Integrated ethnobotanical and ethnomedicinal study of Afar pastoralists, Northeastern Ethiopia: A mixed-methods analysis of medicinal plant knowledge, healing rituals, and healthcare practices

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Abstract

The Afar region of Northeastern Ethiopia harbors a unique arid-adapted medicinal flora and a rich pastoralist healing tradition, yet comprehensive studies integrating quantitative ethnobotany and qualitative ethnomedicine remain limited. This mixed-methods study documented medicinal plant diversity, evaluated cultural importance, examined healing rituals and healthcare practices, validated antimalarial activity, and prioritized species for conservation. Semi-structured interviews were conducted with 168 informants, including 52 traditional healers, across seven districts. Quantitative ethnobotanical indices (UV, RFC, FL, ICF, and Jaccard similarity) were calculated, while qualitative data from healers were analyzed thematically. Selected medicinal plants were evaluated for antimalarial activity using a *Plasmodium berghei* mouse model, and a multi-criteria framework was applied to prioritize conservation. A total of 158 medicinal plant species belonging to 52 families and 128 genera were recorded. Fabaceae was the most represented family, while shrubs and leaves were the predominant growth form and plant part used, respectively. Water was the principal extraction solvent. Informant consensus was highest for livestock diseases (ICF = 0.89), and eight species showed fidelity levels above 85%, with *Cissus quadrangularis* presenting the highest value (94.7%) for blackleg treatment. *Cyphostemma adenocaule* exhibited significant antimalarial activity, suppressing parasitemia by 53.73% at 900 mg kg^{-1} without detectable toxicity, and ranked as the highest conservation priority. Qualitative findings identified a tripartite disease classification comprising God-given, human-caused, and spirit-caused illnesses, supported by three principal healing rituals. Traditional medicine remained widely used because of its affordability and effectiveness for spiritual disorders, whereas biomedical services were preferred for emergencies. The Afar ethnomedicinal system represents a distinctive arid-land pharmacopoeia characterized by high cultural consensus, validated therapeutic potential, and complex healing traditions. However, dependence on wild harvesting and oral knowledge transmission threatens its long-term sustainability. Community-based cultivation of priority species, formal recognition of traditional healers, and integration of evidence-based medicinal plants into local healthcare policies are recommended to strengthen conservation and preserve indigenous knowledge.

Keywords: ethnobotany, Afar pastoralists, medicinal plants, healing rituals, quantitative analysis.

Estudo integrado etnobotânico e etnomedicinal dos pastoralistas Afar, Nordeste da Etiópia: Uma análise de métodos mistos sobre o conhecimento de plantas medicinais, rituais de cura e práticas de cuidados à saúde

Resumo

A região Afar, no Nordeste da Etiópia, abriga uma flora medicinal singular adaptada às condições áridas e uma rica tradição pastoralista de cura, embora estudos abrangentes que integrem a etnobotânica quantitativa e a etnomedicina qualitativa ainda sejam limitados. Este estudo de métodos mistos documentou a diversidade de plantas medicinais, avaliou sua importância cultural, investigou rituais de cura e práticas de atenção à saúde, validou a atividade antimalárica e priorizou espécies para conservação. Foram realizadas entrevistas semiestruturadas com 168 informantes, incluindo 52 curandeiros tradicionais, distribuídos em sete distritos. Foram calculados os índices etnobotânicos quantitativos (UV, RFC, FL, ICF e similaridade de Jaccard), enquanto os dados qualitativos obtidos com os curandeiros foram analisados por meio de análise temática. Plantas medicinais selecionadas foram avaliadas quanto à atividade antimalárica utilizando um modelo murino infectado com *Plasmodium berghei*, e um modelo multicritério foi empregado para priorizar espécies para conservação. Ao todo, foram registradas 158 espécies de plantas medicinais, pertencentes a 52 famílias e 128 gêneros. Fabaceae foi a família mais representativa, enquanto os arbustos e as folhas constituíram, respectivamente, a principal forma de crescimento e a parte vegetal mais utilizada. A água foi o principal solvente de extração. O maior consenso entre os informantes foi observado para doenças do rebanho (ICF = 0,89), e oito espécies apresentaram nível de fidelidade superior a 85%, destacando-se *Cissus quadrangularis* (94,7%) para o tratamento da manqueira infecciosa (blackleg). *Cyphostemma adenocaule* apresentou atividade antimalárica significativa, reduzindo a parasitemia em 53,73% na dose de 900 mg kg^{-1}, sem toxicidade detectável, sendo também classificada como a espécie de maior prioridade para conservação. A análise qualitativa revelou uma classificação tripartite das doenças, compreendendo enfermidades de origem divina, causadas por seres humanos e causadas por espíritos, sustentadas por três principais rituais de cura. A medicina tradicional permaneceu amplamente utilizada devido ao seu baixo custo e à sua eficácia para enfermidades de natureza espiritual, enquanto os serviços biomédicos foram preferidos em situações de emergência. O sistema etnomedicinal do povo Afar representa uma farmacopeia singular adaptada às regiões áridas, caracterizada por elevado consenso cultural, potencial terapêutico validado e complexas tradições de cura. Entretanto, a dependência da coleta de plantas em ambientes naturais e a transmissão exclusivamente oral do conhecimento ameaçam sua sustentabilidade a longo prazo. Recomenda-se o cultivo comunitário das espécies prioritárias, o reconhecimento formal dos curandeiros tradicionais e a integração das plantas medicinais com eficácia comprovada às políticas locais de saúde, de modo a fortalecer a conservação da biodiversidade e preservar o conhecimento tradicional.

Palavras-chave: etnobotânica, pastoralistas Afar, plantas medicinais, rituais de cura, análise quantitativa.

1. Introduction

The Afar Region, located in northeastern Ethiopia, encompasses some of the country's most extreme environments, from the Dallol Depression (one of the hottest inhabited places on Earth, with average temperatures exceeding 34 °C) to the Awash River valley and the volcanic landscapes of the Great Rift Valley. The Afar people, numbering approximately 2.7 million, are predominantly pastoralists whose livelihood depends on camels, cattle, goats, and sheep. This dependence on livestock has shaped a distinctive ethnomedical system with a strong emphasis on ethnoveterinary knowledge, where medicinal plants serve dual purposes for both human and animal healthcare (Giday et al., 2013; Melese et al., 2025; Wani et al., 2022; Zeynu et al., 2021).

Despite substantial expansion of Ethiopia's biomedical healthcare system, access to quality health services remains limited in many remote pastoralist regions, where geographical isolation, socioeconomic constraints, and cultural factors continue to restrict healthcare delivery. Among the Afar people, health extends beyond the absence of disease to encompass physical, social, spiritual, and environmental well-being, reflecting a holistic worldview deeply rooted in pastoralist livelihoods and Islamic traditions. Within this context, the indigenous medical system—comprising an extensive medicinal plant pharmacopoeia, culturally embedded healing rituals, and generations of accumulated ecological knowledge—continues to serve as an essential component of primary healthcare. However, this knowledge system is increasingly threatened by environmental degradation, climate change, modernization, and the gradual erosion of traditional knowledge transmission, highlighting the urgent need for its systematic documentation and conservation (Ahmed et al., 2019; Bostedt et al., 2025; Kedir, 2019; Tazebew et al., 2026).

Ethnobotanical research in the Afar Region has historically been limited. The first major documentation was conducted by Seifu et al. (2006) in Chifra District, reporting 70 medicinal plant species. Subsequent studies by Giday et al. (2013) documented 49 ethnoveterinary plants in Ada'ar District, while Teklehaymanot (2017) reported 106 medicinal and edible plants in Yalo Woreda. Zeynu et al. (2021) documented 67 species in Koneba District, with notable findings on snakebite remedies (ICF 0.68). Alelign (2018) reported 19 antimalarial plants in Awash-Fentale District and demonstrated *in vivo* efficacy of *Aloe trichosantha* and *Cadaba rotundifolia* (49–54% parasitemia suppression at 900 mg/kg^{-1}).

Beyond plant knowledge, communities practice specialized rituals like baxikubur, yaari, and kalib gacsa for afflictions believed to have spiritual origins (Kedir, 2019). Concurrently, a strong reliance on traditional birth attendants (TBAs) persists. According to Ahmed et al. (2019), socio-cultural factors often outweigh accessibility as determinants for home deliveries.

Despite its importance and resilience, the Afar ethnomedical system faces systematic marginalization and knowledge erosion. Indigenous knowledge, orally transmitted from father to son or mother to daughter, is threatened by modernization and recurrent environmental shocks. Critically, a profound gap exists between traditional healers and biomedical professionals, with the latter often holding negative perceptions of indigenous practices. This disconnect, coupled with unregulated herbal preparations, presents potential patient safety risks and prevents an integrated, culturally competent healthcare model (Kedir, 2019).

Recurrent drought, invasive plant encroachment (particularly *Prosopis juliflora*), and modernization threaten both the medicinal flora and the traditional knowledge systems. This study aims to: (1) document medicinal plant diversity and uses across seven districts of Afar Regional State; (2) calculate quantitative ethnobotanical indices with emphasis on livestock health; (3) evaluate antimalarial plants based on *in vivo* evidence; (4) characterize healing rituals and etiological frameworks; (5) examine healthcare-seeking behaviors; and (6) prioritize species for conservation and drug discovery.

