of the CHT: Epidemiology and Framework

The burden of disability in the Chittagong Hill Tracts encompasses acquired disability from the conditions that have been described throughout this textbook (neurological sequelae of cerebral malaria, post-traumatic disability from landslides and conflict-related injuries, disability from untreated cataract and other avoidable vision disorders, disability from lymphatic filariasis elephantiasis, disability from untreated cleft lip and palate and other congenital abnormalities, disability from advanced rheumatic heart disease, disability from the cognitive sequelae of malnutrition and repeated infection in childhood, and disability from the psychological disorders that impair social and occupational functioning), as well as congenital disability (from the teratogenic consequences of maternal nutritional deficiency, intrauterine infections, birth trauma, and genetic conditions), and work-related disability from the occupational injuries and musculoskeletal disorders of jhum farming and forest labor. The World Health Organization's International Classification of Functioning, Disability and Health (ICF), published in 2001 and updated in its application framework through 2022, provides the conceptual framework for understanding disability not as a fixed characteristic of an individual body but as the product of the interaction between a person's health conditions and the contextual factors (environmental and personal) that shape their functional participation in society. This bio-psycho-social model of disability is particularly resonant in the CHT context, where the same functional limitation (for example, reduced mobility from a lower limb disability) has dramatically different consequences for a person in an urban area with accessible transport and formal employment opportunities than for a person in a remote CHT hill community where subsistence jhum farming on steep terrain requires physical capabilities that the person can no longer meet, and where no accessible formal employment alternatives exist. The disability burden of the CHT is almost certainly underestimated in official statistics, because the national surveys and censuses from which disability prevalence estimates are derived have not been adequately implemented in remote CHT communities, because cultural frameworks in some CHT communities may not classify conditions as disabilities in ways aligned with formal survey instruments, and because the stigma associated with disability in some communities may suppress disclosure.

Rehabilitation medicine in the CHT must be understood as a public health and community development challenge as much as a clinical challenge. The standard rehabilitation medicine model, in which a disabled person receives specialist assessment and individualized therapy from a physiotherapist, occupational therapist, speech therapist, and rehabilitation physician in a specialized facility, is essentially non-existent as a practical option in the CHT: there are no physiotherapists or occupational therapists based in the CHT districts, the nearest rehabilitation medicine specialists are in Chittagong city, and the cost and logistics of regular attendance at an urban rehabilitation facility are prohibitive for the overwhelming majority of CHT families with disabled members. The alternative model, Community-Based Rehabilitation (CBR), recommended by WHO, UNESCO, ILO, and IDDC in the 2010 CBR Guidelines as the appropriate framework for disability inclusion in low-and middle-income settings, delivers rehabilitation support through community-level trained workers, family caregiver training,

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environmental modifications to improve accessibility (including house modifications, assistive device provision, and community infrastructure changes), and the promotion of disabled persons' participation in community economic, educational, social, and political life. The CBR matrix, which organizes CBR across five domains (health, education, livelihood, social, and empowerment), provides a comprehensive framework for planning CHT disability programs that goes beyond the narrow rehabilitation medicine perspective to address the full context of the disabled person's life. The CHT's specific adaptations of the CBR model must include training of CHT indigenous community health workers in basic disability assessment and rehabilitation support (including the detection and referral of avoidable disabilities from cataract, lymphatic filariasis, and cleft lip/palate), provision of locally manufacturable assistive devices (simple wheelchairs, crutches, and orthoses adapted to the terrain requirements of CHT daily life), and engagement of CHT indigenous community organizations in the design of disability-inclusive programs.

9.2 Post-Conflict Disability and the Rehabilitation Needs of Conflict Survivors

The rehabilitation needs of CHT conflict survivors, both those who sustained physical injuries during the 1975 to 1997 armed conflict and those whose functional capacity has been compromised by the psychological and psychosomatic consequences of conflict trauma, represent a largely unaddressed dimension of the CHT's post-conflict health agenda. Physical injuries from the conflict period that may produce lasting disability include amputation (from landmine injury and from other combat-related wounds; the presence of landmines in some former conflict areas of the CHT is documented in historical reports and represents an ongoing injury risk for farmers and forest workers), traumatic spinal cord injury (producing paraplegia or tetraplegia in some survivors), blast-related hearing loss, and the chronic musculoskeletal consequences of untreated fractures and joint injuries sustained during the conflict. The rehabilitation needs of these individuals, now typically middle-aged or elderly, have not been systematically assessed, and no specific program exists to address them. The psychological rehabilitation needs of conflict survivors, as discussed in Chapter One of this part, include trauma-focused psychological intervention for PTSD and complex PTSD, social reintegration support for those who were displaced and have not fully reconnected with community networks, livelihood support for those whose economic productivity has been impaired by trauma-related psychological symptoms, and the advocacy-oriented component of rehabilitation that recognizes that lasting psychological healing is facilitated by acknowledgment of injustice and by the social and political changes that reduce the ongoing sources of stress and insecurity. The disability rights movement, which has been gaining strength globally since the adoption of the UN Convention on the Rights of Persons with Disabilities (CRPD) in 2006 (ratified by Bangladesh in 2007), provides a powerful framework for advocating the rehabilitation and social inclusion of disabled CHT conflict survivors, framing their rehabilitation needs not as charity but as rights-based entitlements of persons whose disability was produced by state or state-adjacent violence.

9.3 Assistive Technology and Prosthetics in the CHT Terrain Context

The design of assistive technology for disabled individuals in the CHT must engage specifically with the terrain challenge, which is not adequately addressed by standard assistive technology

designed for flat, paved urban environments. A standard wheelchair, for example, is entirely non-functional on the steep, narrow, and unpaved paths that connect homes, fields, water sources, and health facilities in remote CHT communities. Crutches designed for pavement use may not provide adequate stability on the wet clay and root-covered forest floor of the CHT. Hearing aids designed for quiet consulting room use may not filter the complex acoustic environment of a CHT jhum field in which background noise from wind, water, and vegetation creates masking interference. The development of terrain-adapted assistive technologies for CHT users is a design challenge that has not yet been systematically addressed by either the global assistive technology community or by Bangladeshi rehabilitation medicine practitioners. Potential approaches include the development of all-terrain manual wheelchairs adapted for CHT paths (using larger wheels, robust frames, and lever-drive mechanisms that improve pushing efficiency on inclines), the use of locally manufacturable walking aids from bamboo (which is abundant in the CHT and has excellent structural properties) as a cost-effective alternative to imported metal crutches, and the design of voice-based communication augmentation that uses the indigenous languages of the CHT. The Bangladesh National Action Plan on Assistive Technology 2022-2030 (aligned with the WHO Global Report on Assistive Technology, published in 2022) identified the provision of essential assistive products as a health system priority but has not yet produced specific programs targeting the CHT's distinctive terrain and cultural context.

MODEL EXAMINATION QUESTIONS: CHAPTER NINE (PART SEVEN)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The World Health Organization's International Classification of Functioning, Disability and Health (ICF) defines disability as: a) A fixed biological characteristic of an individual resulting from a health condition b) The product of the interaction between a person's health conditions and contextual factors (environmental and personal) that shape their functional participation in society c) Any condition that requires the use of assistive technology d) Any condition for which the individual is entitled to government disability benefits. Correct Answer: b.

Community-Based Rehabilitation (CBR) as recommended by WHO addresses disability across five domains organized in the CBR matrix. These domains are: a) Medical, surgical, pharmaceutical, psychological, and social b) Health, education, livelihood, social, and empowerment c) Prevention, detection, treatment, rehabilitation, and palliative care d) Physical, occupational, speech, cognitive, and psychological therapy. Correct Answer: b.

The UN Convention on the Rights of Persons with Disabilities (CRPD) was adopted in which year? a) 2001 b) 2003 c) 2006 d) 2010. Correct Answer: c.

Landmine injury, which is relevant to the CHT given historical conflict-period use of mines in some areas, characteristically produces which category of primary injury? a) Penetrating torso trauma b) Traumatic amputation and blast injury, particularly affecting the lower extremities c) Head injury only d) Spinal cord injury only. Correct Answer: b.

The WHO Global Report on Assistive Technology was published in which year? a) 2015 b) 2019 c) 2022 d) 2024. Correct Answer: c.

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A CHT district rehabilitation program planner is designing a CBR program for Bandarban district. The most critical terrain-specific design adaptation required for assistive technology in this program is: a) Selection of brightly colored assistive devices for visibility in jungle environments b) Design or procurement of assistive technology specifically adapted to the steep, unpaved, narrow, and often wet CHT terrain, recognizing that standard assistive devices designed for flat paved environments are non-functional in the CHT hill community context c) Training rehabilitation workers in scuba diving for access to river communities d) Use of solar-powered motorized assistive devices for all users. Correct Answer: b.

CHAPTER TEN: ADVANCED DIAGNOSTIC REASONING, CLINICAL DECISION-MAKING UNDER UNCERTAINTY, AND THE MEDICAL LOGIC OF THE CHT CLINICIAN

10.1 The Epistemology of Clinical Decision-Making in the CHT

Clinical decision-making, the cognitive process through which a clinician integrates available information to reach a diagnosis, selects a treatment, and manages uncertainty in the service of the patient's wellbeing, is a skill that is taught imperfectly in standard medical curricula and that is tested particularly severely in the CHT context where the information available is incomplete, the time pressure is intense, the resources are severely limited, and the consequences of error are often irreversible. The epistemology of clinical decision-making, meaning the examination of what kind of knowledge the clinician applies to clinical problems and how that knowledge justifies clinical action, is of direct practical importance in the CHT because the knowledge structure of the CHT clinician must be different from that of a clinician practicing in a well-resourced urban setting. The standard medical curriculum in Bangladesh is designed primarily around the clinical realities of Dhaka Medical College Hospital or Chittagong Medical College Hospital: tertiary referral centers with access to CT scanners, echocardiography, intensive care units, subspecialty consultation, and broad laboratory capability. The CHT clinician at an upazila health complex has none of these resources and must practice a form of diagnostic medicine that is simultaneously more demanding (because the absence of confirmatory tests means that every clinical decision rests more heavily on clinical reasoning) and more consequential (because the options for the CHT clinician who gets the diagnosis wrong are far more limited than for the urban clinician who can order additional tests or consult subspecialists). The Medical Logic of the CHT Clinician, articulated in this chapter as an original framework, holds that effective clinical practice in the CHT requires the explicit and systematic integration of five knowledge domains in every clinical encounter: the universal biomedical knowledge domain (pathophysiology, pharmacology, clinical science), the CHT epidemiological domain (local disease prevalence, risk factor distribution, seasonal patterns), the CHT sociocultural domain

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(understanding of how different CHT communities present and understand illness), the CHT resource domain (realistic assessment of available tools and their limitations), and the CHT ethical domain (the commitments to justice, non-abandonment, and advocacy that distinguish ethical CHT practice from mere technical performance).

Bayesian clinical reasoning, the application of Bayes' theorem to clinical diagnosis, is the most rigorous formal framework for quantifying the uncertainty inherent in clinical decision-making and for updating diagnostic probabilities as new information becomes available. Bayes' theorem states that the posterior probability of a diagnosis (the probability after considering the test result or clinical finding) is a function of the prior probability of the diagnosis (the pre-test probability based on prevalence and risk factors) and the likelihood ratio of the finding (the ratio of the probability of the finding in patients with the disease to the probability of the finding in patients without the disease). In the CHT context, the application of Bayesian reasoning means that the clinician must start every encounter with an epidemiologically calibrated prior probability, not the generic prior probabilities taught in a standard medical curriculum that are derived from tertiary hospital case series from Dhaka or international populations. A febrile patient presenting to a CHT UHC in August has a very different prior probability of P. falciparum malaria (perhaps 60 to 70 percent, given the endemic season and the epidemiological context) compared with a febrile patient presenting to Dhaka Medical College Hospital (where malaria would have a prior probability of perhaps 1 to 2 percent among febrile inpatients). This difference in prior probability fundamentally changes the clinical logic: in the CHT, a positive malaria RDT in the August febrile patient confirms a high-probability diagnosis with high positive predictive value, while in Dhaka the same positive result requires more careful consideration of pre-test probability and the possibility of false positivity in a low-prevalence context. The CHT clinician who imports the epidemiological assumptions of urban tertiary care medicine into the CHT clinical context makes systematically miscalibrated diagnostic decisions.

10.2 Diagnostic Pitfalls Specific to the CHT: A Systematic Survey

Several diagnostic pitfalls are specific to or more commonly encountered in the CHT clinical context and deserve systematic documentation for the education of clinicians working in the territory. The first pitfall is the masking of complicated malaria by concurrent traditional botanical medicine. CHT patients who have been treated with herbal preparations before presenting to the health facility may have had their fever partially suppressed by the antipyretic alkaloids present in several CHT botanical medicines (including those from the Cinchona-related Rubiaceae plants, which contain weak anti-Plasmodium activity). This partial antipyresis can produce an atypical malaria presentation in which the classical fever pattern is obscured, the malaria RDT is performed during a trough in parasitemia density (producing a false-negative or weakly positive result), and the true diagnosis is missed or delayed. The clinician must inquire about prior botanical medicine use in every malaria-suspect patient and must apply a higher threshold of clinical suspicion in the epidemiological CHT context. The second pitfall is the misdiagnosis of tuberculous meningitis as bacterial meningitis or as cerebral malaria. The clinical differentiation of bacterial meningitis, tuberculous meningitis, and cerebral malaria in a febrile obtunded patient is one of the most demanding diagnostic challenges in the CHT clinical context, because all three conditions present with fever, reduced consciousness, neck stiffness

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(though neck stiffness may be absent in severe cerebral malaria), and in some cases convulsions. The CSF analysis that distinguishes these conditions (bacterial meningitis showing high neutrophil predominance, high protein, very low glucose, and positive Gram stain or culture in many cases; tuberculous meningitis showing lymphocytic predominance, elevated protein, low glucose, and characteristic AFB smear or GeneXpert-positive in some cases; viral encephalitis showing lymphocytic pleocytosis with normal or minimally elevated protein and glucose; and in cerebral malaria, the CSF is typically normal or shows at most a mild non-specific pleocytosis) requires lumbar puncture, which is technically feasible at the district hospital level but not at most UHCs, and CSF analysis capacity that is limited to district hospitals with functional laboratory infrastructure. The third pitfall is the underdiagnosis of hypertension in CHT patients presenting for other reasons. Blood pressure measurement, the simplest and most cost-effective tool for preventing cardiovascular disease, stroke, and renal failure, is performed inconsistently in CHT health facilities, and hypertension, which is a growing burden in the CHT as diet and lifestyle change, is frequently identified only when the patient presents with a complication (stroke, acute coronary syndrome, or hypertensive renal failure) rather than being detected and treated at an asymptomatic stage. A systematic blood pressure measurement for every adult patient attending any CHT health facility, regardless of the presenting complaint, would identify a significant proportion of previously undetected hypertensives and initiate a treatment pathway that is both highly cost-effective and profoundly impactful in terms of stroke and heart disease prevention.

10.3 The CHT Clinical Reasoning Case Series: Integrative Application

This section presents three integrative clinical reasoning cases that synthesize the diagnostic, epidemiological, sociocultural, and resource-constraint themes of this textbook, requiring the application of the full CHT Contextual Diagnostic Doctrine to clinically realistic scenarios drawn from the CHT health context. Each case is followed by an analytical commentary that models the application of the Medical Logic of the CHT Clinician framework.

Case One: A 7-year-old Chakma girl is brought to the Khagrachhari District Hospital by her parents in late September. She has had a productive cough for three months, progressive weight loss, and low-grade fever for the past six weeks. She has not been to school for one month because of weakness. Her father had a similar illness two years ago and was treated at the same hospital (he cannot recall the diagnosis or the treatment). Physical examination reveals a thin, pale child (MUAC 11.5 cm, in the SAM range), with dullness to percussion at the right upper lobe, reduced breath sounds in the same area, and a positive Mantoux tuberculin skin test (18 mm induration). Chest X-ray shows right upper lobe infiltrate with early cavitation. Sputum cannot be produced reliably (the child cannot expectorate adequately for sputum collection), but induced sputum produced with hypertonic saline nebulization is sent for GeneXpert MTB/RIF analysis.

Clinical reasoning commentary: The combination of three months of productive cough, weight loss, low-grade fever, right upper lobe consolidation with cavitation on chest X-ray, positive Mantoux, severe acute malnutrition, and a household contact with a similar illness two years previously creates a high-probability clinical picture for pulmonary tuberculosis. The

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epidemiological prior probability of TB in a malnourished Chakma child with a TB-sick household contact and classic clinical and radiological features is extremely high. GeneXpert analysis of induced sputum is the optimal diagnostic approach in this patient given her inability to expectorate adequately; GeneXpert has higher sensitivity than sputum smear microscopy, particularly in children who generally have lower bacillary loads than adults, and it simultaneously provides rifampicin resistance information. If GeneXpert is negative but clinical suspicion remains high, the WHO 2022 updated guidance on TB in children supports initiation of empirical TB treatment in the presence of strong clinical and epidemiological evidence, even without microbiological confirmation. Treatment must include simultaneous management of her severe acute malnutrition with F-75 in the stabilization phase, progressing to F-100 and then RUTF, since TB treatment without nutritional support in a child with this degree of malnutrition is likely to produce inadequate response and increased risk of paradoxical reactions. Screening of all household contacts for TB is mandatory.

Case Two: A 55-year-old Marma woman from a remote Bandarban community is brought to the Alikadam Upazila Health Complex by her son after two days of sudden-onset right-sided arm and leg weakness, slurred speech, and headache. She had no prior medical history known to her family, though her son recalls that she was once found to have "high blood pressure" during a health camp visit two years ago, for which she received no treatment. Physical examination reveals blood pressure of 190/115 mmHg, right-sided hemiplegia with upper motor neuron pattern (hyperreflexia, positive Babinski on the right), dense aphasia (she is able to follow simple two-step commands), and no fever. Blood glucose is 7.1 mmol/L. Malaria RDT is negative.

Clinical reasoning commentary: The clinical picture is consistent with acute left hemisphere ischaemic or haemorrhagic stroke, with the high blood pressure, absence of fever, and upper motor neuron pattern on examination supporting a vascular rather than infectious etiology. The negative malaria RDT and absence of fever significantly reduce the probability of cerebral malaria, and the acuity of onset (sudden maximum-deficit presentation is more typical of embolic or haemorrhagic stroke than of the progressive obtundation of cerebral malaria). The UHC has no CT scanner, without which haemorrhagic stroke cannot be definitively distinguished from ischaemic stroke. This distinction is critical for treatment: thrombolysis (which would be beneficial in ischaemic stroke within 4.5 hours of onset) is absolutely contraindicated in haemorrhagic stroke where it would cause catastrophic expansion of the haematoma. Given the absence of CT and the blood pressure of 190/115 mmHg (which is consistent with hypertensive haemorrhagic stroke), the safest approach at the UHC level is to stabilize blood pressure (aiming for a cautious reduction to approximately 160/100 mmHg in the acute phase, using oral antihypertensives if tolerated or parenteral labetalol if available), maintain airway and oxygenation, avoid aspirin until hemorrhagic stroke is excluded by imaging, and arrange urgent transfer to Chittagong Medical College Hospital for CT imaging, thrombolysis assessment if ischaemic stroke is confirmed and the time window is open, and neurosurgical assessment if haemorrhagic stroke is confirmed. The blood pressure of 190/115 mmHg in a patient who had uncontrolled hypertension documented two years ago and received no treatment illustrates precisely the missed opportunity for stroke prevention through systematic blood pressure measurement and management at the primary care level.

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Case Three: A 28-year-old Mro man from Kurukpata, Alikadam, presents to the Alikadam UHC in April with a three-week history of painless but progressively enlarging ulcer on his left cheek, which began as a small red papule and has grown to a 3 cm indurated ulcer with raised, rolled edges and central necrosis. He has no fever, and his systemic examination is normal. He reports that several other people in his village have had similar skin lesions in recent months. He works as a forest collector of rattan and non-timber forest products, spending most of his working hours in the deep forest.

Clinical reasoning commentary: The combination of a chronic painless ulcerating skin lesion with raised rolled edges, the endemic geographic context (the southern Bandarban borderland with Myanmar), the occupation involving deep forest exposure, and the cluster of similar cases in the same community raises the differential diagnosis of cutaneous leishmaniasis (Leishmania tropica or related species causing the Old World dry form, or Leishmania major causing a more acute moist form) versus cutaneous diphtheria (rare in Bangladesh but associated with skin wounds and endemic in regions of low vaccination coverage), early squamous cell carcinoma of the skin (less likely in a 28-year-old without significant sun damage history), and sporotrichosis (a subcutaneous mycosis caused by Sporothrix schenckii, associated with soil and plant material contact, which could be plausible given his occupational exposure). The most important immediate investigation in the CHT UHC setting is careful examination and documentation of the lesion characteristics, collection of a slit-skin smear from the lesion edge for Leishman-Donovan body visualization (the amastigote form of Leishmania), and referral to Chittagong Medical College Hospital for tissue biopsy and polymerase chain reaction (PCR) confirmation of species. The cluster of similar cases in the same community strongly suggests a shared exposure, consistent with cutaneous leishmaniasis in which sandfly bites from a shared vector habitat produce a cluster of cutaneous disease in exposed individuals in the same community, and the public health investigation of the case cluster should proceed simultaneously with the individual patient management.

MODEL EXAMINATION QUESTIONS: CHAPTER TEN (PART SEVEN)

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

In Bayesian clinical reasoning, the "prior probability" of a diagnosis refers to: a) The probability assigned after the diagnostic test result is known b) The probability of the diagnosis before considering the test result, based on prevalence and clinical risk factors c) The probability that the treatment will work d) The probability that the patient will comply with treatment. Correct Answer: b.

In Case One of the integrative case series, the clinical diagnosis of pulmonary tuberculosis in the 7-year-old Chakma girl is supported by all of the following features EXCEPT: a) Three months of productive cough and weight loss b) Right upper lobe cavitating infiltrate on chest X-ray c) Positive Mantoux tuberculin skin test d) Complete resolution of symptoms with one week of antibiotics. Correct Answer: d.

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In Case Two, the reason that aspirin should be avoided in the CHT stroke patient before CT imaging is: a) Aspirin causes hypertension b) Aspirin is contraindicated in haemorrhagic stroke, where it would increase the risk of haematoma expansion c) Aspirin is contraindicated in all patients over 50 d) Aspirin would mask the symptoms of stroke. Correct Answer: b.

The clinical syndrome in Case Three (chronic painless ulcerating skin lesion with raised rolled edges in a forest worker from southern Bandarban) most specifically suggests which diagnostic category requiring tissue confirmation? a) Bacterial skin infection with Staphylococcus aureus b) Cutaneous leishmaniasis from Leishmania species, requiring slit-skin smear and tissue PCR for confirmation c) Viral exanthem from dengue d) Burns from jhum cultivation. Correct Answer: b.

The "Medical Logic of the CHT Clinician" framework integrates how many knowledge domains in every clinical encounter? a) Two b) Three c) Four d) Five. Correct Answer: d.

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A physician at an upazila health complex in Rangamati sees a 35-year-old Chakma man with two months of cough, weight loss, and night sweats who had been treated with herbal medicines by a local Baiddya for the first six weeks of his illness. Sputum smear microscopy for AFB is negative. GeneXpert MTB/RIF, which is available at the district hospital to which you will refer the patient, is ordered. Clinical suspicion for pulmonary TB remains high given the epidemiological context, the symptom duration, and the household contact who died of a similar illness. According to the WHO 2022 guidance on TB in resource-limited settings, the appropriate immediate management while awaiting GeneXpert result is: a) Withhold all treatment until laboratory confirmation b) Begin empirical TB treatment immediately with the standard four-drug regimen (isoniazid, rifampicin, pyrazinamide, ethambutol) if the clinical probability of TB is high and the patient is clinically deteriorating, recognizing that in the resource-limited CHT context, the risk of treatment delay exceeds the risk of empirical treatment c) Prescribe a broad-spectrum antibiotic instead of anti-TB drugs d) Refer the patient to Dhaka for further investigation without initiating any treatment. Correct Answer: b.

A medical officer at Khagrachhari District Hospital systematically measures blood pressure in every adult patient attending the outpatient department regardless of presenting complaint. In one week, this clinician identifies 23 previously undiagnosed hypertensive patients among 340 adults screened, a detection rate of 6.8 percent. The clinical and economic justification for this systematic screening approach in the CHT context rests on all of the following arguments EXCEPT: a) Hypertension is asymptomatic until complications occur, making active screening the only way to identify most cases b) Blood pressure measurement is extremely low-cost and requires minimal training c) Hypertension treatment reduces the risk of stroke, acute coronary syndrome, and renal failure, which are high-burden, high-cost conditions in the CHT d) Blood pressure measurement at every visit is the most expensive component of routine clinical care in the CHT. Correct Answer: d.

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EPILOGUE TO PART SEVEN: THE SYNTHESIS OF ADVANCED ANALYSIS AND THE CHT'S CONTINUING IMPERATIVE

The ten chapters of Part Seven have traversed a landscape of medical knowledge and public health theory that is as varied and demanding as the terrain of the Chittagong Hill Tracts itself. From the neuropsychiatric depths of intergenerational trauma to the molecular surveillance of artemisinin-resistant Plasmodium falciparum; from the political ecology of land rights as a health determinant to the terrain-adapted design of assistive technology; from the clinical pharmacology of psychiatric medications in malnourished patients to the Bayesian epistemology of diagnostic reasoning without laboratory confirmation: each of these domains represents a dimension of CHT health that the fully competent CHT clinician, public health practitioner, or researcher must master. The synthetic insight that emerges from traversing all ten chapters simultaneously is that the CHT health system's failures are not primarily technical in nature. They are not primarily failures of drug supply, diagnostic technology, or clinical training, though all of these deficits exist and must be addressed. They are primarily failures of political will, of distributive justice, of institutional respect for the rights and dignity of the CHT's indigenous peoples, and of the imagination that would allow policy-makers to see these communities not as objects of charity or security management but as rights-bearing citizens whose health is the state's obligation and whose knowledge, resilience, and cultural wealth are resources on which the entire health system should draw. The clinician who graduates from reading Part Seven of this textbook should understand that the most important diagnostic tool available in the CHT is not the GeneXpert machine or the malaria RDT, indispensable as these are. It is the capacity for political and structural analysis that allows the clinician to see the full causal architecture of the disease they are treating and to respond to it with both the technical skills of the healer and the moral commitment of the advocate. The CHT awaits, and its people deserve no less.

PART SEVEN COMPREHENSIVE ASSESSMENT: INTEGRATIVE EXAMINATION QUESTIONS

The following integrative questions are suitable for FCPS Part 2, MD qualifying examinations, MPH qualifying examinations, and FRCS written assessments:

Question 1: A 32-year-old Tripura woman from a remote Khagrachhari community presents to the district hospital with a 4-week history of progressive jaundice, fever, right upper quadrant pain and tenderness, and a right pleural effusion on auscultation. She is from a community with no toilet facilities and relies on a hill stream for drinking water. She has a 5-year-old child with recent diarrhea at home. Ultrasound (if available) or clinical assessment of hepatic enlargement with focal tenderness is consistent with a liver space-occupying lesion. Apply the CHT Contextual Diagnostic Doctrine to generate the differential diagnosis, design the diagnostic cascade appropriate to the CHT UHC level, and outline the management approach including transfer criteria. The differential must include amoebic liver abscess, pyogenic liver abscess, right-lobe cholangiocarcinoma (given the fluke exposure history in some CHT communities that

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eat raw freshwater fish), and hepatocellular carcinoma from hepatitis B, with amoebic liver abscess having the highest prior probability given the sanitation context and clinical features.

Question 2: Design a comprehensive 5-year community mental health program for a remote Chakma community in Rangamati district with documented high rates of depression, PTSD, and alcohol use disorder in conflict survivors. The program must address all four principles of the Psychoecological Health Philosophy (Landscape-Mind Integration, Collective Trauma Somatization, Healing Ecology, and Structural Pathology Recognition), incorporate mhGAP-adapted protocols for the community health worker cadre, engage Buddhist monks as community mental health partners, include narrative exposure therapy delivered in the Chakma language by trained indigenous facilitators, address alcohol use disorder through culturally appropriate brief interventions and referral pathways, and include a transitional justice advocacy component that demands formal acknowledgment of conflict harms as a dimension of the health program.

Question 3: You are an epidemiologist appointed by the Bangladesh government to investigate a cluster of deaths from a febrile illness in an indigenous community near the Bandarban-Myanmar border in October 2025. In the first week of investigation, you identify 28 cases of acute febrile illness with high fatality (7 deaths, case fatality rate 25 percent) in a community of approximately 400 people. Clinical features include high fever, severe myalgia, headache, petechiae, and in some fatal cases, hemorrhagic manifestations including hemoptysis and gastric bleeding. Malaria RDTs are negative in all tested cases. Standard bacterial cultures from the district hospital are negative at 48 hours. Outline your full outbreak investigation protocol applying the six-step methodology with CHT-specific adaptations, your differential diagnosis for this unusual hemorrhagic febrile illness including potential zoonotic etiologies relevant to the CHT-Myanmar border ecology, the specimens you would collect and transport for reference laboratory analysis (specifying the biosafety requirements for potential viral hemorrhagic fever), and the immediate public health control measures you would implement while the laboratory investigation is pending.

PART EIGHT: ADVANCED CLINICAL MEDICINE, ANTIMICROBIAL RESISTANCE, NON-COMMUNICABLE DISEASE EPIDEMIOLOGY, PHARMACOLOGICAL PRINCIPLES, AND TRANSLATIONAL HEALTH RESEARCH IN THE CHITTAGONG HILL TRACTS

Foreword to Part Eight

Part Eight of this textbook arrives at a moment of convergence. The Chittagong Hill Tracts now confronts, simultaneously, the unresolved burden of its ancient infectious diseases and the emergent burden of conditions that were, until a generation ago, considered diseases of affluence

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and urban modernity. This convergence is not coincidence. It is the predictable arithmetic of incomplete development, in which the risk factors for chronic disease accumulate in populations that have not yet been freed from the infectious diseases those same development deficits perpetuate. Part Eight is dedicated to navigating this convergence with clinical precision, epidemiological depth, and philosophical honesty. It draws on the most recent research from 2024, 2025, and early 2026, integrates the theoretical frameworks established in the preceding seven parts of this textbook, and extends the analysis into territories of clinical medicine and public health science that previous parts introduced but did not fully explore. The student who masters Part Eight will emerge with the capacity to practice advanced clinical medicine in the CHT context, to understand the mechanisms and implications of antimicrobial resistance as they apply specifically to the CHT, to diagnose and manage the non-communicable diseases that are rising rapidly in the territory, to reason through the pharmacological complexities that attend drug use in a genetically, nutritionally, and ecologically distinct population, and to situate their clinical and research work within the theoretical frameworks of translational medicine that represent the frontier of health science in this uniquely challenging geography.

CHAPTER ONE: NON-COMMUNICABLE DISEASE EMERGENCE AND THE METABOLIC TRANSITION IN THE CHITTAGONG HILL TRACTS

1.1 The Theory of Compressed Metabolic Transition

The metabolic transition, understood in conventional epidemiological theory as the population-level shift from a physiology calibrated for nutritional scarcity and physical labor to a physiology confronting caloric surplus and physical inactivity, has been described in global health literature as a process that unfolds across decades in populations undergoing economic development. The Compressed Metabolic Transition, as this textbook defines it, is the phenomenon specific to communities like those of the CHT, in which the metabolic transition occurs not smoothly across time but in compressed, uneven, and pathologically intensified bursts, driven by the rapid introduction of processed food markets, shifts in occupational structure, reductions in physical activity from agricultural mechanization, and exposure to chronic psychosocial stress, all operating simultaneously on populations whose bodies remain metabolically calibrated for the nutritional scarcity and physical exertion of traditional subsistence life. The Compressed Metabolic Transition is not merely a faster version of the standard metabolic transition. It is a qualitatively different biological process, because it imposes new metabolic demands on physiological systems that have been shaped by centuries of exposure to low caloric density, high physical workload, and the specific micronutrient profiles of traditional CHT diets, producing patterns of metabolic disease that do not map neatly onto the clinical presentations described in textbooks derived from Western or even South Asian plains populations. The evidence for this process in the CHT is visible in several converging data streams: the emergence of type 2 diabetes mellitus and hypertension in communities that had no recorded clinical burden of these conditions a generation ago, the appearance of obesity in settings where severe stunting remains simultaneously prevalent (creating the paradox of malnutrition-associated metabolic disease), and the growing reports from CHT district hospital outpatient departments of

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cardiovascular presentations in middle-aged adults who had no prior diagnosed risk factors and who present de novo with hypertensive crises or acute myocardial infarction. The clinical understanding of these patterns requires a theoretical framework that recognizes the CHT metabolic transition as a biologically distinct event, not a mere replication of transitions observed in other settings.

The Compressed Metabolic Transition operates through five distinct biological mechanisms that interact with each other and with the CHT's pre-existing disease ecology in ways that produce emergent pathological patterns not predictable from analysis of any single mechanism in isolation. The first mechanism is Fetal Metabolic Programming, the process, originally described in the thrifty phenotype hypothesis of Hales and Barker and substantially refined in the developmental origins of health and disease (DOHaD) framework developed in the subsequent three decades, by which exposure to nutritional inadequacy during intrauterine development programs the fetal metabolic system for a life of nutrient scarcity, producing insulin resistance, reduced beta-cell mass, and altered adipose tissue distribution that become pathological when the individual is subsequently exposed to caloric sufficiency or excess. Given the extraordinarily high rates of maternal malnutrition, low birth weight, and intrauterine growth restriction documented across CHT indigenous communities, an unusually high proportion of the CHT population carries this programming for metabolic disease from birth. The second mechanism is Microbiome Disruption, the alteration of the gut microbial ecosystem produced by dietary transitions from traditional high-fiber, low-processed-sugar, fermented-food-rich indigenous diets to the refined carbohydrate and ultra-processed food diets that are increasingly accessible in CHT market towns, with consequences for intestinal barrier integrity, systemic inflammation, insulin sensitivity, and lipid metabolism that are being elucidated in a rapidly expanding body of research from 2024 and 2025. The third mechanism is Stress-Associated Adipose Dysregulation, the consequence of chronic psychosocial stress (operating through the hypothalamic-pituitary-adrenal axis, sympathoadrenal activation, and the cortisol-insulin interaction) on adipose tissue distribution, fat deposition in visceral and ectopic compartments, and the inflammatory cytokine output of adipose tissue that drives insulin resistance and cardiovascular risk. The fourth mechanism is Mitochondrial Metabolic Inflexibility, the reduced capacity of mitochondria in muscles and liver, produced by a combination of nutritional deficiency during critical developmental periods and the specific micronutrient inadequacies of CHT diets (particularly deficiency of B vitamins, zinc, and iron, all of which are essential cofactors in the mitochondrial respiratory chain), to shift efficiently between fatty acid and glucose oxidation in response to nutrient availability changes, leading to intracellular lipid accumulation, reactive oxygen species generation, and metabolic disease. The fifth mechanism is Epigenetic Metabolic Inheritance, the transmission across generations of epigenetic modifications of metabolic genes produced by the nutritional deprivation and psychosocial stress experienced by preceding CHT generations, including the generation that experienced the Kaptai displacement and the conflict period, creating an inherited metabolic vulnerability across the CHT population that extends the consequences of historical injustice into the biological present.

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1.2 Type 2 Diabetes Mellitus in the CHT: A Disease Reconceptualized

Type 2 diabetes mellitus, defined in this textbook not as merely a disorder of glucose homeostasis but as a systemic state of accelerated metabolic-inflammatory aging driven by the interaction between genetically encoded insulin resistance susceptibility and environmentally delivered metabolic stressors, is emerging as a significant clinical burden in the CHT at a pace and in a pattern that the conventional diabetes epidemiology literature does not fully describe. The conventional epidemiological understanding of type 2 diabetes emphasizes the roles of obesity, physical inactivity, high caloric intake, age, and family history as primary risk determinants. In the CHT, this framework requires substantial modification. The CHT population includes large numbers of individuals who are not overtly obese by body mass index (BMI) criteria yet who demonstrate impaired fasting glucose, impaired glucose tolerance, and full clinical type 2 diabetes at BMI thresholds substantially lower than those at which European populations develop these conditions. This phenomenon, well-documented in South and Southeast Asian populations generally and plausibly operating in CHT indigenous populations specifically, reflects the higher visceral adiposity-to-total adiposity ratio of these populations, the developmental metabolic programming described in Section 1.1, and the specific genetic architecture of insulin sensitivity in indigenous populations whose evolutionary history has been shaped by recurrent nutritional stress. The WHO and American Diabetes Association both recognize lower BMI thresholds for diabetes risk assessment in Asian populations (with 23 kg/m2 as the overweight threshold and 27.5 kg/m2 as the obese threshold in Asian adults, compared with 25 and 30 kg/m2 respectively in European populations), but these revised thresholds have not been validated specifically in CHT indigenous communities, and it is likely that further downward adjustment of risk-stratification BMI thresholds would be appropriate for at least some CHT ethnic groups.

The clinical presentation of type 2 diabetes in CHT patients differs from the textbook presentation in several clinically important ways. First, the classic presentation with polyuria, polydipsia, and polyphagia, the triad of symptoms produced by severe hyperglycemia exceeding the renal glucose threshold, is less likely to prompt early healthcare seeking in CHT communities than in urban populations, because these symptoms are frequently attributed to overwork, heat, spiritual imbalance, or dietary transgression within the frameworks of indigenous illness cosmology discussed in Parts One through Three of this textbook. Patients who do not recognize these symptoms as indicators of medical illness and who do not have access to blood glucose testing will continue to develop the disease for months or years before presenting to biomedical services. Second, the most common first presentation of type 2 diabetes in the CHT is with a complication rather than with the disease itself, reflecting the delay-to-care pathway that is a structural feature of healthcare access in the territory. Patients may present first with a non-healing wound (diabetic foot ulcer), with worsening vision (diabetic retinopathy), with symptoms of renal failure (diabetic nephropathy), or with a cardiac event (macrovascular complication). Each of these complication-first presentations represents a diagnostic and management scenario qualitatively different from the scenario of an early, uncomplicated diagnosis, and the clinical approach must adapt accordingly. Third, the interaction between type 2 diabetes and the infectious diseases endemic in the CHT produces clinical scenarios with no direct analog in the diabetes management guidelines derived from high-income country

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experience. Diabetic patients in the CHT face elevated risk of serious infection from pathogens that are rarely encountered in diabetic patients in high-income countries, including Plasmodium falciparum malaria (severe malaria in diabetic patients has a particularly high case fatality rate because hyperglycemia impairs the immune response to the parasite and because the cerebral malaria-hypoglycemia interaction is particularly dangerous in diabetic patients on insulin or sulfonylurea therapy), Mycobacterium tuberculosis (diabetes is one of the strongest known risk factors for progression from latent to active tuberculosis, with diabetic individuals having approximately three times the risk of TB compared with non-diabetic individuals), and melioidosis (caused by Burkholderia pseudomallei, a soil organism documented in Myanmar and Southeast Asia, with diabetes as the primary host risk factor, and with growing concern about its presence in the CHT given the territory's proximity to endemic Southeast Asian regions and its ecological overlap with the melioidosis-endemic soil environments of the Greater Mekong Subregion).

The management of type 2 diabetes in the CHT requires a clinical protocol adapted to the resource realities, cultural contexts, and comorbidity profiles of the territory. The CHT Diabetes Management Protocol, as articulated in this textbook, has four pillars. The first pillar is Culturally Integrated Dietary Counseling, which engages with the patient's actual food environment and cultural food practices rather than imposing a generic diabetic diet derived from urban Bangladesh or global guidelines. The CHT indigenous diet, when traditional and unmodified by market transition, is often actually a near-ideal diabetic diet: high in fiber from traditional vegetables, leafy greens, tubers, and fermented preparations; low in refined carbohydrates; rich in specific antioxidant and anti-inflammatory plant compounds; and moderate in total caloric density. The clinical opportunity is to affirm and strengthen traditional dietary practices while modifying the specific items introduced through market access (white rice in excess, refined wheat products, commercial sweet drinks, and processed snack foods) that drive glycemic dysregulation. The second pillar is Physical Activity Preservation, which recognizes that the physical labor of jhum farming, forest work, and fishing constitutes a substantial and metabolically beneficial physical activity load, and that the shift away from these activities toward more sedentary occupational patterns (which is occurring in some CHT communities, particularly among younger people who have obtained education and moved into administrative or service sector work) represents a major driver of metabolic disease risk that must be addressed in lifestyle counseling. The third pillar is Community-Based Glucose Surveillance, using point-of-care blood glucose testing through community health worker networks to detect undiagnosed diabetes and prediabetes in the CHT population before complications develop, creating the opportunity for intervention at the stage where lifestyle modification can produce meaningful glycemic improvement without pharmacotherapy. The fourth pillar is Rational Pharmacotherapy, applying the principles of pharmacology discussed in Chapter Six of this Part, with specific attention to the dosing adjustments required in patients with renal impairment (which is common in late-presenting diabetic patients in the CHT), the interactions between oral hypoglycemic agents and traditional botanical medicines (which are commonly used concurrently), and the practical challenges of insulin cold-chain maintenance in a territory with limited refrigeration infrastructure.

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1.3 Hypertension in the CHT: The Silent Epidemic and Its Terrain-Specific Drivers

Hypertension, defined in this textbook as a condition of sustained elevation of the systolic or diastolic blood pressure beyond the adaptive range of the arterial system, generating progressive structural remodeling of the vessel wall, accelerated atherogenesis, left ventricular hypertrophy, and end-organ damage across the kidney, brain, eye, and heart, is the most prevalent non-communicable disease in Bangladesh and is increasingly documented in CHT populations. The conventional risk factor profile for hypertension includes age, excess body weight, high dietary sodium intake, physical inactivity, chronic alcohol consumption, tobacco use, and psychological stress. In the CHT, this risk factor profile is present in modified form: the CHT population is younger on average than the Bangladesh national average, but hypertension is appearing in younger age groups than expected; dietary sodium intake, while not typically as high as in processed-food-dominant urban diets, has been increasing with the introduction of commercially prepared condiments, fermented fish products (some of which have very high salt content), and market-purchased processed foods; and chronic psychological stress, as documented extensively in Parts Three and Eight of this textbook, is a particularly potent and chronically active hypertension driver in CHT populations burdened by the historical and ongoing experience of structural violence.

The Terrain-Conditioned Hypertension Model, introduced in this chapter, holds that hypertension in the CHT is not simply the same disease as hypertension in urban Bangladesh or in high-income countries, presented in a different geographic setting, but is a pathophysiologically distinct syndrome in which the terrain-specific risk factor constellation of the CHT (psychosocial stress from political marginalization, dietary transition patterns unique to the CHT context, the specific inflammatory burden of chronic parasitic infection in the renal and cardiovascular system, the altitude-associated effects on blood pressure regulation in the higher communities of Bandarban, and the genetic architecture of renin-angiotensin-aldosterone system regulation in CHT indigenous populations, which has not been systematically studied but is likely to differ from the Bangladeshi plains population genetic architecture given centuries of reproductive isolation) produces blood pressure phenotypes and patterns of end-organ damage that may respond differently to standard pharmacological management. This model has direct clinical implications: the assumption that antihypertensive drug classes that perform well in randomized controlled trials conducted predominantly in European, American, and South Asian plains populations will produce equivalent efficacy and equivalent adverse effect profiles in CHT indigenous populations is an assumption that has not been validated and that carries clinical risk. The CHT physician prescribing antihypertensives must recognize this gap and apply particular vigilance in monitoring treatment response and adverse effects.

The chronic inflammatory burden of parasitic infection adds a dimension to CHT hypertension that is essentially absent from the guideline-generating evidence base of global antihypertensive drug trials. Plasmodium falciparum malaria, through its generation of systemic inflammatory cytokines (including tumor necrosis factor alpha, interleukin-6, and interleukin-1 beta), its induction of anemia with compensatory cardiovascular stress response, and its capacity to produce renal impairment (through immune complex deposition and hemoglobin-mediated tubular toxicity in severe infection), contributes to hypertension pathogenesis and to the

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acceleration of hypertensive end-organ damage in individuals with both conditions. Similarly, helminthic infection, through its induction of chronic systemic inflammation, may contribute to endothelial dysfunction and arterial stiffness in ways that amplify the hypertensive effect of other risk factors. The interaction between parasitic infection and hypertension in the CHT has not been formally studied in a prospective cohort design, representing a major gap in the CHT-specific cardiovascular literature that urgently requires investigation.

1.4 Chronic Kidney Disease in the CHT: An Emerging and Invisible Burden

Chronic kidney disease (CKD), the progressive, irreversible loss of glomerular filtration capacity over months to years, resulting from the cumulative damage of diabetes, hypertension, glomerulonephritis, tubular injury, and structural abnormalities, is a disease that is essentially invisible in the CHT health literature because its investigation requires laboratory tests (serum creatinine, urinalysis with protein quantification, estimated glomerular filtration rate calculation) that are not routinely available at most CHT health facilities and whose availability even at district hospital level is inconsistent. Yet CKD is almost certainly present in the CHT at a prevalence substantially higher than is currently recognized, for reasons that are intrinsic to the CHT's disease ecology. The population of CHT adults has been repeatedly exposed over their lifetimes to multiple CKD risk factors that are more intensely concentrated in the CHT than in any other region of Bangladesh. These include recurrent P. falciparum malaria with its renal hemolytic and immune complex-mediated injury; chronic hyperglycemia from undetected and untreated type 2 diabetes; hypertension, also frequently undetected; chronic dehydration from inadequate water access during agricultural labor in high-heat conditions; heavy metal exposure from some CHT water sources; analgesic nephropathy from the overuse of non-steroidal anti-inflammatory drugs (NSAIDs), which are the most commonly self-purchased pharmaceutical analgesics in CHT market towns; and direct toxic nephropathy from traditional herbal preparations that contain nephrotoxic compounds (some CHT ethnomedicinal plants contain pyrrolizidine alkaloids, aristolochic acid analogs, and other nephrotoxins that can produce irreversible tubular injury with chronic use). The convergence of these risk factors in the same population means that the CHT is likely a zone of high CKD burden, and the clinical consequence of this undetected burden is that large numbers of CHT adults are at elevated risk of acute kidney injury from conditions and interventions that would be tolerable in individuals with healthy renal function: a severe malaria infection, a dehydrating diarrheal illness, a contrast media administration, or the initiation of nephrotoxic antibiotic therapy can each precipitate acute-on-chronic kidney injury in a CHT patient with unrecognized pre-existing CKD, with potentially fatal consequences.

MODEL EXAMINATION QUESTIONS: CHAPTER ONE

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The Compressed Metabolic Transition as defined in this textbook refers to which phenomenon? a) The rapid acceleration of economic development in the CHT over the past decade b) The phenomenon in which metabolic transition from subsistence to processed-food diets occurs in compressed, uneven bursts in CHT communities, producing metabolic disease in populations

physiologically calibrated for nutritional scarcity c) The reduction in the duration of the traditional agricultural calendar due to climate change d) The compression of hospital stays for metabolic disease patients due to bed shortages in CHT hospitals (Correct Answer: b)

Which of the following represents the most common first presentation of type 2 diabetes mellitus in CHT patients, as described in this textbook? a) Classic triad of polyuria, polydipsia, and polyphagia b) Routine blood glucose screening at an outpatient department c) A diabetic complication such as non-healing wound, visual deterioration, or cardiac event d) Incidental finding during antenatal care glucose testing (Correct Answer: c)

The thrifty phenotype hypothesis (Hales and Barker) as applied to CHT populations relates to which mechanism of the Compressed Metabolic Transition? a) Microbiome Disruption b) Stress-Associated Adipose Dysregulation c) Fetal Metabolic Programming d) Mitochondrial Metabolic Inflexibility (Correct Answer: c)

The revised overweight BMI threshold applicable to Asian adults for diabetes risk stratification, as recognized by the WHO and American Diabetes Association, is: a) 25 kg/m2 b) 23 kg/m2 c) 27 kg/m2 d) 30 kg/m2 (Correct Answer: b)

Melioidosis, caused by Burkholderia pseudomallei, is most relevant in the CHT context because: a) It is the most common cause of pneumonia in Rangamati district b) Diabetes is its primary host risk factor and it is documented in neighboring Myanmar and Southeast Asia, raising concerns about its presence in the CHT c) It is the most common cause of diarrheal disease in Bandarban d) It is transmitted by the same Anopheles mosquitoes that transmit malaria (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 48-year-old Chakma male farmer presents to Rangamati District Hospital with a non-healing ulcer on his right heel that has been present for three months. He has no prior documented medical history and has not previously sought biomedical care. Random blood glucose is 19.4 mmol/L. Serum creatinine is 198 micromol/L. Urinalysis shows 3-plus proteinuria. This clinical scenario best illustrates which concept from this chapter? a) Acute presentation of type 1 diabetes with diabetic ketoacidosis b) Complication-first presentation of type 2 diabetes, with concurrent undetected diabetic nephropathy producing advanced CKD, reflecting the delay-to-care pathway and the convergence of multiple CHT-specific CKD risk factors c) Drug-induced nephropathy from traditional herbal preparations without concurrent diabetes d) Postinfectious glomerulonephritis following malaria (Correct Answer: b)

Which of the following CHT-specific pathophysiological mechanisms most directly mediates the interaction between recurrent P. falciparum malaria and the progression of hypertensive end-organ damage? a) Direct parasitic invasion of cardiomyocytes b) Systemic inflammatory cytokine generation (TNF-alpha, IL-6, IL-1 beta), malaria-associated anemia producing compensatory cardiovascular stress, and immune complex-mediated renal injury combining to amplify hypertensive vascular and renal damage c) Antimalarial drug toxicity to the cardiac

conduction system d) Malaria-induced thrombocytopenia producing paradoxical hypertension through platelet-vasomotor interactions (Correct Answer: b)

A CHT public health researcher designing a community-based hypertension screening program identifies that the most prevalent and amenable-to-intervention risk factor in the target population is chronic psychosocial stress from political marginalization and land insecurity, operating through the hypothalamic-pituitary-adrenal axis. According to the Terrain-Conditioned Hypertension Model, the most appropriate complementary intervention beyond antihypertensive pharmacotherapy would be: a) Sodium restriction counseling only b) Vigorous exercise programs in community settings c) Integration of psychosocial stress reduction interventions (including mindfulness, narrative therapy, and community social support strengthening) with advocacy for structural change addressing the land rights and political participation determinants of chronic stress d) Referral to Dhaka for specialist psychiatric care (Correct Answer: c)

CHAPTER TWO: ANTIMICROBIAL RESISTANCE IN THE CHITTAGONG HILL TRACTS: MECHANISMS, SURVEILLANCE, AND CLINICAL IMPLICATIONS

2.1 The CHT Antimicrobial Resistance Doctrine

Antimicrobial resistance (AMR) in the CHT is defined in this textbook not merely as the microbiological phenomenon of pathogen survival in the presence of antibiotic concentrations that would normally inhibit or kill it, but as a compounded socioecological crisis in which the molecular mechanisms of microbial adaptation to antimicrobial agents are amplified by the specific social, behavioral, regulatory, and ecological conditions of the CHT into a clinical and public health emergency with catastrophic potential for the populations of the territory. This definition demands elaboration. The molecular mechanisms of AMR, which include enzymatic drug inactivation (beta-lactamase production, aminoglycoside-modifying enzymes, chloramphenicol acetyltransferase), target site modification (penicillin-binding protein alteration producing beta-lactam resistance in pneumococci and staphylococci, ribosomal mutation producing aminoglycoside and macrolide resistance, DNA gyrase mutation producing fluoroquinolone resistance), efflux pump overexpression (which reduces intracellular drug concentration across multiple drug classes), outer membrane protein downregulation (reducing the penetration of hydrophilic antibiotics into gram-negative organisms), and horizontal gene transfer via plasmids, transposons, and integrons (which allows resistance determinants to spread rapidly across bacterial species and genera), are universal biological processes occurring in microbial populations globally. What makes the CHT a uniquely dangerous AMR environment is the set of conditions that accelerate the selection and spread of resistant organisms in this specific territory: the widespread, unsupervised use of antibiotics from informal pharmacies and drug shops where prescription-only antimicrobials are dispensed without prescription and frequently at sub-therapeutic doses or in incomplete courses; the near-total absence of systematic AMR surveillance producing the data that would be needed to guide empirical therapy and monitor resistance trends; the proximity to Myanmar, which the 2024 Global Antimicrobial Resistance and Use Surveillance System (GLASS) data identified as one of the countries with

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the highest documented AMR burden in Southeast Asia; the population movements across the porous CHT-Myanmar border that create pathways for importation of highly resistant organisms; the high burden of enteric infections, respiratory infections, and wound infections that create large populations exposed to antibiotic selection pressure; and the inadequate infection prevention and control infrastructure in CHT health facilities that allows nosocomial amplification and transmission of resistant organisms.

The CHT Antimicrobial Resistance Doctrine holds that AMR in the CHT must be understood and managed through a One Health framework that simultaneously addresses the human health, animal health, and environmental dimensions of resistance emergence and spread. The environmental dimension is particularly important and particularly underappreciated in the CHT context. Agricultural antibiotic use, including the use of veterinary antibiotics in poultry and pig farming (both of which are practiced in multiple CHT communities), the application of antibiotic-containing manure to jhum fields, and the contamination of water sources with antibiotic residues from animal husbandry, all contribute to the environmental resistome (the totality of resistance genes present in microbial communities in a given environment) that provides a reservoir from which resistance determinants can be transferred to human pathogens. The 2025 study documenting AMR in Bangladesh floodwaters found that flood events, which are common in parts of the CHT, concentrate and distribute resistance genes and multidrug-resistant organisms across large geographic areas, creating landscape-scale AMR dissemination events with public health consequences that extend far beyond the immediate flood zone. In the CHT, the monsoon season, which creates intense surface runoff, flooding of low-lying settlements, and contamination of water sources, may function as an annual AMR dissemination event that resets the ecological baseline for resistance gene concentration in the territory.

2.2 Malaria Drug Resistance in the CHT: The Artemisinin Frontier

The emergence of partial artemisinin resistance in Plasmodium falciparum in the Greater Mekong Subregion (GMS) and its progressive westward spread toward Bangladesh represents the most urgent specific AMR threat in the CHT's clinical landscape, and one that demands detailed and technically precise engagement in this textbook. Artemisinin-based combination therapies (ACTs) are the current gold standard treatment for uncomplicated P. falciparum malaria globally, recommended by WHO as first-line therapy across all malaria-endemic settings. The partial artemisinin resistance phenotype, defined by delayed clearance of parasites from the peripheral blood following ACT treatment (specifically, the persistence of detectable parasitemia on day 3 of artemether-lumefantrine treatment when the expectation is near-complete clearance), is mediated primarily by mutations in the Kelch13 (K13) propeller domain gene of P. falciparum. The K13 C580Y mutation is the most clinically important and most prevalent K13 resistance mutation in the GMS, and it has been documented in Bangladesh P. falciparum isolates collected at the CHT-Myanmar border zone, though its prevalence in CHT isolates from Rangamati and Khagrachhari districts remains incompletely characterized.

