



Ethnopharmacology of medicinal plants in Morocco's Central Plateau: Diversity and knowledge transmission

[Etnofarmacología de las plantas medicinales en la Meseta Central de Marruecos: diversidad y transmisión de conocimientos]

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Abstract

Context: Medicinal plants have historically been integral to Morocco's healthcare traditions, supported by a rich flora and intergenerational knowledge transmission.

Aims: To identify the diversity and traditional uses of medicinal plants in the Central Plateau, and culturally important species were identified using quantitative ethnobotanical indices.

Methods: Structured interviews were conducted with 737 informants across urban and rural localities between [insert exact dates]. Voucher specimens were identified at the Laboratory of Botany, Biotechnology, and Plant Protection (Ibn Tofail University). Relative Frequency of Citation (RFC) and Family Importance Value (FIV) were calculated following standard formulas ($RFC = FC/N$; FIV normalized by total FIV). Data were analyzed using SPSS v11.5.

Results: One hundred seventy species belonging to 58 families were recorded. *Lamiaceae* exhibited the highest normalized FIV (37.41%). The most cited species were *Origanum compactum* ($RFC = 0.774$), *Mentha rotundifolia* ($RFC = 0.651$), *Mentha pulegium* ($RFC = 0.480$), and *Tetraclinis articulata* ($RFC = 0.256$). Leaves were the most used plant part (PPV = 20.21%), and infusion was the predominant preparation method. Digestive disorders represented the leading indication category ($n = 1945$ citations).

Conclusions: The persistence of traditional phytotherapy in the Central Plateau was documented. Prioritized species are proposed for phytochemical and pharmacological validation and for conservation planning. Standardized dosage guidance and sustainable harvesting practices are recommended.

Keywords: ethnobotany; knowledge erosion; Morocco; phytotherapy; quantitative ethnobotanical indices.

Resumen

Contexto: Las plantas medicinales han sido históricamente parte integral de las tradiciones sanitarias de Marruecos, sustentadas por una rica flora y la transmisión intergeneracional de conocimientos.

Objetivos: Identificar la diversidad y los usos tradicionales de las plantas medicinales en la Meseta Central, y se identificaron especies de importancia cultural mediante índices etnobotánicos cuantitativos.

Métodos: Se realizaron entrevistas estructuradas a 737 informantes en localidades urbanas y rurales entre [insertar fechas exactas]. Se identificaron especímenes de referencia en el Laboratorio de Botánica, Biotecnología y Protección Vegetal (Universidad Ibn Tofail). La Frecuencia Relativa de Citación (RFC) y el Valor de Importancia Familiar (FIV) se calcularon mediante fórmulas estándar ($RFC = FC/N$; FIV normalizado por el FIV total). Los datos se analizaron con SPSS v11.5.

Resultados: Se registraron ciento setenta especies pertenecientes a 58 familias. La familia *Lamiaceae* presentó el FIV normalizado más alto (37,41%). Las especies más citadas fueron *Origanum compactum* ($RFC = 0,774$), *Mentha rotundifolia* ($RFC = 0,651$), *Mentha pulegium* ($RFC = 0,480$) y *Tetraclinis articulata* ($RFC = 0,256$). Las hojas fueron la parte de la planta más utilizada (VPP = 20,21 %), y la infusión fue el método de preparación predominante. Los trastornos digestivos representaron la principal categoría de indicación ($n = 1945$ citas).

Conclusiones: Se documentó la persistencia de la fitoterapia tradicional en la Meseta Central. Se proponen especies priorizadas para la validación fitoquímica y farmacológica, así como para la planificación de la conservación. Se recomiendan pautas de dosificación estandarizadas y prácticas de cosecha sostenibles.

Palabras Clave: etnobotánica; erosión del conocimiento; Marruecos; fitoterapia; índices etnobotánicos cuantitativos.