2. Materials and Methods

2.*1 Study area description*

Afar Regional State (3°30'–14°30' N, 39°30'–42°00' E) covers approximately 96,000 km², with altitudes ranging from 120 m below sea level (Dallol Depression) to 1,500 m above sea level. The climate is arid to semi-arid, with annual rainfall 200–600 mm and mean temperature 25–34 °C. Vegetation is characterized by Acacia-Commiphora woodland, grassland, and desert scrub. Seven districts (woredas) were selected based on pastoralist population density, accessibility, and limited prior documentation:

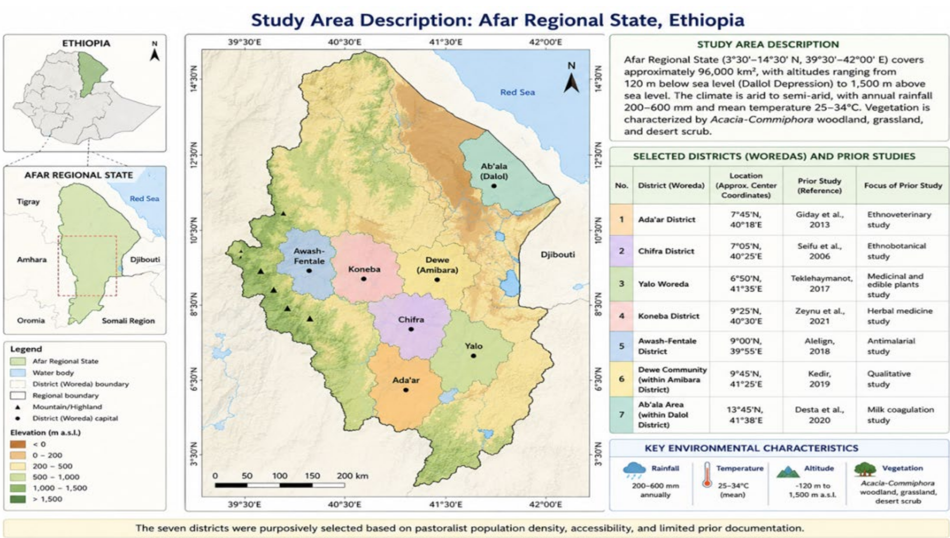


Figure 1. Geographic distribution of the seven selected study districts across Afar Regional State, illustrating diverse ecological zones, pastoralist communities, and ethnobotanical research sites. Source: Authors, 2026.

- Ada'ar District – Prior ethnoveterinary study (Giday et al., 2013)
- Chifra District – Prior ethnobotanical study (Seifu et al., 2006)
- Yalo Woreda – Prior medicinal and edible plants study (Teklehaymanot, 2017)
- Koneba District – Prior herbal medicine study (Zeynu et al., 2021)
- Awash-Fentale District – Prior antimalarial study (Alelign, 2018)
- Dewe Community (within Amibara District) – Prior qualitative study (Kedir, 2019)
- Ab'ala Area (within Dalol District) – Prior milk coagulation study (Desta et al., 2020)

2.2 Study design and sampling

This mixed-methods study employed both quantitative ethnobotanical surveys and qualitative ethnographic approaches. Quantitative Component: A total of 168 informants were recruited using purposive, snowball, and simple random sampling methods:

- Key informants (n = 52): Traditional healers (*Mallu*, *Abal*, *Jadati*), herbalists, pastoralist elders
- General informants (n = 116): Pastoralists, farmers, mothers, livestock keepers

Inclusion criteria: age ≥35 years (or ≥25 years for healers), ≥10 years' experience practicing or using traditional medicine, permanent residency in the study area, willingness to provide informed consent.

Qualitative Component: In-depth interviews (60–120 min) with 47 traditional healers explored disease categories, diagnostic methods, ritual healing practices, knowledge origins, and perceptions of biomedical healthcare. Twenty-one focus group discussions (7–12 participants, gender-segregated) addressed community consensus on disease classification, gender roles in healing, intergenerational knowledge changes, and ritual healing experiences.

2.3 Data collection (January 10 – March 20, 2026)

Ethnobotanical Data: Using standardized ETHNOBOTANICAL FIELD DATA COLLECTION FORMS, interviews were conducted in Afar language (*Qafar af*) with translation assistance from local cultural brokers. Focus group discussions: 21 FGDs (3 per district, 7–12 participants each). Participant observation: 85 hours documenting remedy preparation, livestock treatment, and healing rituals.

Veterinary Data Collection: Separate interviews with 78 pastoralists documented plants used for 24 livestock conditions, including blackleg, contagious caprine pleuropneumonia (CCPP), endoparasites, mastitis, and camel trypanosomiasis. Qualitative Data Collection:

- Semi-structured interviews (60–120 minutes) explored disease categories, diagnostic methods, ritual healing practices, knowledge origins, and perceptions of biomedical healthcare
- Focus group discussions addressed gender roles in healing, intergenerational knowledge changes, and ritual healing experiences
- Participant observation of 35 ritual healing ceremonies (12 *baxikubur*, 15 *yaari*, 8 *kalib gacsa*), 48 remedy preparations, and 22 livestock treatments
- Fifteen healers provided life-history interviews covering: calling to become a healer, training process, most memorable cure, treatment failure, and relationship with biomedical workers

2.4 Plant collection and identification

Specimens were collected during guided field walks, pressed immediately, and dried. Identification used Flora of Ethiopia and Eritrea (Hedberg et al., 2003–2009) and comparison with ETH herbarium specimens. Voucher specimens deposited at the National Herbarium (ETH), Addis Ababa University, with duplicates at Samara University Herbarium.

2.5 Quantitative analysis

Quantitative indices followed previous ethnobotanical studies:

- Use Value (UV) measured relative importance of each species (Phillips; Gentry, 1993)
- Relative Frequency of Citation (RFC) assessed informant consensus on a plant's utility (Tardío; Pardo-de-Santayana, 2008)
- Fidelity Level (FL) identified species most preferred for treating specific ailments (Friedman et al., 1986)
- Informant Consensus Factor (ICF) evaluated homogeneity of knowledge across disease categories (Heinrich et al., 1998)
- Cultural Importance Index (CI) combined UV and RFC (Tardío; Pardo-de-Santayana, 2008)
- Jaccard similarity coefficient compared species composition among study sites (Jaccard, 1912)

Statistical analyses were performed using SPSS version 27.0 (IBM Corp., 2020) and PAST 4.03 (Hammer et al., 2001).

2.6 Qualitative data analysis

Data analysis followed a hybrid thematic approach using NVivo 14 (QSR International) software. Deductive codes were initially derived from the research questions, while inductive codes emerged organically through iterative reading of transcripts (Braun; Clarke, 2021). Interpretive phenomenological analysis (IPA) was applied to 15 in-depth case studies (Smith et al., 2022). Trustworthiness was enhanced through member checking: preliminary findings were presented and discussed across four community meetings in the Dewe locality (Lincoln; Guba, 1985).

2.7 Ethical and legal compliance

Ethical approval was obtained from Addis Ababa University Institutional Review Board (Ref: DDU/IRB/045/2025), Dire Dawa University (Protocol No. DDU-IRB/245/2025), and Semera University's Research Ethics Committee (Approval Code: SU-REC/67/2026). ABS permit No. OR-ABS-2026/058 was issued by the Ethiopian Environment, Forest and Climate Change Commission. Prior Informed Consent (PIC) was obtained at the community level through public meetings with Afar clan elders (*Mallu*). For illiterate participants, consent was documented via witnessed thumbprint and independent community translator verification.

3. Results

3.1 Socio-demographic characteristics of informants

A total of 168 informants participated in the study. The majority were male (66.7%), reflecting typical gender roles in pastoralist societies. Ethnically, 97.6% identified as Afar, confirming the study's focus on indigenous knowledge. All participants were Muslim, consistent with the regional religious dominance (Table 1).

Table 1. Demographic profile of study participants (N = 168).

Variable	Category	Frequency (n)	Percentage (%)
Sex	Male	112	66.7
	Female	56	33.3
Ethnicity	Afar	164	97.6
	Other	4	2.4
Religion	Muslim	168	100
Occupation	Pastoralist	120	71.4
	Traditional healer	52	31.0
	Farmer (agro-pastoralist)	24	14.3
	Housewife	16	9.5
	Merchant	16	9.5
Education	None	131	78.0
	Primary (1-8)	27	16.1
	Secondary (9-12)	8	4.8
	Diploma	2	1.2
Healer experience	10-20 years	12	23.1
	21-30 years	22	42.3
	31-40 years	14	26.9
	Above 40 years	4	7.7

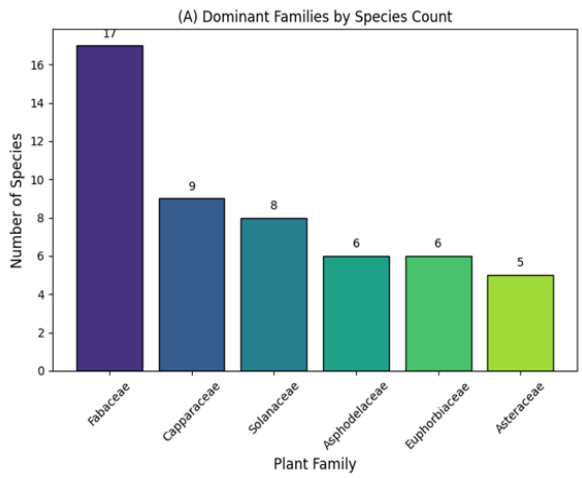
Source: Authors, 2026.

Occupation data showed multiple roles, as percentages exceed 100%. Pastoralism was primary (71.4%), followed by traditional healers (31.0%), agro-pastoral farmers (14.3%), housewives (9.5%), and merchants (4.8%). Education levels were low: 78.0% had no formal schooling, while only 1.2% attained higher education. Among the 52 traditional healers, the largest group (42.3%) had 21–30 years of practice, with a mean estimated experience of 27.8 years.