The clinical implications of partial artemisinin resistance in the CHT are profound and demand immediate attention from clinicians and program managers. Partial artemisinin resistance does not mean that ACTs are completely ineffective: in isolates with K13 mutations but without

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concurrent resistance to the ACT partner drug (lumefantrine in the case of artemether-lumefantrine, or piperaquine in the case of dihydroartemisinin-piperaquine), treatment outcomes remain acceptable in the majority of cases. However, the combination of K13-mediated artemisinin partial resistance with concurrent partner drug resistance, which is the pattern producing the highest rates of treatment failure in the GMS (specifically, the combination of K13 C580Y with PfKelch13-mediated reduced sensitivity to piperaquine in Cambodia-origin strains), creates a situation of effective ACT failure that leaves patients with no accessible pharmacological alternative in settings where injectable artesunate for severe disease is unavailable and where the next-generation antimalarials (such as KAF156-M5717 combination, ganaplacide-lumefantrine, and other compounds in the WHO malaria drug development pipeline as of 2025) are not yet approved or available. The CHT clinician must therefore maintain heightened clinical vigilance for treatment failure, defined as persistent fever and parasitemia on day 3 of ACT treatment, persistent high parasitemia on day 2, or recrudescence of P. falciparum after apparent clearance within 28 days of treatment, and must have a clear escalation protocol for managing apparent ACT treatment failure, which in the CHT context should include immediate referral to district hospital level for intravenous artesunate and closer monitoring.

The tuberculosis drug resistance situation in the CHT, while less acutely crisis-level than the artemisinin resistance threat, represents a chronically escalating AMR risk that the healthcare system has not adequately measured or addressed. Multidrug-resistant tuberculosis (MDR-TB), defined as resistance to at least isoniazid and rifampicin, the two most powerful first-line anti-TB drugs, requires treatment with longer, more complex, more expensive, and more toxic second-line drug regimens over eighteen to twenty-four months, with cure rates substantially lower than those achieved with first-line regimens in drug-sensitive TB. The CHT's geographic proximity to Chin State in Myanmar, where TB drug resistance rates have been documented at levels substantially higher than the Bangladesh national average, and the cross-border population movements described in Chapter Ten of Part One of this textbook, create conditions for ongoing importation of MDR-TB into the CHT. The current national TB surveillance system in Bangladesh does not routinely perform drug sensitivity testing for M. tuberculosis isolates from remote CHT communities, meaning that MDR-TB cases in these communities may be treated empirically with first-line regimens to which the organism is resistant, with consequent treatment failure, continued transmission, and progressive acquisition of additional resistance mutations. The introduction of the GeneXpert MTB/RIF assay, which detects rifampicin resistance in approximately two hours and serves as a proxy marker for MDR-TB, to all CHT district hospitals represents a minimum standard of care that should be implemented immediately and sustained with appropriate supply chain management.

Typhoid fever drug resistance in the CHT is now an urgent and rapidly evolving clinical concern following the detection in April 2024 of a ceftriaxone-resistant Salmonella Typhi strain (genotype 4.3.1.2, harboring the bla-CTX-M-15 gene on the pCROB1 plasmid) in Bangladesh. This outbreak, documented in forty-seven cases during April to September 2024, signals the emergence of a resistance phenotype that critically threatens the management of typhoid fever in resource-limited settings including the CHT, where ceftriaxone is the most commonly accessible parenteral antibiotic for severe infection management at district hospital level. The ceftriaxone-resistant S. Typhi isolates reported in 2024 belong to the genotype 4.3.1.2 lineage that also

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harbors resistance to first-line drugs (chloramphenicol, ampicillin, trimethoprim-sulfamethoxazole) and to fluoroquinolones (ciprofloxacin), making this effectively an extensively drug-resistant typhoid strain, treatable only with azithromycin (to which resistance is also emerging, with current prevalence below 4 percent but with documented 38-fold increase in azithromycin consumption in Bangladesh creating strong selection pressure for further resistance development) or with carbapenems (which are essentially unavailable in the CHT and available only in major urban reference centers). The clinical implication is that typhoid fever presenting in the CHT in 2026 and beyond must be treated with extreme caution, with the recognition that empirical ceftriaxone therapy may fail and that the optimal management of severe, ceftriaxone-resistant typhoid in the CHT context requires urgent escalation to a facility with access to advanced microbiological susceptibility testing and to carbapenem-class antibiotics.

2.3 The Informal Pharmacy System and Antibiotic Stewardship in the CHT

The informal pharmacy system of the CHT, encompassing the thousands of licensed and unlicensed drug shops, rural medical practitioners (locally called doctors but without formal medical qualification), and village-level drug dispensers who provide the first-line of pharmaceutical access for the majority of CHT indigenous community members, is the most important and most neglected battleground for AMR in the territory. In most remote areas of the CHT, the formal health system is functionally absent as a first-contact provider, and the drug shop is the de facto healthcare provider to which community members turn when they are ill, when their child has a fever, when their family member has a wound, or when they have a cough that will not resolve. Drug shops in the CHT dispense antibiotics across a wide spectrum, including amoxicillin, ampicillin, tetracycline, metronidazole, ciprofloxacin, and azithromycin, without prescription, without diagnostic confirmation of bacterial infection, and frequently at doses and durations inconsistent with evidence-based treatment guidelines. The resulting antibiotic exposure is fragmentary, unpredictable, and highly conducive to resistance selection: sub-therapeutic doses select for resistant mutants without eliminating susceptible organisms; inadequate treatment durations leave partially treated infections as incubators for resistance; and the unrestricted dispensing of broad-spectrum agents creates unnecessary selection pressure on the commensal microbiome that harbors transferable resistance genes.

The Antibiotic Stewardship Doctrine for the CHT, as articulated in this textbook, holds that antibiotic stewardship in the CHT cannot be modeled on the inpatient stewardship programs developed for tertiary care hospitals in high-income settings, where a stewardship team with access to full microbiological data guides prescribing through electronic surveillance and prospective audit-and-feedback mechanisms. CHT antibiotic stewardship must operate at the community level, through the informal pharmacy network, and must engage drug shop operators, rural medical practitioners, community health workers, and community members themselves as the primary stewardship agents, rather than relying on formal prescribers (who are rarely present at the point of first antibiotic contact in remote CHT communities) or on regulatory enforcement (which is structurally impossible in the terrain of the CHT). The evidence base for community-level antibiotic stewardship in low-income settings suggests that training drug shop operators in rational antibiotic dispensing, combined with community education about appropriate antibiotic use and the consequences of antibiotic resistance, can meaningfully reduce antibiotic misuse in

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these settings. These approaches have not been systematically implemented in the CHT and represent a major unaddressed opportunity for AMR mitigation.

2.4 Laboratory Capacity for AMR Surveillance in the CHT: An Honest Assessment

The gap between the AMR surveillance capacity that the CHT needs and the AMR surveillance capacity that actually exists in the CHT is vast, and it must be articulated honestly in this textbook because it is the gap that makes all subsequent discussion of AMR management hypothetical in nature. Effective AMR surveillance requires the capacity to collect clinical specimens from infected patients, to culture pathogenic organisms from these specimens, to identify organisms to species level by standardized microbiological methods, to perform antimicrobial susceptibility testing using validated methods (disk diffusion, broth microdilution, or automated systems such as VITEK or BD Phoenix), to report results with appropriate quality assurance, and to aggregate results into interpretable epidemiological data that can guide prescribing practice and policy. None of these capabilities exists in the remote primary and secondary care facilities of the CHT. Culture and sensitivity testing is available at the three CHT district hospitals in principle, but supply chain inconsistencies (culture media, reagents, and quality control organisms must be sourced from Chittagong or Dhaka and are frequently unavailable due to transportation delays and procurement failures), equipment maintenance gaps, and the absence of trained microbiologists from most CHT facility staffing complements mean that in practice, clinical microbiology services in CHT district hospitals are intermittent, often unreliable, and vastly underutilized. The practical consequence is that essentially all antibiotic prescribing in the CHT is empirical, based on clinical judgment and epidemiological knowledge rather than on microbiological diagnosis of the individual patient's infection, and that empirical therapy guidelines cannot be locally calibrated to CHT-specific resistance patterns because those patterns are not being measured.

The Minimum Viable AMR Surveillance System for the CHT, as proposed in this textbook, would consist of the following components: a sentinel surveillance network of three to five health facilities (one per district, at district hospital level) with the laboratory capacity to perform culture and standardized antimicrobial susceptibility testing on a defined panel of specimen types (blood cultures, sputum, urine, and wound swabs) from a defined panel of common clinical presentations (febrile illness, pneumonia, urinary tract infection, wound infection, and diarrheal disease); a data management and reporting system to aggregate and analyze susceptibility data from the sentinel network and produce regular antimicrobial resistance reports; and a linkage to the national and regional AMR surveillance systems (Bangladesh GLASS reporting, WHO regional AMRSP) to contextualize CHT-specific data within the broader resistance landscape of South Asia. This system, while far below the ideal of universal surveillance, would provide the minimum data infrastructure needed to detect the emergence of critical resistance phenotypes (such as ceftriaxone-resistant typhoid or artemisinin-resistant malaria) in the CHT before they have caused irretrievable clinical damage, and to generate empirical prescribing guidelines calibrated to the CHT's specific resistance ecology rather than extrapolated from national data that may not reflect CHT-specific patterns.

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2.5 Case Study: The Management of a Complex Antimicrobial Resistance Scenario in the CHT

A 35-year-old male Tanchangya patient, a subsistence jhum farmer from a remote area of Khagrachhari district, presents to the Khagrachhari District Hospital with a two-week history of high fever, severe headache, generalized malaise, and abdominal discomfort. He reports having received two separate courses of antibiotics from a local drug shop over the preceding ten days (the first course was unspecified tablets he took for five days, identified retrospectively as amoxicillin-clavulanate 250/125 mg twice daily, a subtherapeutic dose and insufficient duration; the second course was ciprofloxacin 250 mg twice daily for three days, again subtherapeutic). On examination, he is febrile at 39.4 degrees Celsius, has a relative bradycardia (pulse 76 beats per minute despite high fever, a finding that should immediately raise the clinical probability of enteric fever), and has a faintly palpable spleen on deep inspiration. A malaria RDT is negative (both HRP2 and pLDH formats). A full blood count shows white cell count 3.8 x10^9/L (leukopenia, another finding consistent with enteric fever), hemoglobin 10.2 g/dL (mild anemia), and platelets 118 x10^9/L (thrombocytopenia). Liver function tests show mild elevation of alanine aminotransferase (ALT) at 78 IU/L. Widal test is positive at O antigen 1:320 and H antigen 1:160. Blood culture is collected and sent to Chittagong Medical College for processing (with full awareness of the time delay this entails).

The clinical diagnosis of probable enteric fever (typhoid or paratyphoid) in this patient is made on clinical, epidemiological (the CHT has endemic typhoid transmission), and serological grounds, while awaiting blood culture confirmation. The AMR complexity arises from the need to select empirical treatment in the context of documented ceftriaxone-resistant S. Typhi in Bangladesh from 2024, combined with this patient's prior exposure to fluoroquinolone (ciprofloxacin) that may have selected for fluoroquinolone non-susceptibility in the infecting organism, and considering that azithromycin (the remaining oral option for drug-resistant typhoid) has its own emerging resistance trend. The clinician's decision, following consultation with the on-call infectious disease physician at Chittagong Medical College Hospital by telephone, is to initiate parenteral meropenem (a carbapenem, available at Khagrachhari District Hospital as part of the essential medicines procurement) at 1 g every 8 hours intravenously, with recognition that this represents the most broad-spectrum and resistance-overcoming option available in the facility while blood culture susceptibility results are awaited, and with antibiotic stewardship review scheduled for 48 to 72 hours after culture and sensitivity reporting. This case illustrates both the clinical urgency of the 2024 ceftriaxone-resistant S. Typhi development and the need for clinical decision-making capacity at CHT district hospitals to manage complex resistance scenarios through pre-established consultation pathways with tertiary referral centers.

MODEL EXAMINATION QUESTIONS: CHAPTER TWO

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The primary genetic mechanism of partial artemisinin resistance in Plasmodium falciparum, as described in this chapter, involves mutations in which gene? a) Pfcrt (chloroquine resistance

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transporter) b) Pfmdr1 (P-glycoprotein homolog) c) Pfkelch13 (K13 propeller domain gene) d) Pfdhfr (dihydrofolate reductase) (Correct Answer: c)

Ceftriaxone-resistant Salmonella Typhi detected in Bangladesh during 2024 harbored resistance mediated by which specific beta-lactamase gene? a) bla-TEM-1 b) bla-SHV-12 c) bla-CTX-M-15 d) bla-NDM-1 (Correct Answer: c)

Multidrug-resistant tuberculosis (MDR-TB) is defined as resistance to at least which drugs? a) Streptomycin and ethambutol b) Isoniazid and rifampicin c) Pyrazinamide and cycloserine d) Rifabutin and moxifloxacin (Correct Answer: b)

The relative bradycardia (pulse-temperature dissociation) in the enteric fever case study is a classic finding that arises from: a) Drug-induced cardiac toxicity from prior antibiotic use b) Autonomic neuropathy from malnutrition c) The effect of Salmonella endotoxin-mediated vagal stimulation and direct myocardial depression on heart rate despite high fever d) Complete heart block from direct cardiac invasion by Salmonella Typhi (Correct Answer: c)

The horizontal gene transfer mechanism most responsible for the rapid spread of plasmid-borne resistance determinants (including bla-CTX-M genes) among Enterobacteriaceae is: a) Transduction by bacteriophage b) Transformation through naked DNA uptake c) Conjugative transfer via self-transmissible plasmids d) Transposition by mobile genetic elements exclusively (Correct Answer: c)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A CHT district hospital physician must choose empirical antibiotic therapy for a critically ill patient with suspected severe typhoid fever (altered consciousness, high fever, abdominal distension, leukopenia) in 2026, knowing the following: fluoroquinolone non-susceptibility is present in more than 90% of S. Typhi in Bangladesh; ceftriaxone-resistant S. Typhi was detected in a 2024 Bangladesh outbreak; azithromycin resistance is below 4% but rising; meropenem is available at the facility. The most appropriate choice is: a) Oral azithromycin 500 mg once daily for 7 days b) Intravenous ceftriaxone 2g once daily c) Intravenous meropenem 1g every 8 hours, with blood culture collection and planned antibiotic stewardship review at 48 to 72 hours pending susceptibility data d) Intravenous ampicillin 2g every 6 hours (Correct Answer: c)

A CHT public health officer proposes a community-level antibiotic stewardship program for remote Bandarban communities. According to the Antibiotic Stewardship Doctrine for the CHT articulated in this chapter, the primary focus of this program should be: a) Regulation of all drug shops through police enforcement b) Training hospital prescribers in antimicrobial stewardship protocols c) Training drug shop operators in rational antibiotic dispensing and educating community members about appropriate antibiotic use d) Establishing a full clinical microbiology laboratory in every upazila health complex (Correct Answer: c)

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CHAPTER THREE: ADVANCED DERMATOLOGICAL AND PARASITIC DISEASE DIAGNOSIS AND MANAGEMENT IN THE CHITTAGONG HILL TRACTS

3.1 The Dermatological Burden: A Landscape of the Skin

The skin, the largest organ of the human body and the primary interface between the human organism and the external environment, bears in the CHT a disease burden that reflects the totality of the territory's environmental, ecological, and social conditions with particular directness and visibility. The CHT's dermatological burden is structured by the convergence of five environmental-biological axes: the vector and pathogen-rich forest ecology that creates opportunities for arthropod-transmitted, fungal, bacterial, and parasitic skin infections; the occupational hazard profile of jhum farming, forest work, and fishing that creates mechanical skin trauma, chemical exposures, and prolonged sun and water exposure; the nutritional deficiency that impairs skin barrier function, wound healing, and immune defense against skin pathogens; the WASH deficit that creates conditions for proliferation of skin-infecting organisms in overcrowded, water-insecure households; and the indigenous medical practices that include topical application of plant preparations of variable sterility and composition. Understanding the CHT dermatological burden as a reflection of these structural conditions, rather than as a collection of discrete, individually explicable skin diseases, is the foundational principle of the CHT Dermatological Diagnostic Framework.

Scabies, caused by the mite Sarcoptes scabiei var. hominis, is the most prevalent skin disease in most CHT community surveys, and its epidemiology in the CHT illustrates the structural determinants of skin disease with particular clarity. Scabies transmission requires prolonged, direct skin-to-skin contact with an infested individual, and it is therefore fundamentally a disease of overcrowding, poverty, and limited access to water for bathing and washing. In CHT communities where multiple family members sleep together on mats in a single bamboo room, where bathing facilities are limited to shared access to streams or rivers (which may be seasonal in their accessibility), and where the itching-induced scratching and subsequent secondary bacterial superinfection of scabies lesions is treated with traditional topical preparations (some of which are efficacious, others of which may cause chemical irritation or introduce additional organisms) rather than with permethrin or ivermectin (the pharmacological gold standards for scabies treatment), scabies produces not merely the primary skin infestation but a cascade of secondary complications including impetigo (Staphylococcus aureus and Streptococcus pyogenes infection of scabies excoriations), glomerulonephritis (Group A streptococcal infection of scabies lesions is a documented trigger for post-streptococcal glomerulonephritis in resource-poor settings, with potential long-term renal consequences), and sepsis (from the bacteremic spread of scabies-associated streptococcal and staphylococcal skin infections in malnourished, immunocompromised children). The CHT scabies-streptococcal-renal injury pathway represents a causal chain that links skin disease directly to chronic kidney disease through a mechanism of particular relevance in the CHT given the co-existence of scabies, malnutrition, inadequate WASH, and the developing CKD burden described in Chapter One.

Tinea versicolor (pityriasis versicolor), caused by Malassezia species (lipophilic yeasts that are normal skin commensals), is almost universally prevalent in the CHT's warm, humid climate,

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particularly in the post-monsoon season when the combination of heat, humidity, and sweat retention under clothing creates optimal conditions for Malassezia overgrowth. Tinea versicolor produces the characteristic hypo- or hyperpigmented, fine-scaling macules that are most visible on the trunk and upper extremities, and while the infection itself is benign and non-communicable, its cosmetic impact in communities where skin discoloration may carry social stigma, and its overlap in appearance with other hypopigmentation conditions (particularly vitiligo and pityriasis alba, and more importantly, the hypopigmented leprosy lesion) demands accurate clinical differentiation. The Wood's lamp examination (producing the characteristic yellowish-green fluorescence of Malassezia under ultraviolet light) and potassium hydroxide (KOH) preparation microscopy (demonstrating the classic "spaghetti and meatballs" appearance of Malassezia hyphae and yeast cells) are the primary diagnostic tools for tinea versicolor and should be available at upazila health complex level. The specific dermatological concern in the CHT context is that tinea versicolor may be misidentified as a hypopigmented leprosy lesion (in leprosy-endemic districts, where the threshold of suspicion for leprosy should be maintained), or vice versa, because the visual appearance can be superficially similar in some presentations, and the clinical consequences of misidentification in either direction are significant.

3.2 Leprosy in the CHT: History, Persistence, and Clinical Vigilance

Leprosy, caused by Mycobacterium leprae, occupies a specific position in the CHT health landscape that is historically significant and clinically important. Bangladesh was declared to have achieved leprosy elimination (defined by the WHO as fewer than 1 case per 10,000 population at the national level) in 1998, and reported new case detection rates have been maintained below the elimination threshold nationally. However, leprosy elimination at the national level does not mean elimination in all districts, and the CHT, given its combination of poverty, overcrowding, nutritional deficiency (which impairs the cellular immune response that normally contains M. leprae infection), delay-to-care patterns, and the documented presence of leprosy-endemic conditions in neighboring Chin State of Myanmar, represents a territory where the risk of persisting leprosy transmission above the elimination threshold is plausible and where clinical vigilance for the disease must be maintained. The clinical diagnosis of leprosy in a CHT setting requires familiarity with the full spectrum of its clinical presentations, from the single, well-defined hypopigmented anesthetic patch of paucibacillary tuberculoid leprosy (the form associated with strong cellular immune control, low bacillary load, and characteristic nerve involvement producing anesthesia in the skin lesion and nerve thickening) to the widespread, bilaterally symmetric infiltrated plaques, nodules, and leonine facies of multibacillary lepromatous leprosy (the form associated with impaired cellular immunity, high bacillary load, systemic dissemination, and the full range of leprosy complications including claw hand, foot drop, lagophthalmos, corneal exposure, and reactive states including erythema nodosum leprosum). The diagnosis of leprosy in a resource-limited CHT setting is clinical, based on the identification of one or more of the three cardinal signs (a skin lesion with definite sensory loss, thickened peripheral nerves, and positive acid-fast bacilli on skin smear), and does not require specialized laboratory testing. This makes leprosy diagnosis accessible at the primary care level in the CHT, provided that clinicians and health workers have sufficient clinical training to recognize the disease in its early presentations.

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3.3 Leishmaniasis in the CHT: An Emerging or Neglected Threat

Visceral leishmaniasis (kala-azar), caused by Leishmania donovani and transmitted by the sandfly Phlebotomus argentipes, is a major public health problem in the Mymensingh, Rajshahi, and Rangpur divisions of Bangladesh, where the disease is hyperendemic, but has historically been reported as absent or rare in the CHT. This absence has been attributed to ecological factors including the different sandfly fauna of the CHT (Phlebotomus argentipes preferring plains environments with specific soil conditions, while the CHT's forest ecology may support different sandfly species of lower L. donovani transmission competence), but the question of whether L. donovani transmission is truly absent from the CHT or merely underdiagnosed due to limited surveillance has never been definitively resolved. The clinical and epidemiological case for maintaining leishmaniasis in the differential diagnosis of chronic febrile illness with splenomegaly in CHT patients rests on several considerations. First, the border with Myanmar's Chin State creates conditions for cross-border leishmaniasis transmission; Leishmania species including L. donovani and L. tropica have been documented in Myanmar, and population movements bring individuals from leishmaniasis-endemic Myanmar regions into the CHT regularly. Second, the cutaneous leishmaniasis complex, caused by L. major and related species transmitted by Old World sandflies in arid environments, is not geographically implausible in some CHT border areas, and the chronic, non-healing ulcerative skin lesion that characterizes cutaneous leishmaniasis could easily be misattributed to other causes (Buruli ulcer from Mycobacterium ulcerans, chronic staphylococcal or streptococcal wound infection, chromoblastomycosis from dematiaceous fungi) in a CHT clinical setting where leishmaniasis is not in the standard differential diagnosis.

3.4 Helminthic and Other Parasitic Infections: Advanced Clinical Management

The helminthic infection burden of the CHT, described in its epidemiological dimensions in Part One, Chapter Five of this textbook, demands deeper clinical engagement in the advanced diagnostic and therapeutic context of Part Eight. The clinical management of helminthic infections in the CHT is complicated by four factors that distinguish CHT helminthic disease from helminthic infection in better-resourced settings. First, polyhelminthism (simultaneous infection with multiple helminth species) is the norm rather than the exception in CHT communities with high soil-transmitted helminth (STH) prevalence, and the clinical presentation reflects the aggregate parasitological burden rather than the signature presentation of any single species. A child with concurrent Ascaris lumbricoides, Trichuris trichiura, and hookworm infection (a combination documented in high-STH-burden settings globally) will exhibit a composite of the anemia from hookworm blood loss, the nutritional competition and occasional intestinal obstruction from heavy Ascaris burden, and the dysentery and growth failure from heavy Trichuris infection, creating a clinical picture more complex than the textbook description of any single helminth species. Second, malnutrition, which is profound and prevalent in CHT children, produces an immune state that impairs the normally protective T-helper-2 (Th2)-dominated response to helminths, allowing worm burdens to accumulate to higher levels than in adequately nourished individuals before any clinically detectable immune response develops. Third, the interaction between helminthic infection and malaria has been the subject of significant scientific controversy: some research suggests that the Th2 immune polarization

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induced by helminthic infection may dampen the Th1 response needed to control Plasmodium infection, potentially increasing malaria susceptibility and severity in helminth-coinfected individuals, while other evidence suggests more complex or neutral interactions. The clinical relevance of this controversy in the CHT context, where coinfection with both malaria and helminths is common, is that clinicians managing malaria in helminth-endemic CHT communities should be aware of the potential for helminthic coinfection to modify malaria's clinical course and should consider routine helminth treatment alongside malaria management in children presenting from high-STH-burden communities.

Lymphatic filariasis, caused by Wuchereria bancrofti and transmitted by Culex mosquitoes, is present in parts of Bangladesh and has been documented in some CHT districts, where the Culex breeding conditions of stagnant water in human settlements create transmission opportunities. The clinical spectrum of lymphatic filariasis ranges from asymptomatic microfilaremia (the microfilariae are detectable in peripheral blood, with characteristically nocturnal periodicity reflecting the peak nighttime biting activity of Culex vectors, but the individual is clinically well) through acute filarial fever (recurrent febrile episodes produced by the local inflammatory response to dying adult worms or microfilariae in the lymphatics) to chronic lymphedema and elephantiasis (the irreversible lymphatic obstruction and tissue changes produced by repeated inflammatory episodes around adult worms, resulting in grotesque swelling of the affected limb or genitalia). The clinical diagnosis of lymphatic filariasis in the CHT setting requires blood sampling at night (ideally between 10 PM and 2 AM) for the detection of microfilariae on thick blood film or by membrane filtration, or the use of antigen detection tests (the immunochromatographic card test, ICT, which detects circulating W. bancrofti antigen regardless of time of day and regardless of microfilaremia status). The management of lymphatic filariasis in the CHT includes the pharmacological treatment of active infection (diethylcarbamazine citrate, DEC, is the primary treatment for W. bancrofti lymphatic filariasis, with or without albendazole and ivermectin co-treatment depending on the regional co-endemic status of other filarial parasites) and the long-term management of established lymphedema (through limb hygiene protocols, elevation, compression bandaging, and treatment of secondary bacterial infections, which are a major driver of progressive lymphedema deterioration and which are particularly prevalent in CHT patients with existing skin barrier compromise from nutritional deficiency and scabies).

MODEL EXAMINATION QUESTIONS: CHAPTER THREE

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The scabies-streptococcal-renal injury pathway described in this chapter connects skin disease to chronic kidney disease through which mechanism? a) Direct infection of the kidneys by Sarcoptes scabiei b) Group A streptococcal superinfection of scabies excoriations triggering post-streptococcal glomerulonephritis c) Ivermectin nephrotoxicity from scabies treatment d) Autoimmune crossreaction between scabies antigens and glomerular basement membrane (Correct Answer: b)

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The microfilaremia of Wuchereria bancrofti filariasis in Bangladesh shows which temporal periodicity in peripheral blood? a) Diurnal periodicity (peak daytime, trough at night) b) No periodicity, constant throughout the day and night c) Nocturnal periodicity (peak at night, trough during the day) d) Crepuscular periodicity (peak at dusk and dawn) (Correct Answer: c)

The three cardinal signs used for clinical diagnosis of leprosy in resource-limited settings are: a) Fever, splenomegaly, and skin nodules b) Skin lesion with definite sensory loss, thickened peripheral nerves, and positive acid-fast bacilli on skin smear c) Anesthetic skin lesions, alopecia, and nasal collapse d) Leonine facies, saddle-nose deformity, and madarosis (Correct Answer: b)

The KOH preparation of a tinea versicolor lesion scraping characteristically shows: a) Thick-walled spherical spores of Cryptococcus b) Broad hyphae with right-angle branching consistent with Mucor c) Short hyphae and clusters of round yeast cells (spaghetti and meatballs appearance) d) Branching septate hyphae with conidiophores consistent with Aspergillus (Correct Answer: c)

Which of the following T-helper cell subtypes provides the primary immune response to helminthic infections? a) Th1 (primarily IFN-gamma secreting, important for intracellular pathogens) b) Th2 (primarily IL-4, IL-5, IL-13 secreting, important for large extracellular parasites) c) Th17 (primarily IL-17 secreting, important for extracellular bacterial infections) d) Treg (regulatory T cells, suppressing immune responses) (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 9-year-old Mro child from Alikadam is brought to the upazila health complex by her parents with a three-month history of a single, well-defined, pale patch on her left forearm. The patch is flat, does not itch, and the child reports that she cannot feel touch in the area. She has no fever and appears otherwise well. The physician notes that the left ulnar nerve is slightly thicker than normal on palpation. According to the diagnostic criteria articulated in this chapter, this presentation is most consistent with: a) Tinea versicolor requiring topical antifungal treatment b) Vitiligo requiring dermatological referral c) Paucibacillary tuberculoid leprosy requiring multidrug therapy initiation and notification to the national leprosy program d) Post-inflammatory hypopigmentation not requiring specific treatment (Correct Answer: c)

A CHT district hospital physician encountering a 45-year-old male Marma fisherman with a three-month history of fever, progressive weight loss (8 kg over three months), massive splenomegaly, and pancytopenia should include which organism in the differential diagnosis as specifically relevant to the CHT-Myanmar border context described in this chapter? a) Only Plasmodium falciparum (malaria) b) Only Mycobacterium tuberculosis (visceral tuberculosis/miliary TB) c) Leishmania donovani (visceral leishmaniasis/kala-azar) alongside malaria and tuberculosis, given the CHT-Myanmar border context and the potential for underdiagnosed L. donovani transmission in the territory d) Only Schistosoma mansoni (schistosomiasis) (Correct Answer: c)

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CHAPTER FOUR: CARDIOVASCULAR DISEASE, STROKE, AND CEREBROVASCULAR DISORDERS IN THE CHITTAGONG HILL TRACTS

4.1 The Cardiovascular Epidemiology of the CHT: Mapping the Emerging Burden

Cardiovascular disease (CVD), encompassing coronary artery disease, acute myocardial infarction, heart failure, stroke, and peripheral arterial disease, represents the single largest category of death by disease globally according to the 2024 Global Burden of Disease data, responsible for approximately 18 million deaths annually. In Bangladesh, cardiovascular diseases account for an estimated 30 percent of all deaths according to WHO estimates, representing the leading cause of mortality in the adult population. The CHT has historically been characterized in the national health discourse as a territory whose primary health challenges are infectious and nutritional rather than cardiovascular, and this characterization was accurate for most of the twentieth century and into the early twenty-first century. It is no longer accurate, and the clinical and public health failure to recognize the emergence of cardiovascular disease as a significant and growing CHT health burden risks creating a generation of undetected, untreated, and preventable cardiovascular events in the CHT population. The CHT Cardiovascular Epidemiology Principle, introduced here, holds that the cardiovascular risk profile of the CHT population is the product of the interaction between the classical cardiovascular risk factors (hypertension, diabetes, dyslipidemia, tobacco use, obesity, family history, age, and male sex) and the CHT-specific risk modifiers (the chronic inflammatory burden of parasitic infection, the specific patterns of malnutrition-associated metabolic programming, the psychosocial stress of structural violence, the dietary transition described in Chapter One, the altitude effects on cardiovascular physiology in high-CHT communities, and the genetic architecture of cardiovascular risk in specific CHT ethnic populations), producing a risk profile that cannot be accurately estimated from standard cardiovascular risk calculators derived from non-CHT populations.

The relationship between chronic Plasmodium falciparum malaria and long-term cardiovascular disease risk is a dimension of CHT cardiovascular epidemiology that is beginning to be elucidated in the research literature and that has significant clinical implications. Severe malaria episodes are associated with acute cardiovascular stress through multiple mechanisms: the hemolytic anemia of severe malaria reduces oxygen-carrying capacity and forces compensatory increases in cardiac output that may precipitate acute cardiac decompensation in individuals with pre-existing left ventricular dysfunction; the systemic inflammatory cytokine storm of severe malaria produces transient myocardial depression; the acute microvascular obstruction of P. falciparum-parasitized erythrocytes (which are stiff, less deformable, and prone to cytoadherence to the vascular endothelium of multiple organ systems including the heart and brain) can produce focal myocardial ischemia and cerebrovascular events; and the recurrent nature of malaria in high-transmission areas of the CHT means that some individuals experience multiple severe malaria episodes over years or decades, with each episode potentially producing cumulative cardiovascular damage that aggregates into clinically manifest cardiovascular disease. This malaria-cardiovascular trajectory has been proposed theoretically in the literature but has not

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been demonstrated in long-term prospective cohort studies conducted in the CHT, representing a critical gap in the understanding of cardiovascular disease pathogenesis in this population.

4.2 Stroke in the CHT: Diagnosis, Management, and the Time-to-Treatment Crisis

Stroke, the acute focal neurological deficit produced by sudden interruption of blood supply to a region of the brain (ischemic stroke, accounting for approximately 87 percent of strokes globally) or by rupture of a blood vessel within the brain (hemorrhagic stroke, accounting for the remaining 13 percent), is a medical emergency in which every minute of delay in diagnosis and treatment results in the death of approximately 1.9 million neurons, 14 billion synapses, and 12 kilometers of myelinated nerve fibers (the "time is brain" quantification of stroke urgency). In the CHT, the management of stroke faces obstacles that make the neurological time-sensitivity of the condition catastrophically difficult to address within the structural realities of the territory. The nearest facility with computed tomography (CT) imaging capability required for the primary diagnosis of stroke (to distinguish ischemic from hemorrhagic stroke, a distinction on which the entire subsequent management pathway depends) is Chittagong Medical College Hospital, a journey from remote CHT communities that may require six to twelve hours or more under favorable road conditions and up to 24 hours or longer during monsoon season when roads are impassable. The 4.5-hour thrombolytic therapy window for ischemic stroke (the time from symptom onset within which intravenous tissue plasminogen activator, tPA, can be administered safely with expected benefit) is effectively closed for the vast majority of CHT stroke patients before they can reach CT imaging capability, meaning that thrombolysis is not a realistic treatment option for most CHT ischemic strokes.

The appropriate management protocol for stroke in the CHT, given the absence of thrombolysis capability, focuses on three achievable goals: first, accurate clinical recognition of stroke using the validated stroke recognition tools (particularly the FAST mnemonic: Face drooping, Arm weakness, Speech difficulty, Time to call for help), which can be taught to community health workers and community members to accelerate recognition and referral; second, stabilization and supportive care at the primary facility level (blood pressure management, blood glucose monitoring and correction of hypoglycemia or severe hyperglycemia, aspiration prevention through appropriate patient positioning, airway management, and prevention of secondary complications including deep vein thrombosis and pressure sores); and third, urgent referral to a facility with CT capability and specialist neurology or internal medicine consultation, with meticulous documentation of time of symptom onset to allow accurate assessment of the thrombolytic window and to enable appropriate early antiplatelet therapy for ischemic stroke (aspirin 300 mg loading dose is safe and beneficial in ischemic stroke from 24 to 48 hours after onset, or immediately after hemorrhage has been excluded by imaging, and represents a practically achievable secondary prevention intervention at the CHT primary care level). The clinical diagnosis of stroke in a resource-limited CHT setting must rely on the history and physical examination, with particular attention to the pattern of neurological deficit (sudden onset, focal, maximum at onset for ischemic stroke; often associated with severe headache and progressive deterioration for hemorrhagic stroke), the identification of vascular risk factors (hypertension history, diabetes, atrial fibrillation suggested by irregular pulse, tobacco use, prior stroke or transient ischemic attack), and the exclusion of stroke mimics (hypoglycemia, which

can produce focal neurological signs indistinguishable from stroke and which must be tested by bedside blood glucose in every apparent stroke patient as an urgent priority; Todd's palsy following a focal seizure; hyperosmolar hyperglycemic state; and subdural hematoma following head trauma).

4.3 Rheumatic Heart Disease: The Unfinished Business of Poverty Cardiology

Rheumatic heart disease (RHD), the cardiac valvular damage produced by the autoimmune inflammatory response to Group A Streptococcal (GAS) pharyngitis (through the molecular mimicry mechanism in which antibodies against streptococcal M protein cross-react with cardiac tissue antigens, particularly in the mitral and aortic valves), remains a significant and underdiagnosed cardiovascular burden in the CHT, representing what global cardiovascular health advocates have called the "unfinished business of poverty cardiology" in low-income settings where primary prevention through prompt streptococcal pharyngitis treatment with benzathine penicillin G has not been implemented systematically. The epidemiology of RHD in the CHT has not been rigorously studied, and community-based echocardiographic screening of the kind used in global RHD prevalence studies (which have documented subclinical or clinical RHD rates of 2 to 5 percent in school-age children in high-burden countries) has not been conducted in the CHT. However, the risk factors for GAS pharyngitis and for progression from GAS infection to acute rheumatic fever and subsequent RHD are all strongly present in the CHT: overcrowded household living conditions that facilitate GAS transmission; limited access to healthcare for prompt antibiotic treatment of pharyngitis; malnutrition impairing the immune response to GAS; and the absence of primary prevention programs (including school-based benzathine penicillin administration for documented or suspected GAS pharyngitis) in remote CHT communities. The clinical consequence is that the CHT likely carries a burden of established RHD in young adults (presenting with mitral stenosis or mitral regurgitation in the third and fourth decades, producing dyspnea, atrial fibrillation, heart failure, and thromboembolic stroke) that is invisible to the health system because routine cardiac examination and echocardiography are not available in most CHT clinical settings.

4.4 Heart Failure Management in the CHT: A Clinical Protocol for Resource-Limited Practice

Heart failure, the clinical syndrome in which the heart is unable to maintain sufficient cardiac output to meet the metabolic demands of the body, or is able to do so only at the cost of abnormally elevated filling pressures, producing dyspnea, fluid retention, exercise intolerance, and the progressive deterioration of end-organ function, is the final common pathway of most forms of cardiovascular disease and is therefore the most common presentation of cardiovascular disease to CHT health facilities. The clinical recognition of heart failure in the CHT requires the integration of clinical history (dyspnea on exertion or at rest, orthopnea, paroxysmal nocturnal dyspnea, leg swelling, reduced exercise capacity), physical examination (elevated jugular venous pressure, bibasal lung crackles, S3 or S4 heart sounds, displaced apex beat, peripheral edema, hepatomegaly, ascites in right heart failure), and point-of-care diagnostics that are realistically available at CHT district hospital level (chest radiograph demonstrating cardiomegaly and pulmonary venous congestion, electrocardiogram demonstrating left ventricular hypertrophy,

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prior myocardial infarction, atrial fibrillation, or other causative arrhythmias). N-terminal pro-brain natriuretic peptide (NT-proBNP) or brain natriuretic peptide (BNP) measurement, the biomarker-based cornerstone of heart failure diagnosis in high-income country guidelines, is not realistically available at CHT facilities and should not be included in CHT heart failure management protocols as a prerequisite for diagnosis.

The pharmacological management of heart failure in the CHT requires rational adaptation of evidence-based guidelines to the medicine availability, patient factors, and monitoring capacity of the CHT setting. The cornerstone of heart failure with reduced ejection fraction (HFrEF) management is the combination of renin-angiotensin-aldosterone system (RAAS) blockade (ACE inhibitor or ARB, with the 2024 ESC guidelines recommending angiotensin receptor-neprilysin inhibitor, ARNI, as preferred over ACE inhibitor where feasible), beta-blockade (bisoprolol, carvedilol, or metoprolol succinate), mineralocorticoid receptor antagonism (spironolactone or eplerenone), and sodium-glucose cotransporter-2 (SGLT2) inhibition (empagliflozin or dapagliflozin, which have demonstrated robust mortality and hospitalization reduction in HFrEF in multiple large randomized controlled trials from 2019 to 2024). The practical availability of these agents in CHT facilities requires honest assessment: ACE inhibitors (enalapril or lisinopril) are available at most CHT district hospitals and should be first-line RAAS blockade in CHT heart failure management; beta-blockers (bisoprolol or carvedilol) are generally available and should be included in every CHT HFrEF management protocol; spironolactone is available and affordable; but ARNI (sacubitril-valsartan) and SGLT2 inhibitors (empagliflozin, dapagliflozin), despite their evidence base, are not yet reliably available in CHT facilities and cannot be included in first-line CHT protocols, though they should be considered when available and when the patient's economic circumstances permit. Digoxin, while no longer a guideline-recommended drug for mortality improvement in heart failure, retains a role in heart failure management in the CHT for rate control in atrial fibrillation complicating heart failure, and requires careful dose adjustment in CHT patients with renal impairment (a common concurrent condition, as discussed in Chapter One).

MODEL EXAMINATION QUESTIONS: CHAPTER FOUR

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The FAST mnemonic for community recognition of stroke stands for: a) Fever, Ataxia, Speech difficulty, Trauma b) Face drooping, Arm weakness, Speech difficulty, Time to call for help c) Focal weakness, Altered consciousness, Syncope, Tingling d) Fatigue, Angina, Shortness of breath, Tachycardia (Correct Answer: b)

The time window within which intravenous tissue plasminogen activator (tPA) can be administered safely for ischemic stroke is: a) 1 hour from symptom onset b) 4.5 hours from symptom onset c) 12 hours from symptom onset d) 24 hours from symptom onset (Correct Answer: b)

Rheumatic heart disease is caused by the autoimmune inflammatory response to Group A Streptococcal pharyngitis, operating through which mechanism? a) Direct bacterial invasion of

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cardiac valves b) Deposition of immune complexes in the valve leaflets c) Molecular mimicry in which antibodies against streptococcal M protein cross-react with cardiac tissue antigens d) T-cell-mediated granulomatous inflammation of cardiac valves (Correct Answer: c)

The SGLT2 inhibitors (empagliflozin, dapagliflozin) have demonstrated which benefit in heart failure with reduced ejection fraction (HFrEF) in recent major randomized controlled trials? a) Benefit in heart failure only in diabetic patients b) Robust reduction in cardiovascular mortality and heart failure hospitalization regardless of diabetic status c) Improvement in ejection fraction as the primary mechanism of benefit d) Blood pressure lowering as the sole mechanism of cardiovascular benefit (Correct Answer: b)

The neurological assessment finding in a stroke patient that most urgently requires immediate blood glucose measurement before any other diagnostic step is: a) Unilateral arm weakness b) Slurred speech c) Any focal neurological deficit, because hypoglycemia can cause focal signs mimicking stroke and must be immediately excluded d) Loss of consciousness (Correct Answer: c)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 38-year-old Chakma woman presents to Rangamati District Hospital with progressively worsening dyspnea over two months, now present at rest. She has an irregular pulse, bilateral basal lung crackles, and a loud, rumbling, low-pitched diastolic murmur best heard at the cardiac apex. She has a history of recurrent throat infections in childhood for which she never received antibiotic treatment. The most likely underlying diagnosis and its specific pathogenetic mechanism are: a) Dilated cardiomyopathy from nutritional deficiency; mechanism is diffuse myocardial fiber loss b) Mitral stenosis from rheumatic heart disease; mechanism is molecular mimicry between anti-streptococcal antibodies and mitral valve leaflet antigens producing chronic inflammatory valvular fibrosis, calcification, and stenosis c) Hypertensive heart disease with mitral annular calcification; mechanism is pressure overload left ventricular hypertrophy d) Infective endocarditis from subclinical bacteremia; mechanism is direct bacterial adherence to valve leaflets (Correct Answer: b)

CHAPTER FIVE: CANCER EPIDEMIOLOGY AND ONCOLOGICAL CARE DEFICITS IN THE CHITTAGONG HILL TRACTS

5.1 The Cancer Burden: Invisible, Untreated, and Preventable

Cancer in the CHT is a domain of extraordinary and largely invisible suffering. Invisible because most CHT cancer patients never receive a confirmed cancer diagnosis, dying instead with a recorded cause of death that is vague, untestable, or simply absent from any formal registration. Untreated because the distance from the nearest oncology service (at Chittagong Medical College Hospital or at national cancer centers in Dhaka) is so great and the financial cost so prohibitive that the vast majority of CHT cancer patients who do receive a diagnosis cannot

access treatment. Preventable in significant proportion because the most prevalent cancers in the CHT are strongly associated with exposures that are potentially modifiable: tobacco and betel nut use driving oral, pharyngeal, laryngeal, and esophageal cancers; human papillomavirus (HPV) infection driving cervical cancer; hepatitis B and C infection driving hepatocellular carcinoma; aflatoxin contamination of poorly stored maize, groundnut, and rice (crops widely grown in jhum fields and stored in conditions of temperature and humidity that favor Aspergillus flavus growth) contributing to hepatocellular carcinoma risk; and helicobacter pylori infection driving gastric cancer. Each of these preventable cancer drivers is amenable to intervention through immunization (HPV vaccine, hepatitis B vaccine), infection treatment (H. pylori eradication), tobacco cessation, food storage improvement, and screening programs that detect precancerous lesions or early-stage cancers when curative treatment is possible.

The oral cancer burden of the CHT demands the most urgent and specific clinical attention of any cancer category, because it is the most prevalent cancer type with the most directly modifiable risk factor (betel nut-tobacco chewing), the most accessible cancer for clinical screening by visual examination (the oral cavity can be inspected without specialized equipment), and the most dramatically late-presenting in CHT patients who lack access to routine oral health services. Betel nut chewing, a practice integrated into the social fabric of multiple CHT ethnic communities (the offering and acceptance of betel nut is a gesture of social hospitality and communal belonging in Chakma, Marma, Tanchangya, and other communities), exposes the oral mucosa to the arecoline alkaloid of the areca nut (which is a direct-acting genotoxin and a Group 1 human carcinogen as classified by the International Agency for Research on Cancer) and, when tobacco is added to the betel quid preparation, to the additional carcinogenic assault of nitrosamines and polycyclic aromatic hydrocarbons from the tobacco. The progression from betel nut-tobacco chewing to oral cancer follows a well-characterized pathological sequence: normal oral epithelium, leukoplakia (white hyperkeratotic plaques that represent early dysplasia), erythroplakia (red velvety patches with a higher risk of high-grade dysplasia than leukoplakia), oral submucous fibrosis (a specific fibrotic reaction to arecoline that produces progressive submucosal fibrosis, reduced mouth opening, and a dramatically elevated malignant transformation rate of 7 to 13 percent over a decade), and ultimately frank oral squamous cell carcinoma. Each stage of this sequence is clinically detectable by visual oral examination, and the detection of leukoplakia, erythroplakia, or oral submucous fibrosis at a CHT primary care encounter represents an opportunity for secondary prevention through counseling to cease chewing and referral for definitive assessment and management.

Cervical cancer is the leading cause of cancer death in women of reproductive age across South Asia and is almost certainly the leading cancer cause of death in women in the CHT, where the risk factors for cervical cancer (early age at first intercourse, multiple sexual partners, high parity, tobacco use, immunocompromise from malnutrition and parasitic infection, and most importantly, HPV infection with high-risk oncogenic types, particularly HPV-16 and HPV-18) are prevalent, and where cervical cancer screening through Pap smear or visual inspection with acetic acid (VIA) is essentially unavailable in remote communities. The national cervical cancer vaccination program using the quadrivalent HPV vaccine has been rolled out in Bangladesh for school-age girls, but coverage in remote CHT communities, particularly those with limited school attendance rates among girls (a specific problem in the most marginalized communities),

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has been incomplete and represents a specific HPV vaccine equity gap that requires targeted outreach program design.

Hepatocellular carcinoma (HCC) in the CHT is almost certainly more prevalent than officially recorded, given the documented prevalence of hepatitis B virus (HBV) infection in CHT indigenous communities (HBV is the leading global etiological agent for HCC, causing 50 to 55 percent of HCC cases worldwide), the high prevalence of aflatoxin exposure from poorly stored food, and the documented alcohol use disorder in some CHT communities (alcohol itself is a hepatic carcinogen and a synergistic cofactor with both HBV and aflatoxin in HCC pathogenesis). The clinical presentation of HCC in CHT patients is almost universally at advanced, unresectable stages, because the insidious development of the tumor within a liver already compromised by chronic HBV infection and the delay-to-care pathway of the CHT mean that the tumor is typically large, multifocal, or complicated by portal vein thrombosis or distant metastases by the time the patient seeks biomedical care. The CHT Hepatocellular Carcinoma Primary Prevention Strategy, as outlined in this textbook, should prioritize the completion of HBV vaccination coverage (the childhood HBV vaccination program in Bangladesh has achieved high coverage in accessible areas but has not fully reached the most remote CHT communities), the provision of HBV antiviral therapy (tenofovir or entecavir) to individuals with chronic HBV infection and active viral replication (who are at highest HCC risk and in whom antiviral treatment reduces HCC incidence by 40 to 50 percent in randomized controlled trials), and the improvement of food storage practices to reduce aflatoxin exposure through community education and the introduction of simple, affordable food storage technologies appropriate to the CHT context.

5.2 The Philosophical Problem of Oncological Justice in the CHT

The concept of oncological justice, introduced in this textbook, refers to the ethical principle that every person diagnosed with cancer is entitled to a standard of diagnostic evaluation and therapeutic opportunity proportional to what the scientific evidence shows is achievable in treating that cancer, regardless of the geography, ethnicity, or socioeconomic status of the person. Applied to the CHT, the principle of oncological justice exposes a profound inequity: a person of identical age and cancer stage living in Dhaka and a person in Alikadam face radically different probabilities of survival from the same cancer, not because their biology differs but because their geography determines their access to surgery, radiotherapy, chemotherapy, immunotherapy, and supportive care. The structural causes of this oncological injustice are the same structural causes that underlie all health inequities in the CHT: poverty, geographic inaccessibility, inadequate health infrastructure, financial barriers to tertiary care, and the systemic underinvestment in the health of indigenous communities that is the expression in healthcare of a broader pattern of political marginalization. The philosophical response of this textbook is not to accept this injustice as inevitable but to demand its interrogation and its progressive reduction through a combination of clinical innovation (mobile oncology outreach services, community-based palliative care programs, primary and secondary prevention programs that are CHT-specific and culturally appropriate), policy advocacy (increased health financing for remote indigenous communities, cancer screening program extension to the CHT),

and research (CHT-specific cancer epidemiology to document the burden, identify the highest-impact preventable causes, and guide resource allocation).

MODEL EXAMINATION QUESTIONS: CHAPTER FIVE

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Arecoline, the alkaloid responsible for much of the carcinogenicity of betel nut, is classified by the International Agency for Research on Cancer (IARC) as which level carcinogen? a) Group 2B (possibly carcinogenic to humans) b) Group 2A (probably carcinogenic to humans) c) Group 1 (carcinogenic to humans) d) Group 3 (not classifiable as to carcinogenicity) (Correct Answer: c)

Aflatoxin contamination of stored food crops in the CHT (maize, groundnut, rice) produces which primary cancer risk? a) Oral squamous cell carcinoma b) Hepatocellular carcinoma c) Cervical carcinoma d) Colorectal carcinoma (Correct Answer: b)

The HPV types most strongly associated with cervical cancer development (high-risk oncogenic types) are: a) HPV-6 and HPV-11 (most commonly causing genital warts) b) HPV-16 and HPV-18 c) HPV-31 and HPV-33 only d) HPV-45 and HPV-52 only (Correct Answer: b)

Oral submucous fibrosis, the premalignant condition associated with betel nut chewing, has a reported malignant transformation rate of approximately: a) Less than 1 percent over a decade b) 7 to 13 percent over a decade c) 50 percent over a decade d) Greater than 75 percent over a decade (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A CHT district hospital physician performing a routine examination of a 52-year-old Marma man who has chewed betel nut with tobacco for 35 years observes bilateral white plaques on the buccal mucosa that cannot be scraped off, with areas of red, velvety texture interspersed, and bilateral restriction of mouth opening to 25 mm (normal greater than 40 mm). Biopsy reveals oral submucous fibrosis with moderate epithelial dysplasia. The most important immediate clinical action beyond biopsy is: a) Initiate radiotherapy immediately for presumed oral carcinoma b) Advise complete and permanent cessation of betel nut and tobacco chewing, arrange close surveillance follow-up at 3-monthly intervals, and refer for specialist oral surgery assessment for evaluation of dysplastic areas c) Prescribe topical antifungal for presumed oral candidiasis d) Reassure the patient that this is a benign condition not requiring treatment (Correct Answer: b)

CHAPTER SIX: PHARMACOLOGY IN THE CHT: DRUG METABOLISM, PHARMACOGENOMICS, AND THERAPEUTIC CHALLENGES

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6.1 The Pharmacological Uniqueness of the CHT Patient

Pharmacology, the science of drug action and the body's handling of drugs, is conventionally taught as a universal discipline in which the same drug at the same dose produces the same effect in all patients. This universality is a pedagogical simplification, not a biological reality. The CHT patient is pharmacologically distinct from the patient described in drug labeling and clinical trial participant profiles in ways that are clinically significant and that can produce unexpected drug responses, dangerous adverse effects, or therapeutic failure if not recognized and accommodated. The CHT Pharmacological Uniqueness Principle, articulated here for the first time as a formal clinical concept, holds that the combination of the CHT patient's nutritional status, genetic background, concurrent disease burden, ethnomedicinal co-treatment, and specific organ function profile produces a pharmacological milieu that is uniquely configured, differing systematically from the pharmacological milieu in which most clinically used drugs were tested and characterized, and demanding specific adaptations in drug selection, dosing, monitoring, and substitution in the CHT clinical context.

The nutritional dimension of CHT pharmacology is the most pervasive and the most practically important. Protein-energy malnutrition, which is prevalent across CHT indigenous communities as documented throughout this textbook, alters virtually every parameter of drug handling. Absorption of orally administered drugs may be reduced by the mucosal atrophy and reduced intestinal motility of chronic malnutrition, reducing bioavailability below that expected in well-nourished individuals and potentially requiring higher oral doses to achieve therapeutic blood levels. Distribution of drugs throughout the body is altered by the reduced plasma protein binding capacity of malnutrition (hypoalbuminemia means less drug is protein-bound in the plasma, increasing the free drug fraction and potentially intensifying pharmacological effects at given total drug concentrations); by the reduced lean body mass that decreases the volume of distribution for lipophilic drugs; and by the altered body water composition of severe malnutrition (edema in kwashiorkor increases the volume of distribution for water-soluble drugs, while the dehydration of severe wasting may reduce it). The hepatic metabolism of drugs is impaired by malnutrition through reduced activity of cytochrome P450 enzymes (the primary drug-metabolizing enzyme superfamily in the liver), reduced hepatic blood flow, and reduced synthesis of the conjugating enzymes that perform phase II metabolism. Renal excretion of drugs and their metabolites is potentially compromised by the reduced glomerular filtration rate that accompanies malnutrition-associated renal impairment. The aggregate effect of these malnutrition-induced pharmacological changes is that standard drug doses may produce higher blood levels, more prolonged drug effects, and a higher risk of concentration-dependent adverse effects in severely malnourished CHT patients compared with well-nourished individuals.

6.2 Pharmacogenomics and Ethnicity-Specific Drug Responses in the CHT

Pharmacogenomics, the study of how genetic variation influences drug response, has demonstrated that polymorphisms in genes encoding drug-metabolizing enzymes, drug transporters, drug targets, and immune molecules produce clinically important differences in drug efficacy and adverse effects among individuals and among population groups with different ancestral genetic backgrounds. The pharmacogenomic landscape of CHT indigenous populations

is almost completely uncharacterized, representing a profound knowledge gap that has direct clinical consequences. The specific pharmacogenomic variants known to be clinically relevant in South and Southeast Asian populations, and that may be present in CHT indigenous populations given their genetic relationships to these broader ethnic groups, include the following.

CYP2C19 polymorphisms affect the metabolism of proton pump inhibitors (particularly omeprazole and pantoprazole, which are now prescribed with increasing frequency for H. pylori eradication and for acid-related conditions in CHT district hospitals), clopidogrel (an antiplatelet drug important in cardiovascular secondary prevention that is a prodrug requiring CYP2C19-mediated bioactivation to its active thiol metabolite, meaning that poor metabolizers of CYP2C19 who carry the loss-of-function alleles CYP2C19*2 and *3 have reduced clopidogrel activation and may not receive adequate antiplatelet protection), and several antidepressants including sertraline and escitalopram. The CYP2C19*3 allele, which is rare in European populations but present at clinically relevant frequencies in East and Southeast Asian populations (with whom CHT indigenous communities share genetic ancestry through the Tibeto-Burman linguistic and ancestral heritage), may be relevant in CHT populations and should be considered when standard CYP2C19 substrate drug doses appear ineffective or when unexpected drug accumulation occurs.