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INTRODUCTION

Moreover, due to the presence of active principles, medicinal plants have been used in drug discovery and development, as they contain secondary metabolites with pharmacological properties. It has been estimated that drugs derived from active phytochemical constituents 18 and about 50–60% of all world-approved drugs are natural products/derivatives of plants, which remain the main sources (Bencheikh et al., 2023; Vadhel et al., 2023). The use of plants is still very widespread in the world, and especially in developing countries, where plant drugs are easily accessible, affordable, and play important roles as therapeutic agents. For decades, reported estimates indicated that over 80% of the African population in many countries relies on traditional medicine as another primary healthcare option, mainly due to the widespread availability and oral transmission of this indigenous knowledge (Ndaye et al., 2023; Ngbolua et al., 2016; Samy et al., 2020).

Morocco is characterised by its wide range of ecosystem diversity, and an advantageous geographical location, the latter having a quite rich floral heritage, related to old ethnobotanic traditions for medicinal, food, and handicraft uses. Several investigations

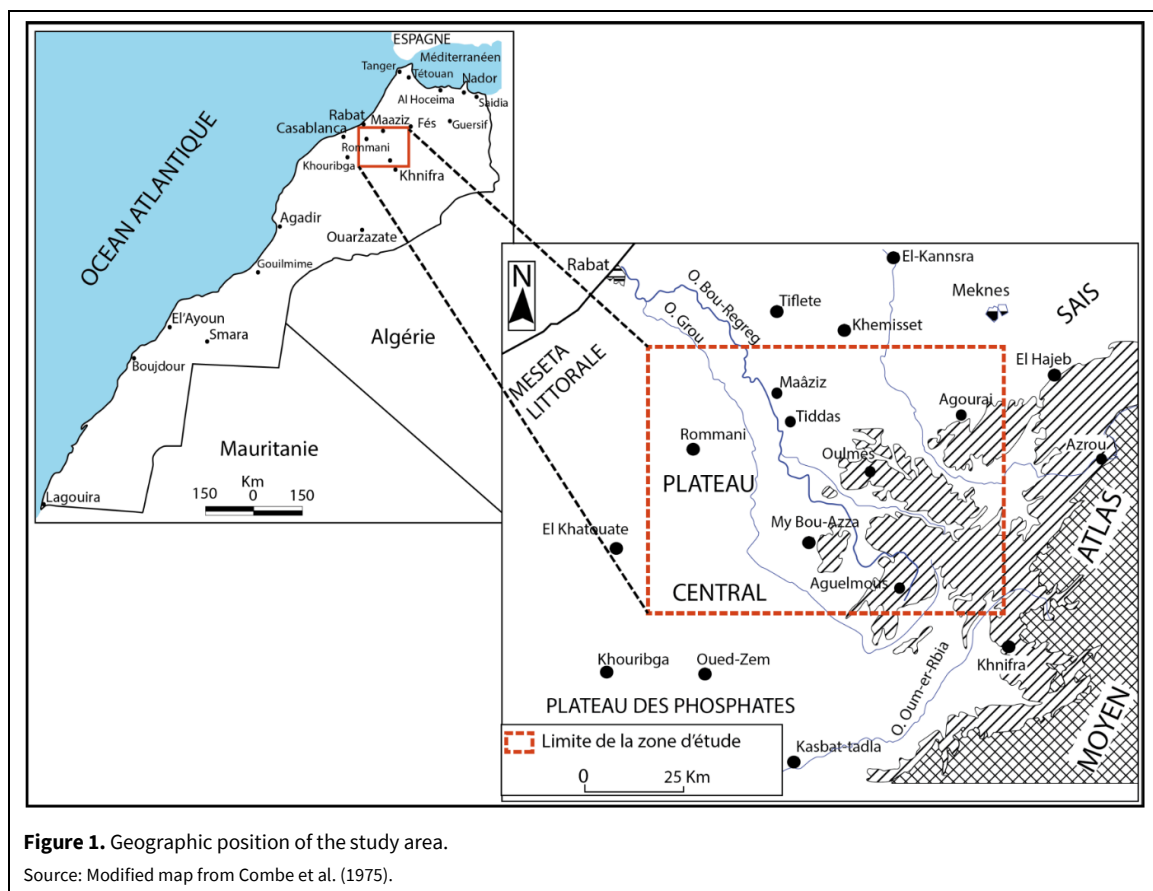
mention the use of plants from Zaër, Rif, and Essaouira, but the Central Plateau is largely unexplored.