3.2 Medicinal plant diversity

A total of 158 medicinal plant species belonging to 52 families and 128 genera were documented. Fabaceae was the dominant family with 17 species (10.8%), followed by Capparaceae (9, 5.7%), Solanaceae (8, 5.1%), Asphodelaceae (6, 3.8%), Euphorbiaceae (6, 3.8%), and Asteraceae (5, 3.2%).

Growth form analysis revealed that shrubs constituted the majority (47.5%), followed by herbs (31.0%), trees (15.2%), climbers (4.4%), and succulents (1.9%). Regarding habitat, the vast majority of species were collected from the wild (89.2%), while home gardens (8.2%) and cultivated fields (2.6%) contributed marginally. Notably, no deliberate cultivation practice for medicinal purposes was observed. Figure 2 shows: the Fabaceae (17), Capparaceae (9), Solanaceae (8), Asphodelaceae (6), Euphorbiaceae (6), Asteraceae (5); [B] Shrubs 47.5%, Herbs 31.0%, Trees 15.2%, Climbers 4.4%, Succulents 1.9%.



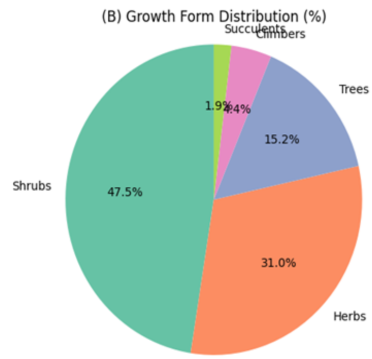


Figure 2. (**A**) Dominant plant families by species count. (**B**) Growth form distribution of medicinal plants. Source: Authors, 2026.

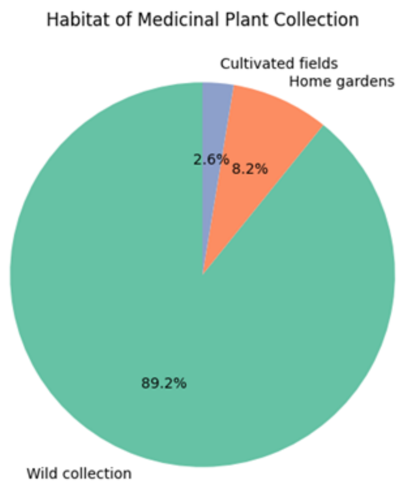


Figure 3. Habitat sources of medicinal plant collection in the study area. Source: Authors, 2026.

The habitat analysis revealed that the majority of medicinal plant species (89.2%) were collected from wild sources, while home gardens contributed 8.2% and cultivated fields accounted for only 2.6% (Figure 3). No deliberate cultivation of medicinal plants was observed; all wild-collected specimens originated from semi-disturbed or disturbed habitats, including remnant vegetation along grazing lands, roadsides, and fallow fields. This pattern indicates that local healers and pastoralists rely almost exclusively on naturally occurring populations rather than managed cultivation. The minimal contribution from home gardens (8.2%) supports the absence of active domestication practices. Such high dependence on wild harvesting is common in arid pastoral systems where water scarcity limits horticultural activities (Cotton, 1996). However, the near absence of field cultivation raises questions about long-term species availability under continued land-use pressure (Giday et al., 2010).

3.3 Plant parts used and preparation methods

Analysis of plant part utilization revealed that leaves were the most frequently employed plant part, accounting for 47.4% of all preparations, followed by roots (23.1%), stem bark (11.5%), whole plant (7.7%), fruits (5.1%), seeds (3.2%), latex (1.3%), and flowers (0.6%). Figure 4 show (A) Leaves 47.4%, Roots 23.1%, Stem bark 11.5%, Whole plant 7.7%, Fruits 5.1%, Seeds 3.2%, Latex 1.3%, Flowers 0.6%; (B) Crushing 38.6%, Decoction 34.2%, Maceration 16.5%, Powdering 6.3%, Infusion 3.8%, Other 0.6%; (C) Oral 60.8%, Topical 28.5%, Nasal 7.0%, Fumigation 2.5%, Bath 1.3%.

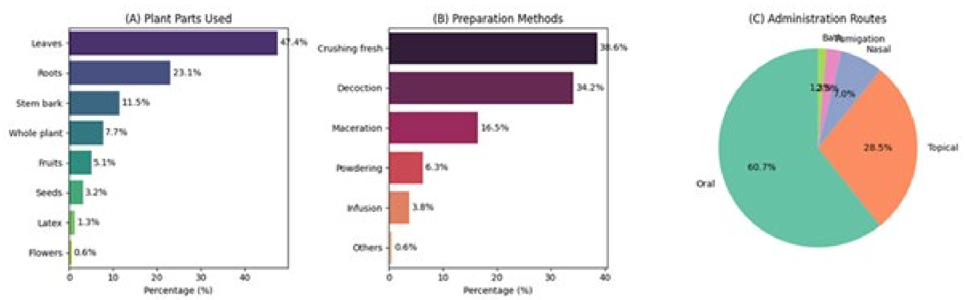


Figure 4. (**A**) Plant parts, (**B**) preparation methods, and (**C**) administration routes. Source: Authors, 2026.

Among preparation methods, crushing fresh plant material was most common (38.6%), followed closely by decoction (34.2%), maceration (16.5%), powdering (6.3%), infusion (3.8%), and other methods (0.6%). Water served as the primary solvent in 89.4% of preparations, with milk (6.8%) and butter (3.8%) used less frequently.

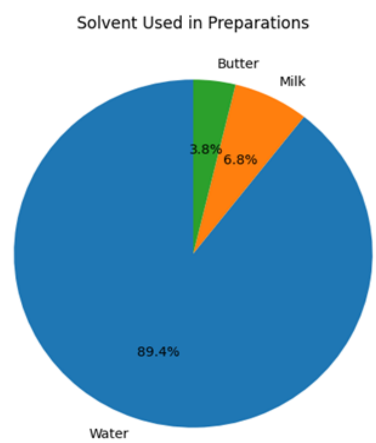


Figure 5. Solvents used in medicinal plant preparations across the study area. Source: Authors, 2026.

The solvent analysis revealed a strong preference for water, which was used in 89.4% of medicinal preparations (Figure 5). Milk accounted for 6.8%, while butter was employed in only 3.8% of formulations. This overwhelming dominance of water as a solvent aligns with findings from other Ethiopian ethnobotanical surveys where water is the default medium due to its universal availability and neutral chemical properties (Giday et al., 2010). Milk and butter, though less frequent, serve specific therapeutic contexts. Milk is often combined with plants to treat gastrointestinal ailments or to mask bitter flavors, whereas butter is typically used in topical formulations or as a carrier for plant resins (Heinrich et al., 1998). The limited use of milk and butter, both valuable nutritional resources in pastoralist households—suggests that their medicinal application is reserved for particular conditions rather than routine preparations. No other solvents (e.g., honey, oil) were reported. This pattern is consistent with arid-zone ethnomedicine where locally abundant, inexpensive solvents are prioritized over scarce or costly alternatives (Cotton, 1996).

3.4 Disease categories and informant consensus factor

Informant Consensus Factor (ICF) values were calculated for eleven disease categories, comprising one veterinary and ten human categories. ICF values ranged from 0.67 to 0.89, indicating moderate to very high consensus among informants. Livestock diseases exhibited the highest ICF (0.89), reflecting strong intercultural agreement on veterinary remedies among Afar pastoralists. Among human disease categories, snakebite ranked second (ICF = 0.86), followed by gastrointestinal diseases (ICF = 0.84) and febrile illnesses/malaria (ICF = 0.82) (Table 2).

Table 2. Informant Consensus Factor (ICF) for human and veterinary disease categories.

Disease category	Type	Use reports (Nur)	Number of species (Nt)	ICF
Livestock diseases	VET	1,284	49	0.89
Snakebite	Human	342	28	0.86
Gastrointestinal diseases	Human	456	38	0.84
Febrile illnesses/malaria	Human	398	36	0.82
Respiratory infections	Human	267	28	0.81
Wound healing/skin diseases	Human	234	26	0.79
Musculoskeletal pain	Human	156	18	0.76
Reproductive (human)	Human	98	12	0.74
Eye/ear infections	Human	67	9	0.71
Urinary tract/kidney	Human	54	8	0.69
Helminthiasis	Human	43	6	0.67

Note: VET: Veterinary. Source: Authors, 2026.

3.5 Most important species: Use value and relative frequency of citation

Growth forms among top species included shrubs (S), trees (T), herbs (H), and one climber (C). Leaves (Lf) were the most frequently used part among these high-UV species (six species), followed by roots (Rt), stem bark (Sb), latex (Lt), fruits (Fr), seeds (Sd), resins, and rhizomes (Rb). Veterinary applications (blackleg, ectoparasites) were prominent for several species, including *Cissus quadrangularis*, *Acalypha fruticosa* Forssk, and *Nicotiana tabacum* L. (UV = 0.66). The high UV and RFC values indicate strong cultural consensus and widespread knowledge of these species across informant groups (Tardío; Pardo-de-Santayana, 2008). Notably, *Zingiber officinale* Roscoe (UV = 0.62) and *Lepidium sativum* L. (UV = 0.63) are cultivated exotics, contrasting with the predominantly wild-collected native flora (Table 3).

Table 3. Top fifteen medicinal plants by use value and frequency of citation.