The G6PD deficiency polymorphism, already discussed in the context of primaquine-related hemolysis in malaria management (Chapter Five of Part One), has broader pharmacogenomic relevance beyond primaquine. G6PD-deficient individuals are also at risk of hemolytic anemia from other oxidant drugs including dapsone (used in leprosy multidrug therapy as a component of the WHO-recommended regimen), nitrofurantoin (used for urinary tract infections), and some sulfonamides (including sulfadoxine in SP combinations, though the hemolytic risk from SP at antimalarial prophylactic doses is lower than from primaquine). The wide range of G6PD activities documented across the eleven ethnic groups of the CHT (demonstrated in a published study from the CHT), rather than a single G6PD deficiency prevalence rate, means that ethnic-specific G6PD activity data are needed to guide clinical management and that the current single-threshold-based approach to G6PD testing and primaquine dosing may not adequately capture the complexity of G6PD activity variation in the CHT population.

The N-acetyltransferase 2 (NAT2) polymorphism affects the acetylation of isoniazid, the primary first-line antituberculosis drug and one of the most commonly prescribed drugs in the CHT given the high TB burden. NAT2 slow acetylators, who accumulate isoniazid to higher plasma concentrations than rapid or intermediate acetylators, are at higher risk of isoniazid-induced peripheral neuropathy (which occurs in up to 20 percent of slow acetylators on standard doses without pyridoxine supplementation) and potentially of isoniazid hepatotoxicity. The prevalence of NAT2 slow acetylator genotypes varies significantly across ethnic groups, with South Asian populations generally having intermediate prevalence (lower than European populations, higher than East Asian populations). Without CHT-specific NAT2 genotyping data, the clinician prescribing isoniazid to CHT patients should ensure routine pyridoxine (vitamin B6) supplementation (10 to 25 mg daily) for all patients on isoniazid-containing TB regimens, as pyridoxine prevents isoniazid-induced peripheral neuropathy regardless of NAT2 genotype and represents a simple, affordable protective measure.

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6.3 Drug-Ethnomedicinal Interactions: A Neglected Clinical Frontier

The concurrent use of biomedical pharmaceuticals and traditional ethnomedicinal plant preparations, which is the norm rather than the exception in CHT patient care as demonstrated in the diagnostic cascade discussion of Part One, creates a specific pharmacological challenge: the potential for pharmacokinetic and pharmacodynamic interactions between biomedical drugs and the bioactive compounds in ethnomedicinal plants. This interaction territory is almost completely unstudied in the CHT context, representing a research gap with immediate clinical implications. The global ethnopharmacology literature provides evidence that numerous commonly used medicinal plants possess significant cytochrome P450 enzyme inhibitory or inductive activity, which can dramatically alter the blood levels of co-administered pharmaceutical drugs. St. John's Wort (Hypericum perforatum) is the most extensively characterized plant CYP inducer, but numerous Asian ethnomedicinal plants have been shown to possess comparable enzyme-modulating activity. Several specific plant species documented in the CHT ethnomedicinal pharmacopoeia (Chapter Four of Part One) have CYP-modulating properties identified in vitro or in animal studies that may be clinically relevant in co-treated patients.

Andrographis paniculata (Kalmegh, locally called Bhui Neem in some CHT communities), used in the CHT for fever and liver conditions, has been shown to inhibit CYP3A4 and CYP2C9 activity in in vitro studies, which could increase plasma concentrations of artemether and lumefantrine (both CYP3A4 substrates) to potentially toxic levels in patients receiving artemether-lumefantrine for malaria who are also taking Andrographis preparations, or could increase the plasma concentrations of warfarin (a narrow therapeutic index CYP2C9 substrate) in patients on anticoagulation therapy who self-treat with this plant. Curcuma longa (turmeric, widely used in CHT cooking and as a medicinal preparation), at the high medicinal doses used in traditional treatment (far exceeding dietary intake levels), has demonstrated CYP3A4 inhibitory activity that could affect the metabolism of multiple pharmaceutical drugs commonly used in the CHT. Piper betle (betel leaf, used in betel quid preparations and as a medicinal plant in some CHT communities), contains safrole and related compounds that are CYP inducers, potentially reducing the blood levels of co-administered drugs that are CYP substrates. The clinical CHT Pharmacological Safety Principle derived from this evidence holds that the clinician prescribing pharmaceutical drugs to a CHT patient who is also using traditional botanical preparations should specifically inquire about all traditional preparations being taken, should consider potential pharmacokinetic interactions involving CYP enzyme modulation, and should intensify clinical monitoring (and where possible, therapeutic drug monitoring) in the first weeks of a new pharmaceutical prescription in patients with ongoing ethnomedicinal co-treatment.

6.4 Cold Chain Challenges and Pharmaceutical Stability in the CHT

The maintenance of pharmaceutical cold chains, critical for the preservation of temperature-sensitive medicines including vaccines, insulin, oxytocin (for postpartum hemorrhage prevention), some antibiotics, and certain diagnostic reagents, is one of the most practically challenging logistical problems in CHT health system operations. The tropical climate of the CHT, with maximum temperatures frequently exceeding 35 degrees Celsius during the pre-monsoon season, combined with the unreliable electricity supply across most remote CHT

communities (most rural areas of the CHT receive electricity intermittently through the rural electrification network, and the most remote communities have no grid connection at all), creates conditions that routinely compromise the cold chain for temperature-sensitive medicines. The consequences of cold chain failure are multiple and serious: vaccines exposed to temperatures above the required storage range (typically 2 to 8 degrees Celsius for most vaccines; specific vaccines including live-attenuated ones such as BCG and varicella have narrower requirements) may partially or completely lose immunogenic potency, resulting in immunization that provides inadequate protection; insulin exposed to high temperatures beyond the 30-degree Celsius threshold for 28-day stability at room temperature degrades and loses its hypoglycemic activity; oxytocin stored above 2 to 8 degrees Celsius loses its uterotonic potency, potentially contributing to postpartum hemorrhage deaths in CHT delivery settings. The CHT Cold Chain Management Protocol, as outlined in this textbook, should include: regular training of CHT health facility staff in cold chain management practices including thermometer calibration, correct storage practices, excursion documentation, and vaccine vial monitor (VVM) reading; deployment of solar-powered refrigeration units for cold chain maintenance in off-grid communities; development of alternative last-mile vaccine delivery strategies (microplanning for more frequent delivery from cold chain-intact facilities, use of insulated vaccine carriers with phase-change material ice packs for outreach immunization sessions); and routine stock and temperature monitoring with digital data collection and real-time reporting to district health management teams.

MODEL EXAMINATION QUESTIONS: CHAPTER SIX

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

CYP2C19 polymorphism is clinically relevant to the efficacy of clopidogrel because: a) Poor metabolizers of CYP2C19 produce excessive active metabolite, causing bleeding complications b) Clopidogrel is a prodrug requiring CYP2C19-mediated bioactivation to its active thiol metabolite; poor metabolizers produce insufficient active drug and may not receive adequate antiplatelet protection c) CYP2C19 determines clopidogrel renal excretion d) CYP2C19 regulates clopidogrel protein binding rather than its biotransformation (Correct Answer: b)

The most important clinical measure to prevent isoniazid-induced peripheral neuropathy in CHT tuberculosis patients, regardless of their NAT2 genotype, is: a) Dose reduction of isoniazid to 50% of standard b) Routine pyridoxine (Vitamin B6) supplementation at 10 to 25 mg daily c) Monthly serum isoniazid level monitoring d) Substituting isoniazid with rifampicin in all CHT TB regimens (Correct Answer: b)

Malnutrition-induced hypoalbuminemia clinically relevant to drug therapy because: a) Protein-bound drugs are pharmacologically active; reduced albumin means less active drug b) Less drug is protein-bound in the plasma, increasing the free (pharmacologically active) drug fraction and potentially intensifying effects at standard total drug concentrations c) Albumin directly metabolizes most drugs in the plasma d) Reduced albumin increases renal clearance of all drugs (Correct Answer: b)

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The Vaccine Vial Monitor (VVM) is a device that: a) Measures the number of doses remaining in a vaccine vial b) Indicates cumulative heat exposure of a vaccine vial through a colorimetric change, allowing the user to assess whether the cold chain has been compromised c) Automatically records the vaccine lot number and expiry date d) Measures the electrical conductivity of the vaccine to confirm potency (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 42-year-old Marma woman with newly diagnosed chronic hepatitis B infection and type 2 diabetes is prescribed tenofovir disoproxil fumarate (TDF) for HBV and metformin for diabetes. She mentions that she is also taking a traditional Baiddya preparation containing concentrated turmeric (Curcuma longa) and Andrographis paniculata for "liver health." According to the CHT Pharmacological Safety Principle and the drug-ethnomedicinal interaction evidence cited in this chapter, the most important pharmacokinetic concern requiring enhanced monitoring is: a) Andrographis inhibition of CYP3A4 potentially increasing plasma TDF levels and risk of TDF-associated renal toxicity b) Turmeric direct toxicity to pancreatic beta cells opposing metformin's glucose-lowering effect c) No interaction is possible because traditional plant preparations are natural and cannot interact with pharmaceutical drugs d) Andrographis induction of renal excretion increasing metformin clearance below therapeutic levels (Correct Answer: a)

CHAPTER SEVEN: OPHTHALMIC AND EAR-NOSE-THROAT DISORDERS IN THE CHITTAGONG HILL TRACTS

7.1 The CHT Ophthalmic Burden: From Nutritional Blindness to Cataract

Ophthalmology in the CHT sits at the intersection of nutritional deficiency, infectious disease, agricultural hazard, and the aging process in a population that has historically had no access to eye care services. The ophthalmic burden of the CHT is dominated by five categories of preventable or treatable visual impairment: vitamin A deficiency-associated xerophthalmia and blindness, cataract, trachoma (if present, given regional endemic status in some bordering areas), refractive error uncorrected for lack of spectacles, and the ophthalmic complications of systemic diseases (diabetic retinopathy, hypertensive retinopathy, and the corneal scarring complications of measles and onchocerciasis, the latter not documented in Bangladesh but noted for completeness of differential diagnosis in patients with border-crossing histories). The cumulative effect of these conditions on visual function in CHT adults, particularly those in the older age groups who have been exposed to these ophthalmic risk factors across decades without access to corrective intervention, is a population-level visual impairment burden that has not been systematically measured but is almost certainly very substantial.

Vitamin A deficiency and its ocular consequences are most devastating in children and pregnant women. Night blindness (nyctalopia), the earliest and most recoverable clinical sign of vitamin A deficiency, occurring when rod photoreceptor function is impaired by the reduced availability of 11-cis retinal, the chromophore formed from dietary vitamin A in the photochemical cycle of

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vision, is a common and underreported symptom in CHT communities where vitamin A deficiency is prevalent, particularly in the pre-harvest lean season when dietary vitamin A sources are least available. The progression from night blindness to Bitot spots (triangular or oval white foamy patches on the temporal bulbar conjunctiva composed of keratin debris, metaplastic epithelial cells, and Corynebacterium xerosis organisms that produce the characteristic whitish, foamy appearance), and ultimately to corneal xerosis, keratomalacia, and corneal ulceration leading to permanent blindness, represents the full spectrum of xerophthalmic vitamin A deficiency and is a clinical emergency at its advanced stages, particularly in malnourished children with concurrent measles (which dramatically accelerates the severity of vitamin A deficiency-associated ocular disease and was a major driver of measles-related blindness globally before systematic vitamin A supplementation was incorporated into measles case management protocols). The high-dose vitamin A supplementation recommended in measles management (described in Part One, Chapter Nine) applies precisely to this risk of xerophthalmic progression in vitamin A-deficient CHT children with measles.

Cataract, the opacification of the crystalline lens of the eye producing progressive visual impairment, is the leading cause of treatable blindness globally and is very likely the leading cause of visual impairment in CHT adults over 50 years of age. The risk factors for cataract include advanced age (the primary driver of nuclear sclerotic cataract), prolonged ultraviolet B radiation exposure (a specific risk in the CHT context for the outdoor agricultural workforce who work without eye protection during peak sunlight hours), dehydrating illnesses (particularly diarrheal diseases with severe dehydration, which have been shown in epidemiological studies to accelerate cataract formation through osmotic and oxidative lens fiber injury), tobacco use (with documented association with posterior subcapsular and nuclear cataract types), and systemic disease associations including diabetes (posterior subcapsular cataract is the characteristic diabetic cataract type, occurring at a younger age and progressing more rapidly than the age-related nuclear cataract type) and the extended corticosteroid use that may occur in some CHT patients treated with traditional preparations containing steroids (a practice uncommon in orthodox CHT ethnomedicine but possible in the informal pharmaceutical sector where corticosteroids are dispensed without prescription). Cataract surgery (phacoemulsification or extracapsular cataract extraction with intraocular lens implantation) is highly effective in restoring vision in patients with visually significant cataract, with cure rates exceeding 90 percent in patients without coexisting posterior segment disease, but requires referral to an ophthalmology facility not available in the CHT territory itself, requiring patients to travel to Chittagong or Dhaka for surgical correction.

7.2 ENT Disorders: Chronic Suppurative Otitis Media and Its Consequences

Ear-nose-throat (ENT) disorders in the CHT are dominated in their clinical burden and their preventability-through-intervention potential by chronic suppurative otitis media (CSOM) and its complications. CSOM, defined as chronic infection of the middle ear cleft with persistent tympanic membrane perforation and intermittent or persistent mucopurulent otorrhoea for more than two weeks, is a disease of poverty and inadequate primary care, whose incidence and prevalence are inversely related to socioeconomic status, living conditions, and healthcare access quality across global studies. Its prevalence in CHT communities, while not formally measured,

is presumed to be high based on the prevalence of its primary risk factors: recurrent acute otitis media in childhood (driven by the same respiratory viral and bacterial pathogens responsible for the high childhood ARI burden documented in the CHT), inadequate antibiotic access for acute otitis media treatment (meaning that acute episodes are not adequately treated and progress to chronic suppuration), malnutrition (impairing the immune response to middle ear infection), and the use of traditional topical preparations in the ear canal (some of which may introduce additional organisms or irritate the perforated drum). The hearing loss produced by CSOM (a conductive hearing loss from the tympanic membrane perforation and the fluid or scar tissue in the middle ear cleft) has consequences that extend beyond the audiological to the developmental (in children, the hearing loss impairs language development, educational performance, and social interaction in ways that have lasting consequences for the child's life trajectory) and the social (adults with significant hearing loss face communication barriers that affect their employment, their healthcare interactions, and their social relationships in ways that compound the marginalization they already experience as indigenous CHT community members). The prevention of CSOM in the CHT requires prompt and adequate treatment of acute otitis media episodes, which in turn requires antibiotic availability and prescribing at the primary care level, combined with the nutritional and immunological improvements that reduce acute otitis media incidence.

The Chronic Ear Disease Prevention and Management Protocol for the CHT, as articulated in this textbook, consists of three levels. At the primary prevention level, the protocol focuses on vaccination against Streptococcus pneumoniae and Haemophilus influenzae type b (the primary bacterial pathogens in otitis media), promotion of exclusive breastfeeding for the first six months of life (breast milk provides protective immune factors that reduce otitis media incidence and severity), nutritional status improvement (reducing the immune vulnerability that makes otitis media more severe and more prone to CSOM development), and smoke exposure reduction (both indoor cooking fire smoke and tobacco smoke increase otitis media risk through mucosal irritation and ciliary dysfunction in the Eustachian tube). At the secondary prevention level, the protocol focuses on early recognition and treatment of acute otitis media with appropriate antibiotics (amoxicillin as first-line, with dose adjustments for age and weight, for a minimum of five days), aural hygiene education (keeping the ear canal dry, avoiding the introduction of contaminated water, and not inserting objects including cotton buds into the ear canal), and identification and referral of patients with persistent perforation for specialist otolaryngology assessment. At the tertiary management level, the protocol focuses on treating active CSOM infection (with both topical ciprofloxacin eardrops for milder cases and systemic antibiotic therapy with culture-guided selection where laboratory capability is available for more severe cases), managing CSOM complications (mastoiditis, cholesteatoma, intracranial extension of infection requiring neurosurgical intervention), and auditory rehabilitation (hearing aids or surgical tympanoplasty) for patients with permanent conductive hearing loss.

MODEL EXAMINATION QUESTIONS: CHAPTER SEVEN

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Bitot spots in vitamin A deficiency are located on: a) The corneal surface, appearing as white ulcers b) The temporal bulbar conjunctiva, appearing as triangular or oval white foamy patches c) The lower eyelid conjunctiva, appearing as papillary hypertrophy d) The sclera adjacent to the limbus, appearing as yellow deposits (Correct Answer: b)

Night blindness (nyctalopia) in vitamin A deficiency is caused by: a) Impaired aqueous humor drainage increasing intraocular pressure b) Corneal clouding from keratitis c) Reduced availability of 11-cis retinal for rod photoreceptor photochemical cycle, impairing rod-mediated vision in low light d) Optic nerve demyelination from vitamin A deficiency (Correct Answer: c)

The hearing loss associated with chronic suppurative otitis media (CSOM) is characteristically: a) Sensorineural (cochlear or retrocochlear) b) Mixed (combined sensorineural and conductive) c) Conductive (from tympanic membrane perforation and middle ear disease, with normal cochlear function) d) Functional (no organic basis, purely psychological) (Correct Answer: c)

Posterior subcapsular cataract is most specifically associated with which systemic condition? a) Hypertension b) Chronic renal failure c) Diabetes mellitus d) Chronic obstructive pulmonary disease (Correct Answer: c)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 7-year-old Mro child presents with a 4-month history of ear discharge from the right ear, which has been treated intermittently with traditional preparations (local oil and plant juice instillations). Examination shows a central tympanic membrane perforation with mucopurulent discharge in the right ear, no erythema of the postauricular area, no tenderness on mastoid palpation, and a normal contralateral ear. Pure tone audiometry reveals a 35 dB conductive hearing loss in the right ear. According to the CHT CSOM management protocol outlined in this chapter, the immediate clinical management should prioritize: a) Referral directly to Chittagong for immediate tympanoplasty surgery b) Topical ciprofloxacin otic drops for 2 weeks combined with aural hygiene instruction, observation for complications, and follow-up assessment, with referral for specialist otolaryngology evaluation if not resolving c) Systemic ampicillin for 10 days as the primary treatment d) No treatment needed as CSOM is a self-limited condition (Correct Answer: b)

CHAPTER EIGHT: GERIATRIC HEALTH, AGING, AND PALLIATIVE CARE IN THE CHITTAGONG HILL TRACTS

8.1 The Emerging Geriatric Crisis in an Aging CHT Population

The aging of the CHT population, a process that is occurring gradually but measurably as life expectancy at birth in Bangladesh has increased from 46 years in 1971 to an estimated 73 years in 2025, represents a coming demographic transformation with profound implications for the health system of the territory. The generation of CHT indigenous adults who are now entering

the age of 60 years and above is a generation that has lived through extraordinary adversity: many have survived the Kaptai displacement as children or young adults, the conflict period of 1975 to 1997, and the chronic structural marginalization that has characterized CHT indigenous life across the post-independence period. Their bodies carry the biological record of these experiences in the form of the allostatic load accumulated through decades of chronic stress, nutritional inadequacy, infectious disease exposure, and physical labor in demanding environmental conditions. This allostatic load, the cumulative biological cost of the body's repeated stress response activation over a lifetime, is expressed in accelerated biological aging, higher rates of chronic disease, greater burden of multimorbidity (the presence of multiple concurrent chronic conditions), and a functional decline trajectory that begins earlier and proceeds faster than in the aging populations of higher-income settings.

The qualitative study of barriers to healthcare access for elderly CHT indigenous people (cited in Part One of this textbook) documented that elderly indigenous individuals cited lack of knowledge about healthcare needs, geographical barriers, poor financial conditions, higher costs of medical services, scarcity of nearby hospitals, and communication barriers as the primary determinants of inadequate healthcare access. These barriers, which are severe for the general CHT population, are compounded for the elderly by additional age-specific factors: reduced physical mobility that makes the journey to a health facility even more arduous; cognitive impairment (from dementia or from the cumulative neurological effects of repeated malaria, cerebrovascular events, and nutritional deficiencies) that impairs the ability to self-navigate healthcare encounters; reduced social support in contexts where adult children have migrated to urban areas for economic reasons, leaving elderly parents without the family caregiver who is essential for healthcare navigation in the CHT context; and the specific communication barriers produced by age-related hearing loss and the need to speak through a family interpreter in language-discordant consultations. The aggregate effect is that elderly CHT indigenous individuals have the highest healthcare need and the lowest healthcare access of any demographic group in the territory, a pattern of inverted care that has profound ethical and practical implications for health system design.

The Geriatric Assessment Doctrine for the CHT, introduced in this textbook, holds that the clinical evaluation of elderly CHT patients requires a specific and adapted form of the comprehensive geriatric assessment (CGA) that has been validated as the gold standard for geriatric clinical evaluation in high-income settings, modified to be practically applicable in the CHT resource context and culturally appropriate for CHT indigenous communities. The full CGA in its high-income-country form encompasses assessment of medical conditions and medications, functional status (activities of daily living, instrumental activities of daily living), cognitive function (using validated dementia screening tools), psychological status (depression and anxiety screening), social circumstances and support, nutritional status, and falls risk. The CHT-adapted CGA retains all of these domains but simplifies the assessment tools to those usable without specialized equipment, validates the cultural and linguistic appropriateness of symptom and function descriptions, and integrates traditional community indicators of functional status (the ability to participate in jhum farming, fishing, weaving, or other community economic activities) as meaningful endpoints in addition to the standardized functional scales developed in Western geriatric research contexts.

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8.2 Dementia and Cognitive Impairment in the CHT: A Hidden Epidemic

Dementia, the progressive neurodegenerative syndrome characterized by deterioration of memory, language, executive function, visuospatial ability, and behavioral regulation severe enough to impair independent functioning, is a disease with a global age-standardized prevalence of approximately 5 to 8 percent in adults over 60 years and higher prevalence in older age groups, and it is almost certainly present in the CHT elderly population at clinically significant prevalence that has received no systematic investigation. The risk factors for dementia in low-income settings include, beyond the universal risk factors of age, genetic predisposition, and cardiovascular risk factors, a set of modifiable factors that are heavily concentrated in the CHT population: educational deprivation (lower educational attainment in earlier life is one of the strongest known modifiable risk factors for dementia, operating through the cognitive reserve pathway), hearing loss (now recognized as the single largest potentially modifiable risk factor for dementia by the 2024 Lancet Commission on Dementia Prevention, Protection and Care), depression, social isolation, physical inactivity, hypertension, diabetes, obesity, tobacco and alcohol use, and traumatic brain injury (from occupational and agricultural accidents that are common in the CHT). The cumulative modifiable risk factor burden in the CHT elderly population, where nearly every item on this list is present at elevated prevalence, suggests that the dementia risk in CHT elderly adults is substantially higher than the global average, and that the opportunity for dementia prevention through risk factor modification in middle-age and early older age is correspondingly substantial.

The clinical recognition of dementia in the CHT setting is complicated by the absence of validated, culturally and linguistically appropriate cognitive screening tools for CHT indigenous languages. The Mini-Mental State Examination (MMSE) and the Montreal Cognitive Assessment (MoCA), the most widely used cognitive screening tools in low-income country clinical practice, were developed in English and validated primarily in literate populations, and they have not been validated in Chakma, Marma, Mro, or any of the other indigenous languages of the CHT. Cultural norms around the assessment of an elderly person's cognitive abilities (which may be experienced as disrespectful or demeaning in some CHT community contexts) further complicate the clinical administration of standardized cognitive tests. The CHT Dementia Recognition Protocol therefore relies primarily on informant-based assessment (structured inquiry of family caregivers about changes in memory, language, orientation, personality, and functional ability) rather than on direct cognitive testing, supplemented where possible by the simple cognitive tests that can be administered without culturally inappropriate elements (such as date and year orientation, three-word recall, and clock drawing adapted to the patient's prior familiarity with clocks).

8.3 Palliative Care in the CHT: Death, Dying, and the Possibility of Dignity

Palliative care, defined by the WHO as an approach that improves the quality of life of patients and their families facing life-threatening illness, through the prevention and relief of suffering by means of early identification and impeccable assessment and treatment of pain and other physical, psychological, and spiritual problems, represents one of the most important and most neglected dimensions of healthcare in the CHT. The vast majority of CHT indigenous people

who are dying from cancer, end-stage organ failure, or progressive neurodegenerative disease die without access to the analgesic medications, symptom control measures, psychological support, spiritual care, and family guidance that constitute the core of palliative care. Pain relief, the most fundamental right of the dying person, is particularly compromised in the CHT by the severe restrictions on opioid analgesic availability in remote health facilities. Morphine and other strong opioids, the most effective medications for the management of severe cancer pain, are not available at CHT upazila health complexes or most district hospital level facilities, and the regulatory framework governing opioid prescribing in Bangladesh, while not prohibiting remote facility supply on clinical grounds, has in practice created an access barrier that leaves dying CHT patients without adequate pain control.

The CHT Palliative Care Doctrine, introduced in this textbook, holds that the development of a CHT-appropriate palliative care model must engage with the rich spiritual and community resources that already exist in CHT communities for the support of the dying, rather than attempting to transplant a biomedical palliative care model from high-income settings into a context where its prerequisites (trained palliative care specialists, opioid medication access, inpatient hospice beds) are absent. The Buddhist monastic community, the traditional community elder networks, and the extended family structures of CHT indigenous communities represent pre-existing capacities for dying support that can be strengthened through training, information sharing, and strategic integration with the biomedical elements of symptom management. A community volunteer-based palliative care model, in which trained community volunteers supported by primary care nurses and physicians provide home-based symptom monitoring, medication management (with simplified protocols for the management of pain, dyspnea, nausea, and other common palliative care symptoms using medicines available at district hospital level), family caregiver training, and the coordination of spiritual and community support, represents the most realistic and most CHT-appropriate framework for expanding palliative care access in the territory.

MODEL EXAMINATION QUESTIONS: CHAPTER EIGHT

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

According to the 2024 Lancet Commission on Dementia Prevention, Protection and Care, which of the following is identified as the single largest potentially modifiable risk factor for dementia? a) Obesity b) Hypertension c) Hearing loss d) Physical inactivity (Correct Answer: c)

The comprehensive geriatric assessment (CGA) encompasses which domains? a) Medical conditions and medications only b) Medical conditions, medications, functional status (ADLs and IADLs), cognitive function, psychological status, social circumstances and support, nutritional status, and falls risk c) Blood tests, imaging, and specialist referral only d) Physical examination and drug prescribing only (Correct Answer: b)

The concept of "allostatic load" refers to: a) The physiological cost of lifting heavy allostatic loads in agricultural work b) The cumulative biological cost of the body's repeated stress response activation over a lifetime, expressed as accelerated biological aging and higher chronic

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disease rates c) The weight of medications prescribed to elderly patients d) The algebraic sum of all risk factors for chronic disease (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

An 82-year-old Chakma woman is brought to a remote community health post in Rangamati by her daughter. The daughter reports that over the past 18 months, her mother has progressively stopped remembering the names of grandchildren, has become confused about which day it is, has twice gotten lost while walking to a familiar neighbor's house, and has become irritable and paranoid, accusing family members of stealing her belongings. She has no history of stroke, is not on any medications, and eats a regular family diet. According to the CHT Dementia Recognition Protocol described in this chapter, the most appropriate immediate action by the health worker at this facility is: a) Administer a full Montreal Cognitive Assessment (MoCA) in English b) Order an urgent CT brain scan c) Conduct a structured informant-based assessment of the observed functional and behavioral changes, document findings, assess for reversible causes (hypothyroidism, B12 deficiency, depression, medication side effects if applicable), and arrange referral for clinical evaluation at district hospital level d) Reassure the family that memory loss is a normal part of aging requiring no evaluation (Correct Answer: c)

CHAPTER NINE: ADOLESCENT HEALTH, GENDER-BASED VIOLENCE, AND SEXUAL AND REPRODUCTIVE HEALTH BEYOND MATERNAL CARE

9.1 The Adolescent Health Landscape of the CHT

Adolescence, the developmental period spanning from the onset of puberty (typically 10 to 11 years) through the completion of physical maturation and the consolidation of adult identity (typically 18 to 19 years, though increasingly extended to age 24 in the global developmental science literature), is a life stage of extraordinary health significance in the CHT because it concentrates in its compressed timeline multiple of the most consequential health transitions of the individual's life course. The adolescent health landscape of the CHT is shaped by the interaction of biological developmental processes with the specific social, economic, and structural conditions of the CHT: early marriage and early childbearing (which terminate adolescence prematurely and impose adult reproductive health risks on individuals whose physical development has not yet reached full maturity), educational disruption (particularly for girls, whose secondary school enrollment rates in remote CHT communities fall dramatically compared with those of boys), nutritional transition (with adolescents, particularly girls, being the demographic group most affected by the nutritional vulnerability of the pre-harvest lean season while simultaneously experiencing the highest nutritional demands of the pubertal growth spurt and, for girls, the added nutritional cost of adolescent pregnancy), and the specific mental health challenges of identity development in a context of political marginalization, cultural disruption, and the intergenerational trauma dynamics described in Part One, Chapter Eight.

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The double burden of anemia in CHT adolescent girls represents one of the most clinically significant and most amenable-to-intervention nutritional emergencies in the territory. Iron deficiency anemia in adolescent girls is produced by the convergence of three factors: the increased iron demand of the adolescent growth spurt and the commencement of menstruation (each of which increases iron requirements substantially above childhood levels); the chronic iron deficiency produced by the consistently iron-poor diets of CHT indigenous communities (whose primary dietary staple is unmilled rice, with limited consumption of meat, poultry, and fish due to poverty, cultural practices, and market access limitations, and with the high phytate content of the rice-based diet inhibiting the absorption of the non-heme iron that is the primary dietary iron source); and the additional iron loss from hookworm infection (which is prevalent in CHT communities and which produces chronic intestinal blood loss of 0.03 to 0.05 mL per worm per day, adding up to clinically significant iron depletion in individuals with heavy worm burdens). The aggregate effect is that iron deficiency anemia rates in CHT adolescent girls are extremely high, impair cognitive function (through the role of iron in neurotransmitter synthesis and myelin maintenance), reduce physical work capacity, increase susceptibility to infectious illness, and create the pre-pregnancy nutritional deficit that perpetuates the cycle of maternal anemia, low birth weight, and childhood malnutrition across generations.

9.2 Child Marriage and Its Health Consequences in the CHT

Child marriage, defined under international law as marriage before 18 years of age and as legally prohibited in Bangladesh under the Child Marriage Restraint Act, is prevalent across CHT communities at rates that exceed the Bangladesh national average and that reflect the intersection of poverty (which creates the economic pressure to reduce the financial burden of a daughter's support), the cultural valuation of girls' early marriage in some CHT communities as a marker of family honor and social standing, limited secondary educational opportunities for girls (which reduce the opportunity cost of marriage), and the absence of effective legal enforcement of the marriage age restriction in remote CHT communities where marriages are performed through customary community ceremonies rather than through formal civil registration. The health consequences of child marriage for the girls who experience it are extensive, documented, and preventable. Early pregnancy (which is the almost universal consequence of early marriage in communities without access to effective contraception) in girls under 18 years, and particularly under 15 years, carries dramatically elevated risks of obstructed labor (because the bony pelvis has not reached adult dimensions, and the fetal presenting part cannot descend through the birth canal without obstruction), obstetric fistula (the permanent injury to the vesicovaginal or rectovaginal tissues from prolonged obstructed labor, producing urinary or fecal incontinence and devastating social consequences), eclampsia (preeclampsia and eclampsia rates are higher in very young primigravidae than in older mothers), and maternal death. The children of adolescent mothers are more likely to be born preterm, to be of low birth weight, to experience childhood undernutrition, and to themselves be married young if female, creating an intergenerational transmission of child marriage's health consequences that is self-perpetuating without specific social and structural intervention.

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9.3 Gender-Based Violence in the CHT: The Clinical and Public Health Response

Gender-based violence (GBV), defined as violence directed at an individual based on their gender, encompassing intimate partner violence, sexual violence, sexual harassment, early and forced marriage, trafficking, and harmful traditional practices, is a significant and profoundly underreported health problem in the CHT. The specific political history of the CHT adds dimensions to GBV in this context that are not present in most other settings. The extensive documentation of sexual violence as a weapon of conflict during the 1975 to 1997 armed conflict period in the CHT, including the documented use of rape and sexual assault against indigenous women and girls as an instrument of military and political terror, has created a legacy of collective trauma around sexual violence in CHT indigenous communities that intersects with the stigma associated with rape survivors in many CHT communities to create powerful silencing forces that prevent disclosure, reporting, and treatment-seeking. The contemporary GBV landscape of the CHT includes ongoing domestic violence within households (with the specific vulnerabilities of women in settings where alcohol use disorder in male partners is prevalent, economic stress is extreme, and social support networks have been disrupted by displacement and political conflict), sexual violence associated with land conflicts and inter-community tensions in areas of active land dispute between indigenous communities and Bengali settlers, and the trafficking of young CHT women and girls (including across the border into Myanmar) that has been documented in reports from civil society organizations working in the CHT.

The clinical management of GBV in the CHT requires a protocol that is simultaneously medically comprehensive, legally aware, culturally sensitive, and practically adapted to the severe resource limitations of the territory. The One-Stop Crisis Centers (OSCCs) established by the Government of Bangladesh in district hospitals provide a framework for comprehensive GBV response (combining medical care, psychosocial support, legal assistance, and temporary shelter) but have not been established in all CHT district hospitals and have not been systematically adapted to the linguistic and cultural needs of CHT indigenous communities. The clinical components of GBV management that must be available at CHT district hospital level include: the forensic examination and documentation of injuries and assault evidence (with properly obtained, documented, and stored forensic samples where criminal prosecution is a possibility); emergency contraception (levonorgestrel 1.5 mg as a single dose, or ulipristal acetate, both effective up to 72 hours and the former somewhat effective up to 120 hours after unprotected intercourse) for sexual assault survivors at risk of unintended pregnancy; HIV post-exposure prophylaxis (PEP, using the standard tenofovir-lamivudine-dolutegravir triple regimen for 28 days, initiated as soon as possible and within 72 hours of exposure) for survivors of sexual assault who may have been exposed to HIV; STI prophylaxis (ceftriaxone for gonorrhea, doxycycline for chlamydia and syphilis, and metronidazole for bacterial vaginosis and trichomonas, as a syndromic package); and psychosocial first aid and referral to mental health services.

MODEL EXAMINATION QUESTIONS: CHAPTER NINE

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

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Emergency contraception with levonorgestrel is most effective when taken within: a) 12 hours of unprotected intercourse b) 24 hours of unprotected intercourse c) 72 hours of unprotected intercourse (with some effectiveness up to 120 hours) d) One week of unprotected intercourse (Correct Answer: c)

The three concurrent factors producing the double burden of anemia in CHT adolescent girls are: a) Malaria, vitamin A deficiency, and thyroid disease b) Increased iron demand from the adolescent growth spurt and menstruation, chronic iron-poor diet with phytate inhibition of iron absorption, and hookworm-associated intestinal blood loss c) Scurvy, rickets, and pellagra d) Sickle cell disease, thalassemia, and G6PD deficiency (Correct Answer: b)

Obstetric fistula is a complication of: a) Gestational diabetes b) Prolonged obstructed labor, producing ischemic injury to the vesicovaginal or rectovaginal tissues c) Postpartum hemorrhage managed with blood transfusion d) Peripartum cardiomyopathy (Correct Answer: b)

HIV post-exposure prophylaxis (PEP) should be initiated within how many hours of potential HIV exposure to be effective? a) 12 hours b) 48 hours c) 72 hours d) One week (Correct Answer: c)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 15-year-old Mro girl presents to the Alikadam UHC, accompanied by her mother, with a 12-hour history of severe lower abdominal pain and vaginal bleeding. She married 6 months ago. Her last menstrual period was 10 weeks ago. Urinary pregnancy test is positive. Examination reveals cervical os is open with products of conception visible at the os, and there is moderate fresh vaginal bleeding. Her pulse is 98 bpm and blood pressure is 95/65 mmHg. According to the clinical and public health principles of this chapter and the preceding reproductive health chapter, this presentation most likely represents which condition, and what is the immediate management priority? a) Normal threatened abortion; observation and bed rest b) Incomplete abortion with hemodynamic compromise; immediate evacuation of uterine contents (manual vacuum aspiration or curettage at the UHC level if trained personnel are available, or urgent referral to district hospital if not), with IV fluid resuscitation, oxytocin administration, and assessment and management of anemia c) Ectopic pregnancy; immediate surgical exploration d) Molar pregnancy; conservative management with follow-up hCG monitoring (Correct Answer: b)

CHAPTER TEN: TRANSLATIONAL RESEARCH, HEALTH TECHNOLOGY ASSESSMENT, AND EVIDENCE-BASED PRACTICE IN THE CHITTAGONG HILL TRACTS

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10.1 The Translational Research Gap in CHT Medicine

Translational research, the process by which discoveries at the bench (basic science) level are converted into clinical interventions (bedside application) and then into population-level public health practice (community implementation), represents the scientific engine of medical progress. The Translational Research Gap in the CHT, as defined in this textbook, refers to the systematic failure of the research cycle at every stage of translation within the CHT context: basic science discoveries relevant to the specific biology of CHT diseases and populations are rarely made in CHT research institutions; clinical research conducted in the CHT is sparse and often of low methodological quality; the evidence from research conducted elsewhere is incompletely or inappropriately translated to the CHT context because of the ecological, genetic, and social distinctiveness of the CHT population; and the translation of even well-conducted CHT-specific research into changes in clinical practice, health policy, and community health programs is slow, inconsistent, and frequently blocked by the structural barriers of inadequate health system funding and political disengagement from the CHT health agenda. The consequence of the Translational Research Gap is that CHT patients are treated with evidence generated in other populations, sometimes applicable and sometimes not; that the specific therapeutic opportunities afforded by the CHT's rich ethnomedicinal pharmacopoeia are not being systematically investigated and validated; that the clinical and public health interventions implemented in the CHT are often adaptations of programs designed for the Bangladesh plains rather than purpose-built for the CHT's unique medical geography; and that the knowledge base needed to guide equitable, effective, and culturally appropriate healthcare in the CHT accumulates far too slowly relative to the pace of the health crises it is needed to address.

The framework for addressing the Translational Research Gap in the CHT involves three interrelated strategies. The first strategy is CHT-Based Research Capacity Building, which means the systematic investment in developing research capability at CHT-based institutions (including the CHT medical colleges, if and when established, the research units of NGOs operating in the CHT, and community-based participatory research models that train and support CHT community members as co-investigators in health research). The second strategy is CHT-Specific Translational Trials, meaning the conduct of adaptive clinical trial designs that specifically test the efficacy and safety of both biomedical and traditional ethnomedicinal interventions in CHT populations, with outcomes measures appropriate to the CHT context, using methodologies that are feasible in resource-limited CHT research environments (such as community randomized trials, stepped wedge designs, and pragmatic trials embedded within routine care delivery). The third strategy is Implementation Science Integration, meaning the systematic application of implementation science frameworks (including the Consolidated Framework for Implementation Research, CFIR; the Reach-Effectiveness-Adoption-Implementation-Maintenance, RE-AIM, framework; and the Behavior Change Wheel) to understand the barriers to and facilitators of evidence-based practice adoption in CHT health facilities and communities, producing actionable knowledge about how to bridge the implementation gap between evidence and practice in this specific setting.

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10.2 Health Technology Assessment in the CHT: Principles of Rational Resource Allocation

Health technology assessment (HTA), the systematic evaluation of the clinical effectiveness, safety, cost-effectiveness, and broader social and ethical implications of health technologies (including medicines, medical devices, diagnostic tests, screening programs, and clinical procedures), is the methodological foundation of rational health resource allocation in evidence-based health systems. In the CHT, where health resources are chronically and severely inadequate relative to the health needs of the population, the allocation of the limited available resources to the interventions with the greatest health impact per unit of resource invested is not merely an administrative desideratum but an ethical imperative with direct consequences for life and death. The CHT Health Technology Assessment Doctrine, introduced in this chapter, holds that HTA in the CHT must incorporate a CHT-specific assessment of four dimensions that standard HTA frameworks do not adequately address: first, the Terrain Feasibility Assessment (the realistic evaluation of whether a health technology can be implemented, maintained, supplied, and monitored in the geographical and infrastructural conditions of the CHT, which may differ fundamentally from the assessment of the same technology's feasibility in a better-resourced setting); second, the Community Acceptability Assessment (the systematic evaluation of whether the health technology is acceptable to the specific CHT ethnic communities for whom it is intended, considering cultural, linguistic, cosmological, and historical factors that may create barriers or facilitators to technology adoption not captured in standard acceptability assessments); third, the Equity Impact Assessment (the evaluation of whether the health technology disproportionately benefits accessible, better-off communities within the CHT while failing to reach the most remote, most marginalized, and most health-deprived communities, which would make the technology an instrument of health inequity amplification rather than reduction); and fourth, the Structural Interaction Assessment (the evaluation of how the implementation of a health technology interacts with the structural determinants of health in the CHT, considering whether it addresses or bypasses the structural causes of the health problem it targets and whether its implementation is likely to strengthen or weaken the systemic capacities needed for long-term health system sustainability).

10.3 Evidence-Based Practice in the CHT: Adapting Global Evidence to Local Reality

Evidence-based medicine (EBM), the explicit, conscientious, and judicious use of current best evidence from clinical research in making decisions about the care of individual patients, was formally articulated by Gordon Guyatt and colleagues at McMaster University in the early 1990s and has since become the dominant paradigm for clinical decision-making in modern medicine globally. The CHT Contextual Evidence Principle, as developed in this textbook, holds that EBM as applied in the CHT must extend beyond the application of globally generated evidence to CHT patients, to include the critical appraisal of that evidence's applicability to the CHT context, the integration of CHT-specific evidence where it exists, and the disciplined use of Bayesian reasoning to adjust clinical decisions based on the CHT's specific epidemiological prior probabilities. The most common failure mode of evidence-based practice in the CHT is not the disregard of evidence but the uncritical application of evidence generated in populations, settings, and resource contexts fundamentally different from the CHT, without the critical appraisal step that would reveal the limitations of that evidence's applicability to the CHT. An

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example: the WHO stroke management guideline recommends CT imaging before any stroke therapy, which is evidence-based in settings where CT is available. In the CHT, where CT is unavailable at primary and secondary care levels and the time-to-CT exceeds the thrombolytic window, the uncritical application of this guideline results in no stroke-specific treatment being administered at any CHT facility below district hospital level, leaving patients without even the aspirin therapy that is safe, effective, and accessible. The CHT-adapted stroke protocol (described in Chapter Four of this Part) represents the appropriate application of EBM in this context: using the available evidence to identify the maximum evidence-based intervention achievable within the CHT's resource realities, rather than applying an impossible gold standard that results in no intervention at all.

The hierarchy of evidence that underpins standard EBM (with systematic reviews and meta-analyses of randomized controlled trials at the apex, followed by individual RCTs, cohort studies, case-control studies, case series, and expert opinion at the base) requires modification for the CHT clinical context. CHT-specific RCTs are essentially absent from the literature; CHT-specific cohort and case-control studies are sparse; and the available CHT health literature consists predominantly of cross-sectional surveys, qualitative studies, program evaluations, and case reports. The practical consequence is that the CHT clinician must operate with a much higher proportion of their clinical decisions guided by lower-quality, contextually indirect evidence than is the case for a clinician in a high-income country or even in a major urban center of Bangladesh. This is not a counsel of despair but a call for a specific kind of clinical wisdom: the capacity to reason carefully from available evidence, to apply Bayesian updating from CHT-specific epidemiological knowledge, to recognize the limits of extrapolation from non-CHT evidence, to seek CHT-specific evidence through clinical observation and documentation, and to contribute actively to the generation of the CHT-specific evidence base that will gradually reduce the evidence gap that currently compromises CHT clinical practice.

10.4 Digital Health and Telemedicine: Opportunities and Cautions for the CHT

The expansion of mobile telecommunications coverage across Bangladesh, which now extends to a significant proportion of CHT communities including many that were previously completely beyond radio or telephone communication reach, has created new opportunities for telemedicine (the provision of healthcare services using information and communication technology, particularly mobile telephony and internet connectivity) to bridge some of the access gaps that are the structural health burden of the territory. Telemedicine has been implemented in various forms in the CHT, primarily through NGO-supported mobile health programs, the COVID-19-accelerated expansion of government telemedicine services, and the teleconsultation protocols established between some CHT health facilities and tertiary referral centers. The evidence for telemedicine's effectiveness in the CHT is emerging and promising in specific domains: real-time teleconsultation between CHT UHC physicians and specialist physicians at Chittagong Medical College Hospital for management of complex cases (including severe malaria, obstetric emergencies, and mental health crises) has been shown in pilot programs to improve clinical decision-making quality and to reduce unnecessary referral while ensuring that cases requiring specialist input receive it promptly; mobile-based community health worker programs using smartphone applications for data collection, decision support, and real-time supervision have

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improved the quality of malaria rapid diagnostic testing, adherence monitoring for TB treatment, and nutritional assessment accuracy in community settings.

The Cautions about Digital Health in the CHT, which must accompany any enthusiasm about its opportunities, include the following. First, the digital divide within the CHT is itself inequitably distributed: smartphone ownership, data access, and digital literacy are much higher in accessible, better-off communities than in the remote, most marginalized communities that have the greatest health need, meaning that telemedicine services that reach the accessible may not reach the most deprived. Second, the infrastructure preconditions for digital health (reliable mobile network coverage, electricity for device charging, digital literacy, and the language accessibility of digital health platforms) are not uniformly present across the CHT and specifically are absent in many of the most remote communities, limiting the applicability of digital health solutions to areas where these preconditions exist. Third, data privacy and security concerns are particularly sensitive in the CHT context, where indigenous communities have historical reasons to distrust government data collection systems and where the political sensitivity of health data (including data on mental health, substance use, sexual health, and infectious disease status) requires specific community consultation and consent frameworks that are not always present in rapidly deployed digital health programs. Fourth, the quality of clinical care delivered through telemedicine is only as high as the quality of clinical examination and history-taking at the distal end of the teleconsultation: a physician receiving a telemedicine consultation from a CHT community health worker who has limited training in physical examination will have access to impoverished clinical data regardless of the quality of the digital connection, limiting the accuracy of remote clinical decision-making.

10.5 The Future of CHT Health Research: Priorities for the 2025 to 2035 Decade

The ten-year period from 2025 to 2035 is a critical window for the acceleration of CHT health research, because it coincides with a period of heightened national and international attention to CHT indigenous health (catalyzed by the 2025 measles crisis and the international attention it generated), with important methodological advances in health research (including the increasing accessibility of genomic, microbiome, and environmental monitoring technologies that could transform CHT health research capacity), and with a generation of CHT-trained health professionals who are uniquely positioned to conduct the CHT-specific, community-engaged research that the territory needs. The CHT Health Research Priorities for 2025 to 2035, as articulated in this textbook, include the following domains. First, CHT-specific AMR surveillance and its integration with the national GLASS reporting system, producing the evidence base needed for CHT-calibrated empirical antibiotic prescribing guidelines. Second, population-based NCD prevalence studies in CHT indigenous communities, disaggregated by ethnic group, district, and age-sex group, producing the first rigorous estimates of the type 2 diabetes, hypertension, cardiovascular disease, and CKD burden in the territory. Third, validation studies for the CHT-adapted clinical assessment tools described in this Part, including the geriatric assessment protocol, the dementia recognition protocol, and the culturally adapted stroke recognition and response protocol. Fourth, pharmacogenomic characterization of CHT indigenous populations, establishing the frequency of clinically relevant pharmacogenomic variants in each of the eleven CHT ethnic groups and generating the evidence base for CHT-

specific pharmacogenomics-guided prescribing recommendations. Fifth, ethnopharmacological clinical trials investigating the efficacy and safety of promising CHT botanicals (particularly those with the strongest ethnobotanical and in vitro pharmacological evidence) in randomized controlled trial designs, using adaptive methodologies appropriate to the CHT research context. Sixth, long-term cohort studies of the developmental origins of CHT adult disease, tracking cohorts from birth through adolescence and into early adulthood to document the relationship between early-life nutritional and infectious exposures and adult NCD risk, and to provide the evidence base for early-life intervention strategies. Seventh, implementation science studies of the barriers to and facilitators of scale-up for proven CHT health interventions, producing the operational knowledge needed to close the gap between effective programs in pilot settings and effective programs at population scale. Eighth, community-based participatory research studies, co-designed and co-conducted with CHT indigenous community members as full research partners, investigating the health priorities identified by communities themselves rather than imposed by external research agendas, and producing knowledge that is simultaneously scientifically valid and community-responsive.

MODEL EXAMINATION QUESTIONS: CHAPTER TEN

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The term "translational research" refers to: a) Research conducted by researchers who speak multiple languages b) The process by which basic science discoveries are converted into clinical interventions and then into population-level public health practice c) The translation of international health guidelines into Bangla for CHT health workers d) Research conducted jointly by Bangladeshi and international scientists (Correct Answer: b)

The Consolidated Framework for Implementation Research (CFIR) is a tool used in: a) Forensic medicine for criminal investigation b) Implementation science to understand barriers and facilitators of evidence-based practice adoption in health systems c) Clinical chemistry for laboratory quality control d) Public health legislation drafting (Correct Answer: b)

Evidence-based medicine (EBM) was formally articulated by Gordon Guyatt and colleagues at which university? a) Oxford University b) Harvard University c) McMaster University d) Johns Hopkins University (Correct Answer: c)

In the hierarchy of evidence used in standard EBM, which study design is at the highest level? a) Expert opinion b) Case series c) Individual randomized controlled trial d) Systematic review and meta-analysis of randomized controlled trials (Correct Answer: d)

The RE-AIM framework in implementation science evaluates program effectiveness across which five dimensions? a) Research, Education, Assessment, Integration, Monitoring b) Reach, Effectiveness, Adoption, Implementation, Maintenance c) Reliability, Efficiency, Accountability, Innovation, Measurability d) Risk, Equity, Access, Inclusion, Monitoring (Correct Answer: b)

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For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A CHT research team proposes to conduct a study evaluating the effectiveness of a community-based hypertension management program using trained community health workers to screen for, monitor, and refer hypertension cases in three remote Bandarban communities. They plan to use the stepped wedge cluster randomized trial design. According to the CHT Health Technology Assessment Doctrine described in this chapter, the proposal should be evaluated on which four CHT-specific dimensions in addition to the standard HTA criteria of clinical effectiveness and safety? a) Political acceptability, media coverage potential, international donor interest, and cost of the intervention b) Terrain Feasibility Assessment, Community Acceptability Assessment, Equity Impact Assessment, and Structural Interaction Assessment c) Researcher qualifications, publication venue, sample size adequacy, and statistical analysis plan only d) Cultural sensitivity review, language translation quality, ethical committee approval, and pilot testing only (Correct Answer: b)

A CHT district hospital internal medicine physician encounters a clinical scenario in which the WHO guideline recommends a specific diagnostic test before treatment, but that test is unavailable in the CHT facility and the delay in obtaining it would exceed the clinically critical window for intervention. According to the CHT Contextual Evidence Principle as articulated in this textbook, the appropriate approach is: a) Apply the WHO guideline unchanged and withhold treatment until the recommended test is obtained, regardless of clinical risk b) Ignore all guidelines and treat based on intuition alone c) Apply critical appraisal of the guideline's applicability to the CHT resource context, use the available evidence to identify the maximum evidence-based intervention achievable within CHT resource realities, and document the clinical reasoning and the unavailability of the recommended diagnostic test d) Refer all such patients immediately to Dhaka regardless of clinical severity (Correct Answer: c)

CONSOLIDATION: INTEGRATIVE CASE STUDIES FOR PART EIGHT

Case Study A: The Convergent Patient

A 52-year-old Chakma male farmer, Mrinal Chakma, presents to Rangamati District Hospital in March 2025 with a six-month history of progressive breathlessness, ankle swelling, and fatigue. He has been treated at various times over the past decade for malaria (multiple episodes, always in the jhum farming season), is a lifelong betel nut chewer with tobacco, and has had no prior blood pressure or blood glucose measurements. He drinks locally brewed fermented rice beer regularly, consuming an estimated 3 to 4 units daily. He has experienced three to four episodes of "throat illness" over his lifetime for which he received no formal treatment, treating himself with traditional preparations each time. He smokes locally produced cigarettes intermittently.

On clinical examination: blood pressure 168/108 mmHg, pulse 78 beats per minute but irregularly irregular, respiratory rate 22 breaths per minute at rest. JVP elevated to 5 cm above sternal angle. Bilateral inspiratory crackles to mid-lung fields. S1 and S2 present, with an

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additional low-pitched rumbling diastolic murmur best heard at the apex in the left lateral decubitus position. Mild hepatomegaly. Pedal edema to the knees bilaterally. On examination of the oral cavity: bilateral buccal leukoplakia with a central area of red speckled erythroplakia on the left buccal mucosa, and restricted mouth opening to approximately 30 mm (consistent with oral submucous fibrosis).

Investigations: chest X-ray shows moderate cardiomegaly (cardiothoracic ratio 0.58) with upper lobe vascular redistribution and bilateral Kerley B lines; ECG shows atrial fibrillation with fast ventricular rate (ventricular rate 110 bpm) and no acute ST-T changes; hemoglobin 9.8 g/dL (mild anemia); white cell count 7.2 x10^9/L; platelet count 180 x10^9/L; random blood glucose 13.8 mmol/L; serum creatinine 156 micromol/L; alanine aminotransferase 68 IU/L; HBsAg pending; urinalysis 2+ protein.

The clinical synthesis of this patient's presentation demonstrates the convergence principle that is central to Part Eight's analysis. He has heart failure with atrial fibrillation and a diastolic murmur consistent with mitral stenosis, most likely from rheumatic heart disease attributable to his untreated childhood Group A streptococcal pharyngitis episodes. He has newly discovered hypertension and probable type 2 diabetes (random glucose 13.8 mmol/L requires fasting confirmation). He has early CKD suggested by his elevated creatinine and proteinuria, driven by the combination of hypertension, probable diabetes, and possibly the renal effects of recurrent malaria episodes over a decade. He has oral submucous fibrosis with erythroplakia from his chronic betel nut-tobacco chewing, requiring urgent biopsy and oral surgery referral. He has probable alcohol use disorder contributing to his liver enzyme elevation and potentially to his nutritional deficiency. His anemia is likely multifactorial: iron deficiency from inadequate dietary intake, chronic disease anemia, and possibly the contribution of recurrent malaria. This case illustrates the simultaneous convergence of at least five of the major clinical conditions discussed in Part Eight, all traceable to the structural determinants of health in the CHT, and all presenting simultaneously in a single patient because none of the preventive interventions that might have arrested any one of these conditions was accessible to him over the fifty-two years of his life in this territory.

Case Study B: The Antimicrobial Resistance Crisis at the Bedside

A 27-year-old Tanchangya woman, pregnant at 32 weeks, is admitted to Khagrachhari District Hospital with a 10-day history of high fever, severe headache, and abdominal discomfort. She was initially treated at a local drug shop with ciprofloxacin 250 mg twice daily for five days without improvement. On examination: temperature 40.1 degrees Celsius, pulse 82 beats per minute (relative bradycardia for degree of fever), blood pressure 105/70 mmHg, mild splenic enlargement palpable, fundal height appropriate for 32 weeks, fetal heart rate 162 beats per minute (borderline tachycardia consistent with maternal fever). Investigations: white cell count 3.2 x10^9/L (leukopenia), Widal test O 1:640, H 1:320, malaria RDT negative, urine culture pending. Blood culture collected and sent to Chittagong.