Our objective, therefore, has been to compile, such a list for the most used specific plants according to data from the area and also to determine which plants are important because of their ethnobotanical interest, as well as ascertain whether any significant differences exist in traditional knowledge and uses based on age or sex; finally we aim at comparing these results with publications in this respect. Based on relevant quantitative ethnobotanical indices and documentation of traditional preparation methods, new directions for the conservation and sustainable utilization of such plants in the future can be proposed, thereby promoting further investigations into potential ethnomedicinal uses.

MATERIAL AND METHODS

Study area

The Central Meseta is the Moroccan Central Massif; to the north, it borders the southern Rif corridor; in the south, it is enclosed by the phosphate plateau and the Middle Atlas Mountains; in the east, it borders the Middle Atlas Mountains (Combe et al., 1975) (Fig. 1).



The topography is nearly flat, particularly to the west, but becomes gently hilly in almost everything until the east, where it exceeds 1627 m in elevation at Jbel Mtourzguène (stratigraphically very recent uplift), and likely to be linked with a tectonic Middle Atlas fold system activity (Beaudet, 1969). Topography The topography is a checkerboard of plateaus, basins, and ranges with deep valleys and thickly forested slopes. According to soil types and local ecological factors, the composition varies across these cork oak (*Quercus suber*) woodlands and other species. Emerging from that had been the socio-economic development, which, due to limitations in the arable land base, continued to be mainly pastoral. The nomadic way of life is predominant in this population; there are only a small number of sedentary villages, organizations, and human populations that base their activities on small markets limited to the area (Combe et al., 1975).

Methodology

Structured and semi-structured interviews, along with participant observation and field visits, were used to collect ethnobotanical information. The study participants were recruited through a stratified random sampling to represent the various socio-professional categories, age groups, sex, and areas in Morocco. Recruitment occurred in the field when visiting different localities of the region. Interviews were conducted in vernaculars or Arabic, as preferred by the informants. Participants comprised the local population, traditional practitioners, healers, and knowledgeable users of medicinal plants from the community, as well as traditional midwives, and those who had experienced adverse effects in the Central Plateau region. The study was carried out in compliance with ethical guidelines for work with human participants. Oral free, prior, and informed consent was obtained from all participants prior to the interviews, and the confidentiality and anonymity of the information were ensured.

Data analysis

The number of informants interviewed was 737 households (563 traditional and 174 modern medicine practitioners). For each interviewed subject, socioeconomic variables (such as sex, age, education level, marital status, and home location within the study area) were collected. The observed information for each cited plant comprised the vernacular name, medicinal uses, part used, and method of preparation.

Relative frequency citation

The ethnomedicinal information was appraised using Relative Frequency of Citation (RFC), a quantitative measure for determining the stratification of

medicinal plants used against infectious diseases within a community. The RFC was determined using the formula [1].

$$RFC = \frac{FC}{N} \quad [1]$$

where FC is the number of informants who cited a species, and N, the total number of informants interviewed. The RFC varies between 0 and 1, a value close to 1 shows that the respondents are familiar with and use this species frequently.

Fidelity value index (FIV)

The Fidelity Value Index (FIV), which measures the degree of agreement among informants on the use of a particular plant species to treat an ailment, was used. It was estimated using the formula [2].

$$FIV (\%) = \frac{N_p}{N} \times 100 \quad [2]$$

where N_p refers to the number of informants who reported a species used against a given disease and N is the total number of informants interviewed for any disease. High FIV indicates that there is a high level of agreement between informants and thus confidence in the therapeutic use for a specific plant.

Positive perception value (PPV)

The PPV was used to determine the degree of positive appreciation or trust expressed toward each medicinal species by informants. It corresponded to the number of informants claiming divided by the total number of informants mentioning the species. It was calculated using formula [3].

$$PPV = \frac{P}{N} \quad [3]$$

where P is the number of informants who reported a species as being used positively and N is the total number of informants mentioning the species. Greater PPV values reflect higher community beliefs that the plant is useful.