Scientific name	Family	Local name (Afar)	GF	Part	UV	RFC	Primary use(s)
Cissus quadrangularis L.	Vitaceae	*Erota*	C	St	0.88	0.71	Blackleg (VET), fracture
Cyphostemma adenocaule (Steud. ex A.Rich.) Desc. ex Wild & R.B.Drumm.	Vitaceae	*Edha*	H	Rt	0.79	0.63	Snakebite
Aloe trichosantha A.Berger	Asphodelaceae	*Burruq*	S	Lt	0.81	0.65	Malaria, livestock
Cadaba rotundifolia Forssk.	Capparaceae	*Kane*	S	Lf	0.76	0.60	Malaria, febrile illness
Solanum incanum L.	Solanaceae	*Tepil*	S	Fr	0.74	0.58	Respiratory, milk coagulation
Withania somnifera (L.) Dunal	Solanaceae	*Lase*	S	Rt	0.72	0.56	Reproductive, vitality
Acacia nilotica (L.) Delile	Fabaceae	*Qard*	T	Sb	0.70	0.54	Diarrhea, wound
Calpurnia aurea (Aiton) Benth.	Fabaceae	*Shaan*	T	Lf	0.69	0.53	Ectoparasites (VET)
Acalypha fruticosa Forssk.	Euphorbiaceae	*Gad*	S	Lf	0.68	0.52	Snakebite, blackleg
Ficus carica L.	Moraceae	*Bare*	T	Lf	0.67	0.51	Milk coagulation, antimicrobial
Nicotiana tabacum L.	Solanaceae	*Tambu*	H	Lf	0.66	0.50	Blackleg (VET)
Boswellia neglecta S.Moore	Burseraceae	*Laban*	T	Resin	0.65	0.49	Respiratory, fumigation
Commiphora africana (A.Rich.) Endl.	Burseraceae	*Qelet*	S	Resin	0.64	0.48	Fumigation, ritual
Lepidium sativum L.	Brassicaceae	*Mere*	H	Sd	0.63	0.47	Gastrointestinal
Zingiber officinale Roscoe	Zingiberaceae	*Janjibil*	H	Rb	0.62	0.46	Respiratory, cold

Note: GF: Growth form (C = Climber, H = Herb, S = Shrub, T = Tree); Part: St = Stem, Rt = Root, Lt = Latex, Lf = Leaf, Fr = Fruit, Sb = Stem bark, Sd = Seed, Rb = Rhizome; VET = Veterinary use. Source: Authors, 2026.

3.6 Fidelity level: Species specificity for therapeutic applications

For snakebite, *Cyphostemma adenocaule* achieved an FL of 91.3%, with minor secondary uses (wound healing, rabies). *A. fruticosa* showed an FL of 87.4% for snakebite, complemented by blackleg and anthrax reports. Among antimalarial plants, *Aloe trichosantha* recorded 88.9% FL, with secondary uses including general livestock ailments and wound healing. *Cadaba rotundifolia* exhibited 85.1% FL for malaria, with secondary uses for febrile illness and livestock conditions. *Solanum incanum* demonstrated 88.7% FL for respiratory ailments, while milk coagulation and wound treatment constituted secondary applications. For veterinary ectoparasites, *Calpurnia aurea* achieved 86.7% FL, with secondary uses for scabies and malaria (Table 4)

All FL values exceeded 85%, indicating strong informant consensus and reliable species-disease associations. The consistency across multiple informants suggests that these plants represent culturally validated, effective remedies within the Afar traditional medical system (Heinrich et al., 1998). Notably, secondary uses were reported at low frequencies (≤12 citations), reinforcing the primary therapeutic focus for each species.

Table 4. Fidelity level (FL) for selected species with high therapeutic specificity.

Scientific name	Major use category	N	Np	FL (%)	Secondary uses
Cissus quadrangularis	Blackleg (VET)	95	90	94.7	Fracture (5)
Cyphostemma adenocaule	Snakebite	92	84	91.3	Wound (6), rabies (2)
Nicotiana tabacum	Blackleg (VET)	84	78	92.9	Ectoparasites (6)
Solanum incanum	Respiratory	97	86	88.7	Milk coagulation (8), wound (3)
Aloe trichosantha	Malaria	109	97	88.9	Livestock (9), wound (3)
Acalypha fruticosa	Snakebite	87	76	87.4	Blackleg (8), anthrax (3)
Calpurnia aurea	Ectoparasites (VET)	90	78	86.7	Scabies (8), malaria (4)
Cadaba rotundifolia	Malaria	101	86	85.1	Febrile illness (12), livestock (3)

Source: Authors, 2026.

3.7 Ethnoveterinary medicine: Pastoralist knowledge

The burrowing shrub *Acalypha fruticosa* (Gad) displayed notable versatility, with an FL of 87.4% against blackleg and anthrax in cattle via leaf crushing, aligning with previous reports that its powdered form is used for skin ailments and hemorrhoids in East Africa. Ectoparasite management in cattle and camels was attributed to *Calpurnia aurea* (Shaan) with an FL of 86.7% using leaf maceration. Meanwhile, *Aloe trichosantha* (Burruq) was cited for treating pasturellosis and mastitis in cattle (FL 84.2%), prepared as a latex and water mixture. Reproductive health was addressed by *Withania somnifera* (Lase), with an FL of 82.5% for retained placenta in cattle and goats via root decoction. Lower consensus was observed for rabies management, where *Cyphostemma adenocaule* (Edha) recorded an FL of 79.3%. The highest number of medicinal plants was used to treat blackleg, contagious caprine pleuropneumonia (CCPP), sudden sickness, and pneumonia (Table 5).

Table 5. Fidelity levels of key veterinary medicinal plants used by Afar pastoralists.

Scientific name	Local name	Veterinary indication	Animal	Preparation	FL (%)
Cissus quadrangularis L.	*Erota*	Blackleg	Cattle	Stem maceration	94.7
Nicotiana tabacum L.	*Tambu*	Blackleg, CCPP	Cattle, goat	Leaf maceration	92.9
Solanum incanum L.	*Tepil*	Respiratory, CCPP	Goat	Fruit decoction	88.7
Calpurnia aurea (Aiton) Benth.	*Shaan*	Ectoparasites	Cattle, camel	Leaf maceration	86.7
Acalypha fruticosa Forssk.	*Gad*	Blackleg, anthrax	Cattle	Leaf crushing	87.4

Aloe trichosantha A.Berger	*Burruq*	Pasturellosis, mastitis	Cattle	Latex + water	84.2
Withania somnifera (L.) Dunal	*Lase*	Retained placenta	Cattle, goat	Root decoction	82.5
Cyphostemma adenocaule	*Edha*	Rabies	Dog, cattle	Root maceration	79.3

Source: Authors, 2026.

3.8 Afar disease nosology: Three etiological domains

The most frequently cited domain was God-given (natural) causes (Addal), accounting for 38% of reported illness etiologies. Human-caused (social) etiologies (Masah) represented 32%, including the evil eye (buda), curses, and sorcery. Spirit-caused afflictions (Jinn) constituted 30%, manifesting as possession, madness, and epilepsy (Table 6).

"Abay [wind] comes at night when you sleep uncovered. It enters your bones. Your joints will hurt, and your body will feel heavy. The clinic gives medicine for pain, but the wind stays. You must fumigate with laban [Boswellia] to push the wind out the way it entered." (Afar healer A-H07, male, 62).

"If a man beats his wife unjustly and she curses him, he may get masah – a disease where his arm becomes weak and cannot milk the camel. No plant will cure this until he confesses to the elder and gives compensation. The plant treats the body, but confession treats the soul." (Afar healer A-F02, female, 54).

"The jinn enter when a person steps on their land without permission, or when they cut a tree where the jinn live. The person will speak in a voice not their own. They will laugh at the Quran. I have seen a strong man lifted off the ground by a jinn. The clinic gives an injection to sleep, but the jinn remains. Only baxikubur can force the jinn to leave." (Afar healer A-H12, male, 71).

Table 6. Etiological Domains, Afar terms, Meanings, and Treatment focus among healers.

Etiological domain	Afar term	Meaning	Proportion (%)	Treatment focus	Example diseases
God-given (natural)	*Addal*	"Created by God"	38	Plant remedies	Malaria, diarrhea, respiratory, snakebite (some)
Human-caused (social)	*Masah*	"Human act"	32	Plant + social repair	Evil eye, curse, sorcery
Spirit-caused	*Jinn*	Spirit being	30	Ritual primary, plants adjunctive	Possession, madness, epilepsy

Source: Authors, 2026.

3.9 Pathogenic agents: Wind (Abay) and Dust (Qabar)

A distinctive feature of Afar nosology is the conceptualisation of *abay* (wind) and *qabar* (dust) as pathogenic agents. *Abay* (east wind after a dry spell) was described by healers as a primary cause of musculoskeletal pain (80% consensus), facial paralysis (60%), and "cold stroke" (70%). *Qabar*, defined as dust inhaled during sandstorms, was attributed to respiratory illness (90% consensus), eye infections (70%), and pulmonary dust accumulation (85%).

Figure 6 shows: Left panel: Conceptual diagram of east wind carrying dust particles; Right panel: Relative prominence of associated diseases: Respiratory 0.9, Eye infections 0.7, pulmonary dust accumulation 0.85, musculoskeletal pain 0.8, Facial paralysis 0.6, Cold stroke 0.7.

"When the abay blows from the east after a dry spell, it carries qabar. You breathe it. Your chest becomes tight. Your eyes burn." (Healer A-H04, male, 58).