The management of this case requires the integration of six of the major topic areas of Part Eight: antimicrobial resistance (the 2024 ceftriaxone-resistant S. Typhi emergence changes the

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empirical antibiotic choice); pharmacology in the CHT (the pregnancy context requires drug safety assessment for any antibiotic selected, with particular concern for the fetal effects); obstetric management (the 32-week pregnancy with a febrile mother requires fetal monitoring for fetal tachycardia and potential preterm labor, with preparation for possible preterm delivery); health technology assessment (the diagnostic uncertainty from the absence of microbiological susceptibility data reflects the AMR surveillance gap described in Chapter Two); nutritional considerations (the pregnant woman with fever in a resource-limited setting is at high risk of nutritional compromise requiring assessment and support); and translational research (this case represents precisely the kind of clinical scenario for which CHT-specific evidence would guide decision-making, and the absence of that evidence illustrates the research gap described in Chapter Ten). The clinical decision to initiate meropenem-based therapy, while consulting with Chittagong Medical College Hospital neonatology and obstetrics by telemedicine for co-management, with simultaneous fetal monitoring, nutritional support, and blood culture surveillance, represents the CHT Contextual Evidence Principle in action: using all available evidence, CHT epidemiological knowledge, and available technological resources (including telemedicine consultation) to deliver the best achievable clinical care in a complex scenario for which no specific CHT-validated evidence protocol exists.

SUMMARY AND PHILOSOPHICAL REFLECTION ON PART EIGHT

Part Eight has traversed the terrain of advanced clinical medicine in the Chittagong Hill Tracts with the conviction that complexity is not a reason for clinical resignation but a call for deeper engagement, more sophisticated reasoning, and a more expansive conception of what medicine is and what it can achieve. The clinical and public health challenges described in these ten chapters share a common structure: they are complex, they are rooted in structural injustice, they exceed the capacity of the current health system to address them adequately, and they are nevertheless amenable to significant improvement through a combination of clinical excellence, public health innovation, research investment, and advocacy for structural change. The student who reads Part Eight and concludes that the CHT's health challenges are insurmountable has misread it. The conclusion intended is the opposite: that these challenges are specifically knowable, that their causes are identifiable, that their solutions are at least theoretically clear, and that the primary obstacle between the present reality and a significantly better health future for the people of the CHT is not a lack of knowledge or a lack of technical solutions but a deficit of political will, financial investment, and the sustained institutional commitment to equitable healthcare that every human being in the Chittagong Hill Tracts deserves.

The Integrative Medical Philosophy of the CHT, as it emerges from the eight parts of this textbook now completed, holds that medicine in this territory is never merely the application of a technical algorithm to a biological problem. It is always simultaneously an act of clinical science, an exercise in cultural humility, an expression of historical awareness, a commitment to social justice, and a contribution to the ongoing project of making the CHT's remarkable people healthier, more empowered, and more free. The physician who practices in the CHT without understanding this is not fully practicing medicine as the CHT requires it. The physician who

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understands it and practices accordingly is participating in one of the most important, most demanding, and most meaningful medical endeavors in contemporary South Asia.

PART NINE: ADVANCED IMMUNOLOGICAL SCIENCE, GENOMIC AND PRECISION MEDICINE, ENVIRONMENTAL TOXICOLOGY, ADVANCED SURGICAL EMERGENCIES, ORAL HEALTH, HEALTH SYSTEMS GOVERNANCE, INDIGENOUS HEALTH RIGHTS, AND THE PHILOSOPHICAL SYNTHESIS OF MEDICINE IN THE CHITTAGONG HILL TRACTS

Foreword to Part Nine

Part Nine arrives at the convergence of science, philosophy, governance, and clinical practice in the Chittagong Hill Tracts. The eight parts that preceded it have mapped the territory thoroughly: the geomedicinal ecology, the disease burden, the clinical protocols, the pharmacology, the mental health dimensions, the environmental toxicology of everyday life, the political economy of suffering, and the emerging non-communicable disease crisis. Part Nine does not retreat from any of that foundation. It builds upon it, ascending to the most advanced and most integrative levels of medical and public health analysis available in the contemporary scientific literature of 2024 and 2025, and applying those advances relentlessly to the specific circumstances of the eleven indigenous communities of Rangamati, Bandarban, and Khagrachhari. The student who reaches Part Nine should approach it with the full analytical apparatus assembled across the previous eight parts: the understanding that terrain is pathogenic, that structural inequality is clinically expressed, that indigenous cosmological frameworks carry empirical wisdom, that the delay-to-care pathway is itself a disease process, and that the body of the CHT patient is never separable from the land, the history, and the politics that surround it. Part Nine adds to this apparatus the precision of genomic medicine, the depth of mucosal immunology, the rigor of clinical toxicology, the urgency of oral health, the complexity of health system governance under indigenous rights frameworks, and the philosophical honesty required to look at everything the CHT health literature has produced and ask, with equal parts intellectual humility and moral clarity, what it all means for the children who will be born in Alikadam and Thanchi and Sajek five, ten, and fifty years from now.

CHAPTER ONE: ADVANCED IMMUNOLOGY OF THE CHITTAGONG HILL TRACTS: MUCOSAL IMMUNITY, INNATE-ADAPTIVE CROSSTALK, HELMINTH-MEDIATED IMMUNE REGULATION, AND THE IMMUNOLOGICAL CONSEQUENCES OF CHRONIC ENVIRONMENTAL STRESS

1.1 The Immunological Identity of the CHT Population: A Reconceptualization

The immune system of the individual living in the Chittagong Hill Tracts is not the immune system described in the standard immunology textbook. Standard immunology textbooks present the immune system as a universal biological architecture, conserved across human populations, operating by mechanisms that are fundamentally the same whether the individual lives in

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London or Lahore or Bandarban. This universalism is partially correct at the level of molecular mechanism but profoundly incomplete at the level of functional state, immune repertoire calibration, regulatory set-point, and adaptive phenotype. The immune system of a Mro child growing up in the deep valleys of Alikadam in Bandarban district is shaped by an ecological immunological exposure matrix that is radically different from that of a child growing up in Dhaka, and this shaping occurs from the earliest moments of life, beginning in utero through maternal immune programming, continuing through the microbial colonization events of birth and early infancy, and extending through continuous lifelong interaction with the ecological, nutritional, and infectious environment of the CHT terrain. The reconceptualization of the CHT immune system offered in this chapter holds that the immune phenotype of CHT indigenous populations is a functional adaptation to a specific ecological niche, that this adaptation carries both protective and vulnerability dimensions that are clinically significant, and that an immunologically informed approach to CHT clinical practice requires understanding this adapted phenotype rather than treating it as a deficient version of a normative standard derived from populations in fundamentally different ecological circumstances. The immune identity of the CHT population is characterized by four signature features. The first is helminth-mediated Th2 polarization, arising from the high prevalence of soil-transmitted helminthic infection in CHT communities, which skews the adaptive immune response toward a Th2-dominant cytokine profile (IL-4, IL-5, IL-13, IL-10) at the expense of the Th1-dominant profile (IFN-gamma, TNF-alpha, IL-12) required for optimal defense against intracellular pathogens including Mycobacterium tuberculosis, Leishmania donovani, and the Plasmodium species. The second is malnutrition-associated immune suppression, arising from the documented high prevalence of protein-energy malnutrition and micronutrient deficiency in CHT indigenous communities, which impairs both innate immunity (reduced neutrophil function, impaired complement synthesis, defective macrophage oxidative burst) and adaptive immunity (reduced T-lymphocyte count and function, impaired immunoglobulin synthesis, reduced vaccine response). The third is chronic stress-mediated immune dysregulation, arising from the psychoecological burden of political marginalization, land insecurity, and the intergenerational trauma of conflict and displacement, operating through HPA axis dysregulation and glucocorticoid-mediated immune modulation. The fourth is microbially educated innate immune memory, arising from the high and diverse microbial exposure burden of the CHT terrain environment, which through trained immunity mechanisms (epigenetic reprogramming of innate immune cells following early microbial education) may confer some protective advantage against certain categories of pathogen challenge, representing the partial adaptive dividend of a high-exposure ecological niche.

The concept of Ecological Immunophenotyping, introduced in this textbook, defines the systematic characterization of the immune system functional state as shaped by the specific ecological exposure matrix of a defined geographic and ethnic population, with the explicit purpose of informing clinical practice, vaccine strategy design, and public health program targeting for that population. Ecological Immunophenotyping departs from the standard approach to immunology in clinical medicine (which focuses on the identification of specific immune deficiencies or dysregulations in individual patients) by operating at the population level, characterizing the normative immune phenotype of a defined population as an ecologically adapted functional state, and using that characterization as the baseline against which individual

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variations are interpreted and therapeutic strategies are designed. In the CHT, Ecological Immunophenotyping would produce a population-level immune profile that integrates data on helminthic infection prevalence and species distribution (determining the degree of Th2 polarization), nutritional status indicators (determining the severity of malnutrition-associated immune suppression), psychosocial stress biomarkers (determining the degree of HPA-mediated immune modulation), and vaccine response data (providing a direct functional readout of the population immune phenotype in response to standardized antigenic challenge). The value of this approach for vaccine program design in the CHT is immediately apparent: if the immune phenotype of the target population systematically underperforms the immunological assumptions embedded in standard vaccine schedules derived from well-nourished, low-helminth-burden populations in high-income countries, then those standard schedules may systematically underperform in the CHT, and their adjustment (in terms of dose, schedule, route of administration, or adjuvant formulation) requires knowledge of the population immune phenotype that Ecological Immunophenotyping is designed to generate.

1.2 Mucosal Immunity and Its Centrality to the CHT Disease Burden

Mucosal immunity is the frontline defense system of the human body at all surfaces that interface with the external environment, including the gastrointestinal tract, the respiratory tract, the urogenital mucosa, and the conjunctival surface. In populations with a high burden of enteric, respiratory, and vector-borne disease, mucosal immune competence is a primary determinant of population health. The mucosal immune system of the gastrointestinal tract encompasses secretory IgA (SIgA), which is the dominant antibody isotype at intestinal surfaces and which provides the first immunological barrier against enteric pathogens and food antigens; the gut-associated lymphoid tissue (GALT), including Peyer's patches and isolated lymphoid follicles, which are the primary sites of antigen sampling and adaptive immune induction in the intestinal mucosa; the intestinal epithelial barrier, which provides the physical separation between the luminal contents and the underlying mucosal immune tissue; and the intestinal microbiome, which is the most important extrinsic regulator of mucosal immune homeostasis and whose composition is profoundly influenced by diet, infection history, antibiotic exposure, and the ecological characteristics of the environment. In the CHT, the mucosal immune system faces a uniquely severe set of challenges. The high prevalence of diarrheal disease in CHT communities, particularly in children under five years, represents a dual assault on mucosal immune integrity: each episode of enteric infection both exploits and damages the mucosal barrier, increasing intestinal permeability, disrupting epithelial tight junction integrity, generating local inflammatory responses that if chronic cause mucosal architectural damage (villous atrophy, crypt hyperplasia), and depleting the IgA-secreting plasma cell populations of the intestinal lamina propria. The resulting environmental enteric dysfunction (EED), also known as environmental enteropathy, is a subclinical condition of intestinal mucosal damage that is now recognized as one of the most important mediators of malnutrition and growth failure in low-income countries with high enteric pathogen exposure.

Environmental enteric dysfunction, as reconceptualized for the CHT context in this textbook, is defined as the chronic progressive impairment of intestinal mucosal architecture, barrier function, and immune competence arising from cumulative exposure to fecal-orally transmitted

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enteropathogens, occurring in the context of nutritional deficiency that impairs mucosal repair and regeneration, and expressing itself clinically as stunted linear growth, impaired cognitive development, reduced vaccine immunogenicity, and increased susceptibility to systemic infectious disease. EED has been documented in multiple low-income country settings with high enteric pathogen burden, and its hallmarks (elevated fecal markers of intestinal inflammation including calprotectin and lactoferrin, elevated blood markers of intestinal permeability including citrulline and intestinal fatty acid binding protein, reduced intestinal villous height-to-crypt-depth ratios on intestinal biopsy) are consistent with the pathological mechanisms of the growth faltering and malnutrition documented at high prevalence in CHT indigenous communities. A hypothesis-generating analysis of CHT child growth data published in the Lancet Southeast Asia regional analysis of 2025 (noting the extraordinary disparity in minimum dietary diversity between indigenous CHT children and Bengali children in the same district) is fully consistent with a setting in which EED operates as a major mediator of the malnutrition-infection cycle. The clinical implication of EED for vaccine delivery in the CHT is particularly important: the oral vaccines in the national immunization schedule, particularly oral poliovirus vaccine (OPV) and oral rotavirus vaccine (Rotarix), have consistently shown lower seroconversion rates in settings with high EED prevalence, because the damaged intestinal mucosa cannot mount the normal secretory IgA response to the orally administered antigen. This finding calls into question whether the standard CHT EPI oral vaccine schedule is generating adequate seroprotection in communities with the highest EED burden, and it represents a major unaddressed research and policy priority.

1.3 Innate-Adaptive Immune Crosstalk: Toll-Like Receptors, Pattern Recognition, and the CHT Pathogen Landscape

The crosstalk between innate and adaptive immunity is the central organizing principle of contemporary immunological science and the framework within which the CHT's ecological immune challenges can be most precisely analyzed. The innate immune system, operating through pattern recognition receptors (PRRs) including Toll-like receptors (TLRs), NOD-like receptors (NLRs), RIG-I-like receptors (RLRs), and C-type lectin receptors (CLRs), provides the first-response detection of pathogen-associated molecular patterns (PAMPs) and damage-associated molecular patterns (DAMPs), generating the initial inflammatory and antiviral responses that activate and shape the subsequent adaptive immune response through antigen presentation, cytokine signaling, and co-stimulatory molecule expression. In the CHT terrain, the innate immune system is engaged by an extraordinary diversity and intensity of pathogen stimuli. The concurrence of helminthic antigens (which engage TLR2, TLR4, and various CLRs, generating predominantly tolerogenic and Th2-polarizing signals), plasmodial antigens including GPI anchors and hemozoin (which engage TLR2, TLR4, and TLR9, generating potent pro-inflammatory signals through MyD88-dependent pathways), mycobacterial cell wall components (which engage TLR2 and TLR4 with NOD2, generating the IL-12-dependent Th1 response that is the cornerstone of anti-TB immunity), and enteric bacterial antigens through the damaged intestinal epithelial barrier (which engage a broad spectrum of TLRs at the intestinal lamina propria level), creates a state of chronic innate immune polyactivation in CHT populations that has several important clinical consequences. First, the simultaneous engagement of innate immune receptors by multiple divergent pathogen signals creates immunological interference, in

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which the cytokine environments generated by different signaling pathways mutually inhibit optimal effector response development. The Th2-polarizing helminthic immune environment antagonizes the Th1 cytokine milieu required for effective anti-TB and anti-malarial responses, creating a biological basis for the well-documented epidemiological observation that TB is more severe and more difficult to treat in heavily helminth-infected populations. Second, chronic innate immune activation generates a state of trained immunity in long-resident CHT populations, in which epigenetic reprogramming of monocytes, macrophages, and natural killer cells through histone methylation and acetylation patterns confers enhanced (but not optimally calibrated) responses to subsequent pathogen challenges, a phenomenon that may partially explain the apparent partial resistance to malaria clinical disease observed in adults who have lived all their lives in high-transmission CHT zones. Third, chronic innate immune activation at sub-optimal nutritional status generates persistent low-grade systemic inflammation (evidenced by elevated C-reactive protein and other acute phase reactants) that contributes to the metabolic and cardiovascular disease risks emerging in CHT populations, as the inflammatory milieu characteristic of chronic innate immune stimulation is a direct driver of insulin resistance, dyslipidemia, and endothelial dysfunction.

The single-nucleotide polymorphism (SNP) landscape of PRR-encoding genes in CHT indigenous populations is a virtually unstudied dimension of CHT immunology that may hold major clinical significance. TLR4 polymorphisms (particularly Asp299Gly and Thr399Ile, which are associated with altered LPS responsiveness), TLR2 polymorphisms, and NOD2 variants have been associated with differential susceptibility to infectious diseases including TB, leprosy, and inflammatory bowel disease in various populations. The CHT indigenous communities, as ethnic populations whose genetic histories are distinct from the broader South Asian gene pool (with closer genetic affinities to mainland Southeast Asian and East Asian populations, as discussed in the genomics chapter following), may harbor PRR gene variant frequency distributions that produce distinct innate immune response phenotypes not predictable from data derived from Bengali or other South Asian populations. The absence of CHT-specific immunogenomic data represents a significant and clinically consequential gap in the scientific literature, and its filling is a priority for the precision medicine program in the CHT that this textbook advocates.

1.4 Helminth Immunology and the Hygiene Hypothesis in the CHT Context

The helminth-immune axis represents one of the most fascinating and clinically consequential immunological dimensions of CHT indigenous health. As documented throughout the preceding parts of this textbook, soil-transmitted helminthic infection (with Ascaris lumbricoides, Trichuris trichiura, and hookworm species) is highly prevalent in CHT indigenous communities, with infection rates in children under fifteen years estimated to exceed 60 percent in some community surveys from areas without regular deworming program coverage. The immunological consequences of chronic helminthic infection extend far beyond the direct effects of worm-mediated nutrient competition and intestinal inflammation: the helminth-immune interaction fundamentally reconfigures the regulatory architecture of the host immune system in ways that have consequences for responses to virtually every other pathogen and vaccine antigen the host encounters. The reconfiguration is mediated primarily through the generation of a potent regulatory immune environment, characterized by expansion of regulatory T cells (Tregs)

expressing FOXP3, elevated production of IL-10 and TGF-beta, the induction of regulatory B cells producing IL-10 and IL-35, and the polarization of macrophages toward an alternatively activated (M2) phenotype that produces anti-inflammatory mediators and promotes tissue repair. This regulatory environment, while useful for preventing immunopathological damage from the worm itself (and preventing the lethal hyperinflammation that would otherwise result from the massive antigenic load of a high-worm-burden infection), simultaneously dampens the effector responses required for clearance of intracellular pathogens and for optimal vaccine-induced immunological memory.

The hygiene hypothesis, first formally articulated by David Strachan in 1989 as an explanation for the inverse relationship between childhood infection burden and allergic disease prevalence, has evolved into the Old Friends Hypothesis of Graham Rook, which more precisely attributes the regulatory immune phenotype of populations with high infection burden to the evolutionary co-existence of the human immune system with a suite of ancient microbial and parasitic organisms (the Old Friends) whose antigens provide the educational stimuli required for proper regulatory immune circuit development. In the CHT, the Old Friends Hypothesis has a striking and counter-intuitive clinical implication: as CHT communities gain access to clean water, improved sanitation, and deworming programs (reducing their helminth burden), they may simultaneously begin experiencing a rise in allergic and autoimmune disease (as the regulatory immune circuits previously educated by helminth antigens lose their maintenance stimulus), representing an immunological transition cost of development that has been observed in rapidly developing low-income countries globally. The epidemiological data from the CHT do not yet demonstrate this transition clearly, because allergic disease surveillance in CHT communities is too incomplete and too recent to detect secular trend changes. However, the theoretical prediction is well-grounded in immunological mechanism and in observations from other transitioning populations, and it deserves prospective surveillance attention as CHT development proceeds. The clinician in the CHT in 2026 should be aware that the apparently low rates of atopic disease they observe in heavily helminth-infected CHT communities may not persist as helminth control programs succeed, and that the public health success of deworming may bring with it an immunological transition that requires its own clinical response in the form of allergy management capacity development.

MODEL EXAMINATION QUESTIONS: CHAPTER ONE

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The Th2-dominant cytokine profile generated by chronic helminthic infection includes which combination of cytokines? a) IFN-gamma, TNF-alpha, and IL-12 b) IL-4, IL-5, IL-13, and IL-10 c) IL-17, IL-22, and IL-23 d) IL-2, IL-7, and IL-15 (Correct Answer: b)

Environmental enteric dysfunction (EED) in CHT children affects oral vaccine efficacy primarily through which mechanism? a) Impaired hepatic first-pass metabolism of vaccine antigens b) Reduced intestinal mucosal secretory IgA response due to mucosal architectural damage and plasma cell depletion c) Systemic immunosuppression preventing T-cell priming d) Increased intestinal motility reducing vaccine dwell time (Correct Answer: b)

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Secretory IgA (SIgA) at intestinal surfaces is produced by which cell type? a) Intestinal epithelial cells b) Mucosal mast cells c) IgA-secreting plasma cells in the lamina propria d) Intraepithelial lymphocytes (Correct Answer: c)

The Old Friends Hypothesis of Graham Rook specifically attributes the regulatory immune phenotype observed in high-infection-burden populations to: a) Genetic selection for regulatory immune variants in ancient populations b) The educational role of ancient commensal and parasitic organisms (Old Friends) whose antigens maintain regulatory immune circuit development c) The effect of traditional botanical medicines on regulatory T cell populations d) The anti-inflammatory effects of the high-fiber diet of traditional CHT communities (Correct Answer: b)

Trained immunity in innate immune cells (monocytes, macrophages, NK cells) following early microbial education operates through which primary molecular mechanism? a) RAG gene recombination producing new antigen receptor specificity b) Epigenetic reprogramming through histone methylation and acetylation patterns altering gene expression c) Clonal expansion of antigen-specific memory cells d) Somatic hypermutation of innate pattern recognition receptors (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A clinician in Bandarban observes that oral rotavirus vaccine (Rotarix) appears to have lower seroconversion rates in the most remote Mro community compared with rates reported in the national EPI literature. Which of the following best explains this observation in the context of the immunological principles of this chapter? a) The Rotarix vaccine batch was improperly cold-chained during transport to the remote location b) Environmental enteric dysfunction (EED) from chronic high enteric pathogen exposure has damaged the intestinal mucosal architecture and depleted SIgA-producing plasma cells in this community, reducing the mucosal immune response to orally administered vaccine antigens c) The Mro have a genetic variant of intestinal IgA receptors that reduces Rotarix immunogenicity d) Helminth-mediated Th2 polarization directly inhibits the IgA class switch recombination required for rotavirus-specific SIgA production (Correct Answer: b)

A CHT public health researcher is designing a helminth control program using albendazole for children in a remote Bandarban community. Based on the immunological principles of the Old Friends Hypothesis, which of the following monitoring activities should be included in the program design? a) Monitoring for increased susceptibility to malaria after deworming b) Prospective surveillance for emerging atopic and allergic disease as helminth prevalence declines over program years, recognizing the immunological transition risk c) Monitoring for albendazole-associated hepatotoxicity only d) Surveillance for antibiotic resistance in gut bacteria post-deworming (Correct Answer: b)

In a CHT patient with newly diagnosed smear-positive pulmonary tuberculosis who is also found to have a heavy Ascaris and Trichuris co-infection, what immunological principle predicts that co-infection management may improve TB treatment outcomes? a) Anti-helminthic treatment

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reduces bacterial co-infection risk in the intestine b) Deworming removes the Th2-polarizing and regulatory immune environment generated by helminthic infection, shifting the host immune response toward the Th1-dominant, IFN-gamma-rich cytokine milieu required for optimal Mycobacterium tuberculosis containment and clearance c) Albendazole has direct anti-mycobacterial activity d) Deworming reduces malabsorption, improving rifampicin bioavailability (Correct Answer: b)

CHAPTER TWO: GENOMIC MEDICINE, PHARMACOGENOMICS, AND PRECISION HEALTH IN THE CHITTAGONG HILL TRACTS: THE MOLECULAR IDENTITY OF THE HILL PEOPLES AND ITS CLINICAL SIGNIFICANCE

2.1 The Genomic Landscape of CHT Indigenous Populations: Ancestry, Admixture, and Clinical Relevance

The genetic identity of the indigenous communities of the Chittagong Hill Tracts represents one of the most scientifically significant and most clinically underutilized dimensions of CHT medicine. The eleven indigenous ethnic communities of the CHT, as well as the wider Tibeto-Burman and Austro-Asiatic language-speaking populations of mainland Southeast Asia with whom they share deep ancestry, occupy a phylogenetically distinct position in the global human genetic landscape. Genome-wide association studies and whole-genome sequencing projects conducted across South and Southeast Asia in the period from 2018 to 2025 have established with increasing precision that the CHT indigenous communities belong to genetic ancestry clusters that are predominantly derived from the Austro-Asiatic and Tibeto-Burman migration streams that populated mainland Southeast Asia beginning approximately 40,000 to 50,000 years before the present, with subsequent admixture events related to the southward expansion of Tibeto-Burman language-speaking agricultural communities from the Sino-Tibetan linguistic homeland approximately 4,000 to 5,000 years ago, and more recent admixture with Indo-Aryan populations from the Bengali plains that has occurred in varying degrees across the different CHT communities depending on their geographic position, historical contact patterns, and degree of integration with the plains economy. The Chakma, as the most geographically and economically integrated CHT community, show a higher degree of Indo-Aryan admixture than the Mro, Khumi, and Chak, who are among the most isolated communities and who retain genetic profiles more closely aligned with the Austro-Asiatic and Sino-Tibetan ancestry streams. The Marma, with their strong historical connections to the Arakan kingdom (corresponding to present-day Rakhine State in Myanmar) and to the Bamar and Mon ethnic groups of Myanmar, show genetic affinities to the Burmese gene pool alongside their Southeast Asian ancestral profile.

The clinical significance of this genetic ancestry landscape is profound and manifests across multiple dimensions of medical practice. In pharmacogenomics, the frequencies of clinically important genetic variants in drug-metabolizing enzymes, drug transporters, and drug targets differ systematically between populations with East and Southeast Asian ancestry (to which CHT indigenous communities are more closely related) and South Asian populations (to which the

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Bengali population of Bangladesh is more closely related), and the standard pharmacological assumptions applied in Bangladeshi clinical practice are derived from studies conducted in predominantly Bengali and South Asian populations. The most clinically important pharmacogenomic dimensions in the CHT context include CYP2D6 polymorphisms (which affect the metabolism of primaquine for P. vivax radical cure, as well as codeine, tramadol, and several antidepressants), CYP2C19 polymorphisms (which affect the metabolism of proton pump inhibitors, clopidogrel, and certain anticonvulsants), G6PD gene variants (whose relevant allele frequencies in Southeast Asian indigenous populations differ markedly from South Asian frequencies), and HLA gene variants (which determine immunological responses to pathogens and vaccines and which differ between CHT indigenous and Bengali populations in ways that affect the comparative efficacy of several vaccines). The absence of population-specific pharmacogenomic data for CHT indigenous communities means that these clinically important differences are currently invisible to the practicing clinician, who has no basis for anticipating them in individual patients and no CHT-population reference range against which to interpret pharmacogenomic test results if they were performed.

The G6PD deficiency landscape of CHT indigenous populations deserves particular attention because of its direct, life-threatening clinical relevance to primaquine prescription for P. vivax malaria. G6PD deficiency is a sex-linked recessive condition caused by mutations in the G6PD gene on the X chromosome, of which over 200 variants are known. The Southeast Asian endemic G6PD variants include G6PD Mahidol (c.487G>A), which is the most prevalent variant in mainland Southeast Asian and Myanmar-border populations, G6PD Chinese-5 (c.1024C>T), and G6PD Kaiping (c.1388G>A), among others. The distribution of G6PD variants in CHT indigenous communities has not been systematically characterized, representing a critical pharmacogenomic gap. Studies from neighboring Myanmar document G6PD deficiency prevalences of 8 to 14 percent in various ethnic groups, and studies from northeastern India (including Manipur and Mizoram, where ethnically related Tibeto-Burman and Austro-Asiatic populations live) document prevalences of 4 to 15 percent. Extrapolating these ranges to the CHT with appropriate caution, G6PD deficiency may affect a substantial proportion of CHT indigenous males (hemizygotes who are fully deficient) and a proportion of CHT indigenous females (heterozygotes who have intermediate enzyme activity and are also at risk, though typically less severely, from primaquine-induced hemolysis). The routine prescription of primaquine for P. vivax radical cure without prior G6PD testing represents a significant patient safety risk in the CHT, a risk that is currently unmitigated in the majority of health facilities serving remote CHT communities, which lack the point-of-care G6PD testing capability necessary for safe primaquine use.

2.2 Precision Medicine Principles for the CHT: Adapting the Global Precision Health Agenda

Precision medicine, defined in this textbook as the integration of individual-level genomic, phenotypic, environmental, and behavioral data to optimize disease prevention, diagnosis, and treatment for each patient, is a global scientific agenda that has been developed almost exclusively in high-income country settings and predominantly in populations of European ancestry. The application of precision medicine principles to low-income, indigenous populations in the Global South represents both a critical scientific priority and a profound

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ethical challenge. The scientific priority arises from the fact that the genetic diversity represented in populations like the CHT indigenous communities is an irreplaceable scientific resource whose pharmacogenomic, immunogenomic, and disease-genetic information could contribute substantially to both local clinical improvement and global scientific knowledge. The ethical challenge arises from the history of extractive research in indigenous communities (in which genetic samples have been collected for research purposes that serve external scientific agendas, with few tangible benefits returned to the source communities and, in some documented cases, with violations of indigenous community intellectual property and cultural protocols) and from the risk that precision medicine as currently constituted may deepen rather than reduce the health disparities affecting CHT communities by creating a genomically informed healthcare system that is accessible to privileged populations but not to the marginalized indigenous communities of the CHT.

The CHT Precision Health Framework, as proposed in this textbook, identifies five priority dimensions for precision health research and application in the CHT. The first priority dimension is pharmacogenomic safety profiling, specifically the systematic characterization of clinically actionable pharmacogenomic variants (G6PD, CYP2D6, CYP2C19, HLA-B alleles associated with drug hypersensitivity) in each of the eleven CHT indigenous communities, with the specific aim of generating community-specific pharmacogenomic reference data that can be used to design safer prescribing protocols for the most widely used drugs in the CHT, particularly primaquine, antimalarials, anticonvulsants, and antitubercular drugs. The second priority dimension is genomic epidemiology of communicable diseases, specifically the application of whole-genome sequencing to CHT P. falciparum isolates, M. tuberculosis strains, and rotavirus strains to characterize the drug resistance profiles, phylogenetic origins, and transmission dynamics of the major CHT pathogens, generating actionable intelligence for treatment protocol optimization and outbreak control. The third priority dimension is the genomic characterization of CHT population immune response variation, with a focus on HLA allele frequencies and PRR gene polymorphisms, to understand the determinants of differential vaccine immunogenicity and infectious disease susceptibility across CHT communities. The fourth priority dimension is the genetics of chronic disease risk in CHT indigenous populations, recognizing that as the epidemiological transition proceeds in the CHT, the genetic determinants of diabetes, cardiovascular disease, and cancer risk in these specific populations will become clinically important and should be characterized before the NCD epidemic reaches its peak. The fifth priority dimension is the ethics, governance, and community benefit-sharing framework for CHT genomic research, ensuring that precision medicine development in the CHT proceeds in accordance with the principles of indigenous data sovereignty, free prior and informed consent, community benefit-sharing, and respect for indigenous knowledge systems.

2.3 Ancestral Pharmacology: Reading the Ethnomedicinal Pharmacopoeia through the Pharmacogenomic Lens

The intersection of the CHT's rich ethnomedicinal pharmacopoeia and the emerging pharmacogenomics of CHT indigenous populations creates an exciting and largely unexplored scientific space that this textbook terms Ancestral Pharmacology. Ancestral Pharmacology, defined as the systematic investigation of the co-evolution of traditional medicinal plant use and

the pharmacogenomic characteristics of the populations who have used those plants across generations, proceeds from the observation that traditional botanical medicine traditions have been shaped not only by the ecological availability of medicinal plants and the observed efficacy of specific preparations, but also by the pharmacogenomic context of the populations using them. If, for example, a particular CHT community has a high prevalence of a CYP2D6 poor metabolizer variant (which slows the metabolism of certain plant alkaloids and thus extends their duration of action), the traditional dosing protocols for plant preparations containing those alkaloids (which will have been empirically calibrated through generations of use) may implicitly reflect that pharmacogenomic characteristic, representing accumulated dosimetric wisdom that is pharmacogenomically grounded even though the underlying molecular mechanism was never explicitly known to the Baiddya practitioners who developed and transmitted the protocol. Conversely, Baiddya preparations that are used at doses or in combinations that appear sub-therapeutic by standard pharmacological analysis may achieve their traditional therapeutic effect precisely because the CHT population's pharmacogenomic profile results in different drug metabolism kinetics than those assumed in standard pharmacological dosimetry. Ancestral Pharmacology thus proposes that the pharmacogenomic characterization of CHT populations can provide a retroactive scientific framework for understanding the empirically calibrated dosimetry of the Baiddya tradition, and that this understanding can both validate traditional practices that prove pharmacogenomically coherent and identify traditional practices that require modification when used in populations with different pharmacogenomic profiles (including Bengali patients who may use CHT plant medicines purchased from markets).

The most immediately applicable dimension of Ancestral Pharmacology in the CHT concerns the anti-malarial botanical medicines used by Baiddya practitioners from communities in high-malaria-burden areas. Several CHT plant species used for fever and malaria treatment contain alkaloids and polyphenols with demonstrated in vitro anti-Plasmodium activity. The pharmacogenomic factors relevant to these compounds include CYP2D6, CYP3A4, and CYP2C8 variants (which affect the metabolism of quinoline-related alkaloids found in some Rubiaceae species), and UDP-glucuronosyltransferase (UGT) variants (which affect the conjugation and elimination of polyphenolic compounds found in anti-malarial plant extracts). If CHT populations have distinct allele frequencies at these loci relative to the reference populations in which the pharmacokinetics of the plant compounds have been characterized, the traditional dosing protocols of CHT Baiddya anti-malarial preparations may be pharmacogenomically appropriate for CHT patients but sub-therapeutic or potentially toxic in patients with different pharmacogenomic backgrounds. The documentation of this pharmacogenomic dimension of CHT traditional medicine is a scientific contribution with both cultural heritage value (in validating the scientific coherence of traditional dosimetric practices) and immediate clinical safety relevance (in clarifying the population-specificity of traditional medicine prescribing in the CHT).

MODEL EXAMINATION QUESTIONS: CHAPTER TWO

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

G6PD gene is located on which chromosome? a) Chromosome 6 b) Chromosome 11 c) The X chromosome d) Chromosome 22 (Correct Answer: c)

The G6PD variant most commonly associated with G6PD deficiency in mainland Southeast Asian and Myanmar-border populations is: a) G6PD Mediterranean b) G6PD A-minus c) G6PD Mahidol (c.487G>A) d) G6PD Canton (Correct Answer: c)

CYP2D6 enzyme is involved in the metabolism of primaquine and which other clinically commonly used analgesic drug whose conversion to its active form may be impaired in poor metabolizers? a) Ibuprofen b) Paracetamol (acetaminophen) c) Codeine (conversion to morphine) d) Diclofenac (Correct Answer: c)

The Precision Medicine principle of individual-level data integration for optimized treatment includes which categories of data? a) Genomic data only b) Genomic, phenotypic, environmental, and behavioral data integrated for each patient c) Only age, weight, and kidney function for dose calculation d) Laboratory results and imaging data only (Correct Answer: b)

HLA allele polymorphisms are clinically important in pharmacogenomics primarily because they determine: a) Drug metabolism rates in the liver b) Immune-mediated drug hypersensitivity reactions associated with specific HLA alleles (such as HLA-B*57:01 for abacavir and HLA-B*15:02 for carbamazepine) c) Renal drug excretion capacity d) Drug-transporter protein activity (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A clinician in a CHT upazila health complex is treating a Marma patient with confirmed Plasmodium vivax malaria with artemether-lumefantrine for the blood schizontocide phase, and wishes to prescribe primaquine for radical cure. The health complex has no G6PD testing capability. What is the most appropriate clinical management decision according to the precision medicine and patient safety principles of this textbook? a) Prescribe primaquine at standard 0.25 mg/kg/day for 14 days without G6PD testing because the benefit outweighs the risk b) Withhold primaquine entirely because the benefit of radical cure does not justify any risk c) Treat the blood schizontocide phase, document the case, and urgently arrange G6PD testing (referring to a facility with testing capability or advocating for point-of-care G6PD test procurement), prescribing primaquine only after confirming G6PD status, while advising the patient of the relapse risk and the reason for the delay d) Prescribe weekly low-dose primaquine (0.5 mg/kg/week for 8 weeks) as this is safer in G6PD-deficient individuals regardless of G6PD status (Correct Answer: c)

The scientific concept termed "Ancestral Pharmacology" in this textbook holds that traditional Baiddya medicine dosimetric protocols may be pharmacogenomically coherent because: a) Baiddya practitioners have always understood CYP enzyme pharmacokinetics b) Traditional dosing protocols have been empirically calibrated through generations of use in populations with specific pharmacogenomic profiles, implicitly reflecting the drug metabolism kinetics of those populations even without explicit molecular knowledge c) Plant-based medicines are inherently

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safer than pharmaceutical drugs at any dose d) Buddhist cosmological principles of dosimetric moderation happen to correspond to optimal pharmacological dosimetry (Correct Answer: b)

CHAPTER THREE: ENVIRONMENTAL TOXICOLOGY OF THE CHITTAGONG HILL TRACTS: CHEMICAL HAZARD ASSESSMENT, OCCUPATIONAL EXPOSURES, HEAVY METAL TOXICOLOGY, AND THE CLINICAL MANAGEMENT OF TOXIC ILLNESS IN RESOURCE-LIMITED SETTINGS

3.1 The Environmental Toxicological Landscape of the CHT: A Systematic Survey

Environmental toxicology in the CHT has received far less systematic attention than infectious disease epidemiology, yet the chemical hazard landscape of the CHT terrain presents a set of exposures that are clinically significant, measurable, and in many cases preventable. The environmental toxicological hazards of the CHT can be organized into four primary categories: naturally occurring geochemical hazards (arising from the mineral chemistry of the CHT's Miocene-Pliocene sedimentary formations and the dissolution of minerals into water and soil), agricultural chemical hazards (arising from the pesticides, herbicides, and chemical fertilizers used in jhum fields and terraced gardens), occupational chemical hazards (arising from the work environments of CHT subsistence farmers, forest workers, fishermen, rubber plantation workers, and construction laborers), and household chemical hazards (arising from the combustion products of solid cooking fuels, the chemical composition of construction materials, and the use of traditional plant-based preparations with potential toxicological effects).

The geochemical hazard profile of the CHT is determined by the lithological character of the underlying rock formations. The CHT is underlain predominantly by Miocene-Pliocene sedimentary sequences of the Indo-Burman fold belt, comprising alternating sandstone, shale, siltstone, and mudstone beds with localized concentrations of heavy mineral placers in stream beds. Manganese concentrations in CHT river sediments and stream waters have been documented at levels that warrant health monitoring, as chronic low-level manganese exposure through drinking water is associated with neurodevelopmental impairment in children, including reduced IQ and motor coordination deficits, at exposures above the WHO guideline value of 0.08 mg/L. Iron concentrations in CHT groundwater and spring water are frequently elevated above aesthetic and potentially health-relevant thresholds. Barium, naturally occurring in some CHT geological formations, has been detected in spring water samples from the Bandarban hills at concentrations that require monitoring. Unlike the Bengal plains, where arsenic contamination of groundwater from Quaternary alluvial aquifers is a massive and well-documented public health problem, arsenic contamination of CHT water sources is generally low because the CHT's rock formations do not include the arseniferous Holocene alluvial aquifers that characterize the Bengal delta geology. However, this arsenic-relative-safety of CHT water sources should not produce complacency about other geochemical hazards that are distinctly CHT-specific.

The fluoride geochemistry of CHT spring and groundwater represents a specific concern in certain areas of the CHT, particularly in parts of Bandarban district where the underlying

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geology includes fluoride-bearing mineral phases. Chronic exposure to fluoride in drinking water above the WHO guideline value of 1.5 mg/L causes dental fluorosis (manifesting as white streaks, pitting, and in severe cases, brown staining and structural damage of tooth enamel) at all levels of chronic elevated exposure, and skeletal fluorosis (causing joint stiffness, pain, and in advanced cases, crippling osteosclerosis and neurological compression from vertebral lesions) at high chronic exposures typically above 3 to 6 mg/L. In areas of the CHT where spring water fluoride concentrations exceed these thresholds, the co-occurrence of fluorosis with the severe dietary calcium deficiency typical of CHT indigenous communities (whose diets are low in dairy products and calcium-rich plant foods) creates a compounding pathological interaction: calcium deficiency increases fluoride absorption from the gut and reduces the body's capacity to compete with fluoride for bone mineral binding sites, effectively increasing the biological impact of a given fluoride exposure. The clinical recognition of dental fluorosis in CHT children during routine examination is thus not merely a cosmetic finding but a marker of ongoing fluoride exposure that should trigger investigation of the local water source fluoride concentration and consideration of alternative water sources or defluoridation interventions.

3.2 Agricultural Pesticides and the CHT Farming Community: Exposure Assessment, Health Effects, and Clinical Management

Agricultural pesticide use in the CHT has increased substantially over the past three decades as subsistence farmers have incorporated commercially produced crop protection chemicals into their farming practices alongside or in replacement of traditional botanical pest control methods. The transition from traditional to chemical pest management has been driven by the compression of jhum rotation cycles (which reduces natural soil regeneration and increases pest pressure in crops planted on depleted soils), the introduction of commercial rice varieties with different pest susceptibility profiles from traditional landraces, the availability of subsidized pesticides through agricultural input supply programs, and the loss of traditional botanical pest control knowledge as younger generations disengage from traditional farming practices. The pesticide classes most commonly used in CHT agricultural communities include organophosphate insecticides (including chlorpyrifos, malathion, and profenofos), carbamate insecticides, synthetic pyrethroid insecticides, herbicides including glyphosate, paraquat, and various acetolactate synthase inhibitor formulations, and fungicides including mancozeb and copper-based preparations.

Organophosphate pesticide exposure is the most clinically urgent dimension of CHT agricultural chemical toxicology because organophosphate poisoning (both acute and chronic) is a significant cause of morbidity and mortality in agricultural communities globally, and the limited clinical capacity for managing acute organophosphate poisoning in CHT health facilities creates a scenario in which even moderately severe poisoning cases have high case fatality rates. Organophosphates are irreversible inhibitors of acetylcholinesterase (AChE), the enzyme responsible for the breakdown of acetylcholine at nerve terminals and neuromuscular junctions. Inhibition of AChE leads to accumulation of acetylcholine at muscarinic receptors (producing the muscarinic features of organophosphate poisoning: excessive salivation, lacrimation, urination, defecation, gastrointestinal cramping and diarrhea, bronchospasm, bradycardia, miosis) and at nicotinic receptors (producing the nicotinic features: muscle fasciculations, weakness, and ultimately respiratory paralysis). The clinical diagnosis of acute organophosphate

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poisoning in the CHT context requires recognition of the cholinergic toxidrome in a patient with a plausible exposure history (typically recent agricultural pesticide application without adequate personal protective equipment, which is essentially never used by smallholder farmers in the CHT due to cost, unavailability, and lack of training). The SLUDGE mnemonic (Salivation, Lacrimation, Urination, Defecation, Gastrointestinal distress, Emesis) captures the muscarinic features of acute organophosphate poisoning and is a useful clinical teaching tool for CHT health workers. Management requires atropine (a muscarinic receptor antagonist) for the cholinergic crisis, pralidoxime (2-PAM) for cholinesterase reactivation if administered early enough before aging of the AChE-organophosphate bond, and supportive care including airway management and intensive monitoring.

The challenge of managing acute organophosphate poisoning in remote CHT health facilities is severe because the standard management protocol requires atropine in large and repeated doses (initial doses of 2 to 4 mg IV every 5 to 10 minutes, titrated to drying of secretions and cessation of bronchospasm, with total doses sometimes exceeding 100 mg in severe poisoning), and many remote CHT facilities have very limited atropine supplies. Pralidoxime is frequently unavailable outside district hospitals. The airway management requirements of severe organophosphate poisoning (including endotracheal intubation and mechanical ventilation for respiratory muscle paralysis) are available only at the district hospital level in the CHT, meaning that the vast majority of remote CHT communities have no realistic capacity to manage severe acute organophosphate poisoning and must rely on timely referral to district-level facilities, with all the access barriers that entails. The development of a CHT-specific acute poisoning management protocol that accounts for the resource constraints of remote facilities, including guidance on pre-referral stabilization measures, optimizing the use of available atropine, and early warning indicators that should trigger emergency evacuation, is a health system preparedness need that has not been adequately addressed.

Chronic low-level organophosphate exposure among CHT farming families, through dermal contact during agricultural work, inhalation of spray aerosols, and consumption of produce with pesticide residues, produces a sub-acute toxicity syndrome characterized by fatigue, headache, memory impairment, irritability, depression, and peripheral neuropathy. This syndrome, which corresponds to the clinical picture of chronic organophosphate-induced neuropsychiatric disorder, is likely under-recognized in CHT clinical practice because its presentation overlaps extensively with the presentations of other common CHT conditions (including nutritional deficiency, anemia, and psychosocial stress reactions) and because the occupational history that would suggest pesticide exposure is not routinely elicited in standard CHT clinical consultations. The recognition of chronic pesticide-induced neuropsychiatric disorder as a distinct diagnostic category in the CHT requires the systematic incorporation of occupational history into the clinical assessment protocol for all adult CHT patients presenting with fatigue, cognitive complaints, or mood disorder, a practice change that is both low-cost and high-yield.

Paraquat deserves specific mention because of its extreme acute toxicity and its availability in CHT farming communities for weed control, where it is used without adequate understanding of its lethality. Acute paraquat poisoning produces a lethal lung injury through the generation of reactive oxygen species that cause progressive, irreversible, fibrosing alveolitis, typically

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manifesting 24 to 72 hours after ingestion, progressing to respiratory failure and death in the majority of cases with significant paraquat ingestion. There is no antidote for paraquat poisoning, and the progressive pulmonary fibrosis it causes is not reversible even with intensive supportive care. The case fatality rate for acute paraquat poisoning is approximately 50 to 90 percent depending on ingested dose, and death typically occurs from respiratory failure within 2 to 4 weeks of ingestion. In the CHT context, where paraquat is used on farms without safety awareness programs and where it is sometimes accessible in unlocked storage by individuals with suicidal ideation (paraquat ingestion for deliberate self-harm is a documented method of suicide in Asian agricultural communities), the presence of paraquat in farm households represents a specific and preventable cause of premature death that intersects with both the occupational health and the mental health dimensions of CHT community life. The removal of paraquat from the market in Bangladesh (which has been partially achieved through regulatory action but incompletely implemented in the informal agricultural input market) is a public health measure whose most direct benefit would be felt in precisely the kinds of remote agricultural communities that predominate in the CHT.

3.3 Heavy Metal Toxicology in the CHT: Lead, Mercury, and the Mining Interface

Lead exposure in the CHT is a complex and insufficiently studied public health concern. Unlike the well-characterized lead exposure pathways of urban industrial environments (leaded paint, leaded fuel exhaust, industrial smelter emissions), lead exposure in the CHT operates through several less obvious pathways that require specific clinical awareness. Traditional pottery and ceramic household vessels, some of which are glazed with lead-containing ceramic glazes (a practice that persists in some traditional craft communities), can leach lead into food and beverages stored in them, particularly acidic foods. Some traditional cosmetic preparations used in CHT communities, including certain red and black pigments used in traditional tattooing practices of the Marma and Mro communities and in cosmetic face paint preparations used for festivals, contain inorganic lead compounds. The grinding of certain mineral pigments for traditional art and body decoration produces lead-contaminated dust that can be inhaled or ingested. While no systematic blood lead level surveys have been conducted in CHT indigenous communities (a significant surveillance gap), the presence of multiple low-level lead exposure pathways, acting in combination, warrants monitoring attention, particularly for children, in whom even very low blood lead levels (now recognized as having no safe threshold) produce measurable neurodevelopmental impairment including reduced cognitive performance and behavioral dysregulation.

Mercury exposure in CHT river-fishing communities represents a distinct toxicological concern that arises from the biogeochemical context of the CHT terrain and the food security dependence of CHT indigenous communities on river fish as a primary protein source. Mercury from geological sources and from anthropogenic inputs (including the illegal gold mining activities that have been reported in some areas of the Myanmar-Bangladesh border region) enters the aquatic environment in inorganic forms that are methylated by anaerobic sulfate-reducing bacteria in sediments, producing methylmercury, which bioaccumulates through the aquatic food chain with a biomagnification factor that concentrates mercury most intensively in large predatory fish species. Regular consumption of large predatory fish species from rivers with

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elevated methylmercury levels can produce chronic methylmercury toxicity, characterized by paresthesia, ataxia, visual field constriction, hearing impairment, and in severe cases, progressive neurological deterioration (Minamata disease in its classic form). Pregnant women and developing fetuses are disproportionately vulnerable to methylmercury neurotoxicity because methylmercury crosses the placental barrier and the blood-brain barrier, concentrating in fetal brain tissue and producing teratogenic neurological effects (including cerebral palsy, cognitive impairment, and seizure disorders) at lower exposures than those required to produce overt toxicity in adults. The public health implications of this in the CHT, where fish is the principal protein source of many communities and where alternative protein sources are limited by poverty and terrain, are complex: blanket fish consumption warnings risk worsening already severe protein-energy malnutrition in communities that depend on fish protein for survival, while ignoring methylmercury exposure risks harm to pregnant women and developing children. The appropriate public health response requires community-specific fish mercury monitoring, with targeted advice on fish species selection and consumption frequency rather than blanket warnings.

MODEL EXAMINATION QUESTIONS: CHAPTER THREE

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The SLUDGE mnemonic for organophosphate poisoning stands for: a) Stridor, Lacrimation, Urticaria, Diaphoresis, Gastrointestinal upset, Emesis b) Salivation, Lacrimation, Urination, Defecation, Gastrointestinal distress, Emesis c) Syncope, Lethargy, Urticaria, Diarrhea, Gastritis, Emesis d) Salivation, Lassitude, Urinary retention, Dyspnea, GI pain, Edema (Correct Answer: b)

The antidote for the muscarinic features of organophosphate poisoning is: a) Pralidoxime (2-PAM) b) Atropine c) N-acetylcysteine d) Digoxin-specific antibody Fab fragments (Correct Answer: b)

Chronic exposure to fluoride in drinking water above WHO guideline values causes which of the following conditions? a) Kidney stones only b) Dental fluorosis (at all levels of chronic excess exposure) and skeletal fluorosis (at high chronic exposures) c) Liver cirrhosis and portal hypertension d) Peripheral neuropathy only (Correct Answer: b)

Paraquat poisoning produces lethality primarily through which mechanism? a) Hepatic necrosis b) Renal tubular destruction c) Progressive irreversible fibrosing alveolitis from reactive oxygen species-mediated lung injury d) Cardiac arrhythmia (Correct Answer: c)

Methylmercury in aquatic environments is produced by the methylation of inorganic mercury by which organisms? a) Phytoplankton and algae b) Anaerobic sulfate-reducing bacteria in sediments c) Large predatory fish via liver metabolism d) Atmospheric photochemical reactions (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

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A CHT upazila health complex receives a farmer presenting with profuse sweating, severe salivation, miosis, bradycardia of 42 beats per minute, bronchospasm with wheeze, and diarrhea, four hours after spraying chlorpyrifos on a jhum field without protective equipment. What is the immediate priority intervention? a) Establish IV access and give activated charcoal b) Administer IV atropine 2 to 4 mg immediately and repeat every 5 to 10 minutes titrated to drying of secretions and cessation of bronchospasm, while assessing airway and arranging emergency referral c) Administer pralidoxime 1 g IV first before atropine d) Perform gastric lavage before any antidote administration (Correct Answer: b)

A public health officer in Bandarban discovers that a remote community's only spring water source has a fluoride concentration of 2.8 mg/L. Survey of the community reveals that several children aged 6 to 12 have brown-stained, pitted enamel affecting multiple permanent teeth. What is the most appropriate immediate public health response? a) Advise the community that this is a cosmetic issue and does not require intervention b) Identify an alternative water source with lower fluoride concentration as a priority, or implement a community-level defluoridation intervention, while also investigating skeletal fluorosis risk in adult community members with joint pain c) Prescribe calcium and vitamin D supplements to the affected children d) Apply fluoride varnish to the children's teeth to prevent further damage (Correct Answer: b)

CHAPTER FOUR: ADVANCED SURGICAL EMERGENCIES, TRAUMA SURGERY, ANAESTHESIA, AND INTENSIVE CARE IN THE CHITTAGONG HILL TRACTS: THE OPERATING TABLE AT THE EDGE OF THE WORLD

4.1 The Surgical Burden of the CHT: An Honest Epidemiological Picture

The global surgery movement, catalyzed by the Lancet Commission on Global Surgery whose landmark 2015 report estimated that 5 billion people worldwide lacked access to safe, affordable surgical care, has increasingly recognized that remote, mountainous, and geographically isolated populations bear a disproportionate share of the unmet surgical burden. The CHT is a paradigmatic case of this geographic surgical inequity. The territory's combination of occupational injury risks (from subsistence agriculture, forestry, and fishing), obstetric emergency rates (from inadequate antenatal care and the persistence of home delivery without skilled attendance in the most remote communities), vector-related surgical emergencies (including snakebite requiring limb-saving intervention and the complications of severe malaria that sometimes require neurosurgical management), and the physical hazards of the mountainous terrain itself (including falls, landslides, and drowning) creates a surgical burden that is substantial and largely unmet. The surgical capacity of the CHT health system is severely limited. The three district hospitals (Rangamati General Hospital, Bandarban District Hospital, and Khagrachhari District Hospital) provide the only facilities in the CHT with surgical theatre capability, and all three are significantly below international standards for surgical volume, anaesthetic capacity, blood banking, and post-operative care. Upazila health complexes across the CHT have no surgical capability. The consequence is that the vast majority of surgical emergencies arising in remote CHT communities cannot be managed at the nearest health facility

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and require referral to the district hospital level, across distances and terrain that make timely arrival impossible in many cases.

The concept of the Surgical Golden Hour is well established in trauma management: for the most time-critical surgical emergencies (including hemorrhagic shock, obstetric hemorrhage, ruptured ectopic pregnancy, and surgical airway obstruction), definitive surgical intervention within approximately 60 minutes of injury or onset dramatically improves outcomes compared with delayed intervention. In the CHT, the geographic reality makes the surgical golden hour unachievable for the majority of the population in most emergency scenarios. A community located 40 kilometers from the district hospital by unmetalled mountain road, with a journey time of 3 to 5 hours under the best dry-season conditions and 6 to 8 hours during the monsoon when roads are flooded or landslide-damaged, cannot benefit from the golden hour regardless of the quality of surgical care available at the district hospital. The appropriate response to this geographic reality is not to abandon the surgical golden hour standard as irrelevant to the CHT but to develop a pre-hospital care and damage control resuscitation framework that stabilizes the patient during the extended transit time, reducing the physiological deterioration that makes surgical intervention more hazardous when the patient eventually arrives at the district hospital. Damage control resuscitation (DCR), encompassing permissive hypotension management (accepting systolic blood pressure of 80 to 90 mmHg in penetrating trauma to avoid diluting clotting factors before surgical hemorrhage control), hemostatic resuscitation principles (minimizing crystalloid and preferring blood products in the appropriate ratio), tourniquet application for extremity hemorrhage (which saves lives in the pre-hospital setting), wound packing with hemostatic dressings for non-tourniquet-amenable hemorrhage sites, and airway management with basic airway adjuncts (jaw thrust, oropharyngeal airway, bag-mask ventilation), can be taught to community health workers and health facility staff at the upazila level, potentially transforming the pre-referral phase from a period of unmanaged deterioration into a period of active stabilization.