The collected plant specimens were identified in the field and finally validated by a specialist taxonomist of Laboratory Botany, Biotechnology and Plant Protection at the Faculty of Science, Kenitra, leafing through standard floras and reference books (Bellakhdar, 1997; Fennane et al., 1999; 2007; 2014; Hmamouchi, 1999). The ethnobotanical data were coded in SPSS v11 for descriptive and inferential statistics, such as Chi-square (of independence) and Vde Cramer, to determine the correlations between demographic variables and knowledge of medicinal plants.

The revision of the botanical names was essential for scientific reasons and taxonomical correctness of the information obtained. The botanical nomenclature and author citations of species were verified and standardized using World Flora Online (<https://www.worldfloraonline.org/>), a global database of herbarium specimens. This ensured that the nomenclature is consistent with current international standards and with recent progress in systematics.

Table 1. Respondents' demographics and preferred therapeutic practices.

Variable		Informant (n)	Frequency (%)	TM (24.15%)	TMM (52.24%)	MM (23.61%)	χ^2	ddl	p-value	V de Cramer
Age	<30 years	91	12%	14 (7.87%)	51 (13.28%)	26 (14.85%)	33.42	6	<0.0001	0.151
	30–50	331	45%	81 (45.50%)	146 (38.02%)	104 (59.43%)				
	50–70	249	33.79%	63 (35.39%)	152 (39.59%)	34 (19.43%)				
	>70 years	66	8.95%	20 (11.24%)	35 (9.11%)	11 (6.29%)				
Gender	Female	466	63.23%	112 (24.03%)	250 (53.65%)	104 (22.32%)	1.65	2	0.44	0.047
	Male	271	36.77%	66 (24.35%)	134 (49.45%)	71 (26.20%)				
Level of study	Illiterate	531	72.11%	132 (74.15%)	319 (83.08%)	104 (59.44%)	47.61	6	<0.0001	0.18
	Primary	102	13.84%	20 (11.24%)	32 (8.33%)	38 (21.71%)				
	Secondary	97	13.16%	26 (14.61%)	29 (7.55%)	30 (17.14%)				
	University	7	0.95%	0 (—)	4 (1.04%)	3 (1.71%)				
Family situation	Married	661	89.58%	155 (87.29%)	348 (90.60%)	158 (90.83%)	2.39	2	0.30	0.057
	Single	76	10.42%	23 (12.71%)	36 (9.40%)	17 (9.17%)				
Habitat	City	290	39.40%	78 (44.07%)	80 (20.89%)	94 (53.71%)	91.30	4	<0.0001	0.25
	Town	230	31.17%	54 (30.51%)	130 (33.94%)	41 (23.85%)				
	harmelt	217	29.43%	46 (25.42%)	174 (45.17%)	40 (22.94%)				

RESULTS AND DISCUSSION

Description of the sample

A well-detailed population profile of the study area has been established based on variables collected during interviews, including sex, age, educational status, marital status, and place of residence. This information is important for distinguishing various socio-professional groups and thereby understanding ethnobotanical practices within the studied population.

Of the 737 sampled individuals in the Central Plateau, the finding was that, usually, more females are found than males. The findings are consistent with national data, which suggest that women use medicinal plants more than men do (Chaachouay, 2020).

The most considerable part of the sample consists of participants aged between 30 and 50 years, followed by 50–70-year-olds. By contrast, those under 30 years contribute to an even smaller percentage, whereas those above 70 years constitute the smallest number. Quite a fair percentage of participants are actually illiterate, educationally speaking. Following that, fewer individuals have completed elementary education, fewer still have enrolled and graduated from secondary education, and the least is anyone who has graduated from college. These findings are consistent with those of Bouzid et al. (2017) and Lahsissène et al. (2009).

Respondents in villages and douars came second and third, while most respondents live in the city. Most of them are married, while the rest are mostly single.

Some have recourse to modern medicine, as evidenced by an ethnobotanical survey of a heterogeneous sample, while others prefer traditional treatment. The vast majority apply the integrated method, i.e., the simultaneous use of both treatments (MMT). Table 1 presents, in detail, the application of the different treatment methods by age group, gender, educational level, marital status, and place of residence.