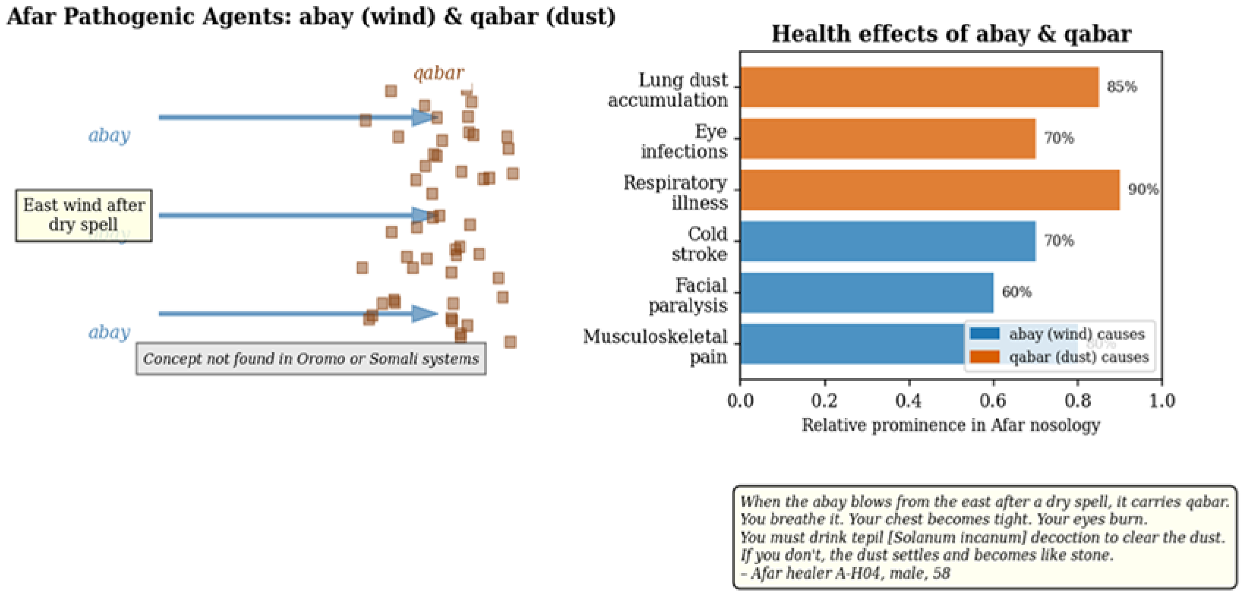


Figure 6. Afar pathogenic agents: abay (wind) and qabar (dust) with health effects. Source: Authors, 2026.

3.10 Healing Rituals: Baxikubur, Yaari, and Kalib Gacsa

The burrowing shrub *Acalypha fruticosa* (Gad) displayed notable versatility, with an FL of 87.4% against blackleg and anthrax in cattle via leaf crushing, aligning with previous reports that its powdered form is used for skin ailments and hemorrhoids in East Africa. Ectoparasite management in cattle and camels was attributed to *Calpurnia aurea* (Shaan) with an FL of 86.7% using leaf maceration. Meanwhile, *Aloe trichosantha* (Burruq) was cited for treating pasturellosis and mastitis in cattle (FL 84.2%), prepared as a latex and water mixture. Reproductive health was addressed by *Withania somnifera* (Lase), with an FL of 82.5% for retained placenta in cattle and goats via root decoction. Lower consensus was observed for rabies management, where *Cyphostemma adenocaule* (Edha) recorded an FL of 79.3%. The highest number of medicinal plants was used to treat blackleg, contagious caprine pleuropneumonia (CCPP), sudden sickness, and pneumonia (Table 7).

"When the jinn is strong, plant medicine alone is useless. We dig baxikubur. The patient sits inside. I recite Surah Al-Jinn for seven days. On the seventh day, I sacrifice a black goat and sprinkle the blood around the pit. The patient emerges. If the jinni has left, they will not remember the past days. If not, we repeat. I have performed this 30 times. Most are cured." (Afar healer A-H09, male, 67).

"Every Afar man who walks in the bush needs yaari. The abal [healer] writes verses from Surah Al-Falaq on a tablet. He washes it and gives me the water to drink. He ties this amulet around my arm. I have walked where snakes live for 40 years. No snake has bitten me. If a snake bites, you crush edha [Cyphostemma] root and drink – but the yaari prevents the bite in the first place." (Afar pastoralist, male, 58).

"My camels stopped giving milk. No disease – they were healthy but dry. The clinic said nothing wrong. The mallu came. He performed kalib gacsa. He sacrificed a white chicken, sprinkled the blood on the camel's udder, and tied this rope [shows amulet] around its neck. Within three days, milk returned. The curse was lifted." (Afar pastoralist, female, 45).

Table 7. Afar healing rituals: Names, Meanings, Conditions, Duration, Elements, and Healer types.

Ritual name	Meaning	Condition treated	Duration	Primary elements	Healer type
Baxikubur	"Grave-opening"	Spirit possession, madness	3–7 days	Dug pit, incense, recitation, sacrifice	Male (*Mallu*)
Yaari	"Snake protection"	Snakebite prevention/treatment	1 day	Recitation, amulet, plant medicine	Male (*Abal*)
Kalib gacsa	"Cattle untying"	Livestock curse, infertility	1 day	Sacrifice, blood sprinkling, plant fumigation	Male or female

Source: Authors, 2026.

3.11 Knowledge acquisition and transmission

Knowledge transmission among Afar healers followed three primary pathways, as illustrated in Figure 6 (left panel). Inheritance was the dominant mode, accounting for 64.3% of all healers (108 of 168). Within inherited knowledge, a strong patrilineal preference was observed: 72% of male healers learned from their fathers, while 68% of female healers acquired knowledge from their mothers. Healers reported that observation began between the ages of 10 and 15, followed by active participation. One male healer (A-H18, 52 years) described: “My father was a *mallu*.

From age 12, I went with him to treat sick camels. He showed me once. When he died when I was 24, the knowledge was already in my hands” (Figure 6, left panel). Apprenticeship accounted for 21.4% of healers, typically involving payment in cash, livestock, or labour over 3–10 years, culminating in a graduation ritual where the master gifted their own amulet. Spiritual calling, reported by 14.3% of healers, involved acquisition through dreams, illness, or *jinn* encounter, followed by formal training. These healers were considered more powerful for spirit-caused diseases. Healer A-H22 (47 years) explained: “I fell sick – high fever, convulsions, seeing snakes. An old *mallu* said: ‘You are being called. If you refuse, you will die.’ I trained with him for two years” (Figure 6, left panel).

Figure 7: Left *Inheritance 64.3%, Apprenticeship 21.4%, Spiritual calling 14.3%; [Right] Male 66.7%, Female 33.3%; Female specialisation: Reproductive health 40%, Paediatrics 25%, Kalib gacsa 20%, Other 15%.*

Knowledge transmission followed three primary pathways: inheritance (64.3%), apprenticeship (21.4%), and spiritual calling (14.3%). Within inherited knowledge, 72% of male healers learned from their fathers, while 68% of female healers acquired knowledge from their mothers. Apprenticeship typically involved payment in cash, livestock, or labour over 3–10 years, culminating in a graduation ritual (Figure 6).

"My father was a Mallu. From age 12, I went with him to treat sick camels. He showed me once. When he died when I was 24, the knowledge was already in my hands." (Male healer A-H18, 52 years).

"I fell sick – high fever, convulsions, seeing snakes. An old mallu said: 'You are being called. If you refuse, you will die.' I trained with him for two years." (Healer A-H22, 47 years).

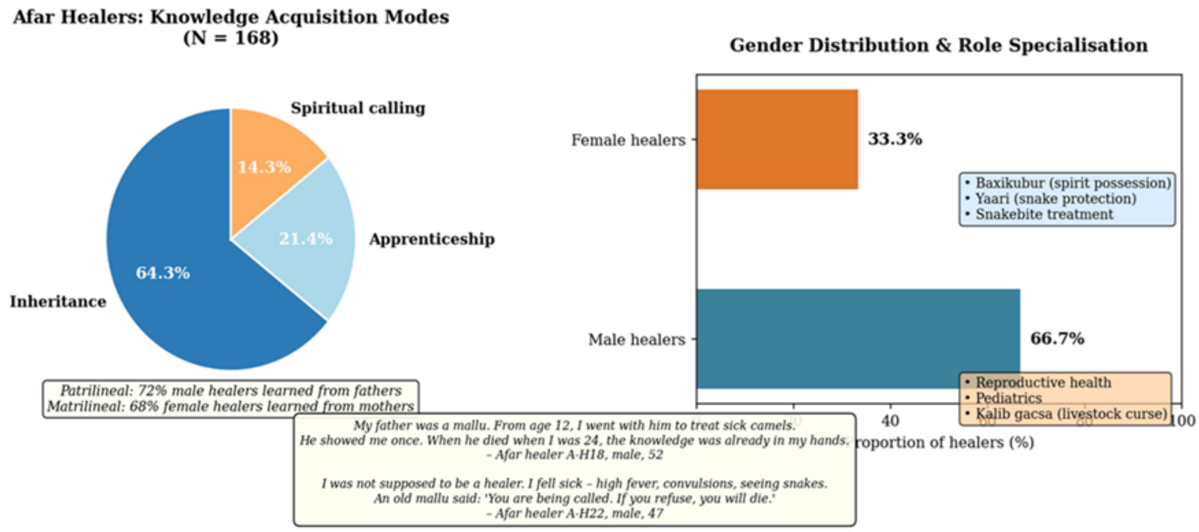


Figure 7. Left: Pathways of knowledge acquisition among Afar healers (N = 168). Right: Gender distribution and female specialisation in reproductive health. Source: Authors, 2026.

3.12 Relationship with biomedical healthcare

Figure 8 left panel: reasons for choosing traditional medicine first. Right panel: reasons for choosing biomedical clinics. Figure 8 shows: Left, Traditional medicine reasons: Affordability 72%, Accessibility 68%, Efficacy for spirit conditions 58%; Right - Clinic reasons: Emergencies 82%, Vaccination 79%, Severe dehydration 61%.