4.2 Obstetric Surgery in the CHT: Caesarean Section Capacity and the Emergency Obstetric Care Deficit

Caesarean section (CS) is the most life-saving surgical procedure in the world for pregnant women in the context of obstructed labor, uterine rupture, placenta praevia, abruptio placentae with fetal distress, cord prolapse, severe pre-eclampsia with failed induction of labor, and other obstetric emergencies that cannot be safely managed through vaginal delivery. The global standard for basic emergency obstetric care (BEmOC) includes signal functions that do not require CS capability (including administration of oxytocics, anticonvulsants, and antibiotics, as well as manual removal of placenta and assisted vaginal delivery), while comprehensive emergency obstetric care (CEmOC) specifically requires CS capability and blood transfusion. The WHO recommends at least one CEmOC facility per 500,000 population. Applying this standard to the CHT, with an estimated population of 1.8 million, the territory requires at least three to four CEmOC facilities. The three district hospitals theoretically provide this coverage, but the practical inaccessibility of these facilities from the majority of the CHT population (due to the geographic barriers described above) means that the functional coverage of CEmOC in the CHT is far below the nominal coverage that facility counts suggest. The result is a maternal

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mortality landscape in which the risk of death from obstructed labor, uterine rupture, and hemorrhagic obstetric emergencies is substantially higher in remote CHT communities than in areas with better access to CS capability, with the communities furthest from district hospitals bearing the highest risk.

The development of upazila-level CS capability in selected strategically located CHT upazila health complexes is a health system investment whose cost-effectiveness in terms of maternal lives saved per health dollar invested is almost certainly very high, and whose technical feasibility has been demonstrated by successful programs in comparable settings in Sub-Saharan Africa (the Malawi and Tanzania programs for task-shifting CS to clinical officers with 3-month surgical training), South Asia (the programs in rural Nepal and northern India for integrating emergency obstetric surgery into secondary-level facilities), and Bangladesh itself (the BRAC-supported efforts to build CS capacity in remote Bangladeshi district health facilities). The standard objection that upazila-level surgical programs cannot be sustained due to lack of qualified anaesthetic and surgical personnel is valid but not insurmountable: the task-shifting models developed for rural Africa and South Asia demonstrate that non-physician clinicians with focused surgical and anaesthetic training can perform CS and manage its immediate complications safely, with outcomes comparable to physician-performed CS in the resource-constrained settings for which the task-shifting protocols were designed. The barrier in the CHT is political and economic rather than technical: the investment in training, equipping, and supporting task-shifted surgical personnel at upazila level requires sustained health system financing and political commitment that has not been forthcoming.

4.3 Ketamine: The Essential Anaesthetic Agent for the CHT

Ketamine hydrochloride is the single most important anaesthetic drug for the CHT context, and an understanding of its pharmacology, clinical applications, and limitations is essential for every clinician practicing in the CHT. Ketamine is a dissociative anaesthetic agent that acts primarily as an NMDA (N-methyl-D-aspartate) receptor antagonist, producing a state of dissociative anesthesia characterized by profound analgesia, a trance-like cataleptic state with eyes open, preservation of protective airway reflexes (laryngeal and pharyngeal reflexes remain largely intact, reducing (but not eliminating) the risk of aspiration compared with other anaesthetic agents that suppress these reflexes), and hemodynamic stimulation (ketamine increases heart rate, cardiac output, and blood pressure by stimulating sympathetic tone and inhibiting catecholamine reuptake, making it particularly valuable in the hemodynamically compromised patient who would be further destabilized by the vasodilation and myocardial depression produced by volatile agents or propofol). These pharmacological properties make ketamine uniquely appropriate for the CHT surgical context, where patients frequently arrive in a state of hypovolemic compromise, where sophisticated airway management equipment (laryngoscopes, endotracheal tubes, ventilators) may be unavailable or in limited supply, and where the procedure may need to be performed by a non-specialist health worker with limited anaesthetic training. Ketamine can be administered intramuscularly (4 to 6 mg/kg for induction of anesthesia) or intravenously (1 to 2 mg/kg for induction), and its relatively long duration of action (10 to 15 minutes for IV dosing with incremental top-up doses available as needed) provides sufficient operating time for many emergency procedures including CS, wound

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debridement, fracture reduction and stabilization, and initial management of burns. The WHO includes ketamine in the Model List of Essential Medicines, and it is present on the essential medicines list of Bangladesh, though its reliable availability at remote CHT facilities remains inconsistent.

The principal limitation of ketamine as a sole anaesthetic agent in the CHT context is its tendency to produce emergence phenomena: vivid dreams, hallucinations, and agitation during recovery from ketamine anaesthesia, which can be distressing to the patient and disruptive in a resource-limited facility without the monitoring and nursing capacity to manage emergence agitation effectively. The co-administration of a benzodiazepine (typically diazepam or midazolam at low dose) significantly reduces the incidence and severity of emergence phenomena without compromising ketamine's airway-protective and hemodynamic-stimulating properties, and this combination (ketamine plus benzodiazepine) is the standard for ketamine anaesthesia in resource-limited settings. Ketamine is also an outstanding analgesic agent at sub-anaesthetic doses (0.1 to 0.5 mg/kg IV) that can be used for procedural analgesia, wound care, fracture reduction, and the management of severe acute pain in CHT health facilities that lack opioid analgesic resources. Its use in the management of acute pain in snakebite, trauma, and obstetric emergencies represents a significant and underutilized clinical opportunity in the CHT.

4.4 Snakebite Surgical Complications and Limb-Saving Protocols

Snakebite was identified in Part Two of this textbook as a major occupational emergency in the CHT, with the Russell's viper (Daboia russelii) and the king cobra (Ophiophagus hannah) among the most clinically significant species in the territory. The surgical complications of snakebite, which are among the most challenging management problems in CHT surgical practice, include compartment syndrome (from venom-induced tissue edema and necrosis within tight facial compartments of the limb, requiring urgent fasciotomy to relieve pressure and preserve limb viability), wound necrosis and gangrene (from the direct cytotoxic and proteolytic effects of venom at the bite site and surrounding tissues, requiring serial debridement, skin grafting, or in severe cases amputation), and hemorrhagic complications in systemic envenomation (including deep tissue hematoma, hemarthrosis, and retroperitoneal hemorrhage from venom-induced coagulopathy). The management of snakebite surgical complications in the CHT is constrained by the same access barriers that constrain all surgical care: by the time a patient with limb-threatening compartment syndrome reaches a facility with fasciotomy capability, irreversible muscle necrosis may already be established, transforming a limb-saving intervention into a limb-salvage attempt with limited prognosis.

The clinical recognition of compartment syndrome following snakebite is a priority skill for every CHT health worker regardless of the level of surgical capability at their facility, because early recognition and rapid referral are the only interventions available at the primary care level that can alter the outcome. The four Ps of compartment syndrome (Pain out of proportion to the injury, Pressure in the compartment elevated to palpation, Paresthesia in the distribution of nerves running through the compartment, Pallor of the distal limb with impaired or absent pulses in advanced cases) provide the clinical recognition framework, with the caveat that in snakebite compartment syndrome the typical trauma-related mechanism (tight bandaging, cast constriction,

or crush injury) is absent and the pathological pressure arises from venom-induced edema and hemorrhage into the compartment. The traditional first aid measure of tight tourniquet application proximal to a snakebite, widely practiced in CHT communities, is contraindicated because it does not prevent systemic envenomation (most clinically important venom toxins are absorbed too rapidly and via lymphatic routes that are not occluded by limb tourniquets) while it increases local tissue ischemia and worsens the ischemia-reperfusion injury and compartment syndrome risk that contribute most to limb loss. Community health education about the harmfulness of tourniquet application for snakebite is a public health priority in the CHT that has not received adequate attention.

MODEL EXAMINATION QUESTIONS: CHAPTER FOUR

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The primary mechanism of action of ketamine as an anaesthetic agent is: a) GABA-A receptor positive allosteric modulation (like propofol and benzodiazepines) b) NMDA (N-methyl-D-aspartate) receptor antagonism c) Mu-opioid receptor agonism d) Sodium channel blockade (like local anaesthetics) (Correct Answer: b)

The WHO recommended minimum number of CEmOC (Comprehensive Emergency Obstetric Care) facilities per population is: a) 1 per 100,000 population b) 1 per 500,000 population c) 1 per 1,000,000 population d) 1 per 2,000,000 population (Correct Answer: b)

The clinical tetrad "Four Ps" used to recognize compartment syndrome includes all EXCEPT: a) Pain out of proportion to the injury b) Pressure elevated in the compartment c) Paresthesia in the distribution of nerves through the compartment d) Pyrexia (fever) (Correct Answer: d)

Which of the following properties of ketamine makes it particularly valuable for anaesthesia in hemodynamically compromised CHT trauma patients? a) It causes profound vasodilation and myocardial depression b) It stimulates sympathetic tone, increasing heart rate, cardiac output, and blood pressure c) It depresses all protective airway reflexes, facilitating intubation d) It has no effect on blood pressure or heart rate (Correct Answer: b)

Damage control resuscitation (DCR) in the pre-hospital phase of managing traumatic hemorrhage includes which of the following principles? a) Aggressive fluid resuscitation with large volumes of normal saline to restore normal blood pressure b) Permissive hypotension (accepting systolic BP 80-90 mmHg), hemostatic resuscitation, tourniquet application for extremity hemorrhage, and wound packing with hemostatic dressings c) Immediate administration of broad-spectrum IV antibiotics before transport d) Oral rehydration therapy for pre-hospital hemorrhage management (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A Chakma farmer is brought to an upazila health complex 3 hours after Russell's viper bite to the right foot while working in a jhum field. He has a tight traditional tourniquet applied above the

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knee by community members. The foot is swollen, cool, and mottled, with absent dorsalis pedis pulse. The patient has 20/20 vision, no bleeding from the gums, and urine is clear. What is the most appropriate immediate management? a) Keep the tourniquet in place to prevent systemic envenomation and arrange antivenom b) Remove the tourniquet carefully while monitoring for reperfusion injury, assess the limb for viability and compartment syndrome, administer polyvalent antivenom if available, obtain coagulation studies, and arrange emergency referral for limb assessment and possible fasciotomy c) Apply a second tourniquet distal to the bite for additional venom containment d) Incise and suck the wound to remove venom before tourniquet removal (Correct Answer: b)

A district hospital surgeon in Rangamati is planning to expand CS capability to two remote upazila health complexes in his district using task-shifted non-physician personnel. Based on global health evidence from comparable programs in Sub-Saharan Africa, South Asia, and Bangladesh, what is the most evidence-supported conclusion about the safety and feasibility of this approach? a) Task-shifted CS by non-physician clinicians is too dangerous to recommend in any setting b) Non-physician clinicians with focused surgical and anaesthetic training can perform CS and manage its immediate complications safely, with outcomes comparable to physician-performed CS in resource-constrained settings, and this model has been successfully implemented in multiple low-income country settings c) Task-shifted CS is only feasible for uncomplicated elective CS, not for emergency cases d) The task-shifting model requires a physician supervisor physically present in the operating room at all times (Correct Answer: b)

CHAPTER FIVE: ORAL HEALTH AND DENTAL MEDICINE IN THE CHITTAGONG HILL TRACTS: THE MOST NEGLECTED DIMENSION OF CARE

5.1 The Oral Health Burden of CHT Indigenous Communities: Mapping the Invisible Disease

Oral health in the Chittagong Hill Tracts is the most comprehensively neglected dimension of the already severely neglected health agenda for the territory. The oral cavity is both a mirror of systemic health and an independent determinant of wellbeing, nutritional capacity, psychological functioning, and social participation, yet oral health receives essentially no dedicated clinical or public health attention in the CHT health system. There is no dental service at any government facility below the district hospital level in the CHT, and even the district-level dental services are limited to extractions and basic restorations in facilities that lack the specialist equipment, materials, and trained personnel for comprehensive dental care. Community surveys have not been conducted with sufficient rigor or coverage to produce reliable estimates of oral disease prevalence in CHT indigenous communities, but the available data from comparable low-income indigenous community settings in South and Southeast Asia, combined with the known risk factor profile of CHT communities (high sugar consumption in the form of unrefined palm sugar and betel nut preparations, tobacco use including traditional smoking and chewing preparations, fluoride exposure in some areas, severe dietary micronutrient deficiencies particularly vitamin C and calcium, and limited exposure to the preventive dental services that have reduced caries

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burden in wealthier populations) paint a picture of severe oral disease burden that should catalyze attention.

Dental caries (tooth decay) is almost certainly the most prevalent specific disease condition in CHT communities when measured by point prevalence across the population, though this claim cannot be made with certainty due to the absence of systematic prevalence data. Dental caries arises from the fermentation of dietary sugars by oral bacteria (primarily Streptococcus mutans) in the dental plaque biofilm, producing acids that demineralize the tooth enamel and dentine, progressing through cavitation to pulp involvement, abscess formation, and tooth loss if untreated. The risk factors for dental caries in CHT indigenous communities are multiple and synergistic: high intake of fermentable carbohydrates (both from rice, which is the dietary staple, and from the unrefined palm sugar, sugarcane products, and betel preparations widely consumed in CHT communities), inadequate or absent mechanical tooth cleaning (toothbrush and fluoride toothpaste use is limited by cost and availability in remote areas, while traditional chewing stick tooth cleaning practices, though somewhat effective at mechanical plaque removal, do not provide the chemical protection of fluoride), and the fluoride exposure paradox (where some communities are exposed to excess fluoride causing fluorosis-related enamel damage that paradoxically increases caries risk in fluorotic teeth by compromising enamel structural integrity, while other communities have essentially zero fluoride exposure and thus no protection from the anti-caries effect of fluoride). The progression from untreated dental caries to dental pulp infection, periapical abscess, and cellulitis of the jaw and neck (Ludwig's angina) represents a specific and potentially lethal risk in communities with no access to dental extractions or antibiotic treatment for dental infections. Ludwig's angina (bilateral submandibular and sublingual space infection) can cause death from airway obstruction within hours, and its management in a CHT health facility without surgical airway capability or ENT expertise represents a critical emergency. Several deaths from Ludwig's angina in resource-limited settings are documented annually in the global literature, and it would be surprising if similar deaths do not occur in remote CHT communities without being captured in any mortality surveillance.

5.2 Betel Nut, Tobacco, and Oral Cancer: The CHT Mucosal Carcinogen Burden

The chewing of areca nut (Areca catechu, widely known as betel nut or supari) mixed with betel leaf (Piper betle), slaked lime (calcium hydroxide), and often tobacco (in preparations locally called zarda, gul, or tobacco-mixed betel), is one of the most widespread oral behaviors in CHT indigenous communities, practiced across age groups and by both sexes in many communities, with particular prevalence among adult women in some CHT ethnic groups where betel chewing has deep cultural and social significance. The International Agency for Research on Cancer (IARC) classifies areca nut as a Group 1 carcinogen (definitely carcinogenic to humans) based on its direct causal role in the etiology of oral submucous fibrosis (a precancerous condition characterized by progressive fibrosis of the oral submucosal connective tissue, producing trismus, burning sensation, and restriction of mouth opening that ultimately makes eating, speaking, and swallowing difficult) and squamous cell carcinoma of the oral cavity, oropharynx, and esophagus. The addition of tobacco to betel preparations dramatically increases the carcinogenic potency of the combination: tobacco contains nitrosamines, polycyclic aromatic hydrocarbons, and other carcinogens whose carcinogenic effects are synergistic with the areca

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nut alkaloids (particularly arecoline, which promotes reactive oxygen species generation and inhibits DNA repair mechanisms) in producing chromosomal instability and malignant transformation in oral mucosal cells. The World Health Organization estimates that oral cancer attributable to betel-tobacco chewing is the leading cause of cancer incidence and mortality in many Southeast Asian populations, and the CHT population's high prevalence of betel-tobacco chewing habits, combined with their essentially zero access to cancer screening, oral cancer awareness programs, or early oral cancer treatment, creates a scenario of predictable and preventable carcinogenesis that is proceeding largely unobserved and unchecked.

The clinical recognition of the oral precancerous spectrum in CHT patients is a critical skill for all health workers in the CHT, because oral precancerous lesions and early-stage oral cancers are visually diagnosable at the primary care level without expensive equipment, and early detection dramatically improves survival. The three primary precancerous conditions associated with betel-tobacco use in the CHT context are oral leukoplakia (white patches on the oral mucosa that cannot be removed by wiping and that carry a malignant transformation risk of approximately 1 to 5 percent per year), oral submucous fibrosis (OSMF, recognizable by the pale, fibrotic, leathery appearance of the oral mucosa, restricted mouth opening, and the inability to pinch the oral mucosa between the thumb and forefinger due to fibrous stiffness of the submucosa), and erythroplakia (red, velvety patches on the oral mucosa that are significantly more likely than leukoplakia to represent high-grade dysplasia or early invasive carcinoma, with malignant transformation rates of 14 to 50 percent in published series). The practical incorporation of oral cancer screening into every clinical encounter with adult CHT patients who use betel-tobacco preparations requires only a tongue depressor, a good light source, and the clinical knowledge to recognize the precancerous spectrum described above. This intervention costs essentially nothing, requires no equipment beyond what is already available at primary care level, and has the potential to detect oral cancers at a stage when surgical cure is feasible.

5.3 Periodontal Disease: The Systemic Dimension of CHT Gum Disease

Periodontal disease (disease of the supporting structures of the teeth, including the gingiva, alveolar bone, and periodontal ligament) is the most common chronic inflammatory disease in adults globally and is estimated to affect 45 to 50 percent of the adult population worldwide. In populations with the nutritional profile of CHT indigenous communities (vitamin C deficiency is particularly relevant, as severe vitamin C deficiency causes scurvy with its characteristic bleeding gum presentation that represents extreme periodontal fragility, while even subclinical vitamin C deficiency impairs the collagen synthesis required for periodontal ligament integrity and gingival wound healing), the prevalence and severity of periodontal disease is likely high. The systemic consequences of chronic periodontitis have been established by a large and growing body of evidence: periodontal pathogens (including Porphyromonas gingivalis, Tannerella forsythia, and Treponema denticola) enter the systemic circulation through the inflamed and ulcerated periodontal pocket epithelium, generating persistent bacteremia and systemic inflammatory responses that contribute to the pathogenesis of cardiovascular disease (atherosclerosis, acute myocardial infarction, and stroke), diabetes mellitus (the bidirectional periodontal-diabetes relationship is well-established: diabetes worsens periodontal disease through impaired neutrophil function and advanced glycation end-product accumulation, while

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periodontal disease worsens glycemic control through systemic inflammatory cytokine generation), adverse pregnancy outcomes (preterm birth and low birth weight are associated with chronic periodontitis in the pregnant woman), and possibly respiratory disease (through aspiration of oral pathogens into the lower respiratory tract). In the CHT, where the systemic disease burden includes the same conditions that periodontal disease is documented to worsen (cardiovascular disease, diabetes, adverse pregnancy outcomes, and respiratory infections), the oral-systemic health connection is particularly clinically consequential and particularly ignored.

MODEL EXAMINATION QUESTIONS: CHAPTER FIVE

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

IARC (International Agency for Research on Cancer) classifies areca nut in which carcinogen group? a) Group 2A (probably carcinogenic) b) Group 2B (possibly carcinogenic) c) Group 1 (definitely carcinogenic to humans) d) Group 3 (not classifiable as to carcinogenicity) (Correct Answer: c)

Oral submucous fibrosis (OSMF) is a precancerous condition primarily caused by: a) Tobacco smoking only b) Areca nut (betel nut) chewing, with or without tobacco c) Human papillomavirus (HPV) infection d) Nutritional deficiency alone (Correct Answer: b)

Ludwig's angina is best defined as: a) Unilateral parotid gland abscess b) Bilateral submandibular and sublingual space infection that can cause airway obstruction c) Periapical abscess of a single tooth without spread d) Unilateral submandibular lymph node abscess (Correct Answer: b)

The primary bacterial pathogen responsible for dental caries through acid fermentation of dietary sugars in dental plaque is: a) Porphyromonas gingivalis b) Streptococcus mutans c) Staphylococcus aureus d) Fusobacterium nucleatum (Correct Answer: b)

Vitamin C deficiency (scurvy) affects oral/dental health by causing which specific manifestation? a) Dental caries through reduced salivary pH b) Bleeding and spongy gums (gingival hemorrhage) from impaired collagen synthesis in the periodontal tissues c) Tooth discoloration from iron deficiency d) Parotid enlargement from acinar cell dysfunction (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A CHT public health officer designing a community-level oral cancer prevention program for a remote Mro community in Alikadam where betel-tobacco chewing is practiced by more than 70 percent of adults should prioritize which of the following evidence-based interventions? a) Providing comprehensive dental care including restorations and root canal treatment through a mobile dental clinic b) Training community health workers and primary care physicians to perform visual oral cancer screening at every clinical encounter, identifying leukoplakia, erythroplakia, and OSMF for specialist referral, combined with betel-tobacco cessation

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counseling and community health education about the carcinogenic risks of betel-tobacco use c) Distributing free toothbrushes and fluoride toothpaste d) Providing free dentures to edentulous community members (Correct Answer: b)

The bidirectional relationship between periodontitis and type 2 diabetes mellitus operates through which mechanisms? a) Insulin produced by the pancreas is directly inactivated by periodontal bacterial endotoxins b) Periodontitis worsens glycemic control through systemic pro-inflammatory cytokine generation (increasing insulin resistance) while diabetes worsens periodontitis through impaired neutrophil function and advanced glycation end-product accumulation in periodontal tissues c) Diabetes causes direct salivary glucose elevation that promotes periodontal bacterial growth only d) Both conditions share a single genetic determinant without causal interaction (Correct Answer: b)

CHAPTER SIX: HEALTH SYSTEMS GOVERNANCE, INDIGENOUS HEALTH RIGHTS, AND THE POLITICAL ARCHITECTURE OF HEALTHCARE IN THE CHITTAGONG HILL TRACTS

6.1 The International Human Rights Framework for Indigenous Health: UNDRIP and Its CHT Application

The United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), adopted by the United Nations General Assembly on September 13, 2007, represents the most comprehensive international normative framework for the rights of indigenous peoples and has direct and specific application to the health rights of CHT indigenous communities. Bangladesh voted in favor of UNDRIP, which means that as a matter of international political commitment (though UNDRIP is not a legally binding treaty instrument) Bangladesh has endorsed the principles it articulates. The health-relevant provisions of UNDRIP are extensive and specific. Article 21 affirms that indigenous peoples have the right, without discrimination, to the improvement of their economic and social conditions, including specifically in health. Article 23 affirms that indigenous peoples have the right to determine and develop priorities and strategies for exercising their right to health and other relevant rights, and that they have a right to be actively involved in developing and determining health programs affecting them and, as far as possible, to administer such programs through their own institutions. Article 24 affirms that indigenous peoples have the right to their traditional medicines and to maintain their health practices, including the conservation of their vital medicinal plants, animals, and minerals, and specifically affirms that indigenous individuals have the right of access, without any discrimination, to all social and health services. Article 25 affirms the rights of indigenous peoples to maintain and strengthen their distinctive spiritual relationship with their traditionally owned or otherwise occupied and used lands, territories, waters, and coastal seas, a provision with direct relevance to the land rights dimensions of CHT indigenous health that have been documented throughout this textbook.

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The gap between the UNDRIP framework and the operational reality of CHT indigenous health is measurable and morally significant. The CHT Peace Accord of 1997, as noted in Part One, included provisions for devolution of health service management to the CHT Regional Council and the three District Hill Councils, which is an institutional expression of the right of indigenous peoples to develop and administer health programs through their own institutions. The inadequate implementation of this devolution, documented in Part One and in extensive NGO monitoring reports from the post-Accord period, represents a direct and documented failure to honor the UNDRIP principle of indigenous self-determination in health. The absence of language-concordant health services (with no government health workers trained in the indigenous languages of the CHT despite the language barrier being one of the most frequently documented barriers to healthcare access) is a direct violation of the UNDRIP principle of access to health services without discrimination. The systematic exclusion of traditional medicine practitioners from the formal health system architecture, rather than their integration as recognized contributors to CHT healthcare (in the manner envisioned by the right to maintain health practices in Article 24), is an ongoing governance failure with direct health consequences. Applying the UNDRIP framework to CHT health governance is not a matter of idealism or legal formalism. It is a practical guide to health system transformation that the evidence consistently shows would produce measurable improvements in health outcomes if implemented.

The Free Prior and Informed Consent (FPIC) principle, which is articulated in UNDRIP and which requires that indigenous peoples' consent be obtained freely, before activities affecting them begin, based on full and accurate information, and through a process that respects their collective decision-making processes, has specific and urgently needed application to health service delivery in the CHT. Health programs that are designed and implemented without the prior consultation and consent of the communities they are intended to serve, even when technically sound, systematically underperform in terms of coverage, uptake, and sustained impact in CHT communities. The evidence for this is visible in the immunization coverage gaps documented in the 2025 measles crisis, in the suboptimal uptake of malaria rapid diagnostic testing in communities where the testing protocol was developed without community input, and in the persistent underutilization of maternal health services in communities where the service model does not accommodate the cultural norms and practical constraints of indigenous women's lives. FPIC is not a bureaucratic delay mechanism. It is a health effectiveness framework that the evidence consistently validates: programs designed with FPIC-based community engagement achieve better coverage, higher uptake, greater community trust, and more sustainable impact than programs imposed without it.

6.2 Health System Decentralization and the CHT Regional and District Councils

The architecture of health system governance in the CHT is formally decentralized by the provisions of the CHT Peace Accord, which established the CHT Regional Council (headed by a Chair elected by the three District Councils) and the three District Hill Councils (each headed by a Chair who must be from an indigenous community) as the primary governance bodies for the CHT, with formal authority over certain government services including health. In practice, as documented across Parts One through Eight of this textbook, this formal decentralization has not produced functional decentralization of health system management authority to the Council

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bodies, because the financial resources, technical capacity, and administrative authority required for effective health system management have not been transferred from central government departments to the Council bodies in the manner the Peace Accord envisioned. The result is a governance vacuum: the central government health bureaucracy (the Ministry of Health and Family Welfare and its Directorate General of Health Services) continues to manage CHT health services through its standard administrative channels, applying national health program templates that were designed for the plains of Bangladesh and that address neither the specific disease burden nor the specific cultural and linguistic context of CHT indigenous communities, while the Council bodies lack the capacity to exercise their formal governance mandate and are reduced to peripheral advisory roles in health service management decisions.

The concept of Health Sovereignty, as applied to the CHT in this textbook, denotes the right and capacity of indigenous communities in the CHT to make the authoritative decisions about the design, resourcing, implementation, monitoring, and evaluation of the health services that affect their communities. Health sovereignty is not merely a political ideal in the CHT context: it is a practical health effectiveness imperative. The evidence consistently demonstrates that health programs designed and managed with genuine indigenous governance participation achieve better outcomes than those imposed from outside the community, because indigenous governance participation produces programs that are culturally appropriate, linguistically accessible, built on community trust, and responsive to community-identified needs rather than externally defined program mandates. The 2024 WHO report on the health of indigenous peoples globally reinforced this evidence base with specific reference to the performance superiority of indigenous-governed health programs in multiple country contexts, and its conclusions are fully applicable to the CHT. Building genuine health sovereignty in the CHT requires not merely the formal legislative changes that the Peace Accord theoretically provides but the sustained capacity-building investment in Council governance institutions (including training of Council health staff, development of Council health planning and monitoring systems, and transfer of adequate financial resources to the Council health budget) that the national government has so far declined to make.

6.3 The National Immunization Program and the Coverage Equity Challenge in the CHT

The Bangladesh national Expanded Programme on Immunization (EPI) is one of the most successful public health programs in South Asian history. Since its establishment in 1979, Bangladesh EPI has achieved national vaccination coverage rates that rank among the highest in the South Asian region, and its contribution to the dramatic declines in vaccine-preventable disease mortality in Bangladesh over the past four decades is incontestable. However, the EPI's extraordinary success at the national aggregate level has masked persistent and documented coverage gaps in specific geographic and demographic subpopulations, of which the indigenous communities of the CHT are the most significant and the most consequential, as demonstrated most recently by the 2025 measles outbreak. The structural causes of EPI coverage gaps in CHT indigenous communities have been analyzed in detail across the preceding parts of this textbook: geographic inaccessibility of remote communities to fixed-facility vaccination services, language barriers that prevent effective communication between vaccination teams and indigenous community members, cultural mistrust of government programs rooted in the political history of

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the CHT, the cold chain limitations that compromise vaccine potency in remote areas with unreliable electricity, and the inadequate community engagement and social mobilization strategies of the EPI outreach program in indigenous communities. These causes are all structural, all documented, and all addressable with sufficient political will and resource investment.

The equity-adjusted immunization coverage framework, which measures not merely aggregate national coverage but the distribution of coverage across different geographic, ethnic, and economic subgroups of the population, reveals the CHT as Bangladesh's most significant immunization equity gap. A 2024 analysis of Bangladesh EPI coverage data disaggregated by division and district found that CHT districts, and particularly remote CHT unions, had the lowest coverage for DPT-3, measles-rubella, and rotavirus vaccines of any administrative units in Bangladesh, with coverage rates in some remote CHT unions below 40 percent compared with national averages above 85 percent. This 45-plus percentage point coverage gap represents hundreds of thousands of children and adults who are unprotected against diseases for which safe, effective, and nationally available vaccines exist. The design of equity-oriented immunization coverage improvement strategies for the CHT requires a departure from the standard EPI program model in several respects. First, fixed-facility vaccination services must be supplemented by mobile and outreach vaccination campaigns specifically designed to reach geographically isolated communities, with sufficient logistical planning (including helicopter or boat transport for the most inaccessible areas during monsoon season) to ensure that these communities receive regular scheduled visits rather than ad hoc coverage. Second, community engagement and social mobilization must be conducted through community-trusted intermediaries rather than external program staff, using the indigenous languages of each target community rather than Bengali, and building on the trust of community leaders including monks, elders, and traditional healers whose endorsement of vaccination is the most effective social mobilization tool in these communities. Third, the cold chain must be extended to the point of service delivery in remote communities through investment in portable cold chain technology (vaccine carriers with adequate ice packs for extended field missions), solar-powered refrigeration at strategic upazila level storage points, and the use of temperature-stable vaccine formulations where available.

The measles-rubella vaccine, whose coverage failure contributed to the deaths of children in the 2025 Kurukpata outbreak, deserves specific attention in this governance analysis. The measles-rubella combined vaccine (MR) is administered in Bangladesh at 9 months and 15 months as part of the national EPI schedule. The 2025 outbreak in the Mro community of Alikadam, which killed more than 220 children with the greatest concentration in Kurukpata Union, occurred in a community where vaccination coverage for MR had been essentially zero for an extended period, meaning that a population cohort of unvaccinated children had accumulated over years, creating the conditions for explosive epidemic spread when measles virus was introduced into the community. This pattern (accumulation of unvaccinated cohort followed by epidemic outbreak when the pathogen enters the community) is the classical mechanism of measles outbreak in low-coverage populations, and it was entirely predictable and preventable given the well-documented low coverage of CHT indigenous communities in national EPI data. The failure to act on the documented coverage gap before the outbreak occurred is a governance failure of the highest

order, and its analysis in this textbook is not merely historical: the same accumulation of vaccine-naïve cohorts is continuing in other remote CHT communities for other vaccine-preventable diseases, creating the conditions for future outbreaks that are equally predictable and equally preventable.

6.4 Health Financing and the Cost of Illness for CHT Indigenous Households

The financing of healthcare in the CHT operates primarily through out-of-pocket payments by households, supplemented by the very limited services available through the government health system (which is nominally free at point of service but in practice involves significant user fees, medicine charges, and informal payments) and the programs of NGOs including BRAC, which provides subsidized community healthcare services in some CHT areas. Out-of-pocket health expenditure as a proportion of household income is substantially higher for CHT indigenous households than for the national average in Bangladesh, because CHT indigenous households have lower average incomes, higher average morbidity (requiring more healthcare utilization), longer distances to health facilities (requiring higher transport expenditure for each healthcare episode), and weaker social protection coverage. Catastrophic health expenditure (defined by WHO as out-of-pocket health expenditure exceeding 10 percent of household consumption expenditure) is a significant cause of poverty and economic insecurity in CHT indigenous communities, with households sometimes selling land, livestock, or other productive assets (a process called impoverishment or asset stripping) to finance healthcare episodes, compounding the poverty and land insecurity that are themselves among the root causes of the high disease burden.

The concept of the Healthcare Poverty Trap, as applied to the CHT, describes the self-reinforcing cycle in which poverty causes high disease burden (through malnutrition, inadequate sanitation, inability to access preventive care), high disease burden causes high healthcare expenditure, high healthcare expenditure causes impoverishment and asset stripping, impoverishment causes further deterioration in the conditions that drive disease burden, and the cycle perpetuates itself across generations. The CHT Healthcare Poverty Trap is deepened by the geographic access barriers of the terrain (which increase the unit cost of each healthcare episode for CHT indigenous households relative to plains households), by the linguistic and cultural barriers that create additional transaction costs in navigating the health system (costs of time, of failed consultations due to communication breakdown, and of inappropriate treatment from providers who misunderstand the patient's presentation), and by the land insecurity that prevents CHT indigenous households from using land assets as collateral for healthcare financing, unlike land-owning households in the plains. The design of health financing mechanisms that can interrupt the Healthcare Poverty Trap in the CHT requires both supply-side interventions (increasing the availability and affordability of healthcare services) and demand-side interventions (reducing the financial barriers to utilization, through free care for essential services, conditional cash transfers to offset transport costs, and insurance schemes designed for the CHT context), integrated with the structural determinants interventions (land rights protection, poverty reduction, nutritional security) that address the root causes of the trap.

MODEL EXAMINATION QUESTIONS: CHAPTER SIX

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

UNDRIP Article 24 affirms the right of indigenous peoples to: a) Sovereignty over mineral resources in their traditional territories b) Their traditional medicines, maintenance of their health practices, and access to social and health services without discrimination c) Establishment of separate national governments for indigenous peoples d) Exemption from all national laws (Correct Answer: b)

The CHT Peace Accord was signed between the Government of Bangladesh and which organization? a) The United Nations High Commissioner for Refugees (UNHCR) b) Parbatya Chattagram Jana Samhati Samiti (PCJSS) c) The Bangladesh Human Rights Commission d) Amnesty International (Correct Answer: b)

Free Prior and Informed Consent (FPIC) requires that indigenous peoples' consent be obtained in which manner? a) After a program has been designed and approved, before implementation begins b) Freely, before activities affecting them begin, based on full and accurate information, through a process respecting their collective decision-making c) Through majority vote of the national legislature representing indigenous interests d) Through written consent forms administered by program staff (Correct Answer: b)

"Catastrophic health expenditure" is defined by WHO as out-of-pocket health expenditure exceeding what proportion of household consumption expenditure? a) 2 percent b) 5 percent c) 10 percent d) 25 percent (Correct Answer: c)

The Bangladesh Expanded Programme on Immunization (EPI) was established in which year? a) 1971 b) 1979 c) 1990 d) 2000 (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A health program planner analyzing EPI data for a remote CHT union discovers that measles-rubella (MR) vaccine coverage has been below 30 percent for the past seven years. Using the principles of measles epidemiology and the herd immunity threshold, what is the most accurate prediction about the future health risk for this community? a) Low coverage is acceptable because measles is no longer a serious disease globally b) The community has accumulated a cohort of unvaccinated susceptible individuals over seven years, creating conditions for explosive epidemic spread with high case fatality if measles virus is introduced, and immediate targeted catch-up vaccination and enhanced community engagement are required to prevent an outbreak c) Natural immunity from endemic measles circulation will protect the community d) Only children under 1 year are at risk because older children develop natural immunity (Correct Answer: b)

A public health economist is designing a health financing reform for the CHT that aims to interrupt the Healthcare Poverty Trap. Based on the framework described in this textbook, which of the following programmatic combinations is most comprehensively aligned with breaking the cycle? a) Free essential health services at government facilities only, with no transport subsidies

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or community-level engagement b) Free essential health services at government facilities combined with transport subsidies or conditional cash transfers to offset journey costs, community-level health worker services to reduce the need for costly facility visits, and structural interventions addressing land rights and nutritional security as root causes of high disease burden c) Micro-insurance schemes only, with no free services d) Focusing exclusively on income-generating programs without health system changes (Correct Answer: b)

CHAPTER SEVEN: HEPATOLOGY AND GASTROENTEROLOGY IN THE CHT: LIVER DISEASE, GASTROINTESTINAL MEDICINE, AND THE HEPATIC CONSEQUENCES OF THE CHT DISEASE ENVIRONMENT

7.1 The Hepatological Burden of the CHT: Viral Hepatitis, Nutritional Liver Disease, and the Drug-Metabolizing Liver

The liver bears a disproportionate burden in the health economy of CHT indigenous communities. As the central organ of drug metabolism, detoxification, nutritional biochemistry, and acute phase immune response, the liver is engaged at every interface of the CHT disease environment: it is the site of Plasmodium liver stage development during the pre-erythrocytic phase of malaria infection and the reservoir of P. vivax hypnozoites responsible for relapsing malaria; it is the target organ of hepatitis B virus (HBV) and hepatitis C virus (HCV) infection, both of which are transmitted by routes that are prevalent in CHT communities; it metabolizes the antimalarial drugs, antitubercular drugs, and traditional botanical preparations that are the mainstay of CHT pharmacotherapy; it synthesizes the clotting factors whose deficiency causes the hemorrhagic complications of severe malaria and snake envenomation; it produces the acute-phase reactants and complement proteins that are the biochemical markers and effectors of infection; and it is the primary organ of injury in hepatotoxic drug reactions, which are a significant cause of treatment failure in tuberculosis management in the CHT. A systematic hepatological perspective on the CHT health situation reveals a territory in which liver disease is both an important independent cause of morbidity and mortality and a critical modifier of the clinical course of the territory's many other health challenges.

Hepatitis B virus (HBV) infection is one of the most important chronic infectious diseases in South and Southeast Asian populations, and CHT indigenous communities belong to the ethnic and geographic ancestry clusters with historically high HBV prevalence. The World Health Organization estimates that approximately 3.5 to 4 percent of the global population has chronic HBV infection (surface antigen positive for more than six months), but this global average conceals massive regional variation, with Southeast Asian and Western Pacific populations having chronic HBV prevalence rates of 5 to 10 percent compared with less than 1 percent in Western Europe and North America. The CHT indigenous communities, with their Southeast Asian ancestral profile and their historical patterns of high-prevalence household transmission (mother-to-child transmission during birth, and horizontal transmission in early childhood through skin contact and shared household items), likely have chronic HBV prevalence rates substantially higher than the Bangladeshi national average (estimated at approximately 3 to 4

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percent). The clinical consequences of chronic HBV infection are profound and long-term: approximately 15 to 25 percent of individuals with chronic HBV infection develop progressive liver disease, including chronic hepatitis, cirrhosis, and hepatocellular carcinoma (HCC), over a 20 to 40 year disease course. HCC arising from HBV-associated cirrhosis is one of the most common and most lethal cancers globally, with a five-year survival rate below 15 percent in most low-income country settings where it typically presents at advanced stage due to the absence of screening programs.

The interaction between chronic HBV infection and the medication exposures that are common in CHT healthcare represents a specific and clinically important hepatological challenge. Antitubercular drugs (isoniazid, rifampicin, pyrazinamide, and ethambutol) are all potentially hepatotoxic, and the first-line TB regimen (containing all four drugs) produces clinically significant drug-induced liver injury (DILI) in approximately 5 to 8 percent of patients, with higher rates in those with underlying liver disease including chronic HBV infection. A CHT patient with both tuberculosis (which is not uncommon) and chronic HBV infection (which may affect a significant proportion of the CHT indigenous population) faces a compound hepatotoxic challenge: the antitubercular drugs impair hepatic function through multiple mechanisms, and the underlying viral hepatitis creates a hepatic vulnerability that amplifies the drug-mediated hepatotoxic risk. The clinical management of TB in a patient with chronic HBV infection requires baseline assessment of hepatic function (ALT, AST, bilirubin, and ideally HBV DNA quantification), close monitoring of liver enzymes during the first two months of antitubercular therapy (when hepatotoxic risk is highest), a modified drug substitution protocol in the event of significant DILI (which typically involves removing pyrazinamide first as the most hepatotoxic first-line agent, then reassessing), and consideration of anti-HBV therapy (tenofovir disoproxil fumarate or tenofovir alafenamide, both of which have favorable hepatotoxicity profiles) for patients with significant HBV replication who require TB treatment. In the CHT, where baseline HBV testing is not routinely performed before starting antitubercular therapy and where liver function monitoring during TB treatment is infrequent due to laboratory access limitations, the clinical risk of unrecognized HBV-DILI interaction is substantial.

7.2 Gastrointestinal Helminthic Disease: The Hepatic and Splenic Manifestations of Parasitic Liver Injury

The gastrointestinal parasitic burden of CHT indigenous communities includes not only the soil-transmitted helminths (Ascaris, Trichuris, and hookworm) whose primarily intestinal manifestations have been discussed in preceding parts of this textbook, but also hepatically targeted parasites whose liver and biliary tract manifestations represent a significant but under-recognized clinical burden in the CHT. Clonorchis sinensis (Chinese liver fluke) and Opisthorchis viverrini (Southeast Asian liver fluke) are trematode (fluke) parasites whose metacercariae (infective larvae) are transmitted through consumption of raw or undercooked freshwater fish. Both species are native to mainland Southeast Asia and to the river systems flowing from the Indo-Burmese range into the Bay of Bengal, the precise geographic territory of the CHT. Infection is acquired by eating freshwater fish species (including carp, roach, and various cyprinid species) that have been improperly processed: the traditional CHT practice of making fermented fish preparations (locally called sidol or nappi in various communities), in

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which small freshwater fish are fermented without adequate heat treatment, creates conditions for viable metacercariae transmission if the fish used contain them. Chronic Clonorchis or Opisthorchis infection of the bile ducts produces cholangitis, periductal fibrosis, and over decades of repeated infection a dramatically elevated risk of cholangiocarcinoma (bile duct cancer), which is one of the most lethal cancers with essentially no effective treatment at advanced stage. Opisthorchiasis is estimated to cause approximately 10 percent of all cholangiocarcinoma cases worldwide and is the leading cause of cholangiocarcinoma in endemic Southeast Asian regions. Whether Clonorchis or Opisthorchis species are endemic in CHT river systems, and whether CHT indigenous communities consuming traditional fermented fish preparations have significant liver fluke infection prevalence, is a question that has received no systematic parasitological investigation, representing a significant knowledge gap with important carcinogenic implications.

Schistosomiasis does not currently appear to be endemic in the CHT, as the intermediate snail hosts (Biomphalaria species for S. mansoni and S. japonicum, Bulinus species for S. haematobium) have not been documented in CHT water bodies, but the hydrological character of the CHT's slow-moving riverine habitats and the extensive aquatic surface of Kaptai Lake represent environments that warrant monitoring for the introduction of these snail species, particularly as climate change alters aquatic habitats and as the movement of people and goods across the Bangladesh-Myanmar border creates potential introduction pathways for exotic snail species from Myanmar, where S. japonicum was historically endemic in some regions.

7.3 Alcoholic Liver Disease and Traditional Fermented Beverages in the CHT

The traditional fermented beverages of CHT indigenous communities, including rice wine preparations (known variously as Moua or Cholaani among the Chakma, Jou among the Marma, and various local names in other communities) produced from fermented glutinous rice, represent an important cultural and social institution in CHT community life, as well as a significant hepatological risk factor that intersects with the CHT's already substantial liver disease burden. The alcohol content of CHT traditional fermented rice beverages varies by preparation method and fermentation duration, ranging from approximately 5 to 12 percent alcohol by volume in typical preparations, though higher-concentration preparations are produced for ceremonial and trade purposes. Traditional fermented beverages are consumed at festivals, communal gatherings, lifecycle ceremonies, and as daily beverages in some communities, and their production and distribution represents an important component of the informal CHT economy. The social epidemiology of alcohol use disorders in CHT indigenous communities was addressed in Parts Three and Seven of this textbook: the available data suggest elevated rates of heavy alcohol use and alcohol use disorders in some CHT communities, particularly among adult men, and the intersection of political trauma, social disruption, and economic marginalization with alcohol availability creates conditions conducive to hazardous drinking patterns.

Alcoholic liver disease progresses through three stages: alcoholic fatty liver (steatosis, which is reversible with abstinence and is generally asymptomatic), alcoholic hepatitis (an acute inflammatory injury that can range from subclinical to severe with high short-term mortality),

and alcoholic cirrhosis (end-stage chronic liver disease characterized by irreversible fibrosis, portal hypertension, and liver failure). The severity of alcoholic liver disease at any level of alcohol consumption is amplified by malnutrition (because the hepatoprotective response to alcoholic injury requires adequate protein and micronutrient nutrition, particularly zinc, vitamin E, and the B vitamins, which are deficient in the typical CHT diet) and by viral hepatitis co-infection (because HBV co-infection dramatically accelerates the progression of alcoholic liver injury toward cirrhosis and hepatocellular carcinoma). The clinical recognition of alcoholic liver disease in CHT patients requires systematic inquiry about traditional beverage consumption in the clinical history, which is currently not standard practice in most CHT health facilities, partly because of the cultural sensitivity of alcohol-related inquiry in a context where traditional beverage consumption is an accepted social norm, and partly because health workers lack training in clinical approaches to sensitive behavioral health inquiry. The fatty liver (steatosis) stage of alcoholic liver disease is detectable by abdominal ultrasonography (showing hepatomegaly with increased hepatic echogenicity, the "bright liver" sign), and the wider implementation of focused abdominal ultrasound in CHT health facilities would enable earlier detection of hepatic steatosis in high-risk drinkers, providing a clinical entry point for counseling and intervention before irreversible fibrosis develops.

MODEL EXAMINATION QUESTIONS: CHAPTER SEVEN

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Which of the following antitubercular drugs is considered the most hepatotoxic and is typically the first to be removed from the regimen if drug-induced liver injury occurs during TB treatment? a) Ethambutol b) Rifampicin c) Pyrazinamide d) Isoniazid (Correct Answer: c)

The trematode parasite most strongly associated with cholangiocarcinoma (bile duct cancer) in Southeast Asian endemic populations is: a) Fasciola hepatica b) Schistosoma mansoni c) Opisthorchis viverrini d) Clonorchis sinensis is the only answer that is acceptable, as is Opisthorchis viverrini, but in the context of Southeast Asian endemic populations the question is specifically referring to Opisthorchis species (Correct Answer: c - Opisthorchis viverrini)

The ultrasonographic finding of increased hepatic echogenicity ("bright liver") in a patient with a history of heavy alcohol use is most consistent with which stage of alcoholic liver disease? a) Alcoholic hepatitis (acute inflammatory injury) b) Alcoholic steatosis (fatty liver) c) Alcoholic cirrhosis (end-stage fibrosis) d) Hepatocellular carcinoma (Correct Answer: b)

Hepatitis B virus (HBV) is classified into which virus family? a) Flaviviridae b) Hepadnaviridae c) Herpesviridae d) Retroviridae (Correct Answer: b)

Drug-Induced Liver Injury (DILI) during antitubercular therapy is defined by ALT elevation above what threshold in standard hepatotoxicity monitoring protocols? a) Any detectable rise above baseline b) ALT above 2 times the upper limit of normal (ULN) c) ALT above 3 times ULN (with symptoms) or 5 times ULN (without symptoms), which triggers drug review or cessation d) ALT above 10 times ULN only (Correct Answer: c)

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For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A Marma male patient in Bandarban district is diagnosed with pulmonary tuberculosis (smear-positive, 3+) and started on standard first-line DOTS therapy (HRZE). Baseline HBsAg is positive (chronic HBV infection confirmed). After 4 weeks of treatment, the patient's ALT is 8 times the upper limit of normal and bilirubin is mildly elevated; the patient has nausea and mild jaundice. What is the most appropriate management? a) Continue full first-line DOTS without modification as the hepatotoxicity will resolve spontaneously b) Stop all hepatotoxic antitubercular drugs, recheck liver function in 2 weeks, and restart sequentially with a modified hepatotoxicity-sparing regimen under close monitoring, considering tenofovir for HBV management c) Switch immediately to second-line fluoroquinolone-based TB regimen d) Prescribe silymarin (milk thistle) and continue DOTS (Correct Answer: b)

A public health parasitologist is investigating whether Opisthorchis liver fluke infection might be endemic in CHT river systems and contributing to unexplained cholangiocarcinoma cases in river-fishing communities. Which combination of epidemiological and parasitological investigation methods is most appropriate for answering this question? a) Blood serology for Opisthorchis antibodies in the general population combined with malacological survey for intermediate snail host species in CHT river habitats b) Clinical survey of jaundice cases only c) Review of national cancer registry data for cholangiocarcinoma without community-level investigation d) Survey of marketed fish for metacercariae only (Correct Answer: a)

CHAPTER EIGHT: THE INTEGRATION OF TRADITIONAL AND BIOMEDICAL MEDICINE IN THE CHITTAGONG HILL TRACTS: EVIDENCE, ETHICS, MODELS, AND CLINICAL PATHWAYS FOR A PLURALISTIC HEALTH SYSTEM

8.1 The Philosophical Foundations of Medical Pluralism in the CHT

Medical pluralism, the co-existence and simultaneous utilization of multiple medical knowledge systems and therapeutic traditions by individuals and communities, is not an aberration or a transitional state on the path toward a fully biomedical future. It is the natural condition of health-seeking behavior in most human societies across history, including in most high-income societies where patients routinely use both pharmaceutical medicine and a range of complementary and alternative therapies simultaneously. In the CHT, medical pluralism is the dominant health-seeking reality for the overwhelming majority of the population: CHT patients typically access multiple therapeutic systems concurrently, selecting among government health facilities, BRAC community health workers, traditional Baiddya healers, Buddhist monks, Dai birth attendants, informal drug sellers, and Ayurvedic practitioners according to the nature of the illness, the availability and cost of different options, the social context of the illness episode, and the patient's cosmological interpretation of the illness cause. This medical pluralism is not a sign of irrationality or of incomplete healthcare system development. It is a rational response to a complex health-seeking environment in which no single therapeutic system addresses all the

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dimensions of illness (biological, psychological, social, spiritual, and nutritional) that matter to CHT patients and their communities.

The CHT Medical Pluralism Doctrine, as articulated in this textbook, holds that the policy response to medical pluralism in the CHT should be one of evidence-based integration rather than biomedical replacement. The replacement model, which has dominated health system design in the CHT since the colonial period, treats traditional medicine as a transitional phenomenon to be progressively superseded by biomedical services as healthcare access improves, and it regards traditional healers as competitors or obstacles to the biomedical health system rather than as potential collaborators within it. The evidence consistently shows that the replacement model fails in the CHT context, because biomedical services alone cannot meet the comprehensive health needs of CHT communities (as demonstrated by the persistent underutilization of government health services), because traditional healers continue to provide the majority of first-contact healthcare in remote areas regardless of health system policy, and because the attempt to eliminate rather than integrate traditional medicine results in an adversarial relationship between the formal health system and the community-embedded healing practitioners that ultimately drives healthcare utilization further away from both and into the informal, unregulated drug dispensing sector that provides the worst of all possible healthcare options. The integration model, by contrast, treats the CHT Ethnomedicinal Complex as a complementary resource whose strengths (community trust, linguistic and cultural accessibility, comprehensive illness model, botanical pharmacology of demonstrated efficacy for many conditions) can be strategically combined with biomedical strengths (diagnostic precision, life-saving emergency interventions, pharmaceutical treatment of infectious diseases) to produce a health system that is more comprehensive, more trusted, more culturally appropriate, and more effective than either system operating in isolation.

The evidence base for traditional medicine integration in comparable settings globally is extensive and growing. The WHO Traditional Medicine Strategy 2019-2025 recommends that member states develop national policies for traditional medicine integration based on evidence generation, quality assurance, and access equity principles. Multiple country programs in Sub-Saharan Africa, South and Southeast Asia, and Latin America have demonstrated that community health worker programs that incorporate traditional healer participation achieve better coverage, higher community trust, and superior health outcomes for specific conditions including malaria, HIV/AIDS, mental health, and maternal health compared with programs that exclude traditional practitioners. The incorporation of traditional birth attendant (Dai) training and supervised practice into maternal health programs in Tanzania, Bangladesh, and Cambodia has been shown to improve birth safety outcomes in contexts where skilled birth attendant access is limited, without compromising the quality of care that would be achievable with fully trained midwives. The evidence base for the specific integration of CHT Baiddya healers into the formal health system is currently insufficient because it has not been generated through systematic research, but the absence of research evidence is not evidence of absence of effect, and the global evidence base for comparable programs is strongly supportive of the integration model in principle.

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8.2 Legal and Regulatory Framework for Traditional Medicine Integration in Bangladesh

The regulatory framework for traditional medicine in Bangladesh presents a complex landscape of formal legal structures, informal regulatory norms, and significant governance gaps that collectively create barriers to the systematic integration of CHT traditional medicine into the formal health system. The Bangladesh Medical and Dental Council (BMDC) regulates allopathic medicine practice. Ayurvedic medicine practice is regulated under the Unani and Ayurvedic Practitioners Act of 1965, administered by the Bangladesh Unani and Ayurvedic Board, which registers practitioners who have completed recognized training programs in Unani (Greco-Islamic medicine) or Ayurvedic (classical Indian medicine) systems. Homeopathic practice is regulated by the Bangladesh Homeopathic Board. However, the CHT Ethnomedicinal Complex, which does not correspond to any of the formally recognized complementary medicine systems (Unani, Ayurveda, or Homeopathy), falls entirely outside the formal regulatory framework. CHT Baiddya healers, who have no recognized legal status as healthcare practitioners under Bangladeshi law, cannot be registered, supervised, quality-assured, or compensated within the formal health system under the current regulatory architecture. This regulatory invisibility of the CHT ethnomedicinal system has multiple negative consequences. It means that Baiddya healers who provide healthcare cannot access the legal protections, professional development opportunities, or referral relationships that formal registration would enable. It means that the quality of traditional medicine practice cannot be systematically monitored or improved. It means that the botanical medicines of the CHT pharmacopoeia cannot be quality-assured, standardized, or incorporated into formal drug procurement systems. And it means that the institutional basis for a CHT traditional medicine integration program does not currently exist in Bangladeshi regulatory architecture, requiring legislative action as a precondition for substantive integration.

The development of a specific regulatory framework for CHT Indigenous Medicine (as a formally recognized and distinctly categorized complementary medicine system, distinct from Ayurveda, Unani, and Homeopathy) represents a policy priority whose benefits extend beyond the CHT to include all indigenous communities in Bangladesh and potentially to serve as a model for indigenous medicine recognition across South and Southeast Asia. The essential elements of such a framework include: a registry of recognized CHT traditional practitioners, based on demonstrated community recognition, knowledge assessment, and adherence to ethical practice standards developed with community input; a quality assurance framework for CHT botanical medicine preparations, including standards for plant identification, preparation, storage, and labeling; a continuing education and professional development program for registered traditional practitioners, including training in referral protocols and in the recognition of conditions requiring biomedical management; a formal referral relationship between registered traditional practitioners and government health facilities, enabling bidirectional referral (traditional to biomedical for conditions requiring pharmaceutical or surgical management, and biomedical to traditional for conditions where traditional approaches have demonstrated efficacy and patient preference); and a benefit-sharing arrangement ensuring that the intellectual property value of CHT ethnomedicinal knowledge, including any commercial pharmaceutical applications that may be developed from CHT plant compounds, is appropriately shared with the CHT communities who are the custodians of that knowledge.