Statistical analysis

The χ^2 test revealed that the knowledge and use of medicinal plants species reported on the Central Plateau significantly depended on age ($\chi^2 = 33.42$, $df = 6$, $p < 0.0001$, Cramer's $V = 0.151$), education level ($\chi^2 = 47.61$, $df = 6$, $p < 0.0001$, Cramer's $V = 0.18$) and habitat ($\chi^2 = 91.30$, $df = 4$, $p < 0.0001$, Cramer's $V = 0.25$), while gender ($\chi^2 = 1.65$, $df = 2$, $p = 0.44$, Cramer's $V = 0.047$) and family situation ($\chi^2 = 2.39$, $df = 2$, $p = 0.30$, Cramer's $V = 0.057$) had no significant effect. Adults aged 30–50 years, less-educated people, and urban inhabitants were more involved in the use of medicinal plants (i.e., intergenerational transmission of knowledge; concentration among less educated classes; different practices according to place of residence).

Frequency of medicinal plant use in the central plateau population

In total, 170 species of medicinal plants, grouped into 58 botanical families, were documented. The most numerous were *Lamiaceae*, *Apiaceae*, and *Asteraceae*. The use of plants varied by demographic factors, notably age and education level. They are not of uniform origin: some are spontaneous and endemic, others are cultivated locally, or they are aliens. They can either be collected from the wild and sold by herbalists.

Updating the botanical nomenclature was necessary for scientific rationale and taxonomic validity of the data gathered. Scientific names of the species were verified and standardized with inputs from World Flora Online (WFO, 2025), an international database of herbarium studies. This ensured that the nomenclature aligns with current international standards and reflects contemporary advances in systematics.

Some data have been collected on medicinal plants used by local people to treat various ailments, summarized in Table 2. The botanical families are listed in this table in alphabetical order.

The reported features for each species included scientific and family names, common names in Arabic or Amazigh, frequency of citation (FC), and relative frequency of citation (RFC), calculated as the FC divided

by the total number of informants interviewed (737 in this study).

Among the most frequently cited species in this study were *Origanum compactum* (RFC = 0.774), *Mentha rotundifolia* (RFC = 0.651), *Mentha pulegium* (RFC = 0.480), *Tetralinis articulata* (RFC = 0.256), *Lavandula angustifolia* (RFC = 0.242), *Thymus maroccanus* (RFC = 0.240), *Thymus zygis* (RFC = 0.233), *Ranunculus bullatus* (RFC = 0.229), *Aristolochia baetica* (RFC = 0.195), *Salvia rosmarinus* (RFC = 0.193), and *Apteranthes europaea* (RFC = 0.185). Their high citation frequency and traditional utilization highlight them as prime candidates for targeted pharmacological investigations. Specifically, *Origanum compactum* and *Thymus* spp., traditionally employed for respiratory and gastrointestinal disorders, are suitable for antimicrobial and anti-inflammatory assays. *Mentha rotundifolia* and *Mentha pulegium*, associated with digestive ailments, could be prioritized for antispasmodic and gastroprotective bioassays. Furthermore, *Lavandula angustifolia* and *Tetralinis articulata*, used in dermatological applications, warrant evaluation via wound-healing and topical antimicrobial studies. Such focused pharmacological validation provides a robust scientific basis for the observed ethnobotanical knowledge and informs future drug discovery efforts.

Table 2. List of medicinal plants recorded in the Moroccan Central Plateau.