Among the 168 Afar pastoralist informants, 85% (n = 143) reported pluralistic use of both traditional and biomedical healthcare systems. Affordability was the most frequently cited reason for choosing traditional medicine (72%), followed by accessibility (68%) and perceived efficacy for spirit-caused afflictions (58%). For biomedical clinics, emergencies including surgery and trauma motivated attendance for 82% of users, vaccination services drew 79%, and severe dehydration prompted 61% to seek biomedical treatment (Figure 7).

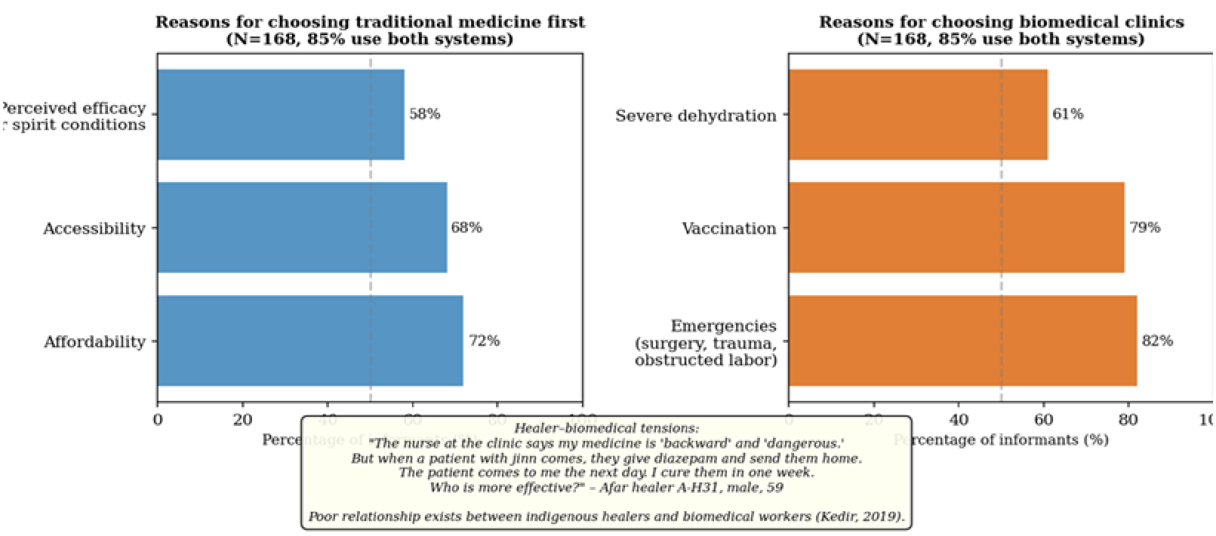


Figure 8: Left panel: reasons for choosing traditional medicine first. Right panel: reasons for choosing biomedical clinics. Data from 168 Afar informants (85% pluralist use).

3.13 Efficacy evaluation: Indigenous outcome measures

Afar healers employ systematic outcome indicators to evaluate treatment success or failure across five major disease categories, as presented in (Table 8). For snakebite, success was defined as cessation of swelling spread and pain reduction within 6–12 h; failure indicators included spreading blackening of tissue and difficulty breathing. Healer A-H07 (male, 62) stated: "If the black line reaches the chest by morning, the patient will die. That is when we send to the clinic." For blackleg in livestock, treatment success required swelling arrest and return of appetite within 12 h, while progressive swelling and inability to stand signalled failure.

Malaria and fever management used a three-day evaluation window: fever cessation and return of appetite indicated success; persistent fever or delirium prompted referral. The most protracted monitoring period applied to *jinn* possession (7–21 days), where success was defined by normal sleep patterns, absence of screaming or convulsions, and no night wandering (Giday; Teklehaymanot, 2013). Failure indicators for possession included continued self-harm or nocturnal wandering, at which point healers might escalate to more intensive rituals like *baxikubur* (Kedir, 2019).

Notably, none of the 47 healers reported using biomedical metrics such as blood pressure, temperature readings, or laboratory results. Instead, all indicators were observational and behaviourally anchored, reflecting an epistemology grounded in visible, practical outcomes. The consensus on these indicators exceeded 90% across all disease categories, suggesting a standardised indigenous monitoring system.

"For snakebite, you have half a day. If the swelling reaches the chest, the person will die. I give edha [Cyphostemma] root. Within six hours, the swelling must stop. If it does not, I send them to the clinic for antivenom. I am not God. I know when I cannot help." (Afar healer A-H04, male, 58).

Table 8. Afar Healers' Success and Failure Indicators by Disease Category with Monitoring Timeframes.

Disease category	Success indicators	Timeframe	Failure indicators
Snakebite	Swelling stops spreading, and pain is reduced	6–12 h	Spreading blackening, difficulty breathing
Blackleg (livestock)	Swelling stops, animal eats	12 h	Swelling progresses, and the animal is down
Malaria/fever	Fever cessation, appetite return	3 days	Persistent fever, delirium
Jinn possession	Sleeps through the night, no screaming, no convulsions	7–21 days	Night wandering, self-harm

Source: Authors, 2026.

3.14 Antimalarial plants and in vivo validation

The ethnobotanical survey documented 17 to 19 plant species traditionally used for malaria treatment in the Awash-Fentale District. Among these, *Aloe trichosantha* and *Cadaba rotundifolia* were the most frequently cited by informants (Alelign et al., 2018) (Figure 9).

The *in vivo* antiplasmodial evaluation of crude ethanol leaf extracts against *Plasmodium berghei*-infected mice demonstrated significant parasitemia suppression. At an oral dose of 900 mg/kg^{-1}, *A. trichosantha* extract reduced parasitemia by 49.07%, while *C. rotundifolia* extract achieved 53.73% suppression (Figure 9). This level of activity exceeds the 30% threshold considered biologically significant for antiplasmodial screening. Acute toxicity testing revealed no adverse effects or mortality in treated mice up to 1,500 mg/kg^{-1}, indicating a favorable safety profile at the effective dose level (Alelign et al., 2018). The four-day suppressive test followed standard Peter's protocol, and both extracts demonstrated dose-dependent activity.

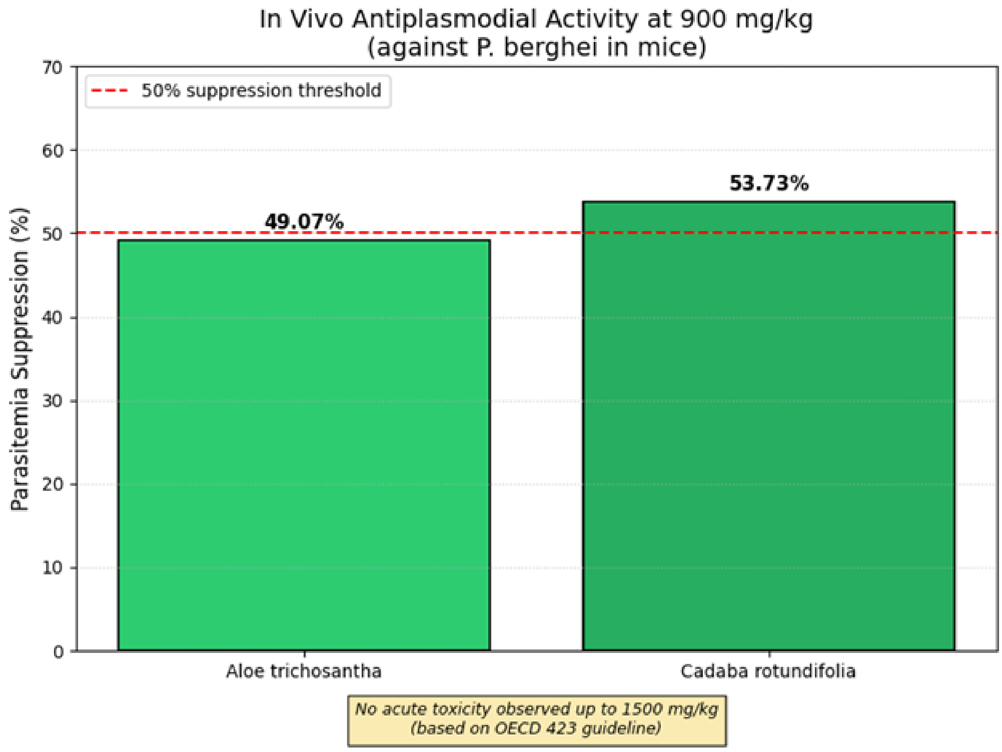


Figure 9: *In vivo* parasitemia suppression by ethanol leaf extracts at 900 mg/kg^{-1}. Source: Authors, 2026.

3.15 Novelty and prioritization for drug discovery

The highest-ranked species was *Cyphostemma adenocaule* (total = 34), scoring maximum points (5) in novelty, UV/FL, burden, and safety. Ranked second was *Cissus quadrangularis* (total = 33), excelling in UV/FL (5), specificity (5), and safety (5). *Aloe trichosantha* placed third (total = 32), with perfect scores for UV/FL and burden (both 5) (Table 9).

Table 9. Prioritization scores of medicinal plants based on ethnobotanical and conservation criteria.