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8.3 Clinical Pathways for Traditional-Biomedical Integration: A Practical Protocol

The development of practical clinical pathways for traditional-biomedical integration in the CHT requires protocols that are operationally feasible in the CHT health system's current resource and capability reality while advancing toward the integration ideal described in the preceding sections. A stepwise integration protocol is proposed here, organized into three phases of increasing integration intensity. Phase One (Awareness and Communication) requires no regulatory change and minimal resource investment: it involves training all CHT government health workers to inquire systematically about traditional medicine use (including the names of practitioners consulted, preparations used, and their approximate timing) as part of every clinical history, to respect and acknowledge the patient's traditional medicine use without dismissive comments that damage the therapeutic relationship, to identify the most common traditional medicine preparations used in their catchment community and to be aware of their potential pharmacological interactions with prescribed biomedical treatments (using the growing literature on CHT plant pharmacology documented in the 2025 ethnobotanical study and the preceding scientific literature), and to identify the recognized traditional practitioners in their catchment area and begin building a respectful working relationship with them. Phase Two (Collaboration and Referral) builds on Phase One and involves the establishment of formal informal referral relationships between government health facilities and recognized traditional practitioners in each upazila, with agreed protocols for bidirectional referral: traditional practitioners receive training on the recognition of "red flag" presentations requiring immediate biomedical referral (high fever with altered consciousness, severe respiratory distress, hemorrhage, signs of severe dehydration, obstructed labor), and government health workers refer patients to recognized traditional practitioners for conditions where traditional approaches are most valued (including management of mild mental distress, spiritually interpreted illness, postnatal ceremonial care, and chronic conditions where patient preference strongly favors traditional management). Phase Three (Formal Integration) requires regulatory change and sustained investment: it implements the traditional practitioner registration system, quality assurance framework, and benefit-sharing arrangements described in the preceding section, creating a fully formalized and systematically quality-assured integration of the CHT Ethnomedicinal Complex into the CHT health system.

MODEL EXAMINATION QUESTIONS: CHAPTER EIGHT

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Medical pluralism refers to: a) The practice of using only one medical system exclusively b) The co-existence and simultaneous utilization of multiple medical knowledge systems and therapeutic traditions by individuals and communities c) The use of multiple pharmaceutical drugs simultaneously (polypharmacy) d) The practice of consulting multiple allopathic physicians for the same condition (Correct Answer: b)

The WHO Traditional Medicine Strategy covers which time period? a) 2000-2010 b) 2014-2023 c) 2019-2025 d) 2025-2035 (Correct Answer: c)

In the context of this textbook's Phase One of the traditional-biomedical integration protocol, what is the primary task for government health workers? a) Registering all traditional practitioners in their catchment area b) Systematically inquiring about traditional medicine use in every clinical history and building respectful working relationships with recognized traditional practitioners c) Educating patients to stop using traditional medicine and use only biomedical services d) Reporting traditional practitioners who claim to treat serious illness to health authorities (Correct Answer: b)

Unani medicine in Bangladesh is regulated by which body? a) The Bangladesh Medical and Dental Council (BMDC) b) The Bangladesh Unani and Ayurvedic Board c) The Directorate General of Drug Administration d) The Bangladesh Homeopathic Board (Correct Answer: b)

The pharmacological interaction of greatest clinical concern when a patient is using both a Baiddya botanical preparation and a prescribed antimalarial is: a) Drug-food interaction with rice c) Cytochrome P450 enzyme interaction affecting the metabolism and plasma levels of the antimalarial drug d) Both b and c are of potential concern (Correct Answer: d - CYP enzyme interaction and potential pharmacodynamic synergy/antagonism)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A Chakma patient with newly diagnosed pulmonary tuberculosis tells her attending physician that she is simultaneously receiving treatment from a local Baiddya for what she understands to be Khumbai illness (chronic wasting), using a preparation that contains Oroxylum indicum bark and Bryophyllum pinnatum leaves in a fermented extract. The physician knows that Oroxylum indicum contains chrysin, a flavone that is a known inhibitor of CYP1A2 and has moderate inhibitory effects on CYP3A4. What is the most clinically relevant concern about this combination? a) No concern, as plant medicines cannot interact with pharmaceutical drugs b) Potential CYP-mediated pharmacokinetic interaction affecting rifampicin and isoniazid plasma levels, with risk of supratherapeutic (toxicity) or subtherapeutic (treatment failure or resistance) drug exposure, warranting careful history-taking, clinical monitoring for drug toxicity signs, and collaboration with the Baiddya to understand the preparation and discuss timing of traditional versus pharmaceutical medicine use c) Only a theoretical concern with no practical management implications d) The Baiddya preparation will directly inactivate the TB bacteria, making pharmaceutical treatment unnecessary (Correct Answer: b)

CHAPTER NINE: ADVANCED NEONATOLOGY, PERINATAL MEDICINE, AND PEDIATRIC CRITICAL CARE IN THE CHITTAGONG HILL TRACTS

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9.1 The Neonatal Health Crisis in the CHT: Perinatal Mortality, Preterm Birth, and Neonatal Infection

The neonatal period (the first 28 days of life) is the most vulnerable period of human existence, and the neonatal health crisis of CHT indigenous communities is among the most severe and least addressed dimensions of the CHT's health burden. Bangladesh as a whole has made remarkable progress in reducing neonatal mortality over the past two decades, with the national neonatal mortality rate declining from approximately 37 per 1,000 live births in 2000 to approximately 20 per 1,000 live births in 2022. However, the national trend conceals a profound geographic and ethnic inequity: neonatal mortality rates in remote CHT indigenous communities are estimated to be substantially higher than the national average, likely ranging from 30 to 50 per 1,000 live births in the most geographically isolated communities, though the absence of comprehensive vital registration systems in the CHT makes precise estimation impossible. The leading causes of neonatal death in the CHT correspond to the global leading causes (preterm birth complications, birth asphyxia, and neonatal sepsis) but their frequency and fatality rates are amplified by the CHT-specific risk factors: the high prevalence of antenatal malnutrition and anemia in pregnant CHT indigenous women (which increases the risk of preterm delivery, low birth weight, and intrauterine growth restriction), the limited availability of skilled birth attendance in remote communities (which increases the risk of birth asphyxia from poorly managed labor and delivery), and the high burden of infections in the neonatal environment (which increases the risk of early-onset neonatal sepsis from group B Streptococcus and gram-negative organisms acquired during delivery, and late-onset neonatal sepsis from hospital-acquired organisms if the neonate is referred to a district facility, or from environmental organisms in the household setting if the neonate remains at home).

The concept of essential newborn care (ENC), which encompasses the evidence-based interventions that prevent the majority of neonatal deaths when universally applied, provides the framework for addressing the CHT neonatal crisis at the primary care and community level. ENC interventions include immediate drying and stimulation of the newborn at delivery (to prevent neonatal hypothermia and stimulate breathing), delayed cord clamping (for at least 60 seconds after birth, to maximize the transfer of iron-rich blood from the placenta to the neonate, reducing neonatal anemia and improving iron stores for the first year of life), skin-to-skin contact between the neonate and the mother (kangaroo care) beginning immediately after birth (to maintain neonatal thermal regulation and promote breastfeeding initiation), early exclusive breastfeeding (within one hour of birth, as colostrum contains maternal antibodies, growth factors, and immune cells that provide critical passive immunity to the neonate and stimulate intestinal mucosal maturation), chlorhexidine application to the umbilical cord stump in home delivery settings (which reduces the risk of omphalitis and neonatal sepsis by inhibiting pathogen colonization of the cord), and recognition of neonatal danger signs (fast breathing, poor feeding, fever or hypothermia, umbilical infection, jaundice) that warrant immediate referral. The delivery of ENC in CHT home delivery settings requires specifically trained traditional birth attendants (Dais) who can perform these interventions reliably and who recognize when referral is necessary, and the training and supervision of Dais as ENC providers represents one of the most cost-effective possible investments in CHT neonatal health.

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Kangaroo Mother Care (KMC) for low birth weight and preterm neonates deserves specific attention in the CHT context because of the high prevalence of low birth weight delivery in CHT indigenous communities (estimated at 20 to 35 percent in some community surveys, compared with the national average of approximately 14 percent) and the complete absence of neonatal intensive care unit (NICU) capability in the CHT below the district hospital level (where even district-level neonatal care is severely limited). KMC, defined as continuous skin-to-skin contact between the low birth weight or preterm neonate and the mother (or other caregiver), exclusive breastfeeding, and early discharge from facility care with appropriate home follow-up, has been demonstrated in multiple randomized controlled trials and systematic reviews to reduce neonatal mortality in low birth weight infants by 36 to 51 percent compared with conventional incubator care, with effects on neonatal infection, hypothermia, and neurodevelopmental outcomes that are at least equivalent to incubator care in settings where incubators are available. For the CHT, where incubators are not available and where the resources for conventional NICU care are entirely absent, KMC is not merely an alternative to incubator care but the only evidence-based neonatal intensive care intervention that is deployable at the level of CHT communities, and its systematic promotion among CHT mothers, Dai birth attendants, and community health workers is a priority health action with immediate life-saving potential.

9.2 Neonatal Sepsis in the CHT: Clinical Recognition and Management in Resource-Limited Settings

Neonatal sepsis, the systemic inflammatory response to blood-borne bacterial (or occasionally fungal) infection in the neonate, is the leading cause of neonatal death in low-income countries and is almost certainly the single most important preventable cause of neonatal mortality in the CHT. Neonatal sepsis is classified as early-onset (arising within the first 72 hours of life, typically from organisms acquired from the maternal birth canal, most importantly Group B Streptococcus and Escherichia coli) and late-onset (arising after 72 hours and up to 28 days of life, from both community-acquired and nosocomial organisms). The clinical presentation of neonatal sepsis is notoriously non-specific and overlaps with numerous other neonatal conditions, creating a diagnostic challenge that is particularly acute in resource-limited settings where blood culture and other confirmatory investigations are unavailable. The neonatal sepsis danger signs that can be recognized at the community level and at primary care facilities without laboratory confirmation include fast breathing (respiratory rate greater than 60 per minute), inability to feed (a neonate who fed well previously and has now stopped feeding is a serious warning sign), fever (axillary temperature above 37.5 degrees Celsius in the neonate, noting that hypothermia, axillary temperature below 35.5 degrees, is also a sepsis danger sign, particularly in preterm neonates), convulsions, reduced level of consciousness or abnormal movements, bulging fontanelle (a sign of meningitis), skin pustules or umbilical redness and discharge (markers of local infection that may progress to systemic sepsis), and jaundice appearing within the first 24 hours of life (which always warrants urgent evaluation as it may indicate hemolytic disease, sepsis, or other serious conditions).

The management of suspected neonatal sepsis in CHT health facilities without blood culture capability requires empirical antibiotic therapy based on the local epidemiology of neonatal sepsis-causing organisms and their antimicrobial susceptibility patterns. The WHO-

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recommended first-line regimen for neonatal sepsis management at the primary care level is ampicillin plus gentamicin (or ampicillin plus gentamicin for serious bacterial infection in the young infant 0 to 2 months, as per the IMCI Handbook). However, the increasing prevalence of extended-spectrum beta-lactamase (ESBL)-producing gram-negative organisms as causes of neonatal sepsis in South Asian settings (a pattern driven by widespread antibiotic use in agriculture and informal healthcare, and by horizontal transmission of resistance genes in the community and healthcare settings) means that the standard ampicillin-gentamicin regimen has progressively decreasing coverage against the most common sepsis-causing organisms in some settings. The antimicrobial resistance epidemiology of neonatal sepsis in the CHT has not been systematically characterized, representing a critical gap: if ESBL-producing organisms are responsible for a significant proportion of CHT neonatal sepsis cases (which is likely given the high antibiotic use without prescription documented in CHT communities in Parts Four and Eight of this textbook), the standard first-line regimen may be inadequate and third-generation cephalosporins or carbapenems may be required for cases failing to respond to first-line therapy. Given that carbapenems are unavailable at any facility below the district hospital level in the CHT, the establishment of an effective referral pathway for neonates with sepsis not responding to first-line therapy is a specific and urgent clinical protocol need.

9.3 Pediatric Critical Care in the CHT: The District Hospital Level of Capacity

Pediatric critical care (the management of life-threatening illness in children requiring intensive monitoring and advanced supportive therapy) in the CHT is essentially confined to the three district hospitals, and even at this level the capacity is severely limited. The major pediatric critical care presentations that are frequent and life-threatening in the CHT include severe malaria with cerebral involvement or severe anemia, severe pneumonia with respiratory failure, severe acute malnutrition with metabolic complications (hypoglycemia, hypothermia, and electrolyte disturbances), neonatal sepsis with shock, severe dehydration from diarrheal disease, and severe snakebite envenomation. The management of each of these conditions requires a set of critical care capabilities (intravenous access, fluid administration and monitoring, oxygen delivery, basic airway management, continuous clinical monitoring, and targeted pharmacological intervention) that are within the technical reach of well-equipped district hospital facilities but that require reliable medicine and equipment supply, trained staff, and functioning monitoring systems that are inconsistently present in CHT district hospitals. The adaptation of standard pediatric emergency and critical care protocols to the resource reality of CHT district hospitals, producing simplified but evidence-based management algorithms that work with available medications and equipment, is the practical clinical science challenge addressed by this section.

The FEAST (Fluid Expansion as Supportive Therapy) trial, published in the New England Journal of Medicine in 2011 and representing one of the most important and unexpected findings in pediatric critical care medicine in the past two decades, demonstrated that aggressive bolus IV fluid resuscitation (20 to 40 mL/kg IV saline boluses) for febrile illness with impaired circulation in African children significantly increased 48-hour mortality compared with no bolus or a smaller bolus, a finding that overturned the previously standard teaching that aggressive bolus fluid therapy was universally beneficial in pediatric septic shock. The FEAST finding has been

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intensively studied and discussed, and its mechanism is now understood to involve the interaction of fluid bolus-induced central venous pressure elevation with impaired cardiac function in severely anemic and malnourished children (who have reduced cardiac reserve), producing a syndrome of fluid overload-mediated organ dysfunction rather than the volume-replacement benefit that the bolus was intended to achieve. For CHT clinicians managing children with febrile illness and circulatory impairment (including severe malaria, septic shock, and severe malnutrition with secondary infection), the FEAST finding means that the reflex to administer large IV fluid boluses should be replaced by a cautious, weight-based approach that considers the child's nutritional status, hemoglobin level, and cardiac status before deciding on the volume and rate of IV fluid administration. This nuanced approach is more difficult than the simple "give a fluid bolus" protocol but it is what the evidence demands and what is most likely to save CHT children's lives.

MODEL EXAMINATION QUESTIONS: CHAPTER NINE

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Kangaroo Mother Care (KMC) is defined as which combination of interventions for low birth weight or preterm neonates? a) Incubator care with overhead heater, IV nutrition, and blood transfusion b) Continuous skin-to-skin contact between the neonate and the mother/caregiver, exclusive breastfeeding, and early discharge with home follow-up c) Phototherapy, IV antibiotics, and mechanical ventilation d) Supplemental oxygen, nasogastric feeding, and warming room (Correct Answer: b)

The WHO-recommended first-line antibiotic regimen for neonatal sepsis management at primary care level is: a) Oral amoxicillin alone b) Ampicillin plus gentamicin c) Ceftriaxone monotherapy d) Oral cotrimoxazole (Correct Answer: b)

The "delayed cord clamping" practice in ENC (Essential Newborn Care) is performed for at least how long after birth, and its primary benefit is: a) 10 seconds; preventing hypothermia b) 60 seconds; maximizing iron-rich blood transfer from placenta to neonate, reducing neonatal anemia c) 5 minutes; reducing risk of neonatal jaundice d) Until the placenta delivers; preventing cord entanglement (Correct Answer: b)

The FEAST (Fluid Expansion as Supportive Therapy) trial's most important clinical finding for pediatric febrile illness management was: a) Aggressive IV fluid boluses universally reduce mortality in febrile African children b) Aggressive IV fluid boluses (20-40 mL/kg) significantly increased 48-hour mortality in febrile children with impaired circulation compared with no bolus, overturning the previous standard teaching c) Oral rehydration is superior to IV fluid for all febrile illnesses d) Colloid solutions are more beneficial than crystalloids for all pediatric sepsis (Correct Answer: b)

Chlorhexidine application to the umbilical cord stump in home delivery settings prevents which condition? a) Neonatal jaundice (hyperbilirubinemia) b) Omphalitis and neonatal sepsis from

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cord stump colonization c) Hemorrhagic disease of the newborn d) Respiratory distress syndrome (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A Mro infant born at home in Alikadam weighing 1.6 kg (low birth weight) to a mother who had no antenatal care is brought to the upazila health complex at 18 hours of age. The infant is cold (axillary temperature 35.2°C), breathing fast, and feeding poorly. The health complex has no incubator. What is the most appropriate evidence-based management for this neonate based on the principles of this chapter? a) Transfer immediately to district hospital without any intervention at the health complex level b) Begin Kangaroo Mother Care (skin-to-skin contact) immediately for thermal regulation, start breastfeeding support, administer ampicillin and gentamicin for suspected sepsis (poor feeding, hypothermia, and tachypnea in the first 24 hours are neonatal sepsis danger signs), maintain warmth, correct hypoglycemia with expressed breast milk or glucose if measured low, and stabilize before arranging referral to the district hospital with the mother maintaining KMC during transport c) Give IV fluid bolus immediately to treat assumed circulatory compromise d) Discharge with advice to keep the baby warm at home (Correct Answer: b)

A district hospital pediatrician in Rangamati is managing a 3-year-old Chakma child with severe falciparum malaria, presenting with unconsciousness, respiratory rate 54 per minute, and severe pallor. Hemoglobin is 3.8 g/dL and blood glucose is 2.0 mmol/L. Based on the FEAST trial findings and the principles of pediatric critical care in this chapter, what is the most appropriate fluid management approach? a) Administer 20 mL/kg normal saline bolus immediately to restore circulation b) Treat hypoglycemia urgently with IV dextrose (glucose), administer blood transfusion for severe anemia (Hb 3.8 g/dL warrants packed red cell transfusion), give IV artesunate for severe malaria, and manage IV fluids cautiously based on the child's hydration status without aggressive bolus therapy, recognizing that aggressive bolus fluid in a severely anemic malnourished child with malaria carries the FEAST mortality risk c) Give 40 mL/kg Ringer's lactate bolus before blood transfusion d) Oral rehydration therapy is preferred for all pediatric severe malaria regardless of consciousness level (Correct Answer: b)

CHAPTER TEN: PHILOSOPHICAL SYNTHESIS, MEDICAL ETHICS, FUTURE MEDICINE, AND THE MEANING OF CARE IN THE CHITTAGONG HILL TRACTS

10.1 The Medical-Philosophical Architecture of CHT Healthcare: A Synthesis

Nine parts of this textbook have built an increasingly complex and increasingly comprehensive picture of health and disease in the Chittagong Hill Tracts. Part Nine itself has added the immunological precision of mucosal science, the molecular specificity of genomic medicine, the toxicological reality of chemical exposures, the surgical urgency of the operating table at the edge of the world, the often-invisible pain of dental neglect, the political architecture of health governance failures, the hepatological consequences of a multiply assaulted liver, the

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philosophical depth of traditional medicine integration, and the fragile miracle of the neonatal period in a place without neonatal intensive care. Standing at the end of Part Nine, with Part Ten still to come, the student of CHT medicine is invited to undertake a philosophical synthesis of what all this science, history, politics, and clinical detail actually means, philosophically, ethically, and existentially, for the practice of medicine in this territory. This synthesis is not a luxury. It is a clinical necessity. The clinician who cannot translate scientific knowledge into philosophical commitment, ethical clarity, and sustained motivation will not persist in the practice of medicine in the CHT, because the structural obstacles, the resource constraints, the political frustrations, and the weight of preventable suffering are too great to be sustained without a coherent philosophical architecture that gives the work its meaning.

The Philosophical Architecture of CHT Medicine, as proposed in this textbook, rests on four pillars. The first pillar is Epistemic Humility, the recognition that the CHT health challenge is too complex, too deeply embedded in history and ecology and politics, for any single discipline, any single theory, or any single practitioner to fully comprehend. The clinician who approaches the CHT with the certainty of the biomedical model alone, believing that the tools of Western scientific medicine are sufficient to diagnose and treat everything that ails the CHT population, will systematically misdiagnose the political causes of biological vulnerability, will fail to engage meaningfully with the cosmological dimensions of illness that matter to CHT patients, and will contribute to the erosion of the community trust that is the most fragile and most valuable resource in the entire CHT health system. Epistemic humility means knowing what you know and knowing what you do not know, and it means approaching the knowledge systems of CHT indigenous communities not as primitive approximations of biomedical truth but as alternative epistemologies with their own validity conditions, their own empirical bases, and their own clinical insights that biomedical practice has not fully integrated. The second pillar is Structural Honesty, the insistence on naming the political, economic, and historical causes of the CHT's health disparities rather than mystifying them as natural, inevitable, or attributable to the deficiencies of the affected communities themselves. Structural honesty requires the clinician to see, to document, and to articulate the structural determinants of the morbidity they treat, including the land alienation that drives malnutrition, the governance failures that produce immunization coverage gaps, the political violence that generates the trauma underlying so much of the CHT's mental health burden, and the colonial and post-colonial policies that have systematically diverted resources away from CHT indigenous communities. This structural honesty is not political partisanship. It is medical science, because the structural determinants of disease are etiologically as important as the pathogens, and their recognition is a prerequisite for effective prevention. The third pillar is Compassionate Pragmatism, the disposition to do the most good possible with the resources available, without surrendering to the paralysis of perfect-being-the-enemy-of-good or to the cynicism of institutional indifference. In the CHT, resources are always inadequate, conditions are always difficult, and the gap between what is needed and what is available is always discouraging. Compassionate pragmatism means performing the best fasciotomy possible with the instruments available, teaching the best KMC protocol to the Dai with the language resources available, prescribing the most appropriate malaria treatment from the formulary that is actually stocked, and building the most effective community health relationship possible within the political constraints that exist, all while advocating persistently for the systemic changes that would make all of these easier and better. The fourth pillar is

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Community Solidarity, the recognition that the practice of medicine in the CHT is not a gift bestowed by a knowledgeable outsider on an ignorant community but a partnership between the practitioner's scientific training and the community's ecological knowledge, cultural wisdom, social capital, and self-determination capacities. Community solidarity means respecting indigenous self-determination in health not only as a legal principle but as a practical effectiveness imperative, building on community strengths rather than cataloging community deficits, and measuring the success of one's medical practice not by the patient encounters completed but by the community's capacity to manage its own health with increasing confidence and decreasing dependence on external expertise.

10.2 Medical Ethics in the CHT: The Four Principles in a Context of Structural Injustice

The four principles of biomedical ethics formulated by Tom Beauchamp and James Childress in their foundational text Principles of Biomedical Ethics (first published in 1979 and now in its eighth edition, 2019) remain the dominant organizing framework for medical ethics teaching globally. The four principles are autonomy (respect for the patient's right to make informed decisions about their own healthcare), beneficence (the obligation to act in the patient's best interest), non-maleficence (the obligation to avoid harm), and justice (the obligation to treat patients fairly and to distribute healthcare resources equitably). In the CHT context, each of these principles requires specific elaboration and contextualization because the structural conditions of the CHT (including language barriers that compromise informed consent, geographical barriers that constrain genuine treatment choices, power differentials between the state and indigenous communities that distort the autonomy framework, and the systematic injustice of the health resource distribution that violates the justice principle at the population level) fundamentally alter the ethical landscape within which clinical practice occurs.

Autonomy in the CHT is not a simple matter of providing information and respecting a patient's expressed preference. Genuine autonomy requires adequate information (which is compromised by language barriers, health literacy limitations, and the cultural inaccessibility of biomedical explanations delivered without cultural mediation), meaningful alternatives (which are constrained by the healthcare access limitations of the CHT terrain), freedom from coercive power differentials (which may be compromised in the context of interactions between indigenous patients and state health workers, given the historical legacy of state violence against CHT indigenous communities), and respect for communal decision-making processes (in indigenous CHT communities, healthcare decisions are frequently made collectively by the patient, the immediate family, and community elders, and the biomedical model's insistence on individual autonomous consent may itself represent a form of cultural imposition that conflicts with the community's own ethical framework). The culturally appropriate expression of the autonomy principle in the CHT requires accommodating collective decision-making processes, investing in language-concordant health communication, and recognizing that the framework of individual consent that is standard in biomedical ethics was developed in a Western, individualist cultural context and may require adaptation for CHT community ethical contexts without abandoning the core value that patients should not be subjected to healthcare interventions without their genuine understanding and agreement.

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Justice in the CHT is a macro-ethical challenge that goes far beyond the clinical consultation. The systematic allocation of health resources in Bangladesh produces dramatically worse health outcomes in CHT indigenous communities than in any comparable geographic or economic group in the country, not because of random variation in individual health behaviors but because of deliberate policy choices about health financing, program design, and governance that systematically prioritize the health of the majority Bengali population over the health of CHT indigenous peoples. This is a structural injustice in the technical sense: it is unjust, it is structural (arising from the architecture of governance, finance, and policy), and it is documented with sufficient scientific rigor to establish causation rather than mere correlation between structural disadvantage and health disparity. The physician who practices medicine in the CHT, seeing daily the health consequences of this structural injustice in the faces of the malnourished children, the women who have died in obstructed labor, the men with untreated TB who present with cavitation and drug resistance, has both a professional and a moral obligation to bear witness to this injustice, to document it in the clinical and public health literature with the scientific rigor it demands, and to advocate for its correction through whatever channels are available. This advocacy is not optional activism beyond the scope of medical practice. It is, under the World Medical Association's Declaration of Geneva and the International Physicians for the Prevention of Nuclear War's tradition, a core professional obligation of the physician.

10.3 The Future of Medicine in the CHT: Scenarios, Priorities, and the Vision of Health Justice

The future of medicine in the Chittagong Hill Tracts over the next two to three decades will be shaped by several powerful forces whose interactions will determine whether the health trajectory of CHT indigenous communities moves toward justice or continues in its current direction of persistent, preventable, and inexcusable disparity. The first force is climate change, which will alter the disease ecology of the CHT in ways that have been partly analyzed in Part Seven of this textbook: the malaria-altitude-temperature interface will shift, the frequency and severity of landslides and floods will increase, the water security of communities dependent on rainfall for agriculture will be compromised, and the heat stress burden on outdoor workers will grow. The second force is the demographic and epidemiological transition, which will continue to evolve toward an increasing NCD burden even as the infectious disease burden remains high, creating the double burden that has been the central theme of CHT health planning since at least the early 2000s. The third force is the digital technology revolution, specifically the proliferation of mobile telecommunications infrastructure in the CHT (which despite its still-incomplete coverage is expanding rapidly), the development of artificial intelligence-assisted diagnostic tools that can function in low-resource settings (including AI-powered malaria RDT reading systems, AI-assisted retinal screening for diabetic retinopathy and trachoma, and AI-based community health worker decision support systems), and the growing feasibility of telemedicine linkages between remote CHT health workers and specialist physicians in Chittagong and Dhaka. The fourth force is the global indigenous health rights movement, which has been gaining institutional momentum through the UNDRIP framework, the WHO global action plan on indigenous health, and the growing body of evidence that indigenous-governed health programs outperform externally imposed programs on the metrics that matter most: coverage, equity, community trust, and sustainability.

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The scenario of health justice for the CHT, as envisioned in this textbook, is not utopian. It does not require unlimited resources, technological miracles, or the resolution of the political disputes that have complicated CHT governance since 1947. It requires only the systematic application of what is already known to work: targeted funding for community health workers who speak indigenous languages, mobile immunization teams that reach every settlement on regular schedules, point-of-care diagnostic tools whose specifications are designed for remote deployment rather than laboratory centralization, Baiddya integration into the formal health system through the regulatory mechanisms that can be legislated, traditional birth attendant training programs that teach ENC skills while respecting traditional practice, community-level mental health and psychosocial support programs staffed by trained community members, and a health governance framework that genuinely transfers authority and resources to CHT indigenous governance institutions. None of these interventions is technically unknown or operationally untested. They are all documented in the literature, proven in comparable settings globally, and achievable with the resources that Bangladesh, as a lower-middle-income country with significant development investments from domestic and international sources, could mobilize if the political will to do so were present. The barrier to health justice in the CHT is not scientific ignorance. It is political will, governance commitment, and the societal choice about whose health matters enough to warrant sustained investment. That is ultimately a political and ethical question, not a medical one, but it is a question that every physician, public health practitioner, and health student who has read this textbook has both the knowledge and the obligation to address.

10.4 Controversies in CHT Health Research and Policy: An Honest Accounting

No textbook that claims intellectual integrity can conclude its discussion of CHT health without engaging honestly with the controversies that surround some of its central claims and policy recommendations. This section identifies and addresses the most significant controversies in the CHT health research and policy literature, not to dismiss or minimize them but to give the student the tools to think through them with rigor and honesty. The first controversy concerns the quality and reliability of CHT health data. Most of the health statistics cited in this textbook, from malnutrition prevalences to malaria case counts to maternal mortality estimates, are derived from studies that are methodologically limited by small sample sizes, geographically restricted sampling frames, non-representative convenience samples, and the fundamental challenge of conducting rigorous epidemiological research in a geopolitically sensitive territory with limited research access. Critics have correctly noted that many CHT health statistics are extrapolated from data collected in accessible areas and may not accurately represent the health conditions of the most remote and most vulnerable communities, who are precisely the communities for whom the statistics matter most. The appropriate response to this critique is not to abandon the available data but to interpret them with appropriate epistemic humility, to invest in better data systems for the CHT (including community-based vital registration, systematic health information system coverage of all upazila health facilities, and periodic CHT-specific population-based health surveys), and to resist the use of CHT health data to support predetermined policy conclusions in the absence of sufficient evidence quality.

The second controversy concerns the politics of the CHT health narrative. Some observers, including representatives of Bengali settler communities in the CHT and some government officials, have contested the characterization of CHT indigenous health disparities as arising from structural injustice and governance failure, arguing instead that the health disparities reflect geographic challenges rather than ethnic discrimination, that the government has made substantial investments in CHT health infrastructure, and that the framing of CHT health as a human rights issue inappropriately politicizes what should be a technical health planning challenge. This controversy is not merely an empirical dispute about the magnitude of health disparities (which the data, with all their limitations, consistently document as real and substantial) but a political dispute about the explanation for those disparities and the policy remedies they require. The physician and public health practitioner is not obligated to resolve this political dispute but is obligated to ensure that the clinical and epidemiological evidence they produce and communicate is accurate, to interpret it within the most complete explanatory framework available (which this textbook argues requires engagement with structural and historical determinants, not only technical health system factors), and to advocate for the interventions that the evidence supports. The third controversy concerns the optimal integration strategy for traditional medicine in the CHT, where a spectrum of positions exists from those who argue that only evidence-based botanical medicines with demonstrated efficacy should be integrated into formal health protocols, to those who argue that the holistic value of traditional medicine practice (including its cosmological, social, and psychological dimensions) is undermined by selective biomedical integration that reduces traditional medicine to its pharmacological components. This controversy reflects a genuine tension between the demands of evidence-based medicine and the demands of cultural respect and community self-determination, and its resolution requires the kind of nuanced engagement that this textbook has attempted to model throughout: taking the evidence seriously, respecting cultural values, and seeking integration pathways that honor both.

MODEL EXAMINATION QUESTIONS: CHAPTER TEN

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The four principles of biomedical ethics as formulated by Beauchamp and Childress are: a) Safety, efficacy, equity, and sustainability b) Autonomy, beneficence, non-maleficence, and justice c) Informed consent, confidentiality, truth-telling, and non-abandonment d) Compassion, competence, communication, and collaboration (Correct Answer: b)

The World Medical Association's Declaration of Geneva, which establishes core physician professional obligations, was first adopted in which year? a) 1900 b) 1948 c) 1964 d) 2000 (Correct Answer: b - 1948)

Free Prior and Informed Consent (FPIC) for health programs affecting indigenous communities is classified as: a) A bureaucratic requirement applicable only to research studies b) A principle of indigenous self-determination with direct evidence-based relevance to health program effectiveness, as programs designed with FPIC-based community engagement consistently achieve better coverage, uptake, and sustainability c) A legal formality with no practical impact

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on program outcomes d) Applicable only to surgical procedures, not public health programs (Correct Answer: b)

"Structural honesty" as a philosophical pillar of CHT medicine in this textbook means: a) Honesty about the structural design of health facilities b) Naming and documenting the political, economic, and historical causes of CHT health disparities rather than attributing them to the deficiencies of affected communities c) Following standard clinical protocols regardless of individual patient context d) Avoiding any political commentary about health systems (Correct Answer: b)

"Epistemic humility" as a philosophical pillar of CHT medicine means: a) Refusing to make clinical decisions without complete information b) Recognizing the limits of any single discipline or theory in comprehending the complexity of CHT health, and approaching indigenous knowledge systems as alternative epistemologies with their own validity rather than as primitive approximations of biomedical truth c) Deferring all clinical decisions to senior physicians d) Avoiding the use of statistical evidence in clinical reasoning (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A public health physician working in the CHT is asked to provide an expert opinion to a government health planning committee on the primary causes of the under-five mortality gap between CHT indigenous communities and the national average in Bangladesh. Based on the comprehensive analytical framework of this textbook, which of the following most accurately represents the full range of causal factors that should be included in the analysis? a) Genetic susceptibility of indigenous populations to childhood infectious diseases b) A combination of structural factors (land insecurity and poverty producing malnutrition; governance failures producing immunization coverage gaps; geographical barriers reducing healthcare access; historical trauma and institutional distrust reducing healthcare utilization) operating alongside proximate biological factors (malnutrition-mediated immune suppression, helminth co-infection, and Th2 polarization increasing infectious disease susceptibility), both of which are documented in the scientific literature and neither of which is adequately addressed without interventions addressing both structural and biological dimensions c) Inadequate personal health behaviors of indigenous parents d) Insufficient number of health facilities in the CHT (Correct Answer: b)

A medical ethicist is reviewing whether the practice of obtaining individual written informed consent for surgical procedures (as standard in biomedical ethics) is fully appropriate for CHT indigenous patients, some of whom make healthcare decisions collectively with family and community elders. Which position best represents the nuanced ethical framework articulated in this textbook? a) Individual written informed consent should be non-negotiable in all settings to protect individual autonomy b) In CHT indigenous communities, the autonomy principle should be expressed in culturally appropriate forms that accommodate collective decision-making processes while ensuring the patient genuinely understands and agrees to the procedure, which may require community elder involvement in the consent process, language-concordant communication, and respect for the community's own ethical framework c) Collective decision-

making processes should replace individual consent entirely in indigenous settings d) Consent is not necessary for life-saving emergency procedures in any setting (Correct Answer: b)

An FCPS candidate in community medicine is asked to write a policy brief on the most important priorities for improving the health of CHT indigenous communities over the next decade. Based on the synthesis provided in Chapter Ten of Part Nine, which combination of priorities is most comprehensively evidence-based and philosophically aligned with the framework of this textbook? a) Building new tertiary hospitals in the three CHT district capitals b) A combination of: targeted funding for indigenous-language community health workers; mobile immunization reaching all remote settlements; point-of-care diagnostics for remote deployment; traditional practitioner integration into the formal health system; traditional birth attendant training with ENC skills; community-based mental health and psychosocial support; health governance transfer of authority and resources to CHT indigenous governance institutions; structural investments in land rights and nutritional security as root causes of disease c) Providing free pharmaceuticals at all CHT health facilities without addressing governance and community engagement d) Training more specialist physicians in Dhaka and Chittagong to treat CHT patients on referral (Correct Answer: b)

Part Nine: Summary and Bridge to Part Ten

Part Nine of this textbook has traversed nine chapters of advanced medical and public health science, applied with precision and depth to the specific circumstances of the Chittagong Hill Tracts. The immunological science of Chapter One established the ecological immunophenotype of CHT indigenous populations and identified the helminth-immune axis, mucosal immunity impairment, and trained immunity as clinically consequential features of the CHT immunological landscape. Chapter Two brought the molecular precision of genomic medicine and pharmacogenomics to bear on the CHT, identifying G6PD deficiency characterization, pharmacogenomic safety profiling, and ancestral pharmacology as priority domains for precision health research in the territory. Chapter Three conducted a systematic survey of the environmental toxicological landscape of the CHT, with particular attention to organophosphate pesticide toxicology, heavy metal hazards, and the clinical management of toxic illness in resource-limited settings. Chapter Four confronted the brutal reality of surgical emergencies in a mountain territory with limited surgical capacity, articulating the principles of damage control resuscitation, task-shifted obstetric surgery, ketamine anaesthesia, and snakebite surgical management that are the practical tools of the CHT surgical practitioner. Chapter Five brought sustained attention to the most neglected dimension of CHT healthcare, oral health, connecting dental caries, oral cancer, and periodontal disease to the CHT's specific carcinogen burdens, nutritional deficiencies, and betel-tobacco cultural practices. Chapter Six analyzed the governance architecture of the CHT health system through the lens of international indigenous health rights law, immunization equity failure, and health financing, identifying the political and institutional changes required for health justice. Chapter Seven examined the hepatological burden of the CHT, from viral hepatitis and liver fluke carcinogenesis to alcoholic liver disease and drug-hepatitis interactions, revealing the liver as a central organ in the CHT's medical

geography. Chapter Eight provided a philosophical and practical framework for traditional-biomedical medicine integration, articulating the CHT Medical Pluralism Doctrine and a stepwise integration protocol. Chapter Nine returned to the most vulnerable CHT lives, neonates and critically ill children, presenting the evidence-based protocols for ENC, KMC, neonatal sepsis management, and the FEAST-informed approach to pediatric fluid management that can save CHT children's lives with the resources that are actually available. Chapter Ten synthesized the entire edifice into a philosophical architecture of epistemic humility, structural honesty, compassionate pragmatism, and community solidarity, applied the four principles of biomedical ethics to the CHT context, and looked honestly at the controversies and uncertainties that every serious intellectual engagement with CHT medicine must acknowledge.

Part Ten, the final part of this textbook, will complete the synthesis by returning to first principles: the public health infrastructure and policy architecture of the CHT, the international health law dimensions of indigenous health rights, the academic and research agenda for the next decade, the role of the CHT health professional as both clinician and advocate, and a final philosophical meditation on what it means to practice medicine in one of the world's most complex, most challenging, and most beautiful medical geographies. The textbook will conclude not with certainty but with commitment: the commitment of every physician, every public health practitioner, every student, and every researcher who has read these pages to carry the knowledge of the CHT's health reality into their professional lives with the intellectual rigor, the ethical integrity, and the human solidarity that the children of the Mro community of Kurukpata, and the children of every community in every valley and ridge of the Chittagong Hill Tracts, deserve.

PART TEN: THE ARCHITECTURE OF HEALTH JUSTICE: PUBLIC HEALTH SYSTEMS, INTERNATIONAL LAW, RESEARCH FRONTIERS, AND THE FUTURE OF MEDICINE IN THE CHITTAGONG HILL TRACTS

Foreword to Part Ten

This final part of the textbook arrives at the place where science meets obligation. Nine preceding parts have built a comprehensive, technically rigorous, historically grounded, and philosophically informed account of health and disease in the Chittagong Hill Tracts. The reader who has journeyed through all nine parts now holds in their mind a picture of extraordinary complexity: the malaria-bearing valleys of the Sangu system, the malnourished children of Alikadam, the ancient pharmacopoeia of the Baiddya healer, the trauma carried in the bones of Kaptai displacement survivors and their descendants, the surgical emergencies performed on bamboo tables by candlelight, the bacterial ecology of bamboo-walled kitchens saturated with cooking smoke, and the measles virus moving through the unvaccinated children of Kurukpata while 220 of them died in the spring of 2025. Part Ten does not add to this clinical and epidemiological inventory. Instead, it asks what we must do with the knowledge we now possess. It examines the architecture of the public health systems that must be rebuilt, the international legal frameworks that establish why those systems must be rebuilt, the research agenda that will sharpen our knowledge, the technological tools that will extend our reach, the non-communicable disease epidemic that is arriving in the CHT even as the infectious disease

crisis has not yet been resolved, and the philosophical and ethical responsibilities that fall on every person who has learned what this textbook has taught. It ends, as it must, not with a triumphant conclusion but with a commitment: the commitment of clinical science, ethical integrity, and human solidarity that the people of the Chittagong Hill Tracts have deserved for centuries and have been denied for too long.

CHAPTER ONE: THE COMPREHENSIVE PUBLIC HEALTH SYSTEMS ARCHITECTURE OF THE CHT: INFRASTRUCTURE, FUNCTION, AND THE ENGINEERING OF EQUITY

1.1 A Systems Theory of CHT Public Health Infrastructure

Public health infrastructure, understood through the lens of contemporary complex systems science, is not a collection of discrete facilities, programs, and personnel but an integrated adaptive system whose emergent properties, meaning the properties that arise from the interactions between its components rather than from any single component alone, determine its capacity to protect and improve population health at the scale and with the equity that the people it serves require. The CHT public health infrastructure, as characterized across the nine preceding parts of this textbook, is a system under chronic adaptive stress: its components are unevenly distributed across geography, its interactions between components are frequently blocked by terrain, language, cultural distance, and political fragmentation, and its emergent properties (coverage, quality, equity, and responsiveness to community need) are systematically inferior to those of comparable health systems in the Bangladesh plains. Understanding the CHT public health system as a complex adaptive system rather than as a simple hierarchical service delivery machine provides a more accurate and more useful framework for thinking about how to reform it, because it reveals that the system's failures are not simply the result of resource deficits (though resource deficits are real and severe) but of structural and relational architecture that produces systematic inequity even when resources are adequate for the most accessible communities. The Systems Architecture of CHT Public Health, as defined in this textbook, refers to the complete set of structural relationships, resource flows, governance arrangements, information pathways, accountability mechanisms, and community interfaces that together determine the capacity of the CHT health system to deliver equitable health protection to every community in the territory, including those communities that are most remote, most poor, most culturally distinct, and most historically excluded from the benefits of the national health system.

The fundamental systems architecture problem of CHT public health is what this textbook calls the Inverse Coverage Law, adapted from Julian Tudor Hart's Inverse Care Law (the observation that the availability of good medical care varies inversely with the need for it in the population served). The Inverse Coverage Law of the CHT states that the communities with the highest disease burden, the most severe poverty, the most limited access to alternative therapeutic resources, and the greatest historical exclusion from the benefits of public services are precisely the communities where the public health system achieves the lowest coverage, provides the lowest quality services, deploys the least qualified personnel, and spends the least money per

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head. This is not an accidental pattern arising from random resource distribution. It is a structural consequence of a public health system architecture that allocates resources according to administrative convenience, road accessibility, and bureaucratic visibility rather than according to the principle of equitable need-based distribution that should govern a rights-based public health system. Changing this architecture requires not marginal improvements in program delivery but structural redesign of the resource allocation mechanisms, personnel deployment policies, supply chain logistics, governance arrangements, and community accountability systems that together produce the Inverse Coverage Law outcome. This structural redesign is the central task of CHT public health systems reform, and its necessity is the central analytical conclusion of this textbook.

The World Health Organization's Building Blocks Framework for health systems, which organizes health system components into six functional domains (service delivery, health workforce, health information systems, access to essential medicines, financing, and leadership and governance), provides a useful analytical scaffold for examining the specific structural failures of each component of the CHT health system. In the service delivery domain, the geographic distribution of CHT health facilities produces massive coverage gaps in the most remote areas, with the three-tier facility structure (district hospital, upazila health complex, union health and family welfare center) failing to extend functional coverage to settlements more than approximately five kilometers from a motorable road and failing entirely during monsoon season when road access collapses. In the health workforce domain, the CHT faces a chronic shortage of qualified health workers at all levels, compounded by the difficulty of recruiting and retaining physicians, nurses, and midwives in remote postings that offer limited professional development opportunities, poor living conditions, and geographic isolation from family and urban amenities. The absenteeism rate among CHT health facility staff, documented in multiple qualitative studies, is substantially higher than the national average, with district health officials and NGO program managers consistently identifying staff absenteeism as one of the primary operational constraints on service delivery quality in remote CHT facilities. In the health information domain, the CHT suffers from a fundamental data architecture deficit: the Health Management Information System (HMIS) of Bangladesh, through which national health statistics are compiled, does not systematically disaggregate data by ethnic group within the CHT, making it effectively impossible to monitor health status, healthcare utilization, or program coverage disaggregated by the indigenous communities who are the most health-disadvantaged population group in the territory. This data architecture deficit is both a product of the political invisibility of CHT indigenous communities and a perpetuator of that invisibility, because without disaggregated data demonstrating the magnitude of ethnic health disparities in the CHT, decision-makers can maintain the fiction that national aggregate progress in health indicators reflects adequate progress for all population groups within the territory.

1.2 The Community Health Worker Architecture: The Indispensable Foundation

The community health worker (CHW) cadre represents the most critical infrastructural component for closing the coverage gaps in the CHT public health system, and its design, training, supervision, and support are therefore the highest-priority systems architecture investments for CHT public health reform. Community health workers, broadly defined as lay or

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para-professional community members trained to deliver a defined package of primary health services and health promotion activities within their own communities, represent the only service delivery modality capable of reaching the populations in remote CHT settlements who are geographically, linguistically, and culturally beyond the reach of facility-based health services. The BRAC shasthya shebika model, which has been operational in parts of the CHT since the early 1990s and which has been credited with significant contributions to malaria case detection and treatment in the territory, provides the most extensively evaluated model of CHW practice in the CHT context. The shasthya shebika (SS) program trains selected women from within the community to conduct household health education, distribute basic medicines (including oral rehydration salt and zinc for diarrhea management, and in the CHT context, antimalarial RDTs and artemether-lumefantrine for confirmed malaria cases), conduct malaria screening with RDTs, refer seriously ill patients to higher-level facilities, and support antenatal care through home visits. The success of the SS program in malaria control in the CHT, documented in multiple peer-reviewed publications and attributed to the program's capacity to reach patients in their homes rather than requiring them to travel to distant facilities, is one of the strongest pieces of evidence for the systems value of linguistically and culturally embedded CHW programs in the CHT. However, the SS program also demonstrates the limitations of the current CHW architecture: SS workers are not paid a living wage (they receive a small commission on medicine sales and a modest monthly stipend), which creates problems of worker motivation, retention, and time commitment in a context where the workers themselves face the economic pressures of subsistence farming households; the program operates primarily in BRAC's geographic coverage areas and does not reach the most remote communities including those of the Mro, Khumi, Chak, and Bawm; and the SS cadre, while working in communities that include multiple ethnic groups, is not systematically trained in the multiple indigenous languages spoken in CHT communities, which limits their effectiveness in communities with low Bangla language proficiency.

The design of a strengthened CHW architecture for the CHT must address these limitations while building on the proven strengths of the existing SS and related models. A reformed CHT CHW architecture would be characterized by five structural features. First, Community Identity Matching, meaning that CHW workers must be recruited from within the specific ethnic community they serve, speaking the community's own language as their primary means of communication, and sharing the cultural frameworks that determine how health and illness are understood within that community. A Mro-language CHW is not merely a convenience for the Mro community of Alikadam: she is a public health infrastructure necessity, because the evidence from the 2025 measles outbreak and from the broader CHT health access literature consistently shows that language-discordant health promotion and service delivery systematically fails in indigenous communities with limited Bangla proficiency. Second, Expanded Clinical Scope, meaning that CHW workers in the CHT context must be trained to manage a wider range of clinical conditions than the current SS program allows, including the recognition and first-line management of childhood pneumonia (using the WHO Integrated Management of Childhood Illness guidelines adapted for CHW level), the recognition of neonatal danger signs and the initiation of basic neonatal care protocols including KMC, the screening for malnutrition using mid-upper arm circumference (MUAC) tape and the appropriate referral of severely malnourished children, the administration of vitamin A supplementation

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during immunization campaigns and during measles illness, and the provision of basic mental health psychosocial support using established lay counselor models. Third, Adequate and Sustainable Compensation, meaning that CHW workers must receive a compensation package that recognizes the economic value of their work and that does not require them to subsidize the public health system through unpaid labor in a context where their own households face severe poverty. Fourth, Effective Supervision and Support, meaning that CHW workers must be connected to a supervisory structure that provides clinical mentorship, re-supply of medicines and diagnostic tools, referral facilitation, and feedback on their performance in a way that maintains competence and motivation over time. Fifth, Integration with the Traditional Medicine Sector, meaning that CHW workers in the CHT should be explicitly trained to work alongside recognized traditional healers (Baiddya practitioners, Buddhist monks, Dai birth attendants) rather than competing with them, implementing the Phase One and Phase Two integration protocols described in Part Nine of this textbook.

1.3 The Supply Chain Architecture: Cold Chains, Drug Procurement, and the Last Mile

The supply chain architecture of the CHT public health system represents one of the most severe operational constraints on service delivery quality and constitutes, from a systems architecture perspective, one of the most critical reform priorities. The supply chain problem in the CHT has two distinct dimensions: the physical logistics challenge of delivering medicines, vaccines, diagnostic supplies, and equipment to remote facilities in a terrain that severely constrains road transport, and the procurement and management challenge of ensuring that the right quantities of the right products are available at the right facilities at the right time. The physical logistics challenge is most acutely felt in the vaccine cold chain and in the supply of artemisinin-based combination therapies to the most remote community health worker points. Vaccines require continuous maintenance within a temperature range of two to eight degrees Celsius from manufacture to administration (the cold chain), and any break in this chain can render vaccines non-potent. In the CHT, where electrical power supply is unreliable in most areas outside district capitals, where road access to many facilities is intermittent, and where the distances between storage points and service delivery points can be enormous, maintaining the cold chain to the last mile is a technical and logistical challenge of enormous difficulty. The 2025 measles outbreak in Kurukpata was partly attributable to the failure to deliver immunization services to that community, and the cold chain challenge is one of the operational factors that has contributed to this failure. The deployment of solar-powered vaccine refrigerators at strategic upazila-level storage points, combined with high-performance passive cold boxes that can maintain vaccine temperatures for 72 to 96 hours without electricity, and with the training of CHW workers in vaccine cold chain monitoring and maintenance, represents the state-of-the-art solution to the last-mile cold chain problem that has been implemented successfully in comparable programs in sub-Saharan Africa and in parts of South and Southeast Asia.

The drug procurement and management challenge in the CHT manifests most commonly as stock-outs: the absence of essential medicines from facility formularies at the time when patients need them. Stock-outs of artemether-lumefantrine (the first-line malaria treatment), amoxicillin (the first-line pneumonia treatment), oral rehydration salt, zinc, and vitamin A are documented in CHT facility surveys and contribute directly to preventable morbidity and mortality by forcing

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patients to either seek treatment from informal drug sellers (who may supply counterfeit or sub-standard products) or delay treatment until the drugs become available. The introduction of electronic stock management systems linked to the national pharmaceutical procurement infrastructure, combined with community-level medicine reserves maintained by CHW workers, represents the evidence-based systems solution to the stock-out problem that must be implemented systematically across the CHT. The 2025 WHO Global Malaria Report, published in December 2025, documented that supply chain disruptions for ACTs and LLINs in Asia-Pacific malaria-endemic countries continued to be a significant constraint on malaria program performance, and that information technology-based supply chain management systems produced measurably superior stock availability at facility level compared with paper-based systems in settings where they had been rigorously evaluated. This evidence base directly supports the investment in CHT supply chain digitalization as a public health systems reform priority.

1.4 The Referral System Architecture: Getting the Right Patient to the Right Level at the Right Time

The referral system architecture of the CHT health system, which encompasses the protocols, transport mechanisms, communication systems, and receiving facility capacity that together enable patients with health conditions exceeding the management capacity of primary and secondary facilities to access the higher-level care they require, is one of the most deficient components of the CHT health system and one of the most directly responsible for preventable deaths in the territory. The architecture of the CHT referral system can be analyzed as a cascade with three critical junctions. The first junction is the decision to refer, which requires that the health worker at the referring facility recognizes that the patient's condition requires a higher level of care and communicates this to the patient and family in a way that motivates action. In the CHT, this first junction fails when health workers lack the clinical knowledge to recognize referral-requiring conditions (including the danger signs of cerebral malaria, severe pneumonia, obstetric emergencies, and neonatal sepsis) and when the language barrier prevents effective communication of the referral decision to patients and families. The second junction is the transport to the referral facility, which requires that a physically accessible, financially affordable, and timely transport option exists between the referring facility and the receiving facility. In remote CHT communities, this junction frequently fails because no motorable transport exists (requiring patients to be carried on foot or improvised stretcher over mountain terrain), because the cost of available transport (boats, motorcycles, or hired vehicles) exceeds the household's financial capacity, and because the journey time is so long that patients with time-critical conditions (hemorrhage, cerebral malaria, obstructed labor, severe septic shock) deteriorate beyond the window of effective intervention during transit. The third junction is the receiving capacity of the referral facility, which requires that the district hospital or tertiary center to which the patient is referred has the clinical capacity (staff, equipment, medicines, and blood bank), the physical capacity (available beds), and the administrative capacity (intake procedures that do not create additional delays) to provide the care the patient needs when they arrive. In the CHT, this third junction fails when district hospitals lack the surgical, anesthetic, or intensive care capacity required for the most complex referral presentations, and when Chittagong Medical College Hospital, the only tertiary center serving the CHT population, is

overwhelmed with complex cases and lacks the capacity for timely assessment of referred CHT patients.

The design of a functioning CHT referral system requires interventions at all three junctions simultaneously. At the first junction, the CHT Contextual Diagnostic Doctrine articulated in Part One, Chapter Seven of this textbook provides the clinical framework, and its translation into simplified, visually accessible clinical decision support tools (pocket guides, laminated reference cards in multiple indigenous languages, and mobile phone-based decision support applications for CHW workers) provides the operational mechanism. At the second junction, the establishment of community referral transport schemes (pre-arranged agreements with vehicle owners, boat operators, or motorcycle taxis in each community for emergency transport at agreed rates subsidized by community health funds, NGO programs, or government emergency transport vouchers) and the development of pre-positioned emergency transport resources (motorcycles, boats, or bicycles maintained at community health worker level in the highest-risk communities) represents the evidence-based systems response. At the third junction, the investment in district hospital capacity for the management of the most common life-threatening referral presentations (including emergency obstetric surgery, severe malaria with ICU-level supportive care, neonatal resuscitation, and severe trauma management) provides the necessary receiving infrastructure.

MODEL EXAMINATION QUESTIONS: CHAPTER ONE

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The "Inverse Coverage Law" as applied to the CHT public health system states that: a) Healthcare coverage is highest in the areas with the highest population density b) Communities with the highest disease burden and greatest historical exclusion have the lowest public health system coverage c) Coverage is determined solely by the number of health facilities d) The poorest communities have the greatest awareness of health services (Correct Answer: b)

Julian Tudor Hart's original "Inverse Care Law" was formulated primarily in the context of: a) Malaria control programs in Africa b) The National Health Service in the United Kingdom c) Vaccination programs in South Asia d) Tropical medicine practice in Southeast Asia (Correct Answer: b)

The WHO Health System Building Blocks Framework organizes health system components into how many functional domains? a) Three b) Four c) Six d) Eight (Correct Answer: c)

Which of the following is the most critical first-junction failure in the CHT referral cascade? a) Lack of hospital beds at the district level b) Health worker inability to recognize referral-requiring conditions combined with language barriers preventing effective communication of referral decisions c) Excessive cost of medicines at district hospitals d) Absence of electricity at upazila health complexes (Correct Answer: b)

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The BRAC Shasthya Shebika (SS) community health worker program in the CHT has been most credited with reducing which specific disease burden? a) Tuberculosis b) Childhood malnutrition c) Malaria through community-level RDT testing and ACT provision d) Maternal mortality (Correct Answer: c)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A district health officer in Bandarban is tasked with designing a strengthened community health worker program to reach Mro and Khumi communities in Alikadam and Ruma upazilas. Based on the five structural features of a reformed CHT CHW architecture described in this chapter, which of the following design choices is most essential for program effectiveness? a) Recruiting CHW workers from district capital towns with secondary school education b) Recruiting CHW workers from within each specific target ethnic community, speaking the community's own language, and sharing its cultural frameworks, regardless of formal educational credentials c) Providing CHW workers with the same training curriculum as nurses in district hospitals d) Limiting CHW clinical scope to health education only, referring all clinical management to facilities (Correct Answer: b)

A public health systems analyst reviewing CHT vaccine cold chain performance identifies that 38% of the most remote union-level health and family welfare centers experienced at least one cold chain failure in the past year, with power outages as the primary cause. The evidence-based systems solution to this problem, based on global best practice in comparable settings, is: a) Stopping immunization outreach to these communities until reliable electricity is established b) Deploying solar-powered vaccine refrigerators at strategic upazila-level storage points combined with high-performance passive cold boxes that maintain vaccine temperatures for 72 to 96 hours, with CHW-level cold chain monitoring c) Switching to non-refrigerated vaccine formulations which do not require cold chain d) Centralizing all immunization services at the district hospital level (Correct Answer: b)

CHAPTER TWO: INTERNATIONAL HEALTH LAW, TREATY OBLIGATIONS, AND THE GLOBAL FRAMEWORK FOR INDIGENOUS HEALTH RIGHTS IN THE CHT CONTEXT

2.1 The International Legal Architecture of Health as a Human Right

The right to the highest attainable standard of physical and mental health, commonly abbreviated as the right to health, is one of the foundational rights in the international human rights framework. Its primary textual source is Article 12 of the International Covenant on Economic, Social and Cultural Rights (ICESCR), which entered into force on January 3, 1976, and to which Bangladesh acceded on October 5, 1998, making it a legally binding international obligation for Bangladesh. The Committee on Economic, Social and Cultural Rights (CESCR), the treaty monitoring body for the ICESCR, published its landmark General Comment No. 14 on the Right to the Highest Attainable Standard of Health in 2000, which remains the definitive authoritative

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interpretation of the right to health under international law. General Comment 14 establishes that the right to health encompasses four essential and interrelated elements: Availability (the presence of functioning public health and healthcare facilities, goods, services, and programs in sufficient quantity), Accessibility (which has four overlapping dimensions: non-discrimination, physical accessibility, economic accessibility or affordability, and information accessibility), Acceptability (meaning that all health facilities, goods, and services must respect medical ethics and be culturally appropriate), and Quality (meaning that health facilities, goods, and services must be scientifically and medically appropriate and of good quality). The four AAAQ elements, applied to the CHT, reveal systematic deficits across all four dimensions that constitute violations of Bangladesh's binding international human rights obligations: availability is deficient through the chronic understaffing and undersupplying of CHT health facilities; accessibility is deficient through geographic inaccessibility, economic barriers, language barriers, and information barriers; acceptability is deficient through the cultural and linguistic inappropriateness of health services delivered by Bangla-speaking personnel to indigenous patients; and quality is deficient through the inadequate qualifications of personnel, unreliable medicine supplies, and absence of functional diagnostic equipment in many CHT facilities.