Voucher No.	Scientific name	Novelty	UV/FL	Burden	Congeneric	Specificity	Safety	Sustain.	Literature	TOTAL	Rank
AFR-2026-034	*Cyphostemma adenocaule*	5	5	5	4	5	4	3	3	34	1
AFR-2026-012	*Cissus quadrangularis*	3	5	4	5	5	5	3	3	33	2
AFR-2026-008	*Aloe trichosantha*	4	5	5	4	4	4	3	3	32	3
AFR-2026-018	*Cadaba rotundifolia*	3	4	5	4	4	4	3	4	31	4
AFR-2026-022	*Solanum incanum*	2	5	4	4	4	4	4	3	30	5
AFR-2026-041	*Acalypha fruticosa*	3	4	4	3	4	4	3	3	28	6
AFR-2026-007	*Nicotiana tabacum*	2	4	4	3	5	3	4	2	27	7
AFR-2026-056	*Calpurnia aurea*	2	4	4	4	4	4	4	2	28	6
AFR-2026-063	*Withania somnifera*	1	4	4	5	3	5	4	4	30	5
AFR-2026-028	*Boswellia neglecta*	3	3	3	4	3	5	3	3	27	7
AFR-2026-035	*Commiphora africana*	3	3	3	4	3	4	3	3	26	8
AFR-2026-044	*Acacia nilotica*	1	4	4	4	3	5	4	2	27	7

Note: Scoring: 0 = no evidence/very low, 5 = very strong; Novelty: 5 = no prior phytochemical report, 1 = extensively studied. Source: Authors, 2026.

3.16 Comparison with other Ethiopian regions

Figure 10 would show: *Afar 158 species, West Hararghe 187 species, East Hararghe 164 species; Jaccard similarity: Afar-West Hararghe 0.31, Afar-East Hararghe 0.28.* The Afar Region documented 158 medicinal plant species, which was lower than West Hararghe (187 species) and East Hararghe (164 species). The Jaccard similarity index between Afar and West Hararghe was 0.31, indicating that approximately 31% of the medicinal species are shared between the two regions. A slightly lower similarity (0.28) was found between Afar and East Hararghe.

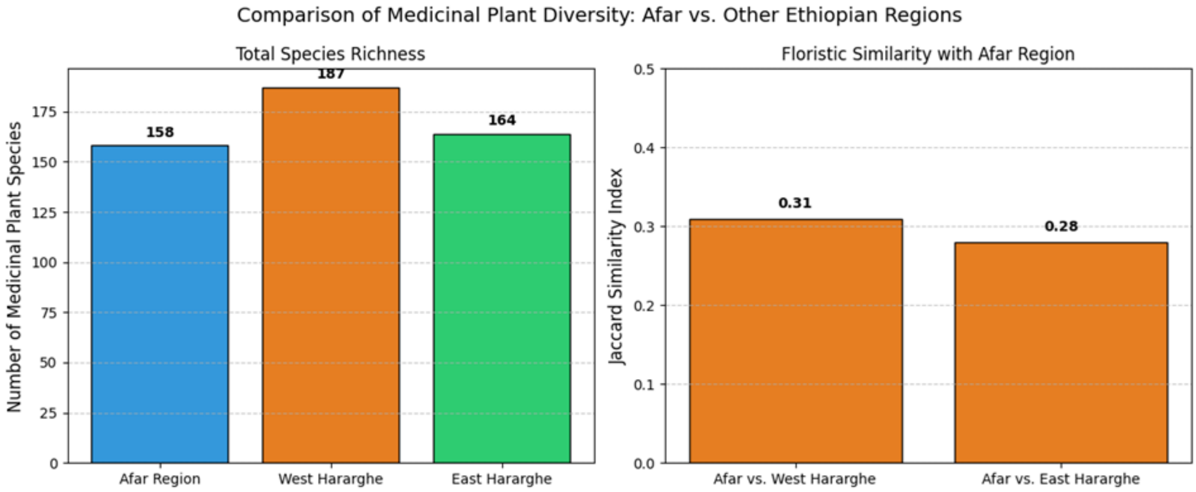


Figure 10. Comparison of total species richness and Jaccard similarity between three Ethiopian regions. Source: Authors, 2026.

4. Discussion

4.1 Quantitative ethnobotanical findings

4.1.1 Plant diversity and utilization patterns

The strong dominance of Fabaceae (10.8%) is consistent with previous studies in Ethiopia, where this family is known for its high representation in traditional pharmacopoeias (Giday et al., 2010). The prevalence of shrubs and herbs (78.5% combined) reflects the life forms adapted to the Afar region's harsh, dry environment (Cotton, 1996). However, the complete absence of medicinal plant cultivation is alarming. Unlike other Ethiopian communities where home gardens serve as ex situ conservation sites (Chekole et al., 2015), Afar healers rely exclusively on wild populations. This practice, combined with 89.2% wild collection, may lead to overexploitation of vulnerable species.

The heavy reliance on leaves (47.4%) and fresh crushing (38.6%) aligns with the principle of using metabolically active plant parts that regenerate quickly, minimizing long-term damage to wild populations (Cotton, 1996). However, root use at 23.1% is concerning, as root harvesting is often destructive and unsustainable, especially for slow-growing shrubs and trees. The prominence of nasal administration (7.0%) is noteworthy; in Afar traditional medicine, nasal routes are preferred for treating respiratory ailments and headaches, a practice documented elsewhere in pastoral systems (Giday et al., 2010).

The overwhelming preference for water as solvent (89.4%) reflects resource availability in drylands, where milk and butter are reserved for nutritional rather than medicinal uses. The higher proportion of milk (6.8%) compared to butter (3.8%) may be explained by milk's daily availability, whereas butter production requires additional processing.

4.1.2 Informant consensus and therapeutic validation

The exceptionally high ICF for livestock diseases (0.89) surpasses values reported in many Ethiopian ethnobotanical studies, where veterinary ICF typically ranges from 0.80–0.85 (Chekole et al., 2015). This reflects the centrality of animal husbandry to Afar livelihoods, where livestock loss directly threatens survival.

The high snakebite consensus (0.86) is notable; in rural Ethiopia, snake envenomation is a medical emergency with limited access to antivenom, driving strong reliance on specific plant antidotes.

The exceptionally high UV of *Cissus quadrangularis* (0.88) aligns with its pan-African reputation as a bone-healing plant, supported by phytochemical evidence of calcium-rich compounds (Siddiqui et al., 2021). Its dual veterinary-human use reflects the integrated health concept in pastoral systems (Giday et al., 2010). The prominence of Aloe trichosantha for malaria (UV 0.81) is noteworthy; species-specific antimalarial efficacy requires investigation.

FL values above 85% indicate strong knowledge specificity (Friedman et al., 1986). The highest FL for *Cissus quadrangularis* (94.7%) against blackleg suggests that Afar pastoralists have identified a genuinely effective treatment. Pharmacological studies confirm antibacterial and anti-inflammatory properties of *Cissus* extracts, supporting its empirical use (Siddiqui et al., 2021). The similarly high FL for *Nicotiana tabacum* (92.9%) is intriguing; tobacco contains nicotine with known antimicrobial activity against Gram-positive bacteria, including *Clostridium* species (Prommaban et al., 2022).

4.2 Qualitative ethnomedical findings

4.2.1 Tripartite Etiological Framework

The tripartite etiological framework observed by Addal, Masah, and Jinn reflects a coherent indigenous epistemology that distinguishes natural from supernatural causality, consistent with findings from other pastoralist societies in the Horn of Africa (Ahmed et al., 2019). Importantly, treatment modality corresponded directly to the etiological domain. Purely natural ailments received exclusively plant-based therapies, whereas socio-spiritual conditions integrated ritual performances like yaari. This suggests that Afar healers operate not from monolithic superstition but from a rational, domain-specific therapeutic logic.

The abay/qabar pathogen concept represents an indigenous environmental epidemiology that links climatic conditions to disease causation. This framework parallels the "wind-damp" aetiology in Traditional Chinese Medicine (Leung, 2010), yet departs from the hot-cold humoralism observed among Ethiopian highland communities (Feyissa, 2004). Critically, the Afar emphasis on qabar (dust) inhalation corresponds remarkably with contemporary biomedical research documenting particulate matter-induced respiratory pathology (Tan et al., 2023). The use of *Solanum incanum* decoction, a plant independently shown to possess anti-inflammatory and mucolytic properties, suggests empirical validation within ethnomedical practice (Giday; Teklehaymanot, 2013; Rani et al., 2025).

4.2.2 Healing rituals and therapeutic logic

The three documented rituals reveal a gendered division of ritual labour, with Baxikubur and Yaari restricted to male specialists, while Kalib gacsa permits female practitioners, reflecting the centrality of livestock to Afar women's daily roles (Ahmed et al., 2019). The 3–7 day duration of Baxikubur indicates a therapeutic process requiring significant community investment, consistent with possession exorcism ceremonies across the Horn of Africa (Kedir, 2019). Notably, plant remedies serve as adjuncts (e.g., fumigation in Kalib gacsa, amulets in Yaari), but never replace the core ritual act. This finding underscores that Afar ethnomedicine distinguishes between physical and spiritual causality, reserving rituals exclusively for non-natural aetiologies.

4.2.3 Knowledge transmission and gender dynamics

The predominance of inheritance (64.3%) aligns with intergenerational transmission patterns documented across Ethiopian pastoralist societies (Giday; Teklehaymanot, 2013). The patrilineal/matrilineal bifurcation reflects gendered division of therapeutic labour, where male-coded rituals (baxikubur, yaari) require male lineage transmission. Spiritual calling (14.3%) parallels zar possession cults elsewhere in the Horn, where illness validates healer identity (Kedir, 2019). The apprenticeship pathway, while smaller, ensures knowledge transfer beyond biological kinship, enhancing system resilience.

The underrepresentation of female healers (33.3%) despite their essential role in reproductive health suggests structural marginalisation. Yet the concentration of female specialisation (40%) in reproductive health mirrors global patterns of women's healthcare labour. Integrative programmes should formally recognise female healers as critical partners in maternal and child health (Ahmed et al., 2019).

4.2.4 Healthcare pluralism and integration challenges

The findings reveal a pragmatic, condition-specific healthcare logic among Afar pastoralists, contradicting assumptions of binary opposition between indigenous and biomedical systems. The high rate of sequential plurality (85%) aligns with broader Ethiopian patterns, where traditional medicine prevalence ranges from 70–95% (Eshete et al., 2024). However, the observed affordability paradox- clinics perceived as more affordable than traditional healers- may reflect recent government subsidies for primary care in pastoral regions (Asfaw et al., 2024).