General Comment 14 also establishes that state parties to the ICESCR have obligations of three types: the obligation to respect (not to interfere with the right to health), the obligation to protect (to prevent third parties from interfering with the right), and the obligation to fulfill (to adopt positive measures that give full effect to the right). The obligation to fulfill includes specifically the obligation to provide a minimum core of essential healthcare services, defined by the CESCR as a non-derogable minimum including access to essential medicines, access to maternal and child healthcare, access to basic immunization, and access to essential public health programs including epidemic prevention and control. The deaths of 220 children from measles in Bangladesh in 2025, concentrated in the Mro community of Kurukpata where immunization coverage was essentially zero, constitute prima facie evidence of a failure to fulfill the minimum core obligation to provide access to basic immunization, which is a non-derogable human rights obligation under international law. This is not merely a matter of academic human rights discourse. The characterization of CHT health disparities as human rights violations changes the legal, political, and institutional framework within which responses are demanded and evaluated: it shifts the conversation from whether it would be nice to improve CHT health services to whether Bangladesh is fulfilling its binding international legal obligations.

2.2 The IHR 2005 Framework and CHT Border Health Security

The International Health Regulations 2005 (IHR 2005), the legally binding international framework governing the detection, assessment, notification, and response to public health emergencies of international concern, have specific and direct relevance to the CHT given its geographic position at the intersection of three countries (Bangladesh, Myanmar, and India) and its extensive border zones with territories that present significant infectious disease emergence and transmission risks. The IHR 2005 requires state parties to develop and maintain core capacities for surveillance, detection, risk assessment, notification, response, and coordination at national, intermediate (provincial/district), and primary (community and health facility) levels. Bangladesh, as a state party to the IHR 2005, has undergone Joint External Evaluations (JEEs) of

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its IHR core capacity performance, and the published JEE reports for Bangladesh have consistently identified surveillance capacity at the sub-district and community levels, and particularly in remote and border areas, as among the weakest elements of Bangladesh's IHR compliance profile. The CHT, with its remote and geographically isolated communities, its language barriers to routine disease reporting, its cross-border population movements, and its documented gaps in health information system coverage, represents Bangladesh's most significant IHR core capacity deficit zone. The failure to detect and respond to the 2025 measles outbreak before it reached epidemic scale in the Mro community of Kurukpata can be analyzed as an IHR core capacity failure: the community-level surveillance that should have detected the accumulating unvaccinated cohort, provided the early warning of an emerging outbreak, and triggered preventive vaccination was absent because the IHR community-level surveillance capacity had never been established in that community.

The border health security dimensions of the IHR 2005 framework are particularly relevant to the CHT given the situation in Myanmar. The February 2021 military coup in Myanmar has produced a catastrophic deterioration of the Myanmar public health system, with massive displacement of the population from Chin State and adjacent areas into border zones adjacent to the CHT. The WHO documented in its 2024-2025 Myanmar health emergency reports that the collapse of health service delivery in conflict-affected areas of Chin State had created conditions of acute disease outbreak risk, including cholera, dengue, malaria, and tuberculosis, in displaced populations living in camps and informal settlements near the Bangladesh-Myanmar border. The IHR 2005 framework requires Bangladesh to maintain surveillance and response capacity at its Points of Entry (PoEs), which include the formal border crossings in the CHT, and to coordinate with Myanmar (or with the international organizations working in the border zone given Myanmar's incapacity) on cross-border infectious disease surveillance. The establishment of sentinel surveillance sites in CHT communities adjacent to the Myanmar border, staffed by trained community health workers using standardized case definitions for epidemic-prone diseases, would constitute both an IHR compliance measure and a practical public health security investment for the CHT territory.

2.3 UNDRIP, Health Sovereignty, and the Legal Gap Between Principle and Practice

The United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), analyzed in detail in Chapter Six of Part Nine, represents the most comprehensive normative framework for CHT indigenous health rights, but its conversion from international principle to domestic legal obligation and operational practice remains the central unresolved challenge of CHT health governance. Bangladesh's vote in favor of UNDRIP at the UN General Assembly in 2007 constitutes a political commitment that, while not creating binding treaty obligations, establishes a standard of conduct against which Bangladesh's treatment of its indigenous peoples' health rights can be assessed and held accountable by the international community. The 2024 report of the UN Special Rapporteur on the Rights of Indigenous Peoples, which reviewed the global implementation status of UNDRIP across all countries that had endorsed it, identified Bangladesh as among the countries where the gap between UNDRIP endorsement and domestic implementation was most significant, with specific reference to the inadequate implementation of the CHT Peace Accord's provisions for indigenous self-governance and the persistent health

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and education disparities affecting CHT indigenous communities. This international documentation of Bangladesh's UNDRIP implementation gap creates a basis for advocacy by CHT indigenous organizations, by the UN human rights treaty bodies, and by international civil society organizations working on indigenous rights, and it has the potential to produce the political pressure that domestic advocacy alone has been insufficient to generate.

The concept of Free Prior and Informed Consent (FPIC), introduced in Chapter Six of Part Nine, deserves extended analysis in the international health law context because its application to health programs affecting indigenous communities is being increasingly operationalized through the procedures of specific UN treaty bodies and through the conditionality frameworks of major international health funders including the Global Fund to Fight AIDS, Tuberculosis and Malaria and the World Bank. The Global Fund's Indigenous Peoples Guidance for 2024-2026 (published in 2023 for the new grant cycle beginning in 2024) explicitly requires that indigenous peoples in Fund-supported countries be meaningfully consulted in the design of national disease programs that affect them, that programs include specific measures to reach indigenous populations with equity-responsive coverage, and that program monitoring disaggregate coverage and outcome data by indigenous community identity. Bangladesh's Global Fund grants for HIV, tuberculosis, and malaria programs include CHT coverage activities, and the application of the Fund's indigenous peoples guidance to these activities creates an accountability mechanism for CHT indigenous health equity that is anchored in a financial relationship with binding conditionality. The progressive strengthening of this accountability mechanism, through more specific FPIC requirements, more rigorous disaggregated monitoring, and more explicit consequences for programs that fail to achieve equity-responsive indigenous community coverage, represents one of the most practically powerful international health law levers for CHT health system reform available to advocates and researchers.

2.4 The Convention on Biological Diversity, the Nagoya Protocol, and the Intellectual Property of CHT Traditional Medicine

An international legal dimension of CHT indigenous health that has received insufficient attention in the health policy literature is the intersection of the CHT Ethnomedicinal Complex with the international framework governing access to biological genetic resources and the fair and equitable sharing of benefits arising from their use. The Convention on Biological Diversity (CBD), adopted at the 1992 Earth Summit in Rio de Janeiro and to which Bangladesh is a party, and the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization (Nagoya Protocol), adopted by the CBD Conference of the Parties in 2010 and entering into force in 2014, establish an international legal framework that has direct relevance to the CHT botanical pharmacopoeia. The CHT's forests contain biological genetic resources of significant commercial pharmaceutical value, as documented in the growing pharmacological literature on CHT plant species with anti-malarial, antimicrobial, antidiabetic, anti-inflammatory, and antineoplastic bioactivity. The traditional knowledge of CHT communities, particularly the Baiddya practitioners and the botanical knowledge systems of each ethnic community, provides the intellectual roadmap to these biological resources: without the indigenous knowledge identifying which plants have therapeutic activity and for what conditions, the pharmacological value of CHT plant species would require expensive and

time-consuming bioactivity screening to discover. Under the Nagoya Protocol, any commercial or research exploitation of CHT biological resources or associated traditional knowledge requires the prior informed consent of the relevant indigenous community (or the national government acting as steward of national genetic resources, though the Nagoya Protocol's principles favor direct community consent), and requires the negotiation of a mutually agreed terms arrangement that provides fair and equitable benefit-sharing with the community. Bangladesh has ratified the Nagoya Protocol (ratification on August 24, 2017) and therefore has binding obligations to establish and enforce the access and benefit-sharing requirements of the Protocol for CHT biological resources and traditional knowledge. The development of a national framework for the implementation of these obligations, specifically including a mechanism for CHT indigenous communities to register their traditional knowledge, claim their rights as knowledge holders, and receive benefits from any commercial applications derived from their knowledge and biological resources, represents both a legal obligation and a potentially significant source of financing for CHT community health and development programs.

MODEL EXAMINATION QUESTIONS: CHAPTER TWO

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The right to the highest attainable standard of health is primarily codified in international treaty law in which instrument? a) The Universal Declaration of Human Rights (UDHR) b) Article 12 of the International Covenant on Economic, Social and Cultural Rights (ICESCR) c) The Convention on the Rights of the Child (CRC) d) The Geneva Conventions (Correct Answer: b)

The four AAAQ elements of the right to health established by CESCR General Comment No. 14 are: a) Affordability, Accessibility, Accountability, and Quality b) Availability, Accessibility, Acceptability, and Quality c) Awareness, Access, Action, and Quality d) Availability, Affordability, Adequacy, and Qualification (Correct Answer: b)

The International Health Regulations 2005 (IHR 2005) entered into force in which year? a) 2000 b) 2005 c) 2007 d) 2010 (Correct Answer: c)

The Nagoya Protocol on Access to Genetic Resources was adopted by the CBD Conference of the Parties in which year and entered into force in which year? a) Adopted 2005, entered into force 2007 b) Adopted 2010, entered into force 2014 c) Adopted 2000, entered into force 2003 d) Adopted 2015, entered into force 2020 (Correct Answer: b)

Bangladesh ratified the Nagoya Protocol in which year? a) 2010 b) 2014 c) 2017 d) 2020 (Correct Answer: c)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A public health legal scholar analyzing the 2025 measles deaths in the CHT argues that they constitute a violation of Bangladesh's binding international human rights obligations. The most legally precise argument supporting this position is based on which provision of international

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human rights law? a) The right to education under ICESCR Article 13 b) The non-derogable minimum core obligation under the ICESCR and CESCR General Comment 14 to provide access to basic immunization as a component of the minimum core of the right to health c) The right to privacy under ICCPR Article 17 d) The right to food under ICESCR Article 11 (Correct Answer: b)

A researcher discovers that a pharmaceutical company is developing a synthetic analog of a bioactive compound isolated from Oroxylum indicum, a plant widely used in CHT Baiddya medicine. The company did not consult CHT communities or obtain their consent for the research leading to the drug candidate. Under the Nagoya Protocol framework, this situation most likely constitutes which type of violation? a) A patent infringement requiring compensation to the pharmaceutical patent holder b) A violation of the access and benefit-sharing requirements of the Nagoya Protocol, which requires prior informed consent from the relevant indigenous community or national authority for commercial exploitation of associated traditional knowledge c) No legal violation, because plants are not protected by intellectual property law d) A violation of the CHT Peace Accord only (Correct Answer: b)

CHAPTER THREE: THE RESEARCH AGENDA FOR CHT HEALTH: METHODOLOGICAL INNOVATION, PRIORITY DOMAINS, AND THE ETHICS OF RESEARCH IN INDIGENOUS COMMUNITIES

3.1 The State of CHT Health Research: A Critical Inventory

The state of health research in the Chittagong Hill Tracts, as of the time of writing in 2026, is best characterized as systematically inadequate relative to the magnitude of the health challenges the territory presents, unevenly distributed in its topical and geographic focus, methodologically constrained by the same access barriers that constrain health service delivery, and ethically compromised in some important cases by the absence of meaningful community participation in research design and governance. A critical inventory of the CHT health research literature reveals several structural patterns that must be acknowledged and addressed if the research enterprise is to generate the knowledge that CHT health systems and policy require. First, the research is topically concentrated in malaria, with a substantial and growing body of epidemiological, clinical, entomological, and operational research on malaria that vastly exceeds the research investment in tuberculosis, diarrheal diseases, malnutrition, maternal health, mental health, non-communicable diseases, environmental health, and the other major contributors to CHT morbidity and mortality. This topical concentration reflects the historical funding priorities of international donors (particularly the Global Fund and USAID's President's Malaria Initiative), the institutional interests of research organizations operating in the CHT (particularly icddr,b, which has historically focused on malaria and diarrheal diseases), and the relative tractability of malaria as a research topic compared with the more diffuse and politically sensitive topics of structural determinants of health, mental health, and indigenous health governance. Second, the research is geographically concentrated in areas adjacent to research infrastructure, particularly around the Bandarban HDSS (Health and Demographic Surveillance System) operated by

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icddr,b, which has generated some of the most rigorous epidemiological data available for the CHT but which covers a relatively small and non-representative geographic area. The most remote and most health-disadvantaged communities, including those of the Mro, Khumi, Chak, and Bawm in the deep valleys of southern Bandarban, are the communities least studied and therefore the communities about whom the least is known and for whom the least evidence-based policy can be developed. Third, the research is ethnically concentrated in its study populations, with the Chakma and to a lesser extent the Marma community being the most researched groups and the smaller, more remote, and more marginalized communities being the least researched.

The January and February 2025 ethnobotanical study that documented sixty-five medicinal plant species in active use by Baiddya practitioners across the CHT represents a significant recent contribution to the CHT research base and illustrates the kind of community-engaged, ethically grounded, systematically documented research that the CHT research agenda requires more of. The study's methodology, which involved extended qualitative interviews with recognized traditional practitioners from three ethnic communities, generated data of ethnographic depth and pharmacological breadth that facility-based clinical research cannot produce, and its explicit recognition of the risk of vanishing ethnomedicinal wisdom as a driver for urgent documentation reflects an appropriate sense of research urgency that should inform the broader CHT research agenda. The 2025 Lancet Southeast Asia publication by Kundu and Das Gupta on the nutritional status of CHT indigenous children represents another recent advance that has achieved international visibility for the CHT nutrition crisis and provided the evidence base for policy advocacy. The continued production of research of this quality and visibility, on the priority topics identified below, is the research community's most important contribution to CHT health justice.

3.2 The Priority Research Domains for the Next Decade

The priority research domains for the CHT health research agenda over the 2026-2036 period, as identified through synthesis of the evidence gaps documented across this entire textbook, can be organized into five thematic clusters. The first cluster is Disease Burden Characterization in Under-Researched Communities and Conditions. The primary gap in this cluster is the absence of community-level disease burden data for the most remote CHT communities (Mro, Khumi, Chak, Bawm, Lushai) and for the conditions that are most prevalent but least researched in the CHT (tuberculosis, soil-transmitted helminthiasis, hepatitis B, oral cancer, non-communicable diseases, mental health disorders including PTSD and depression, and birth defect and genetic disease prevalence). Community-based surveys using standardized methodology, conducted with appropriate community consent, linguistic accessibility, and culturally sensitive protocols, are needed to establish the basic epidemiological parameters for evidence-based health planning in these communities. The second cluster is Environmental Health and Exposure Science. The primary gap in this cluster is the absence of systematic exposure assessment for the major environmental health risks documented in Chapter Six of Part One: indoor air pollution from solid fuel combustion, drinking water microbiology and chemistry in different types of CHT source water, pesticide exposure in jhum farming communities, heavy metal exposure from mining and geological sources, and the cumulative environmental burden that the Environmental Burden Accumulation Principle predicts to be substantially greater than any single-exposure

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assessment would suggest. Third cluster is Health Systems and Health Services Research, encompassing the operational research needed to evaluate and improve the performance of CHT health system components including community health worker programs, traditional medicine integration interventions, referral system designs, and immunization program delivery strategies adapted for remote indigenous communities. Fourth cluster is Climate and Health Research, encompassing the projected effects of anthropogenic climate change on the CHT disease ecology, with particular emphasis on malaria transmission seasonality and altitude-boundary shifts, waterborne disease risk modification through altered rainfall patterns, food security and nutritional status impacts of climate-disrupted agricultural calendars, and mental health consequences of climate-driven displacement and livelihood loss. Fifth cluster is Indigenous Health Knowledge and Integration Science, encompassing the systematic pharmacological characterization of CHT ethnomedicinal plants, the clinical evaluation of traditional healing practices through ethically appropriate research designs, and the development and testing of models for the integration of traditional and biomedical medicine at the community health system level.

3.3 Research Ethics in Indigenous Communities: The CHT Framework

Research ethics in indigenous community settings requires a framework that extends beyond the standard biomedical research ethics principles (autonomy, beneficence, non-maleficence, and justice) to address the specific power dynamics, knowledge sovereignty issues, community rights, and historical context that characterize research in communities with histories of political marginalization and colonial-style exploitation. The CHT Research Ethics Framework proposed in this textbook is organized around four additional principles that supplement the standard biomedical ethics principles in the indigenous community research context. The first additional principle is Community Ownership, which holds that the knowledge generated through research in CHT indigenous communities belongs to those communities as well as to the scientific community, and that communities have rights to review, approve, and where appropriate withhold publication of research findings that they believe could harm community interests, misrepresent community experiences, or be used in ways contrary to community welfare. The second additional principle is Relational Accountability, which holds that research relationships in CHT indigenous communities are not merely contractual (governed by informed consent forms and institutional review board approvals) but relational: the researcher enters into an ongoing relationship of trust, obligation, and reciprocity with the community, and must maintain this relationship through the entire research process including the dissemination and application of findings. The third additional principle is Research as Capacity Building, which holds that all research conducted in CHT indigenous communities should include a deliberate capacity-building component that increases the community's own capacity for health research, data collection, and knowledge generation, so that over time the community becomes not merely a research subject but a research participant and ultimately a research leader. The fourth additional principle is Anti-Extractive Research, which holds that research in the CHT must not follow the extractive pattern of much historical research in indigenous communities, in which researchers collect data, leave the community, publish findings in journals inaccessible to community members, and generate career benefits from the research without returning proportionate benefit to the community that made the research possible. Anti-extractive research practice in the CHT

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includes community-accessible reporting of findings (in indigenous languages where possible), concrete program or policy outcomes that benefit the research community, and the active involvement of community members as paid research team members rather than as unpaid research subjects.

The 2024 revisions to the Declaration of Helsinki, adopted at the World Medical Association General Assembly in October 2024, strengthened the provisions on research in vulnerable and marginalized populations, including specific language recognizing that indigenous communities constitute a group requiring enhanced protections including community-level consent processes, benefit-sharing arrangements, and post-study access to research-generated treatments and interventions. The specific recognition of indigenous community-level consent processes (as distinct from individual participant consent) in the 2024 Helsinki Declaration represents a significant advance in international research ethics standards that aligns with the community consent principles of UNDRIP and that should be operationalized in all health research conducted in the CHT.

3.4 The Role of the CHT as a Living Laboratory for Global Health Innovation

The Chittagong Hill Tracts represents not merely a target for the application of existing global health knowledge but a site for the generation of genuinely novel global health knowledge and innovation. The specific combination of challenges that characterize the CHT, including the extreme geographic access constraint, the multi-ethnic cultural and linguistic complexity, the double burden of infectious and non-communicable disease, the traditional medicine system of demonstrated pharmacological significance, and the political complexity of indigenous health governance, makes it a unique and intellectually valuable setting for the development of health systems innovations, clinical protocols, community health worker models, and medical education approaches that could have applications far beyond Bangladesh. The development and rigorous evaluation of a community health worker model adapted for extreme geographic isolation and multi-ethnic multilingual communities in the CHT, for example, would generate evidence directly applicable to comparable settings across the Southeast Asian mountain zone (including the Golden Triangle borderlands, the Myanmar-China-Laos borderlands, the upland areas of Vietnam, Cambodia, and Laos, and the mountain communities of Northeast India). The pharmacological characterization of CHT ethnomedicinal plants could contribute to the global library of natural product drug candidates from a biodiversity hotspot that has been systematically underexplored by pharmacological research. The development and testing of AI-assisted diagnostic tools adapted for the CHT context, where laboratory confirmation of clinical diagnoses is frequently unavailable, could generate innovations applicable to resource-limited clinical settings globally. Conceptualizing the CHT not only as a site of need but as a site of innovation is an important reframing that could attract the research investment and collaborative attention that the territory's health challenges demand.

MODEL EXAMINATION QUESTIONS: CHAPTER THREE

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

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The 2024 revisions to the Declaration of Helsinki, adopted at the World Medical Association General Assembly, strengthened which provisions specifically relevant to CHT research ethics? a) Requirements for randomized controlled trial design b) Provisions on research in vulnerable and marginalized populations including indigenous communities, adding community-level consent processes, benefit-sharing, and post-study access provisions c) Requirements for peer-reviewed publication of all research findings d) Financial compensation requirements for all research participants (Correct Answer: b)

The Bandarban Health and Demographic Surveillance System (HDSS) operated in the CHT is affiliated with which research institution? a) Dhaka University Medical Faculty b) icddr,b (International Centre for Diarrheal Disease Research, Bangladesh) c) BRAC University d) Johns Hopkins Bloomberg School of Public Health (Correct Answer: b)

The principle of "Anti-Extractive Research" in CHT indigenous communities requires all of the following EXCEPT: a) Community-accessible reporting of findings in indigenous languages where possible b) Active involvement of community members as paid research team members c) Generation of publications in high-impact journals exclusively for researcher career advancement without community benefit d) Concrete program or policy outcomes that benefit the research community (Correct Answer: c)

Which of the five thematic research priority clusters identified in this chapter has historically received the most research investment in the CHT relative to its burden of disease? a) Disease Burden Characterization in Under-Researched Communities b) Environmental Health and Exposure Science c) Malaria (within the Disease Burden cluster, indicating topical concentration) d) Climate and Health Research (Correct Answer: c)

The concept of "Community Ownership" as a CHT research ethics principle holds that: a) Research equipment purchased for CHT studies should be donated to the community b) The knowledge generated through research in CHT communities belongs to those communities as well as to the scientific community, with community rights to review and approve findings c) Community members should be employed as data collectors only, with analysis conducted by external researchers d) Communities may charge research teams for access to their territory (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A research team from a Dhaka university is designing a study on tuberculosis prevalence in the Mro community of Alikadam. The study protocol includes individual signed informed consent forms in Bangla, collection of sputum samples, and publication of findings in an international journal. However, no community-level consultation was conducted before the study design was finalized, no Mro-language materials were developed, and no benefit-sharing arrangement was made with the community. According to the CHT Research Ethics Framework described in this chapter, which ethical principles are being violated? a) Only the non-maleficence principle b) Community Ownership (no community-level consultation), Relational Accountability (no ongoing relationship established), Research as Capacity Building (no community capacity

component), and Anti-Extractive Research (extractive data collection without proportionate community benefit), as well as the 2024 Declaration of Helsinki standards for research in indigenous communities c) Only the autonomy principle d) No ethical principles, because individual informed consent was obtained (Correct Answer: b)

CHAPTER FOUR: CLIMATE CHANGE, PLANETARY HEALTH, AND THE CHT: THE ACCELERATING ECOLOGICAL HEALTH CRISIS

4.1 The Planetary Health Framework Applied to the CHT

Planetary health, defined as the health of human civilizations in the context of the health of the Earth's natural systems upon which they depend, represents the most comprehensive and most urgent conceptual framework for understanding the long-term health trajectory of the Chittagong Hill Tracts. The CHT is simultaneously a site where the consequences of planetary-scale ecological disruption are intensely and immediately felt (through climate change-driven flooding, landslides, altered vector ecologies, and food system disruption) and a site where local ecological practices (deforestation, jhum burning, soil erosion, water source contamination) are contributing to the very planetary ecological degradation whose health consequences they themselves experience. This double positioning of the CHT, as both victim and contributor (at a vastly disproportionate scale) of planetary ecological disruption, reflects the broader global pattern in which the communities least responsible for anthropogenic climate change bear the greatest health burden of its consequences. The per-capita greenhouse gas emissions of CHT indigenous communities are among the lowest in the world: subsistence farmers and forest product gatherers living in bamboo houses and burning wood for cooking are not meaningfully contributing to the atmospheric carbon loading that is driving the climate change that threatens their livelihoods and their health. The structural injustice embedded in this pattern, in which the most marginalized communities bear the costs of the ecological destruction generated by the most powerful and most affluent communities, is not merely a philosophical observation. It is a health equity violation of global scale that the planetary health framework makes visible and that demands a global as well as a local response.

The specific mechanisms through which climate change affects health in the CHT have been analyzed in preceding parts of this textbook but deserve systematic synthesis and projection in this final part. The WHO World Health Organization's 2025 global assessment of climate change and health, published in November 2025 in advance of the COP30 climate conference scheduled for Belem, Brazil in late 2025, identified six primary pathways through which climate change affects human health globally: direct effects of extreme heat; effects of extreme weather events (floods, storms, landslides, drought); effects on infectious disease transmission (particularly vector-borne and waterborne diseases); food and nutrition insecurity; population displacement and associated mental and physical health consequences; and disruption of health systems and health service delivery. All six pathways are operating in the CHT with intensity amplified by the structural vulnerabilities analyzed throughout this textbook. The direct effects of extreme heat are most clinically significant for CHT outdoor agricultural workers who labor in jhum

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fields and forests without shade or hydration access, for the elderly and infirm who have limited capacity for thermoregulatory compensation, and for neonates and young infants whose thermoregulatory capacity is immature. Extreme weather events, particularly the high-intensity monsoon rainfall that is being amplified by climate change, produce flooding and landslides that are both direct causes of mortality (landslide deaths in the CHT are documented annually in the national disaster management reports, with particularly severe events in 2017 and 2021) and indirect causes of morbidity through post-flood water contamination, disease outbreak conditions, and agricultural loss.

4.2 Climate Change and Malaria: The Shifting Frontiers of Transmission

The relationship between climate change and malaria transmission in the CHT is one of the most important and most intensively studied climate-health interactions in Bangladesh. The key climate variables affecting malaria transmission include temperature (which determines the extrinsic incubation period of Plasmodium within the Anopheles mosquito, with warmer temperatures accelerating parasite development and potentially extending the transmission season), rainfall (which determines the availability of Anopheles breeding habitat through the creation and maintenance of standing water), humidity (which affects adult Anopheles survival and thus vectorial capacity), and extreme weather events (which can both create new breeding habitats through flooding and disrupt existing control measures through damage to health facilities and supply chains). Climate modeling studies incorporating projected Bangladesh climate scenarios (including the projections from the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, published in 2021-2022, which projected temperature increases of 1.5 to 2.5 degrees Celsius for Bangladesh by 2050 under intermediate emissions scenarios) have projected that the altitude boundary of intense malaria transmission in the CHT will shift upward, potentially bringing high-transmission malaria risk to higher-elevation settlements that have historically been malaria-free or low-transmission areas due to the temperature-limited development of Plasmodium at altitudes above approximately 1,800 meters. This projection is not merely of academic interest: it means that the villages and communities on the higher ridges of Bandarban and Rangamati, which have not historically been targeted by malaria control programs and whose residents have not developed the partial immunity that comes with lifelong malaria exposure, may face future malaria risk for which neither the individual health immune profile nor the public health program architecture is prepared.

The 2025 WHO World Malaria Report documented global increases in malaria cases (estimated at 282 million cases globally in 2024, an increase of approximately 9 million or 3 percent over 2023) and attributed part of this increase to the effects of climate variability on vector behavior and parasite development. For the CHT specifically, the combination of climate change-driven transmission season extension, the emergence of partial artemisinin resistance in Greater Mekong Subregion P. falciparum strains that could spread westward into CHT parasite populations, and the ongoing deficit in LLIN coverage and IRS implementation in the most remote CHT communities creates a scenario in which the malaria case count reductions achieved between 2008 and 2022 could be reversed under conditions of inadequate programmatic response. Bangladesh's national malaria elimination target of achieving zero indigenous malaria

transmission by 2030, endorsed by the Asia Pacific Leaders Malaria Alliance and supported by the Global Fund, requires a dramatic acceleration of control measures in the CHT precisely as climate change is making the entomological and epidemiological environment progressively more hostile to elimination. The achievement of the 2030 elimination target in the CHT is the single most complex and high-stakes challenge in Bangladesh public health over the next five years, and it requires a comprehensive program strategy that addresses vector control, case detection, treatment access, cross-border transmission, and climate resilience simultaneously.

4.3 Food Security, Climate, and the Nutritional Health Trajectory of the CHT

The nutritional crisis of CHT indigenous communities, documented in detail in Chapter Five of Part One, is being systematically worsened by the climate-driven disruption of the agricultural systems upon which CHT food security depends. The jhum cultivation system, which has historically served as the primary food production system for most CHT indigenous communities, is sensitive to climatic factors in ways that make it particularly vulnerable to the specific changes in rainfall timing, intensity, and distribution that climate change is producing. Jhum cultivation depends on a predictable pre-monsoon dry season for the burning of cleared vegetation (the burning phase of jhum is only possible when the slash is dry enough to ignite) and on the timely onset of monsoon rainfall for the germination and growth of sown crops. The increasing unpredictability of rainfall onset, the greater variability of rainfall timing and intensity, and the more frequent occurrence of late monsoon onset years documented by the Bangladesh Meteorological Department's climate trend analysis for the CHT region have disrupted the agricultural calendar in ways that reduce crop yields, increase crop failure risk, and intensify the food insecurity of the lean season period. The April 2025 study examining climate change impacts on indigenous CHT communities documented that indigenous households across the CHT identified unpredictable rainfall and extreme heat as the primary environmental stressors on their agricultural livelihoods and food security, and reported declining jhum crop yields over the preceding decade that they attributed primarily to climatic changes superimposed on the soil fertility decline caused by shortened rotation cycles. The interaction between climate-driven yield reduction and pre-existing soil fertility decline from compressed jhum cycles represents a compounding agricultural stress that is moving the food security situation of the most vulnerable CHT communities in the wrong direction precisely when the nutritional crisis is already severe enough to be documented in the Lancet Southeast Asia as a "missing piece in Bangladesh's nutrition agenda."

The response to the climate-food-nutrition nexus in the CHT requires a combination of agricultural resilience interventions (development and dissemination of climate-adapted crop varieties for jhum systems, promotion of agroforestry as a more climate-resilient and more nutritionally diverse alternative to monocrop jhum, protection and restoration of wild food environments through community-based forest management, and development of small-scale irrigation for year-round vegetable production where topographically feasible) and social protection interventions (food assistance programs targeted to the lean season vulnerability of the highest-risk communities, cash transfer programs to enable food purchase during production shortfalls, and community-level grain storage systems that buffer household food availability against seasonal shocks). The nutritional supplement delivery programs operated by UNICEF,

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WFP, and national government nutrition programs must be specifically adapted and geographically extended to reach the CHT communities where stunting rates exceed 45 percent, recognizing that the dietary diversity deficit documented in the 2025 Lancet Southeast Asia paper (with only 12 to 13 percent of Mro and Marma children in Bandarban achieving minimum dietary diversity) can only be addressed through combined agricultural, market access, and direct nutrition intervention strategies.

4.4 Landslides, Floods, and the Disaster Risk Profile of the CHT

The geological and hydrological character of the CHT makes it among the most landslide-prone territories in South Asia, and climate change is increasing both the frequency and the severity of the extreme rainfall events that trigger the mass movements responsible for the most catastrophic landslide events. The CHT's Miocene-Pliocene sedimentary geology, characterized by poorly consolidated sandstone and shale formations with limited cohesion, its steep slope topography, and the progressive deforestation that has removed the root systems providing slope stability, create a landscape in which extreme rainfall events readily saturate the regolith and trigger the shallow translational landslides and debris flows that have caused the most significant CHT disaster events. The June 2017 landslides in Rangamati, Bandarban, and Khagrachhari, which killed more than 150 people and displaced tens of thousands, remain the most devastating single disaster event in recent CHT history, but smaller landslide events occur annually in the monsoon season and represent a recurring occupational and residential hazard for communities on steep slopes. The disaster health consequences of landslide events include not only direct mortality from burial and blunt trauma but the secondary health consequences of displacement (disruption of healthcare access, contamination of water sources by landslide debris, and the psychological trauma of sudden loss of home and livelihood), which accumulate in the weeks and months following the event. The health system response to CHT landslide disasters requires both an immediate emergency medical response (trauma care, search and rescue, emergency public health measures to prevent post-disaster disease outbreaks) and a sustained recovery phase public health response (mental health support for survivors, WASH rehabilitation in affected communities, and nutritional support for displaced households).

MODEL EXAMINATION QUESTIONS: CHAPTER FOUR

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The WHO 2025 global assessment of climate change and health identified how many primary pathways through which climate change affects human health? a) Three b) Four c) Six d) Eight (Correct Answer: c)

Bangladesh's national malaria elimination target, supported by the Global Fund and the Asia Pacific Leaders Malaria Alliance, is to achieve zero indigenous malaria transmission by which year? a) 2025 b) 2028 c) 2030 d) 2035 (Correct Answer: c)

The most severe recent landslide disaster event in the CHT, killing more than 150 people, occurred in which year? a) 2007 b) 2012 c) 2017 d) 2021 (Correct Answer: c)

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The "extrinsic incubation period" of malaria refers to: a) The period between mosquito bite and symptom onset in the human host b) The time required for Plasmodium parasites to develop to the infectious sporozoite stage within the Anopheles mosquito, which shortens at higher temperatures c) The latency period of P. vivax hypnozoites in the human liver d) The duration of effective immunity following a malaria episode (Correct Answer: b)

Agroforestry as a CHT food system resilience strategy offers which specific advantages over monocrop jhum cultivation? a) Lower labor requirements b) Greater climate resilience, higher nutritional diversity, improved soil conservation, and more sustainable long-term food production c) Higher yields of the primary staple crop (upland rice) d) Lower dependence on rainfall (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A climate-health modeling team projects that, under an intermediate emissions scenario (RCP 4.5), the altitude boundary of intense P. falciparum malaria transmission in the Bandarban hills will shift upward by 300 to 500 meters by 2050. What are the most important public health system implications of this projection for CHT health program planning? a) No implications because the affected communities are small b) The need to expand LLIN distribution, IRS programs, and community-based malaria surveillance to higher-elevation settlements that are currently non-endemic and whose residents lack partial immunity, combined with the need to ensure artemisinin sensitivity monitoring in the CHT P. falciparum population to detect any resistance spread from the Greater Mekong region c) The need to invest in air conditioning for community health worker facilities d) The recommendation to relocate CHT communities from higher elevations to lower ground (Correct Answer: b)

The interaction between climate-driven agricultural yield reduction and shortened jhum rotation cycles in CHT communities produces which compounding health consequence? a) Increased income from marketing of surplus crops b) Progressive nutritional deterioration through soil fertility decline reducing crop yields, compounded by climate unpredictability increasing crop failure risk, producing food insecurity that intensifies existing malnutrition and immune vulnerability c) Improved dietary diversity through forced adoption of more varied cropping systems d) Reduced exposure to organophosphate pesticides as farming becomes less productive (Correct Answer: b)

CHAPTER FIVE: DIGITAL HEALTH, ARTIFICIAL INTELLIGENCE, AND THE TECHNOLOGICAL TRANSFORMATION OF CHT HEALTHCARE

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5.1 The Digital Health Landscape of the CHT: Infrastructure, Opportunity, and the Digital Divide

Digital health, encompassing the application of mobile telecommunications, internet connectivity, artificial intelligence, remote sensing, and data science to health service delivery, health monitoring, and health system management, represents one of the most rapidly evolving domains of global health technology and one with specific and substantial relevance to the healthcare access challenges of the CHT. The digital infrastructure of the CHT has been expanding rapidly in the 2020s, driven by the national expansion of mobile telecommunications coverage (including 4G coverage to an increasing proportion of upazila-level settlements in the CHT, though many of the most remote valley and ridge communities remain without connectivity), the proliferation of cheap smartphones (enabling data-capable mobile communications for a growing proportion of CHT residents and health workers), and the government's Digital Bangladesh Initiative, which has prioritized rural digital connectivity as a development policy goal. However, the digital divide in the CHT remains substantial: the communities with the highest health need (the most remote, the most poor, the most linguistically distinct from the dominant Bangla digital ecosystem) also have the lowest digital connectivity, the lowest smartphone penetration, the lowest digital literacy, and the least representation in the Bangla-language digital content landscape. This Inverse Digital Divide, in which digital technology exacerbates rather than reduces health equity gaps if deployed without deliberate equity-oriented design, is the most important conceptual challenge for digital health programs in the CHT.

The most immediately applicable digital health tools for the CHT health system, based on a review of the global digital health evidence base and the specific CHT context, include four categories. First, mHealth (mobile health) for community health workers: smartphone-based applications that provide CHW workers with clinical decision support algorithms for the management of the most common CHT health presentations (including malaria case assessment and treatment protocols, pneumonia assessment using WHO IMCI-based algorithms, malnutrition screening with MUAC guidance, and neonatal danger sign recognition), drug dispensing support (stock recording, dosing calculators, and referral forms), and supervision connection (enabling remote supervision by district-level health officers through text messaging or voice call where connectivity permits). Second, telemedicine for remote consultation: the development of telemedicine linkages between CHT upazila health complexes and district hospitals, and between district hospitals and Chittagong Medical College Hospital, enabling specialist consultation for complex clinical presentations without requiring patient transport. A dermatology telemedicine consultation service using asynchronous photo-based consultation (in which the health worker photographs a skin lesion and sends it to a dermatologist for interpretation) has been shown to be feasible and effective for the management of common skin conditions in remote settings in multiple country programs, and its adaptation for CHT leprosy (Hansen's disease), leishmaniasis, and fungal infection presentations would be a high-value specific application. Third, Geographic Information System (GIS) for health planning and surveillance: the use of satellite imagery, GPS location data, and health information system data to map disease burden, health facility catchment areas, coverage gaps, and population distribution in the CHT, enabling evidence-based resource allocation decisions and targeted

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program planning. Fourth, AI-assisted diagnostics: the application of machine learning algorithms to the interpretation of diagnostic images (including thick blood film images for malaria parasite detection, chest X-ray images for tuberculosis diagnosis, and fundus photographs for diabetic retinopathy screening) in a manner that extends the diagnostic capability of community health workers and lower-level facility staff beyond what would be achievable with human interpretation alone.

5.2 Artificial Intelligence in CHT Healthcare: Applications, Evidence, and Ethical Considerations

Artificial intelligence in healthcare, which encompasses machine learning, deep learning, natural language processing, and computer vision applications to clinical diagnosis, treatment decision support, disease surveillance, and health system management, has been advancing rapidly since the deep learning revolution of 2012 and has generated numerous applications of specific relevance to resource-limited settings that face the same diagnostic constraints as the CHT. The AI-powered malaria blood film reader, which uses convolutional neural network image analysis to identify and count Plasmodium parasites in digitized thick and thin blood film images, represents one of the most extensively evaluated AI diagnostic tools in the global health context. Studies evaluating these tools in African and Asian malaria-endemic settings have demonstrated sensitivity and specificity for Plasmodium detection exceeding that of standard manual microscopy by non-specialist microscopists, and the tools have been designed for deployment on standard Android smartphones with offline capability (eliminating the need for internet connectivity during case analysis). The application of AI-powered malaria film reading to CHT health facilities, where microscopy training and quality are inconsistent, represents a technically feasible and clinically valuable enhancement of diagnostic capacity. Critically, the training dataset for AI diagnostic tools used in the CHT must include P. falciparum and P. vivax parasite images from CHT isolates specifically, since parasite morphology varies somewhat between geographic populations and AI tools trained exclusively on African P. falciparum images may not perform optimally on Asian malaria species.

The application of AI natural language processing (NLP) to the challenge of multilingual health communication in the CHT represents a longer-term but transformatively important technological opportunity. The development of speech recognition and machine translation tools for CHT indigenous languages (Chakma, Marma, Tripuri, Mro, and others) would enable the creation of indigenous-language health information applications, automated translation support for clinical consultations, and community health education materials in indigenous languages that do not currently exist in digital form. As of 2026, the major international AI language models have extremely limited coverage of CHT indigenous languages, which lack the large text corpora required to train high-performance NLP systems. The development of CHT indigenous language NLP capabilities requires a deliberate data infrastructure investment including the digital transcription and annotation of spoken indigenous language texts (including traditional healing knowledge, community health education content, and clinical health information), which must be conducted with indigenous community ownership of the resulting language resources, as required by the anti-extractive research ethics principles described in Chapter Three. The 2025-2026 initiative by Google Research's language inclusion team to expand automatic speech

recognition to 100 additional languages underrepresented in current AI systems, which includes some minority languages of the Indo-Burmese range but not yet CHT indigenous languages specifically, represents a potential partnership opportunity for a CHT indigenous language NLP development initiative that Bangladeshi academic institutions and CHT community organizations should actively pursue.

5.3 Drone Technology and Remote Supply Chain Solutions

The application of unmanned aerial vehicle (drone) technology to the last-mile delivery of essential medical supplies in geographically difficult terrain has advanced from experimental proof-of-concept to operational deployment in multiple settings globally between 2015 and 2026. The most extensively documented program is Zipline's drone delivery network in Rwanda and Ghana, where regular commercial delivery of blood products, vaccines, and medicines to remote health facilities by autonomous fixed-wing drones has been operating since 2016 and has been shown to dramatically reduce delivery times and stockout rates for life-saving essential medicines. The terrain and population distribution profile of the CHT is in many respects better suited to drone delivery applications than the African savanna settings where Zipline originally deployed, because the high mountain topography that makes road access most difficult in the CHT also provides the unobstructed air corridors and high landing point altitudes that simplify drone navigation and delivery logistics. A CHT drone delivery program for essential medicines and vaccines to remote community health worker points, operating from upazila-level supply depots with solar charging infrastructure, could provide reliable weekly delivery of ACTs, RDTs, LLINs, vaccines (in cold-capable packaging), and basic essential medicines to settlements that are currently served only by irregular and unreliable porter-based supply or by seasonal boat transport. The capital cost of establishing such a program would be substantial but is not out of reach for a Global Fund grant supplemented by national government and private sector investment, and the recurrent cost per delivery in CHT terrain has been modeled at levels below the cost of porter-based delivery once the program reaches full operational scale. The regulatory framework for drone operations in Bangladesh, which is governed by the Bangladesh Civil Aviation Authority (BCAA) and is being progressively updated to accommodate drone delivery operations, represents the primary governance barrier to rapid deployment, and advance engagement with the BCAA to develop CHT-specific regulatory pathways for medical drone delivery should be a policy priority for CHT health system planners.

MODEL EXAMINATION QUESTIONS: CHAPTER FIVE

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The term "Inverse Digital Divide" as applied to CHT digital health programs refers to: a) The divide between digital and non-digital health services b) The pattern in which digital technology exacerbates health equity gaps when deployed without equity-oriented design, because the communities with the highest health need also have the lowest digital connectivity and digital literacy c) The gap between the number of digital devices and the number of health workers d) The shortage of electricity that limits digital device charging in remote areas (Correct Answer: b)

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Zipline's drone delivery network for medical supplies has been operating since 2016 in which two African countries? a) Kenya and Tanzania b) Nigeria and Senegal c) Rwanda and Ghana d) Ethiopia and Uganda (Correct Answer: c)

The primary data constraint preventing the development of high-performance AI natural language processing (NLP) tools for CHT indigenous languages is: a) Technical limitations of current AI algorithms that prevent them from processing tonal languages b) The absence of the large annotated digital text corpora required to train NLP systems for these languages c) Government restrictions on digital processing of indigenous language content d) Copyright protection of indigenous language content by community organizations (Correct Answer: b)

Asynchronous photo-based telemedicine consultation for skin conditions in remote settings is classified as which type of telemedicine model? a) Synchronous real-time video consultation b) Store-and-forward (asynchronous) telemedicine c) Remote patient monitoring d) Mobile health (mHealth) only (Correct Answer: b)

The Bangladesh Civil Aviation Authority (BCAA) is the regulatory body responsible for which aspect of drone medical delivery program deployment in the CHT? a) The clinical quality of medicines delivered by drone b) The regulatory framework governing drone operations in Bangladeshi airspace c) The cold chain requirements for vaccine delivery d) The training of drone operators in clinical protocols (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A district health program planner in Rangamati is evaluating the feasibility of deploying an AI-powered malaria blood film reading application for use by community health workers in remote valley communities. Based on the AI diagnostic principles described in this chapter, which of the following is the most important technical precondition for effective AI diagnostic performance in the CHT context? a) The application must work only when connected to a 4G network b) The AI algorithm must have been trained on a dataset that includes P. falciparum and P. vivax parasite images from CHT or comparable Asian malaria parasite populations, since training on African isolate images alone may not produce optimal performance on Asian species c) The application must be developed by a Bangladeshi company d) The application must replace rather than supplement human microscopy review (Correct Answer: b)

A public health economist analyzing the cost-effectiveness of a proposed drone delivery program for essential medicines to remote CHT communities compares it with the current porter-based delivery system. Which of the following factors most strongly supports the cost-effectiveness conclusion for drone delivery? a) The aesthetic appeal of drone technology for government health officials b) The recurrent cost per delivery by drone (once fully operational) modeling below the cost of porter-based delivery, combined with the indirect cost savings from reduced stockouts of life-saving medicines, reduced preventable mortality from malaria and pneumonia through better medicine availability, and reduced healthcare facility visit costs borne by households when medicines are unavailable c) The drone program capital cost being zero d) The porter-based delivery system already functioning adequately without cost (Correct Answer: b)

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CHAPTER SIX: NON-COMMUNICABLE DISEASE EMERGENCE IN THE CHT: EPIDEMIOLOGY, PREVENTION, AND MANAGEMENT OF THE ARRIVING EPIDEMIC

6.1 The NCD Transition in the CHT: Evidence, Drivers, and Dimensions

The emergence of non-communicable diseases (NCDs) as a significant and growing component of the CHT disease burden, against the backdrop of the still-dominant and unresolved infectious disease crisis documented across this entire textbook, represents one of the most complex and under-studied dimensions of the territory's contemporary health situation. The NCD transition in the CHT is not following the classical epidemiological transition model, in which infectious disease declines before NCD rates rise, because in the CHT the infectious disease burden has not declined to a level where NCD would replace it as the dominant health challenge. Instead, the CHT is entering a period of genuine double burden, in which cardiovascular disease, type 2 diabetes mellitus, hypertension, chronic obstructive pulmonary disease, and cancer are emerging as epidemiologically significant causes of morbidity and mortality while malaria, tuberculosis, measles, diarrheal disease, and nutritional deficiencies remain major causes of preventable death. This double burden imposes demands on a health system that was already inadequate for the infectious disease agenda alone, requiring the development of new clinical capabilities (for NCD screening, diagnosis, and long-term management), new supply chain arrangements (for antihypertensive, antidiabetic, and cardiovascular medicines that require regular long-term prescription), and new health worker competencies (for chronic disease management, lifestyle counseling, and NCD risk factor assessment) that the current CHT health system does not possess in adequate quantity or distribution.

The primary drivers of NCD emergence in the CHT are the same global forces operating in communities undergoing nutritional and lifestyle transition worldwide, but they are modified in specific ways by the CHT context. Dietary transition, in which the traditional CHT diet (high in complex carbohydrates from upland rice and root vegetables, rich in wild vegetables and forest products, moderate in protein from subsistence livestock and forest fauna, low in processed foods and added sugars) is being progressively displaced by a more energy-dense, less nutrient-diverse, and more processed diet as market access expands and CHT communities are increasingly integrated into the national food market, is the primary dietary driver of NCD risk. The introduction of commercially produced cooking oils (often rich in saturated and trans-fatty acids), refined white rice replacing more diverse grain and root crops, commercial snack foods, and sweetened beverages into CHT diets is increasing caloric density while reducing micronutrient and dietary fiber intake, creating the metabolic environment that predisposes to obesity, dyslipidemia, insulin resistance, and the cardiovascular disease and type 2 diabetes that follow. The tobacco and betel nut use patterns documented in Chapter Eight of Part One (and analyzed in detail in Chapters Five and Eight of Part Nine) represent the single largest potentially modifiable NCD risk factor in the CHT, contributing to cardiovascular disease risk, carcinogenesis, and chronic pulmonary disease. The indoor air pollution from solid fuel combustion, documented in Chapter Six of Part One as the most pervasive environmental health

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exposure in the CHT, is a major risk factor for COPD, lung cancer, and cardiovascular disease. The stress physiology consequences of chronic poverty, land insecurity, political marginalization, and unresolved collective trauma, analyzed through the Psychoecological Health Philosophy in Chapter Three of Part One, contribute to the HPA-axis dysregulation and chronic sympathetic activation that promote hypertension, cardiovascular disease, and metabolic syndrome. Physical inactivity is an emerging risk factor particularly in CHT communities transitioning away from physically demanding subsistence agriculture toward more sedentary livelihoods, though this transition is still early in many areas.

6.2 Cardiovascular Disease: The Silent Epidemic of CHT Adult Health

Cardiovascular disease (CVD), encompassing hypertension, coronary artery disease, stroke, and heart failure, is the leading cause of mortality globally and is increasingly recognized as a major and growing cause of mortality in lower-middle-income countries including Bangladesh. The Bangladesh national burden of disease data, compiled from multiple national surveys and vital registration sources, show that CVD already accounts for approximately 30 percent of all deaths in Bangladesh and that this proportion has been rising steadily. Within the CHT, the epidemiology of CVD is poorly characterized due to the absence of population-based cardiovascular disease surveillance and the severe undercount of non-communicable disease deaths in the CHT's vital registration deficiency. However, the risk factor profile of CHT populations for whom data are available suggests that CVD risk is substantial and likely to be increasing. Hypertension, the single most important modifiable risk factor for both ischemic heart disease and stroke, has been found in community-based cross-sectional studies in CHT upazila-level settings to be prevalent in 15 to 25 percent of adults above 40 years, with awareness, treatment, and control rates substantially below national averages. The low awareness of hypertension among CHT indigenous adults, combined with the absence of routine blood pressure measurement in community-level health encounters and the absence of antihypertensive medicines in reliable supply at CHT primary care facilities, means that the majority of hypertensive CHT adults are undiagnosed, untreated, and therefore at full risk of their first cardiovascular event.

The clinical management of hypertension in the CHT context is governed by the same evidence-based principles as elsewhere but requires adaptation to the specific resource and medicine supply realities of the territory. Amlodipine (a calcium channel blocker), enalapril or perindopril (ACE inhibitors), and hydrochlorothiazide (a thiazide diuretic) are the three classes of first-line antihypertensive agents with the most robust evidence base, the widest availability on essential medicines lists globally, and the lowest unit cost that are most appropriate for deployment at primary care level in the CHT. All three are on the Bangladesh Essential Medicines List and are theoretically available through the government supply chain, but their reliable availability at CHT upazila health complexes and below remains inconsistent and represents a specific supply chain gap that must be addressed as part of the NCD primary care integration agenda. The three-step NCD primary care integration protocol for the CHT, building on the WHO Package of Essential Noncommunicable Disease Interventions (WHO PEN) and the Practical Approach to Lung Health and NCD (PALM-NCD) models developed for resource-limited primary care settings, involves three core activities: routine opportunistic blood pressure measurement at

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every clinical encounter with adults above 40 years (which can be performed by trained community health workers with validated automated sphygmomanometers), standardized hypertension diagnosis protocol using two confirmed measurements at separate visits, and initiation of either lifestyle counseling alone or lifestyle counseling plus antihypertensive medication depending on the severity of hypertension and the presence of additional cardiovascular risk factors, with a defined follow-up protocol and a reliable antihypertensive medicine supply chain.

6.3 Type 2 Diabetes in the CHT: The Metabolic Frontier

Type 2 diabetes mellitus, driven by the combination of genetic susceptibility, dietary transition, and physical inactivity, is an emerging epidemic in urban Bangladesh, with national diabetes prevalence estimated at 12 to 15 percent in adults above 35 years in recent national surveys. The prevalence of type 2 diabetes in CHT indigenous communities is not well characterized, but several converging factors suggest that the diabetes transition is underway in the CHT and will accelerate in the coming decade. First, South and East Asian populations generally show greater insulin resistance and diabetes susceptibility at lower body mass indices than populations of European ancestry (the "Asian paradox" in diabetes epidemiology), meaning that the moderate overweight that accompanies the nutritional transition in CHT communities may trigger insulin resistance at lower thresholds than the biomedical reference ranges derived from Western populations. Second, the dietary transition toward refined white rice and commercial oils increases the glycemic and inflammatory load of the CHT diet in ways that promote beta-cell stress and insulin resistance. Third, the betel nut chewing practice, which is endemic in many CHT communities, has been associated in epidemiological studies from Taiwan, India, and Southeast Asian populations with increased risk of metabolic syndrome and type 2 diabetes, through mechanisms that may involve the arecoline-induced disruption of adipokine signaling and pancreatic function. Fourth, the psychosocial stress and cortisol dysregulation associated with chronic poverty, land insecurity, and collective trauma promote insulin resistance and abdominal adiposity, as documented in the physiological research on HPA-axis dysregulation and metabolic disease.

The specific clinical challenge of type 2 diabetes management in the CHT is not only the diagnostic gap (most CHT diabetics are currently undiagnosed due to the absence of routine blood glucose screening in primary care) but also the treatment gap: the long-term management of type 2 diabetes requires not only the prescription of oral hypoglycemic agents (metformin, which is inexpensive, well-tolerated, and on the Bangladesh Essential Medicines List, is the recommended first-line agent) but also dietary counseling adapted to the CHT food environment (including guidance on reducing refined rice intake, increasing vegetable consumption, limiting commercial cooking oils, and stopping betel-tobacco use), physical activity promotion, and management of the hypertension and dyslipidemia that commonly accompany type 2 diabetes as components of the metabolic syndrome. Delivering this comprehensive package at community health worker level in linguistically and culturally appropriate formats, in the context of a CHT primary care system that was not designed for chronic disease management, represents the core NCD health system challenge of the next decade.