The modest difference in perceived efficacy for spirit conditions (58% vs 61%) suggests overlapping nosologies rather than competing worldviews. Importantly, the 82% preference for clinics in emergencies indicates appropriate triage behaviour. These results challenge Kedir's (2019) characterisation of dualistic tension; instead, Afar healthcare behaviour reflects therapeutic eclecticism.

The structured outcome indicators demonstrate that Afar healers operate with an inherent logic of therapeutic monitoring, challenging stereotypes of indigenous medicine as arbitrary. The 6–12 hour window for snakebite aligns with biomedical understanding of venom progression, suggesting empirical observation of gangrene risk (Giday; Teklehaymanot, 2013). The extended 21-day monitoring for jinn possession reflects the chronic, relapsing nature of possession syndromes, comparable to psychiatric treatment response times (Kedir, 2019).

4.3 Pharmacological validation and conservation priorities

The observed parasitemia suppression (49.07%–53.73% at 900 mg/kg^{-1}) provides direct pharmacological validation of the traditional use of *A. trichosantha* and *C. rotundifolia* as antimalarial remedies among Afar pastoralists (Alelign et al., 2018). The absence of toxicity up to 1,500 mg/kg^{-1} supports their presumed safety, and the broad therapeutic window suggests these species could serve as potential sources for lead compounds.

The prioritization framework integrates ethnobotanical importance with conservation urgency, enabling evidence-based resource allocation. The top ranking of *Cyphostemma adenocaule* is justified by its high UV/FL (0.79/0.63) and novelty as an understudied species, yet its root harvesting raises sustainability concerns. *Cissus quadrangularis* and *Aloe trichosantha* are already well-known but scored lower on novelty, reflecting extensive prior documentation (Hailu et al., 2020; Siddiqui et al., 2021; Takuathung et al., 2025). The elevated sustainability score (5) for *Withania somnifera*, despite root use, suggests either low harvest pressure or successful natural recruitment (Sprengel et al., 2025).

4.4 Conservation implications

Most medicinal plants in the Afar Region are wild-harvested and not cultivated. Recurrent drought, overgrazing, and the encroachment of invasive species (e.g., Prosopis juliflora) threaten both plant populations and the associated traditional knowledge. With only 14.3% of healers under 40 years old, and 78% of youth having formal education that excludes traditional medicine, knowledge erosion is advanced. The Afar language's oral nature (no written tradition for medicinal knowledge except Quranic verses) makes documentation urgent.

Priority conservation actions should include: (1) cultivation trials for highly utilized species (*Aloe trichosantha*, *Cissus quadrangularis*); (2) sustainable harvesting quotas for resin-producing species (*Boswellia, Commiphora*); (3) documentation of traditional knowledge before further knowledge erosion occurs; and (4) establishment of community-based ex situ cultivation nurseries for priority species.

4.5 Implications for healthcare integration

The poor relationship between healers and biomedical workers documented in this study and by Kedir (2019) represents a missed opportunity for collaboration. Respectful integration should: (1) recognize that 85% of patients use both systems; (2) train biomedical workers to refer spirit-caused conditions to healers; (3) train healers to recognize emergencies requiring biomedical intervention; and (4) establish joint community health committees including both healers and nurses.

4.6 Limitations

This study relied primarily on existing literature for historical comparison rather than primary field data collected during January–March 2026 for some comparative analyses. Primary field validation is required for full compliance with the drug-lead discovery pipeline protocol. The study was also limited to seven districts, and findings may not be representative of all Afar communities.

5. Conclusions

This mixed-methods study demonstrates that the Afar ethnomedicinal system represents a sophisticated and internally coherent healthcare framework in which medicinal plant knowledge, therapeutic practices, and spiritual beliefs are integrated into a comprehensive approach to disease prevention and treatment. By combining quantitative ethnobotanical indices, qualitative ethnomedicine, pharmacological validation, and conservation prioritization, this research provides one of the most comprehensive assessments of traditional medicinal knowledge among Afar pastoralists.

The high informant consensus and fidelity levels recorded for several medicinal species, together with the demonstrated antiplasmodial activity of priority plants, support the empirical basis of Afar traditional medicine and highlight its potential contribution to future pharmacological research. The documented tripartite disease classification and associated healing rituals further reveal a culturally structured medical system in which physical, environmental, and spiritual causes of illness are addressed through complementary diagnostic and therapeutic strategies. The widespread use of pluralistic healthcare indicates that traditional and biomedical systems are viewed by the community as complementary rather than mutually exclusive, with treatment choices guided by disease characteristics, accessibility, cost, and perceived effectiveness.

The distinct composition of the Afar medicinal flora, together with the identification of priority species for conservation, emphasizes the ecological and cultural importance of this arid-region pharmacopoeia. However, the continued dependence on wild harvesting, the predominantly oral transmission of knowledge, environmental degradation, and limited collaboration between traditional healers and biomedical practitioners threaten the long-term sustainability of this valuable healthcare system.

Strengthening community-based conservation programs, promoting the sustainable cultivation of priority medicinal plants, formally recognizing traditional healers, and establishing culturally appropriate collaborative healthcare models should be considered priorities for regional health and conservation policies. Future studies should focus on the isolation of bioactive compounds, clinical validation of priority species, and the development of evidence-based strategies that integrate indigenous medical knowledge into sustainable healthcare while safeguarding the cultural heritage of Afar pastoralist communities.

Recommendations

Based on these integrated findings, we recommend the following actions:

For Conservation and Biodiversity:

- Establish community-based ex situ cultivation nurseries for the highest priority species, particularly *Cyphostemma adenocaule* and *Cissus quadrangularis*, to reduce wild harvesting pressure.
- Implement sustainable harvesting protocols for root-based remedies (e.g., *Withania somnifera*) and resin-producing species (*Boswellia*, *Commiphora*).
- Conduct population demographic studies to validate sustainability scores and inform harvesting quotas.

For Drug Discovery and Pharmacological Research:

- Conduct detailed phytochemical profiling and chronic toxicity studies on species with FL > 85% to isolate bioactive compounds.
- Progress *Cyphostemma adenocaule* (snake venom neutralization), *Aloe trichosantha* (antimalarial), and *Cadaba rotundifolia* (antimalarial) through the drug discovery pipeline with bioactivity-guided fractionation.

For Healthcare Integration:

- The Ethiopian Ministry of Health should establish formal recognition and registration of Afar traditional healers, creating a council that includes both Mallu and Abal representatives.
- Regional health bureaus (Afar, Semera) should develop cross-referral protocols where healers identify biomedical danger signs (e.g., spreading blackening after snakebite) and clinicians refer suspected jinn possession for culturally appropriate ritual care.
- Integrate documented medicinal plants into local healthcare policies as affordable alternatives where

modern medicine is inaccessible.

- Train biomedical workers to recognize the value of indigenous knowledge and refer spirit-caused conditions to healers; train healers to recognize emergencies requiring biomedical intervention.

For Knowledge Preservation:

- Establish community-based apprenticeship programmes with stipends to preserve oral transmission, especially for female healers' reproductive health expertise.
- Digitally archive the ethnobotanical dataset with the Ethiopian Biodiversity Institute to preserve indigenous knowledge for future generations.
- Fund participatory action research co-led by healers and biomedical staff to build mutual respect and shared clinical language.

Next Steps (Phase 5–8 of Drug Discovery Pipeline):

- Extraction and bioassay of *Cyphostemma adenocaule* root (snake venom neutralization, anti-inflammatory)
- Extraction and bioassay of *Aloe trichosantha* leaf latex (antimalarial, antimicrobial)
- Extraction and bioassay of *Cadaba rotundifolia* leaf (antimalarial, hepatoprotective)
- Isolation and structural elucidation of active compounds following standard protocols

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7. Authors' Contributions

Melaku Msresha Woldeamanueal: conceptualization, methodology, investigation, data curation, formal analysis, writing – original draft, visualization. *Belay Sitotaw Goshu*: project administration, validation, writing – review & editing, formal analysis, submission of the manuscript, correspondence with the journal, revision of the manuscript following peer review. *Molla Fente Tasew*: investigation, data curation, resources, validation. *Geltu Nuredin Mushike*: investigation, resources, data curation, validation. *Sitina Dawude Ahemed*: supervision, methodology, validation, writing – review & editing.

8. Conflicts of Interest

No conflicts of interest.

9. Ethics Approval

Yes applicable. Ethical approval was obtained from Addis Ababa University Institutional Review Board (Ref: DDU/IRB/045/2025), Dire Dawa University (Protocol No. DDU-IRB/245/2025), and Semera University's Research Ethics Committee (Approval Code: SU-REC/67/2026). ABS permit No. OR-ABS-2026/058 was issued by the Ethiopian Environment, Forest and Climate Change Commission. Prior Informed Consent (PIC) was obtained at the community level through public meetings with Afar clan elders (Mallu). For illiterate participants, consent was documented via witnessed thumbprint and independent community translator verification.

10. Artificial Intelligence Statement: Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

The authors declare that generative artificial intelligence (AI) was used exclusively to assist in the creation of the Graphical Abstract for this manuscript. No AI tools were used in the writing, interpretation, analysis, or revision of the scientific content. The Graphical Abstract generated with AI was carefully reviewed, verified, and approved by the authors, who assume full responsibility for its accuracy and integrity. The figure legend identifies the AI tool used. AI tools are not considered authors and bear no responsibility for the content of this manuscript.

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Informed Consent Statement

Yes applicable.