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6.4 Chronic Obstructive Pulmonary Disease: The Biomass Lung Disease of the CHT

Chronic Obstructive Pulmonary Disease (COPD), defined as a progressive and largely irreversible airflow limitation caused by chronic airway inflammation, is the third leading cause of death globally and is driven in South Asia, unlike in high-income countries where tobacco smoking is the dominant risk factor, primarily by the combination of tobacco smoking, secondhand tobacco smoke exposure, and biomass fuel combustion smoke exposure in the cooking and household environment. In the CHT, COPD risk is generated by exactly this combination: universal solid fuel cooking in poorly ventilated bamboo structures produces chronic indoor biomass smoke exposure for all adult household members, and tobacco use in various forms (cigarettes, traditional pipes, and bidi, a hand-rolled tobacco leaf cigarette common in the CHT) is prevalent across multiple CHT communities. The epidemiology of COPD in CHT indigenous communities has not been systematically characterized through spirometry-based prevalence surveys, which is the only accurate method for COPD diagnosis (COPD is defined by a post-bronchodilator FEV1/FVC ratio below 0.70 on spirometry), and its burden is therefore currently invisible in the CHT health data. Clinical recognition of COPD in CHT primary care settings requires awareness that the classic symptom triad of chronic productive cough, progressive exertional dyspnea, and recurrent respiratory infections in a middle-aged adult with a history of heavy biomass smoke and tobacco exposure should prompt clinical suspicion for COPD even in the absence of confirmatory spirometry. The initiation of trial bronchodilator therapy (short-acting beta-agonist inhaler such as salbutamol) and the response to that therapy provides the most practically available confirmation of airflow obstruction in the absence of spirometry. Long-acting bronchodilators (LAMA and LABA inhalers), which are the most effective maintenance treatment for moderate to severe COPD, are not currently available at CHT primary care level and represent a specific essential medicine gap for the NCD agenda.

MODEL EXAMINATION QUESTIONS: CHAPTER SIX

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

The "Asian paradox" in diabetes epidemiology refers to: a) The paradoxically low diabetes prevalence in East Asian populations despite high rice consumption b) The greater insulin resistance and diabetes susceptibility in South and East Asian populations at lower body mass indices compared with European populations c) The paradoxically high HDL cholesterol in populations consuming traditional Asian diets d) The paradoxical protective effect of green tea against diabetes (Correct Answer: b)

COPD is defined spirometrically by: a) FEV1 below 1 liter in absolute terms b) Post-bronchodilator FEV1/FVC ratio below 0.70 c) Peak expiratory flow rate below 200 L/min d) FVC below 80% of predicted (Correct Answer: b)

The first-line recommended oral hypoglycemic agent for type 2 diabetes in primary care settings globally, and as included in the Bangladesh Essential Medicines List, is: a) Glibenclamide (a

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sulfonylurea) b) Metformin (a biguanide) c) Sitagliptin (a DPP-4 inhibitor) d) Empagliflozin (an SGLT-2 inhibitor) (Correct Answer: b)

Arecoline, the primary alkaloid of areca nut, has been associated in epidemiological studies with increased risk of which metabolic condition? a) Hypothyroidism b) Metabolic syndrome and type 2 diabetes c) Addison's disease d) Cushing's syndrome (Correct Answer: b)

Which of the following is the most important first step in implementing NCD primary care integration for hypertension screening in CHT community health worker programs? a) Deploying electrocardiogram machines to all CHT health facilities b) Routine opportunistic blood pressure measurement at every clinical encounter with adults above 40 years, using validated automated sphygmomanometers c) Blood lipid testing for all adults d) Cardiac stress testing for all adults above 50 years (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A 58-year-old Chakma woman living near Rangamati presents with a 5-year history of worsening exertional breathlessness and a chronic morning cough with white sputum. She has cooked exclusively on a wood fire in a poorly ventilated room for her entire adult life and smoked traditional tobacco for 30 years (30 pack-year equivalent). No spirometry is available at the facility. The most clinically appropriate next step in her management is: a) Empirical antitubercular therapy based on the symptom duration and CHT TB prevalence b) Perform a trial of salbutamol inhaler and assess symptomatic response to assess airflow obstruction, while simultaneously excluding active pulmonary tuberculosis through sputum AFB smear, and initiating a plan for referral for spirometry confirmation of COPD diagnosis with consideration of long-acting bronchodilator maintenance therapy c) Prescribe cough suppressants and discharge d) Diagnose asthma and prescribe inhaled corticosteroids only (Correct Answer: b)

A nutrition researcher studying the emerging diabetes epidemic in a Marma community in Bandarban identifies that mean BMI in the community is 22.3 kg/m2 (within the normal Western reference range) but 18% of adults tested by fasting blood glucose have impaired fasting glucose or frank diabetes. What epidemiological concept explains this finding and what are its clinical implications for diabetes screening cutoffs in CHT indigenous populations? a) This finding is statistically anomalous and requires data cleaning b) This finding illustrates the Asian paradox, in which South and East Asian populations develop insulin resistance and diabetes at lower BMIs than Western populations, with the clinical implication that diabetes screening in CHT populations should use lower BMI thresholds (WHO recommends BMI above 23 kg/m2 as the Asian overweight threshold) and should not rely on Western BMI cutoffs c) The blood glucose testing must have been methodologically flawed d) This finding indicates that the Marma population has a unique genetic immunity to normal-weight obesity (Correct Answer: b)

CHAPTER SEVEN: THE ROLE OF THE CHT HEALTH PROFESSIONAL: CLINICIAN, RESEARCHER, ADVOCATE, AND BUILDER OF SYSTEMS

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7.1 The Multi-Dimensional Professional Identity of the CHT Health Practitioner

The health professional who practices in the Chittagong Hill Tracts occupies a multi-dimensional professional role that is simultaneously clinical, scientific, educational, advocacy-oriented, and system-building, and that demands a broader scope of professional identity and responsibility than the conventional biomedical professional model acknowledges. The conventional model of the health professional in the South Asian and Bangladeshi medical tradition, shaped by the biomedical education system, positions the physician primarily as a clinical scientist: a person trained to diagnose and treat disease in individual patients through the application of biomedical knowledge and clinical skills. This model is necessary but insufficient for the CHT. A physician practicing in the CHT who confines their professional role to individual patient care, however excellent that care may be, is engaged in a form of professional self-limitation that is ultimately both intellectually unsatisfying and practically ineffective, because the causes of the health problems they encounter daily in their clinical practice are fundamentally social, structural, ecological, and political, and cannot be addressed at the individual clinical level alone. The physician who sees the fourth severely malnourished Mro child of the day and treats each with ready-to-use therapeutic food without asking why so many Mro children are malnourished, and without taking action on the structural answers to that question, is a technically competent but intellectually and professionally incomplete practitioner of medicine in the CHT context.

The complete professional identity of the CHT health practitioner encompasses four mutually reinforcing roles. The first is the Clinician role, which encompasses the technical clinical skills and knowledge documented throughout this textbook: diagnostic reasoning adapted to the CHT epidemiological and resource context, emergency management of the life-threatening presentations most prevalent in the territory, clinical communication skills enabling therapeutic relationships across language and cultural barriers, and the ability to manage the double burden of infectious disease and emerging NCD simultaneously. The second is the Researcher role, which encompasses the capacity to generate and document clinical and epidemiological knowledge from the CHT context: maintaining systematic records of case presentations, treatment responses, and patient outcomes that collectively constitute the clinical intelligence from which CHT-adapted medical knowledge is built; conducting or contributing to the operational research studies identified in Chapter Three of this part as priorities for the CHT research agenda; and publishing or otherwise disseminating the knowledge generated through CHT clinical practice to the scientific community that needs this knowledge to develop better CHT-specific evidence. The third is the Educator role, which encompasses the transmission of CHT-relevant clinical and public health knowledge to the next generation of health workers through formal training, mentorship, continuing education, and community health education. The fourth is the Advocate role, which encompasses the professional obligation to translate the clinical evidence of structural injustice encountered in daily practice into advocacy for structural change, through documentation and reporting of health disparities, engagement with health policy processes, participation in professional and civil society organizations working on CHT health equity, and the use of whatever platforms are available (academic publications, professional conferences, media, and political engagement) to ensure that decision-makers who allocate health resources and design health policies are confronted with the reality of CHT health disparities and the evidence-based interventions required to address them.

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7.2 The Clinician-Advocate in the CHT: Historical Models and Contemporary Obligations

The concept of the clinician-advocate, the physician who integrates clinical practice with political advocacy for health equity, has a distinguished tradition in global health history that provides both inspiration and methodological guidance for CHT health practitioners. Paul Farmer and Jim Yong Kim's work with Partners in Health in rural Haiti, which combined the delivery of high-quality clinical care to the poorest communities with rigorous academic documentation of the structural determinants of their patients' suffering and global advocacy for the policy changes needed to address those determinants, represents the most extensively documented and theoretically elaborated model of clinician-advocacy in the global health era. Rudolf Virchow, the nineteenth-century German pathologist and political reformer, whose injunction that "medicine is a social science, and politics is nothing else but medicine on a large scale" represents perhaps the most succinct articulation of the clinician-advocate's philosophical position, provides a more historically distant but no less relevant precedent. In the South Asian context, the tradition of physician-activists who have combined medical practice with advocacy for the social determinants of health includes luminaries such as B.R. Ambedkar (who, though primarily known as a jurist and political figure, trained as a physician and consistently integrated medical evidence about caste-based health disparities into his political advocacy), and more recently the Bangladeshi physicians who documented the health consequences of the CHT conflict in the 1990s at considerable personal risk, contributing to the international human rights record that informed the diplomatic pressure leading to the 1997 Peace Accord.

The contemporary CHT clinician-advocate has available a set of tools and platforms for advocacy that historical predecessors lacked, including the academic publishing ecosystem (in which peer-reviewed publications documenting CHT health disparities reach international policy audiences), the global digital communication infrastructure (which enables CHT health workers to connect with the international health equity advocacy community, to document local health situations in real time, and to participate in global health policy discussions), and the accountability mechanisms of international human rights bodies and treaty monitoring committees (which, as documented in Chapter Two of this part, create formal channels through which documented violations of health rights can be reported and addressed through international processes). The student or practitioner reading this textbook who encounters, in their future practice, a CHT community where children are dying from a preventable disease because the immunization program has not reached them, where women are dying in childbirth because the emergency obstetric facility is too far and too expensive to reach, or where tuberculosis patients are defaulting from treatment because the economic and logistical barriers to compliance are insuperable, is not merely observing a clinical fact. They are witnessing a structural injustice that has been documented in this textbook with the full weight of the scientific and legal analysis that has been compiled across its ten parts, and they have a professional obligation to respond to that witnessing with action.

7.3 Building Institutional Capacity: The CHT Health Professional as System Builder

Beyond their individual clinical, research, and advocacy roles, CHT health professionals have an irreplaceable role as builders of the institutional capacity that the CHT health system needs to

function sustainably. Individual excellence in clinical practice cannot substitute for institutional capacity: a single gifted physician who diagnoses and treats malaria brilliantly in their clinic hours cannot prevent the next outbreak, cannot train the community health workers who extend the health system's reach into remote communities, cannot maintain the cold chain infrastructure for vaccines, and cannot design the health information system that monitors coverage gaps before they become epidemic vulnerabilities. Institutional capacity building in the CHT context encompasses several specific activities that CHT health professionals are uniquely positioned to contribute to. First, clinical training and mentorship of the next generation of CHT health workers, both formal (through participation in medical and nursing education programs, continuing medical education activities, and the supervision and assessment of trainees) and informal (through the daily modeling of clinical excellence, professional ethics, and advocacy commitment that influences the professional formation of junior colleagues). Second, the development and dissemination of CHT-adapted clinical protocols, which translate the evidence base documented in this textbook and in the global health literature into simplified, locally appropriate, and linguistically accessible decision support tools that enable health workers at all levels of the CHT system to deliver evidence-based care with the resources they have. Third, the development and advocacy for the health information systems that the CHT's monitoring and accountability needs require, including the CHT-specific disease surveillance systems, the ethnic-group-disaggregated health data systems, and the community health worker reporting systems that currently do not exist in adequate form.

MODEL EXAMINATION QUESTIONS: CHAPTER SEVEN

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Rudolf Virchow's famous injunction on the relationship between medicine and politics states: a) "The physician is primarily a scientist and must avoid political engagement" b) "Medicine is a social science, and politics is nothing else but medicine on a large scale" c) "Clinical practice and political advocacy are incompatible professional roles" d) "The physician's responsibility ends at the patient's bedside" (Correct Answer: b)

Partners in Health, the organization founded by Paul Farmer and Jim Yong Kim that serves as a model for the clinician-advocate approach, was founded primarily to deliver what type of healthcare? a) Specialist tertiary care in urban hospitals b) High-quality clinical care to the poorest communities combined with academic documentation of the structural determinants of health and global advocacy for policy change c) Research-only activities without direct patient care d) Technology-focused telemedicine services (Correct Answer: b)

The four mutually reinforcing professional roles of the complete CHT health practitioner identified in this chapter are: a) Clinician, Pharmacist, Administrator, and Teacher b) Clinician, Researcher, Educator, and Advocate c) Surgeon, Physician, Nurse, and Community Health Worker d) Diagnostician, Prescriber, Referrer, and Record-Keeper (Correct Answer: b)

The "professional self-limitation" described in this chapter as the risk for CHT physicians who confine themselves to individual clinical care refers to: a) Limiting medical practice to one

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clinical specialty b) Limiting professional impact by addressing only individual-level causes of health problems while the structural determinants of disease remain unaddressed c) Limiting the number of patients seen per day d) Limiting prescribing to the essential medicines list (Correct Answer: b)

The CHT health practitioner's Researcher role includes which activities? a) Conducting randomized controlled trials only b) Maintaining systematic clinical records, contributing to operational research, and publishing or disseminating knowledge generated through CHT clinical practice c) Publishing only in Bangladeshi journals d) Conducting laboratory research in Dhaka-based institutions (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A health officer posted to the Alikadam Upazila Health Complex in Bandarban observes that the same community, Kurukpata, which suffered catastrophic measles mortality in 2025, remains without a functioning community health worker, has had no measles-rubella catch-up campaign despite the outbreak, and has a new cohort of unvaccinated children accumulating for the third consecutive year. Based on the clinician-advocate framework described in this chapter, which combination of responses most fully represents the professional obligations of this health officer? a) Treat measles cases as they present and wait for the national program to address coverage b) Document the situation rigorously (case counts, vaccination coverage, community barriers), report findings formally through official health system channels, advocate to district and division health authorities for immediate targeted catch-up vaccination, engage with local community leaders and UN-supported health rights bodies to escalate the issue if internal channels are ineffective, and simultaneously implement Phase One of the traditional-biomedical integration protocol to build community trust c) Report only to the district hospital and take no further action d) Resign from the post in protest at the inadequacy of the health system (Correct Answer: b)

CHAPTER EIGHT: MEDICAL EDUCATION, TRAINING, AND COMPETENCY ARCHITECTURE FOR CHT-RELEVANT PRACTICE

8.1 The Failure of Conventional Medical Education to Prepare Graduates for CHT Practice

The conventional medical education system in Bangladesh, like that of most South Asian countries, was designed to produce physicians capable of practicing the biomedicine of urban hospital settings: clinicians trained in the diagnosis and management of diseases as they present in well-equipped tertiary hospitals with full laboratory, imaging, and specialist consultation support, among patient populations who are predominantly Bangla-speaking, formally educated, and familiar with biomedical health-seeking norms. This training is valuable and necessary, but it is systematically insufficient for the practice of medicine in the Chittagong Hill Tracts, where almost none of these enabling conditions exist. The newly graduated physician deployed to a CHT upazila health complex has been trained in how to read a CT scan for cerebral malaria diagnosis but has never been taught to diagnose cerebral malaria without CT imaging; has been

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trained to prescribe the full standard antihypertensive regimen but has never been taught to manage hypertension with only amlodipine and hydrochlorothiazide; has been trained in standard patient communication protocols but has never been taught to communicate through a cultural and linguistic intermediary; and has been trained in the principles of evidence-based medicine but has never been taught to apply Bayesian clinical reasoning to high-prevalence CHT diseases in the absence of laboratory confirmation. The result is a predictable pattern of professional distress, clinical error, inadequate management of emergencies, poor community relationships, and premature departure from CHT postings that is well-documented in qualitative studies of CHT health worker experience and that perpetuates the health worker retention crisis that contributes to the health system's chronic underperformance.

The reform of medical education to include CHT-relevant competencies is not a marginal or specialized concern. It is a core medical education priority for Bangladesh because a significant proportion of Bangladeshi physicians will at some point in their careers practice in the CHT or in comparable resource-limited, culturally diverse, geographically complex settings, and their preparation for that practice is a fundamental quality and patient safety obligation of the medical education system. The CHT Medical Education Reform Agenda, as proposed in this textbook, encompasses five domains of competency development that must be integrated into the undergraduate and postgraduate medical curriculum at relevant training institutions. First, Epidemiological Contextual Knowledge, encompassing the disease burden, risk factor distribution, and clinical presentation patterns specific to the CHT and comparable resource-limited settings in Bangladesh. Second, Resource-Adapted Clinical Skills, encompassing the diagnostic reasoning and clinical management skills for the most common life-threatening CHT conditions (malaria, pneumonia, obstetric emergencies, snakebite, neonatal sepsis, severe malnutrition) adapted to the resource and medicine supply realities of CHT primary and secondary care facilities, including the point-of-care diagnostic protocols, empirical treatment algorithms, and emergency stabilization procedures that function without laboratory confirmation or specialist support. Third, Cross-Cultural and Linguistic Communication Skills, encompassing the principles of cross-cultural clinical communication, the use of interpreters and cultural mediators in clinical consultations, the recognition of culturally specific illness narratives and their clinical significance, and the practical skills of working effectively with patients whose health beliefs and communication norms differ substantially from those of the mainstream Bangladeshi biomedical culture. Fourth, Community Health and Public Health Practice Skills, encompassing the capacity to design, implement, and evaluate community health programs adapted to resource-limited, culturally diverse contexts, including community health worker training and supervision, immunization program outreach design, surveillance and epidemic response, and WASH program planning. Fifth, Health Advocacy and Social Medicine, encompassing the professional and ethical framework for clinical advocacy, the structural determinants of health analytical framework, the international human rights framework for health as a right, and the specific social and political context of health in the CHT as documented in this textbook.

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8.2 CHT Field Practicum: Competency-Based Learning in the Territory

The most effective mechanism for developing the CHT-relevant competencies described in the preceding section is not classroom teaching but structured field experience in the CHT itself, through which medical students and postgraduate trainees encounter, under clinical supervision, the full complexity of healthcare delivery in a resource-limited, geographically constrained, culturally diverse, and historically politicized health context. The CHT Field Practicum model, which combines structured clinical rotations at CHT district hospitals and upazila health complexes with community health worker program participation, traditional medicine practitioner interactions, community ethnographic engagement, and public health program observation, provides a comprehensive immersive learning experience that cannot be approximated in any classroom simulation. Several Bangladeshi and international medical institutions have developed CHT-related field experience components for their students and trainees in recent years, and these programs have been consistently evaluated positively by participants as the most clinically formative experience of their training, providing both the specific clinical skills and the broader professional perspective that conventional hospital-based medical education does not deliver. The systematic expansion and institutionalization of CHT field practicum programs, with adequate financial support for student travel and accommodation, appropriate supervision, and integration into formal medical school curricula as a required rather than optional component, represents the most important single investment in building the medical workforce that the CHT health system requires for the next generation.

The postgraduate medical training system in Bangladesh, governed by the Bangladesh College of Physicians and Surgeons (BCPS) for FCPS programs and by the respective universities for MD programs, provides a further lever for CHT medical education reform through the incorporation of CHT-relevant content into specialty training curricula and FCPS examination syllabi. The current examination structure of the FCPS, which evaluates clinical knowledge primarily in the context of urban hospital practice, does not systematically require candidates to demonstrate competency in the resource-adapted clinical practice, cross-cultural communication, or public health advocacy that CHT-relevant practice demands. The development of CHT-specific examination modules for FCPS specialties with the highest CHT relevance (internal medicine, pediatrics, obstetrics and gynecology, general surgery, and community medicine), and the incorporation of CHT case scenarios into FCPS examination papers, would create a formal academic incentive for FCPS candidates to develop CHT-relevant competencies and would signal to the medical profession as a whole that CHT-relevant practice is a valued and examined dimension of clinical excellence in Bangladesh.

8.3 Traditional Medicine Education and the CHT Ethnomedicinal Curriculum

The integration of CHT traditional medicine knowledge into formal health professional training represents a specific and urgently needed curriculum development priority that has not yet been pursued by any Bangladeshi training institution. As documented in Chapter Four of Part One and Chapter Eight of Part Nine, the CHT Ethnomedicinal Complex is a clinically significant and pharmacologically active healthcare system that every practitioner working in the CHT needs to understand, respect, and engage with effectively. The absence of this understanding from

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conventional medical education leaves CHT-posted physicians without the knowledge they need to take accurate traditional medicine use histories, identify potential pharmacological interactions between botanical preparations and biomedical drugs, recognize the cosmological illness frameworks that shape their patients' explanatory models and treatment decisions, or build the collaborative relationships with traditional practitioners that the three-phase integration protocol described in Part Nine requires. The CHT Ethnomedicinal Curriculum module proposed in this textbook would include: an introduction to the five subsystems of the CHT Ethnomedicinal Complex (Botanical, Ritual-Spiritual, Dietary Regulatory, Midwifery, and Physical-Manipulative) and their clinical significance; a survey of the major CHT medicinal plants with documented pharmacological activity, their mechanisms of action, their clinical applications in the traditional context, and their potential interactions with biomedical medications; a framework for cross-cultural clinical communication in the context of indigenous illness cosmologies, including the clinical management of Bhutu, Pi, and Khumbai illness categories as analyzed in Chapter Three of Part One; and a practical field-based experience involving supervised interaction with a recognized Baiddya practitioner and participation in a community-level traditional healing ceremony with appropriate community consent and cultural guidance.

MODEL EXAMINATION QUESTIONS: CHAPTER EIGHT

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Postgraduate medical training in Bangladesh under FCPS programs is governed by which institution? a) Dhaka Medical College b) Bangladesh College of Physicians and Surgeons (BCPS) c) The Ministry of Health and Family Welfare d) The Bangladesh Medical and Dental Council (BMDC) (Correct Answer: b)

The five domains of competency development in the CHT Medical Education Reform Agenda include all of the following EXCEPT: a) Epidemiological Contextual Knowledge b) Resource-Adapted Clinical Skills c) Cross-Cultural and Linguistic Communication Skills d) Advanced molecular genetics and genomics (Correct Answer: d)

The primary advantage of the CHT Field Practicum over classroom-based teaching of CHT-relevant competencies is: a) It is cheaper to implement b) Structured field experience in the CHT provides an immersive learning environment that cannot be approximated in classroom simulation, developing both specific clinical skills and broader professional perspective c) It requires less faculty supervision d) It is shorter in duration (Correct Answer: b)

"Resource-Adapted Clinical Skills" in the CHT Medical Education Reform Agenda specifically includes competency in: a) Performing CT-guided biopsy in field settings b) Point-of-care diagnostic protocols, empirical treatment algorithms for common life-threatening CHT conditions, and emergency stabilization procedures that function without laboratory confirmation or specialist support c) Advanced robotic surgery techniques d) Gene therapy administration (Correct Answer: b)

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The CHT Ethnomedicinal Curriculum module proposed in this chapter would include which of the following as a practical learning component? a) Anatomy dissection using CHT botanical specimens b) Supervised interaction with a recognized Baiddya practitioner and participation in a community-level traditional healing ceremony with appropriate consent and cultural guidance c) Laboratory synthesis of pharmaceutical analogs of CHT plant compounds d) Commercial licensing of CHT ethnomedicinal plant species (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A community medicine FCPS candidate is asked to examine a case scenario involving a Mro community with a measles outbreak, inadequate immunization coverage, language barriers to health communication, and traditional healer resistance to vaccination. The examiner asks for a comprehensive management approach. Which response demonstrates the highest level of CHT-relevant clinical and public health competency as defined by the reform agenda of this chapter? a) Immediately deploy a mass vaccination campaign without community consultation b) Apply the CHT Contextual Diagnostic Doctrine for the clinical management of measles cases (vitamin A supplementation, supportive care, complication monitoring), implement Phase One of the traditional-biomedical integration protocol (engage recognized community leaders and traditional practitioners as health communication partners), develop a Mro-language immunization communication strategy with community input, implement a catch-up vaccination campaign designed with FPIC-based community engagement, and document the structural barriers as evidence for advocacy to higher authorities for sustained program investment c) Defer entirely to the traditional healer's decision about vaccination d) Report the community to national health authorities and await their response before acting (Correct Answer: b)

CHAPTER NINE: GLOBAL HEALTH PARTNERSHIPS, FINANCING ARCHITECTURE, AND THE POLITICAL ECONOMY OF CHT HEALTH DEVELOPMENT

9.1 The Architecture of International Health Financing in the CHT

The global health financing architecture that supports health program delivery in the CHT is a complex and multi-layered system of international and domestic financial flows, each with its own governance structures, conditionality frameworks, reporting requirements, and programmatic restrictions that collectively shape what health programs can be funded, how they are managed, and for whom they deliver benefit. Understanding this financing architecture is not a peripheral administrative concern for CHT health practitioners and policy advocates: it is a practical prerequisite for navigating the resource mobilization environment and for designing programs that are financially sustainable within the constraints and opportunities that the architecture creates. The major international health financing flows supporting CHT health programs include the Global Fund grants for HIV, tuberculosis, and malaria; the GAVI Alliance support for vaccine-preventable disease programs; UNICEF's country program funding for child health, nutrition, and maternal health; the World Bank's Bangladesh health sector operations

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(including the Health, Population and Nutrition Sector Program, HPNSP); bilateral development assistance from Japan (JICA), the United Kingdom (FCDO), the United States (USAID), and the European Union; and the program funding of major international NGOs including CARE, Save the Children, Oxfam, and Terre des Hommes. The aggregate international health investment in Bangladesh is substantial, estimated at approximately 1.5 to 2 billion US dollars annually in recent years, but the proportion of this investment specifically allocated to CHT indigenous community health programs is extremely small relative to the magnitude of the health disparities documented in this textbook, representing a chronic and compounding financing inequity that must be explicitly addressed in health financing reform discussions.

The Global Fund, as the largest single international funder of malaria and tuberculosis programs in the CHT, has the greatest leverage over the programmatic architecture of the CHT disease control agenda. The Global Fund's grant management structure in Bangladesh, which operates through the Ministry of Health and Family Welfare as the principal recipient and BRAC and other NGOs as sub-recipients, creates a specific accountability pathway for CHT program performance: if the grant agreements include explicit CHT indigenous community coverage targets with measurable indicators, then the Global Fund's performance-based financing model creates financial incentives for achieving those targets and financial consequences for failing them. The progressive strengthening of CHT indigenous community coverage requirements in Bangladesh Global Fund grant agreements, building on the Fund's Indigenous Peoples Guidance described in Chapter Two, represents one of the most practically powerful advocacy targets for CHT health equity: changing the performance framework of Bangladesh's largest international health funder to explicitly require equity-responsive CHT indigenous community coverage would translate into program design changes, resource allocation decisions, and monitoring systems that could significantly improve CHT health equity outcomes within the current grant cycle.

9.2 Domestic Health Financing and the Case for CHT-Specific Budget Allocation

Domestic health financing in Bangladesh is primarily channeled through the national health budget, administered by the Ministry of Health and Family Welfare and its Directorate General of Health Services, and supplemented by the out-of-pocket expenditure of households (which accounts for approximately 67 percent of total health expenditure in Bangladesh, one of the highest proportions globally and a major driver of the Healthcare Poverty Trap documented in Chapter Six of Part Nine). The national health budget allocates resources to the three CHT districts through the standard per-capita formula applied across all districts, which systematically underresources the CHT relative to need because it does not account for the additional costs associated with geographic access barriers (which increase the per-unit cost of health service delivery in the CHT relative to plains districts), the additional language and cultural competence requirements (which require investment in training and incentives not required in Bangla-speaking plains districts), or the additional equity-restoration investment needed to close the health gap between CHT indigenous communities and national averages. The per-capita budget allocation formula, applied uniformly across Bangladesh, produces a systematically inadequate budget for the CHT and is therefore a structural financing inequity that perpetuates the Inverse Coverage Law outcome described in Chapter One of this part.

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The advocacy case for a CHT-specific budget supplement, allocated above the standard per-capita formula to reflect the additional cost of equitable health service delivery in the CHT's geographic and cultural context, is supported by both equity and efficiency arguments. The equity argument is straightforward: a health budget allocation formula that systematically produces worse health outcomes for the most disadvantaged population group is unjust, and its reform to produce equitable outcomes regardless of geography, ethnicity, or cultural identity is a basic requirement of the right to health. The efficiency argument is equally powerful: investing adequately in preventive health programs (immunization, malaria control, WASH, nutrition) in the CHT will reduce the much larger downstream costs of treating the preventable disease burden that inadequate prevention allows to accumulate. The economic analysis of the 2025 measles outbreak in the CHT, including the costs of the emergency medical response, the long-term healthcare costs of survivors with neurological complications, the productivity losses from deaths, and the economic impact on Mro community livelihoods of the illness and death toll, substantially exceeds the cumulative cost of the immunization outreach program that, properly funded and designed, would have prevented the entire outbreak. This economic argument, combined with the human rights argument, constitutes a compelling case for CHT-specific health budget supplementation that advocates should be presenting to the Ministry of Finance and the Ministry of Health with the quantitative evidence that this textbook has helped to compile.

9.3 Civil Society, Community Organizations, and the Political Economy of CHT Health Advocacy

The political economy of CHT health development is shaped not only by the institutional actors described in the preceding sections (government ministries, international donors, NGOs) but by the civil society organizations, community organizations, and advocacy groups that represent the interests of CHT indigenous communities in the political arena and that play an indispensable role in holding governments and international organizations accountable for the health equity commitments they make. The CHT indigenous people's movement, represented by organizations including the Parbatya Chattagram Jana Samhati Samiti (PCJSS), the Hill Women's Federation, the Chittagong Hill Tracts Commission, and numerous community-based organizations in each district, has historically engaged with health issues as part of a broader political agenda for indigenous rights, land rights, and political autonomy. The integration of health equity advocacy into the political agenda of CHT indigenous civil society organizations, grounded in the UNDRIP framework and the specific health rights analysis documented in this textbook, strengthens both the health advocacy and the broader indigenous rights agenda by demonstrating the concrete, documented, and legally cognizable health consequences of the governance failures that CHT civil society organizations have long been documenting in political and human rights terms.

The international civil society infrastructure for indigenous health advocacy, including organizations such as the Forest Peoples Programme, Cultural Survival, Survival International, and the International Work Group for Indigenous Affairs (IWGIA), has the capacity to amplify CHT indigenous health equity advocacy at the international level, bringing the documented health disparities of the CHT before the UN human rights machinery, international development banks, and the global media in ways that create the external political pressure that domestic

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advocacy alone has been insufficient to generate. The publication of high-quality academic evidence on CHT health disparities in international journals (such as the 2025 Lancet Southeast Asia article by Kundu and Das Gupta) provides the scientific foundation that international civil society advocacy requires to be credible and effective, and it demonstrates the productive relationship between academic research and civil society advocacy that the CHT health equity agenda requires. The CHT health professional who generates, publishes, and communicates high-quality evidence on CHT health disparities is therefore not merely performing a scientific service but making a political contribution to the advocacy ecosystem that gives that evidence its policy impact.

9.4 The One Health Framework and CHT Health Development Partnerships

The One Health framework, which recognizes the interdependence of human health, animal health, and ecosystem health and advocates for coordinated, multi-sectoral approaches to health challenges that span the human-animal-environment interface, has specific and direct relevance to the CHT's emerging and re-emerging infectious disease landscape. The CHT's forested borders with Myanmar, its dense human-animal-ecosystem interfaces in forest-edge communities, its mobile populations crossing borders with Myanmar, and its role as part of the Greater Mekong Subregion infectious disease geography all place it within the highest-risk zones for zoonotic disease spillover events in South Asia. The operationalization of One Health in the CHT requires partnerships between human health authorities (MOHFW and CHT health service institutions), animal health authorities (Bangladesh Livestock Research Institute and the Department of Livestock Services), environmental health and forest management authorities (the Forest Department and the Department of Environment), and academic research institutions capable of conducting epidemiological surveillance and laboratory analysis across these three domains. The icddr,b, which has the strongest research infrastructure presence in the CHT, has the capacity to serve as the scientific hub of a CHT One Health research and surveillance network, and the development of such a network, with funding from global One Health initiatives (including the USAID-funded PREDICT program successor initiatives and the WHO One Health Joint Plan of Action), represents an important investment both in CHT-specific health security and in the global understanding of zoonotic disease emergence in a critically important and understudied geographic region.

MODEL EXAMINATION QUESTIONS: CHAPTER NINE

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Bangladesh's out-of-pocket health expenditure as a proportion of total health expenditure is approximately: a) 20 percent b) 40 percent c) 67 percent d) 85 percent (Correct Answer: c)

The Global Fund to Fight AIDS, Tuberculosis and Malaria operates in Bangladesh primarily through which model? a) Direct program management by the Global Fund Geneva secretariat b) Grant management through the Ministry of Health as principal recipient with NGOs including BRAC as sub-recipients c) Exclusively through bilateral USAID channels d) Through the Bangladesh private sector only (Correct Answer: b)

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The One Health framework recognizes the interdependence of which three domains of health? a) Primary care, secondary care, and tertiary care b) Human health, animal health, and ecosystem health c) Infectious disease, chronic disease, and mental health d) Community health, hospital health, and environmental health (Correct Answer: b)

The Chittagong Hill Tracts Commission, which monitors implementation of the 1997 Peace Accord, is a body established primarily to: a) Provide technical health services to CHT communities b) Document and report on the state of Peace Accord implementation including governance, land rights, and public service delivery for CHT indigenous communities c) Manage military deployments in the CHT d) Regulate business operations in the CHT (Correct Answer: b)

GAVI Alliance (the Vaccine Alliance) primarily supports what type of program in countries like Bangladesh? a) Malaria drug procurement b) Vaccine-preventable disease programs including vaccine procurement, cold chain strengthening, and immunization system support c) HIV/AIDS treatment d) Emergency surgical care (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A public health team is preparing a funding proposal to the Global Fund for a CHT-specific malaria and tuberculosis program targeting the five most remote and most health-disadvantaged ethnic communities (Mro, Khumi, Chak, Bawm, and Lushai) with a package of community health worker services, mobile diagnostic teams, and traditional medicine integration. Based on the Global Fund's Indigenous Peoples Guidance described in Chapter Two and the financing advocacy principles of this chapter, which elements are most essential to include in the proposal to align with Fund requirements and maximize funding likelihood? a) A proposed budget based on standard per-capita allocation formulas without equity adjustment b) A demonstration that the proposal was developed with meaningful community consultation (FPIC-based), explicit targets for indigenous community coverage with disaggregated monitoring indicators, a culturally and linguistically adapted program model, and a benefit-sharing or community co-governance arrangement for program oversight c) A plan to work exclusively through government channels without NGO sub-recipients d) A focus on technology procurement rather than human resource investment (Correct Answer: b)

CHAPTER TEN: FINAL PHILOSOPHICAL SYNTHESIS: THE MEANING OF MEDICINE IN THE CHT, THE ETHICS OF WITNESS, AND THE COVENANT WITH THE FUTURE

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10.1 The Epistemology of the Sufficient and the Insufficient: What This Textbook Has and Has Not Done

A textbook that spans ten parts, seventy-five or more chapters, and hundreds of thousands of words of sustained engagement with the health of a single territory has unavoidably said some things with great confidence, said others with appropriately hedged uncertainty, and been unable to say still others at all. The intellectual honesty that this textbook has claimed as one of its philosophical foundations requires, in this final chapter, a frank account of what it has and has not accomplished. What this textbook has accomplished: it has provided the most comprehensive and most systematically integrated account of health and disease in the Chittagong Hill Tracts that has yet appeared in a single published work; it has developed and applied theoretical frameworks (Terrain-Conditioned Pathology, the CHT Ecological Epidemiology Doctrine, the Psychoecological Health Philosophy, the CHT Contextual Diagnostic Doctrine, the Environmental Burden Accumulation Principle, the Inverse Coverage Law, and the CHT Medical Pluralism Doctrine) that have genuine analytical purchase on the complexity of CHT health and that provide intellectual tools for clinicians, researchers, and policy practitioners who work in this territory; and it has constructed an argument, sustained across ten parts, that the health disparities of CHT indigenous communities are not natural facts, not inevitable consequences of geography or poverty, but structural injustices with identifiable causes, documented evidence bases, and evidence-based remedies that require only political will and resource commitment to implement.

What this textbook has not accomplished: it has not resolved the fundamental tension between the urgency of the health crisis and the inadequacy of the current data (many of its most important claims are supported by the best available evidence, which is itself often limited, geographically restricted, and methodologically constrained); it has not spoken adequately from within the perspectives of CHT indigenous communities themselves (this is a textbook written primarily for the medical and public health professional community, from within the frameworks of biomedical science and public health theory, and while it has systematically engaged with indigenous knowledge systems and political perspectives, it has not given the communities themselves the authorial voice that the most fully realized account of their health situation would require); and it has not, despite its best efforts, fully captured the lived experience of being sick, being poor, being politically marginalized, and being without adequate healthcare in the forests and valleys of the Chittagong Hill Tracts, because that experience cannot be fully captured in the language of epidemiology, clinical medicine, and public health theory, however comprehensive and however earnest.

10.2 The Ethics of Witness: What It Means to Know and to Be Responsible

The philosopher Iris Marion Young, in her seminal work on political responsibility in global justice contexts, articulated the concept of the "social connection model of responsibility," which holds that individuals and institutions who participate in the social structures that produce injustice bear a political responsibility to work to transform those structures, regardless of whether they are personally or institutionally guilty of directly causing the injustice. Applied to CHT health, this framework means that every health professional who has studied this textbook

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and gained the knowledge it contains has acquired a form of social connection to the structural injustice that produces preventable suffering and death in the CHT, and bears the political responsibility that Young's framework assigns: the responsibility to use their knowledge, their professional platform, and their social position to work for the structural changes that the evidence demands. This is not a counsel of guilt or of paralysis. It is an invitation to purposeful engagement: to take the knowledge of this textbook and carry it into a life of professional practice that is oriented, even in its clinical daily-ness, toward the transformation of the conditions that make clinical practice in the CHT so much harder and so much less effective than it could and should be.

The ethics of witness in the CHT health context has a specific and demanding character that goes beyond the generalized professional obligation of advocacy. The CHT has been a territory of systematic silence: the suffering of its indigenous communities has been insufficiently documented, insufficiently published, insufficiently heard in the policy arenas where decisions about health resources are made, and insufficiently communicated to the national and international public who ultimately bear a political responsibility for the governance of the state that has failed these communities. Breaking this silence is an ethical imperative that this textbook has attempted to perform in part, but that requires the ongoing contribution of every researcher, clinician, public health practitioner, journalist, and community member who bears witness to the health reality of the CHT and who refuses to normalize what should not be normalized: the death of a Mro child from measles when vaccines exist and cost practically nothing per dose; the death of a Chakma woman from postpartum hemorrhage when the surgical procedure to save her life is known and teachable; the death of a Marma man from tuberculosis when the medicines to cure him are available and inexpensive; the growth failure of tens of thousands of indigenous children from malnutrition when the foods and supplementation to prevent it are not beyond the reach of a committed health system.

10.3 The Covenant with the Future: An Intellectual and Ethical Commitment

This textbook ends with a covenant. A covenant is different from a conclusion: a conclusion summarizes what has been established, while a covenant commits to what must be done. The covenant proposed here is addressed to every student, clinician, researcher, public health practitioner, and policy professional who has read these pages, and it has three dimensions. The first dimension is intellectual: the commitment to carry the knowledge of CHT health complexity, CHT health disparities, and CHT health evidence forward into one's professional life with the rigor, the precision, and the epistemic humility that this knowledge requires. The CHT is not a simple problem, and the temptation to reduce its complexity to simple narratives (the geography is too difficult, the communities are too traditional, the politics are too complicated) must be actively resisted by every professional who takes the intellectual covenant seriously. The second dimension is ethical: the commitment to translate the knowledge of structural injustice documented in this textbook into advocacy for structural change, through whatever channels and with whatever voice one's professional position enables. The advocacy may be a published paper documenting CHT health disparities in an international journal, an operational research study evaluating a CHT community health program innovation, a policy brief submitted to the Ministry of Health, a presentation at a medical conference, a conversation with a fellow student, a social

media post that brings the deaths of 220 measles children in Kurukpata to an audience that had not heard of them. All of these are legitimate and important forms of advocacy, and the covenant requires not that one performs all of them but that one performs some of them, with sustained commitment rather than sporadic impulse. The third dimension is relational: the commitment to engage with CHT indigenous communities not as objects of clinical or research attention but as partners, as knowledge holders, as rights bearers, and ultimately as the people whose own leadership of the transformation of their health situation must be the central goal of every external professional contribution.

The final words of this textbook are not the author's. They belong, in the spirit of the relational covenant, to the communities who have been its subject and should be its primary beneficiaries. The council head of Kurukpata, Kratpung Mro, speaking to journalists in April 2025 as children continued to die from measles around him, said that the government should "launch awareness programmes and bring Indigenous communities under vaccination coverage." This is not a complicated demand. It is not ideologically charged, legally contentious, or technically impossible. It is the most basic and most human of public health requests: see us, reach us, protect our children. The covenant of this textbook is to ensure that the scientific, clinical, legal, and philosophical foundations have been laid for the practitioners and policymakers who can make that request a reality to understand both the urgency and the path. The children of Kurukpata, and the children of every valley and ridge of the Chittagong Hill Tracts, are waiting.

10.4 A Note on the Living Textbook: Future Updates and Contributions

A textbook of this scope and ambition, covering a territory whose health situation is actively evolving in response to epidemiological change (the measles outbreak continuing as of the writing of these final pages in May 2026), policy development, climate change, technological innovation, and the unpredictable dynamics of political transformation, cannot claim finality. The most appropriate way to understand this textbook is as a living document: a systematic and rigorous account of the state of knowledge about CHT health as of the current moment, designed with sufficient theoretical and analytical depth to retain its value as successive developments in the territory's health situation are understood and incorporated. Future editions of this textbook will need to incorporate: the outcome of the current national measles outbreak and the immunization program reforms it catalyzes or fails to catalyze; the evolution of artemisinin sensitivity in CHT P. falciparum populations and the implications for malaria treatment protocols; the results of the first systematic population-based NCD prevalence surveys in CHT indigenous communities, when these are eventually conducted; the progress or lack thereof in the implementation of CHT traditional medicine integration programs; the development of CHT indigenous language digital health tools; and the outcome of any advances in indigenous health governance in the CHT arising from Peace Accord implementation or from international human rights processes. The theoretical frameworks and clinical protocols developed in this textbook are offered not as permanent truths but as the best available synthesis of current knowledge, to be revised, refined, and where necessary replaced as evidence and experience accumulate. The enduring contribution of this textbook is not any specific clinical protocol or epidemiological estimate but the systematic intellectual framework, the ethical commitment, and the multi-

disciplinary analytical approach that it has attempted to model, and that it invites every reader to carry forward in their own professional work in this extraordinary territory.

MODEL EXAMINATION QUESTIONS: CHAPTER TEN

For MBBS, BAMS, BUMS, BHMS Undergraduate Examinations:

Iris Marion Young's "social connection model of responsibility" holds that: a) Only direct perpetrators of injustice bear responsibility for its consequences b) Individuals and institutions who participate in social structures producing injustice bear a political responsibility to work to transform those structures c) Political responsibility is limited to elected officials and governments d) Medical professionals have no political responsibilities (Correct Answer: b)

The "covenant" proposed at the conclusion of this textbook differs from a "conclusion" in which essential way? a) A covenant is longer than a conclusion b) A covenant commits to what must be done rather than merely summarizing what has been established c) A covenant is a legal document while a conclusion is a scientific statement d) A covenant applies only to religious professionals (Correct Answer: b)

The three dimensions of the intellectual and ethical covenant proposed at the conclusion of this chapter are: a) Scientific, clinical, and pharmaceutical b) Intellectual (carrying knowledge forward with rigor), ethical (translating knowledge into advocacy for structural change), and relational (engaging with CHT communities as partners, knowledge holders, and rights bearers) c) Medical, legal, and political d) National, regional, and global (Correct Answer: b)

"Epistemic humility" as applied to the evaluation of the limitations of this textbook means: a) Refusing to make any claims about CHT health b) Honestly acknowledging what the textbook has not accomplished: the limited data quality of some claims, the insufficient representation of indigenous community voices, and the inability to fully capture lived experience in the language of biomedical science c) Acknowledging only methodological limitations while claiming completeness in other domains d) Deferring all conclusions to future researchers (Correct Answer: b)

The statement by Kurukpata council head Kratpung Mro that the government should "launch awareness programmes and bring Indigenous communities under vaccination coverage" is characterized in this chapter as: a) A politically charged and legally contentious demand b) The most basic and most human of public health requests, requiring no ideological alignment or technical impossibility for its fulfillment c) A demand that exceeds what the health system can be reasonably expected to deliver d) A misunderstanding of the reasons for the measles outbreak (Correct Answer: b)

For FCPS, MD, MPH, and Postgraduate Entrance Examinations:

A postgraduate community medicine candidate is asked to write a policy proposal for comprehensive CHT health system reform, drawing on the synthesis of this textbook's ten parts.

The most complete and philosophically consistent proposal would include which combination of elements? a) Technical health facility upgrades only, with no governance or structural changes b) A comprehensive package addressing: (1) community health worker deployment with indigenous language community identity matching; (2) immunization equity restoration through mobile outreach with FPIC-based community engagement; (3) CHT-specific budget supplementation above the standard per-capita formula; (4) traditional medicine integration through the three-phase protocol; (5) health governance reform implementing CHT Peace Accord devolution provisions; (6) land rights protection as a structural determinant of nutritional and mental health; (7) One Health border surveillance for zoonotic and cross-border infectious disease threats; (8) digital health infrastructure including mHealth CHW tools, telemedicine, and indigenous language AI development; (9) medical education reform incorporating CHT field practicums and CHT-relevant competency development; and (10) a robust CHT health research agenda with indigenous community ownership, ethical rigor, and anti-extractive practice c) Increasing the number of specialist physicians in Dhaka to take referrals from the CHT d) Eliminating traditional medicine practice and replacing it with government-managed biomedical care only (Correct Answer: b)

An FCPS candidate in internal medicine encounters a severely malnourished, hypoglycemic, and obtunded 28-year-old Bawm man from a remote ridge community in Bandarban during a community health outreach camp. The patient has no documentation of any previous healthcare contact. Based on the CHT Contextual Diagnostic Doctrine and the full clinical and epidemiological synthesis of this textbook, what is the comprehensive assessment this clinician should perform, what are the priority diagnoses to exclude, and what are the immediate management and advocacy actions required? a) Treat hypoglycemia and discharge with nutritional advice b) Apply the CHT diagnostic cascade: assess clinical context (remote Bawm community, likely malaria-endemic, high TB prevalence, high malnutrition, limited healthcare access history); immediately correct hypoglycemia with IV dextrose; perform malaria RDT (P. falciparum malaria with cerebral complication is a priority diagnosis given the presentation in this community); assess for signs of severe malnutrition with metabolic complications (Kwashiorkor/marasmus); consider TB as a cause of wasting and immune compromise (sputum AFB if obtundation resolves); assess for snakebite or other toxic exposure; initiate IV artesunate empirically pending RDT if clinical malaria probability is high; stabilize and arrange urgent referral with continuous monitoring; document the case as evidence for the district health officer of the healthcare access failure that allowed this presentation to reach this severity; and advocate for the establishment of a functioning community health worker in this community c) Administer oral rehydration therapy and request family to transport patient to district hospital independently d) Wait for laboratory confirmation of all diagnoses before initiating any treatment (Correct Answer: b)

PART TEN: Summary and Textbook Conclusion

Part Ten, the final part of this textbook, has completed the synthesis of the most comprehensive academic account of CHT health ever produced, moving from the systems architecture of public

health infrastructure (Chapter One) through the international legal framework of indigenous health rights (Chapter Two), the research agenda and ethical principles for the next decade (Chapter Three), the planetary health and climate crisis (Chapter Four), the digital health transformation (Chapter Five), the NCD double burden (Chapter Six), the multi-dimensional professional identity of the CHT practitioner (Chapter Seven), the reform of medical education (Chapter Eight), the political economy of international health financing (Chapter Nine), and the philosophical synthesis and ethical covenant (Chapter Ten) that gives the entire enterprise its meaning and its direction.

The ten parts of this textbook, taken together, constitute a systematic argument that the health of the people of the Chittagong Hill Tracts is not a peripheral concern of Bangladeshi public health or of the global health community, but a central test of whether the values of equity, justice, and the right to health that are claimed as foundational by both Bangladesh's constitutional order and the international human rights framework are genuinely operational or merely aspirational. The test is currently being failed. The deaths of 220 children from measles in the spring of 2025, the 45 percent stunting rate among Mro and Marma children in Bandarban, the malaria deaths in remote valley communities that are not counted in any national mortality statistic, the untreated tuberculosis patients in bamboo houses who have never heard of DOTS, the Chakma elders whose uncontrolled hypertension is quietly killing them while antihypertensives remain out of stock at their local clinic: all of these are failures of the test. They are also, simultaneously, the invitation to pass the test: to take the knowledge, the ethical commitment, and the professional energy that this textbook has sought to generate and to direct it toward the structural transformations, the programmatic innovations, the research advances, and the political advocacy that the evidence demands and that the people of the CHT deserve.

The Chittagong Hill Tracts is not merely a medical geography. It is one of the world's most biologically diverse, culturally rich, historically complex, and humanly beautiful territories, and its people are among the most resilient, most knowledge-deep, and most deserving of the full realization of their potential for health and flourishing. This textbook has been written in the conviction that medicine, practiced with rigorous science, philosophical depth, ethical commitment, and human solidarity, can make a real and lasting difference in the health of the people of this extraordinary place. Whether it does so depends on the choices made by the students and professionals who have read it. The covenant is offered. The decision is yours.

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GLOSSARY

Accessibility The characteristic of health services being physically reachable affordable and non discriminatory

Allostatic load Cumulative biological cost of chronic stress exposure

Anthropogenic Originating from human activity

Antibiotic stewardship Coordinated interventions to improve appropriate antimicrobial use

Antimicrobial resistance Capacity of microbes to survive exposure to antimicrobial agents

Bayesian reasoning Framework for updating diagnostic probabilities based on prior evidence

Benefit sharing Fair distribution of advantages from research or resource use

Biosocial analysis Examination of health through biological and social determinant interaction

Biomedicine Western scientific medical system

Cold chain Temperature controlled supply chain for vaccines and temperature sensitive medicines

Community based participatory research Research conducted in partnership with community members as co investigators

Complex trauma Psychological injury from prolonged repeated interpersonal trauma

Complex PTSD A distinct trauma diagnosis characterized by emotional dysregulation negative self concept and relationship difficulties

Covenant Binding commitment to future action

DALY Disability Adjusted Life Year combines years lost to premature death and years lived with disability

Diagnostic cascade Sequential levels of diagnostic investigation from history to specialist referral

Double burden Simultaneous presence of high infectious disease and emerging non communicable disease burden

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Ecological Immunophenotyping Characterization of population immune function as shaped by ecological exposure matrix

Ecosyndemics Framework examining how social conditions and infectious disease burdens interact synergistically

Environmental enteric dysfunction Chronic impairment of intestinal function from enteropathogen exposure and malnutrition

Epigenetic Heritable changes in gene expression not involving DNA sequence alteration

Epistemic humility Recognition of the limits of one s knowledge

Evidence based medicine Integration of best research evidence clinical expertise and patient values

Explanatory model Patient derived framework for understanding illness cause and treatment

Extractive research Data collection from vulnerable populations without benefit return

FAST mnemonic Face drooping Arm weakness Speech difficulty Time to call for help

Free prior and informed consent Indigenous peoples right to consent to activities affecting them before they begin

Geomedicine Systematic study of how spatial properties of land water air and ecology shape disease distribution

Geomedical justice Doctrine requiring simultaneous attention to ecological social structural and cultural health determinants

Golden hour Critical 60 minute window for trauma intervention

Health sovereignty Indigenous community capacity to make authoritative decisions about health services affecting them

Helminth Parasitic worm

Horizontal gene transfer Transmission of genetic material between organisms not through reproduction

Hygiene hypothesis Theory that reduced microbial exposure increases allergic disease risk

Implementation science Study of methods to promote uptake of evidence based practices

Incremental cost effectiveness ratio Additional cost per additional unit of health benefit

Indigenous Originating or occurring naturally in a particular place

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International Health Regulations Legally binding framework for public health emergency detection and response

Inverse Coverage Law Communities with highest disease burden and greatest historical exclusion have lowest health system coverage

Jhum Rotational slash and burn cultivation system

Kangaroo Mother Care Continuous skin to skin contact for low birth weight neonates

Medical pluralism Co existence and simultaneous use of multiple medical knowledge systems

mHealth Use of mobile devices for health services and information

Minimum core essential Non derogable minimum healthcare services required under human rights law

Molecular mimicry Immune cross reactivity between pathogen antigens and host tissues

Mucosal immunity Immune defense at surfaces interfacing with external environment

Nagoya Protocol International framework for access to genetic resources and benefit sharing

Neglected tropical diseases Infectious diseases endemic in tropical low income populations

Old friends hypothesis Immune regulatory development requires exposure to ancient commensal organisms

One Health Framework recognizing interdependence of human animal and ecosystem health

Oncological justice Principle that every person with cancer deserves equitable diagnostic and therapeutic opportunity

Out of pocket payment Direct household payment for healthcare at point of service

Pathogen Associated Molecular Patterns Molecular motifs conserved across microbial classes

Pharmacogenomics Study of how genetic variation affects drug response

Planetary health Human health in the context of Earth s natural system health

Point of care diagnostic Test performed at patient encounter delivering rapid results

Political ecology of health Examination of how political and economic power shapes health risk distribution

Polyparasitism Concurrent infection with multiple parasite species

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Precision medicine Integration of individual genomic phenotypic and environmental data for optimized care

Primary healthcare Essential healthcare based on practical scientifically sound and socially acceptable methods

Prior Informed Consent Research consent obtained with full information before participation

Psychoneuroimmunology Study of interactions between psychological processes nervous system and immune system

Reproductive justice Right to have children not have children parent in safe conditions and achieve bodily autonomy

Resistome Total microbial resistance gene content in an environment

Screen and treat Immediate treatment following positive screening result

Secretory IgA Predominant antibody isotype at mucosal surfaces

Social connection model Political responsibility arising from participation in structures producing injustice

Soil transmitted helminth Nematode parasite transmitted through soil contaminated with feces

Stepped wedge trial Design where intervention is rolled out sequentially in randomized order

Store and forward telemedicine Asynchronous consultation using recorded data for later specialist review

Structural violence Systematic harm caused by social structures characterized by inequality and exclusion

Syndromic surveillance Monitoring of clinical syndromes to detect outbreaks before laboratory confirmation

Task shifting Rational redistribution of clinical tasks to other health workers

Terrain Conditioned Pathology Systematic modification of disease by physical chemical biological and social landscape properties

Thrifty phenotype Metabolic programming for nutrient scarcity increasing disease risk with caloric surplus

Trained immunity Epigenetic reprogramming of innate immune cells by prior microbial exposure

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Transitional justice Processes addressing human rights violations after conflict including truth commissions reparations and accountability

Translational research Process converting basic science discoveries into clinical and public health practice

Universal Health Coverage All people accessing needed health services without financial hardship

UNDRIP United Nations Declaration on the Rights of Indigenous Peoples

WHO PEN WHO Package of Essential Noncommunicable Disease Interventions