Family	Scientific name	Common name	Arabic or Amazigh name	FC	RFC	FIV (%)
<i>Amaranthaceae</i>	<i>Dysphania ambrosioides</i> (L.) Mosyakin & Clemants	Anserine	Mkhineza	108	0.147	1.880
	<i>Spinacia oleracea</i> L.	Spinach	Sabanikh	2	0.003	
<i>Amaryllidaceae</i>	<i>Allium cepa</i> L.	Onion	Bassla	8	0.011	0.310
	<i>Allium sativum</i> L.	Garlic	Touma	10	0.014	
<i>Anacardiaceae</i>	<i>Pistacia lentiscus</i> L.	Mastic	Drou	70	0.095	1.730
	<i>Pistacia atlantica</i> Desf.	Atlas pistachio	Btam	27	0.037	
	<i>Searsia pentaphylla</i> (Jacq.) Moffett	Sumac	Tizegha	4	0.005	
<i>Apiaceae</i>	<i>Ammodaucus leucotrichus</i> Coss. & Durieu	Hairy cumin	Kamoun	63	0.085	7.190
	<i>Ammi majus</i> L.	Ajowan (carom seed)	Khila	46	0.062	
	<i>Apium graveolens</i> L.	Celery	Krafess	28	0.038	
	<i>Carum carvi</i> L.	Caraway	Karwiya	77	0.104	
	<i>Coriandrum sativum</i> L.	Coriander	Kouzebar	43	0.058	
	<i>Daucus crinitus</i> Desf.	Wild carrot	Bousfour	9	0.012	
	<i>Eryngium tricuspdatum</i> Sm.	Three-spined Eryngium	Mghizela	12	0.016	

Table 2. List of medicinal plants recorded in the Moroccan Central Plateau (continued...)

Family	Scientific name	Common name	Arabic or Amazigh name	FC	RFC	FIV (%)
	<i>Ferula communis</i> L.	Ferula	Klakh boubal	8	0.011	
	<i>Foeniculum vulgare</i> Mill.	Fennel	Bessbass	64	0.087	
	<i>Magydaris panacifolia</i> (Vahl) Lange	Magydaris	Frifra	2	0.003	
	<i>Petroselinum crispum</i> (Mill.) Fuss	Parsley	Mâadnous	32	0.043	
	<i>Pimpinella anisum</i> L.	Sweet anise	Habat helawa	36	0.049	
<i>Apocynaceae</i>	<i>Apteranthes europaea</i> (Guss.) E.F. Warb.	God's fingers	Daghmous	137	0.186	2.690
	<i>Nerium oleander</i> L.	Oleander	Dafla	20	0.027	
<i>Arecaceae</i>	<i>Chamaerops humilis</i> L.	Dwarf palm	Doum	7	0.009	0.140
	<i>Phoenix dactylifera</i> L.	Date palm	Nkhal	1	0.001	
<i>Aristolochiaceae</i>	<i>Aristolochia baetica</i> L.	Birthwort	Brezetam	144	0.195	2.470
<i>Asparagaceae</i>	<i>Asparagus officinalis</i> L.	Asparagus	Skoum	10	0.014	0.210
	<i>Drimia maritima</i> (L.) Stearn	Sea squill	Besal eddib	2	0.003	
<i>Asteraceae</i>	<i>Artemisia absinthium</i> L.	Wormwood	Chiba	19	0.026	5.240
	<i>Artemisia herba alba</i> Asso	White mugwort	Chih	22	0.030	
	<i>Anacyclus pyrethrum</i> (L.) Lag.	African pyrethrum	Ginass	14	0.019	
	<i>Chamaeleon gummifer</i> (L.) Delile	Gum thistle	Dad	32	0.043	
	<i>Calendula arvensis</i> L.	Field marigold	Jamera	20	0.027	
	<i>Carlina racemosa</i> L.	Clustered carline	Aasfor	2	0.003	
	<i>Centaurea acaulis</i> L.	Wild artichoke	Tafgha	10	0.014	
	<i>Cladanthus mixtus</i> (L.) Chevall.	False pyrethrum	Halala	2	0.003	
	<i>Cynara cardunculus</i> L.	Cardoon	Kharechef	32	0.043	
	<i>Cynara humilis</i> L.	Cynara	Taymat	11	0.015	
	<i>Cynara cardunculus</i> L.	Cultivated artichoke	Gnina	10	0.014	
	<i>Echinops spinosissimus</i> Turra	Globe thistle	Taskra	29	0.039	
	<i>Dittrichia viscosa</i> (L.) Greuter	Viscous inula	Tarehla	59	0.080	
	<i>Matricaria chamomilla</i> L.	Chamomile	Babounje	39	0.053	
	<i>Scolymus hispanicus</i> L.	Spanish thistle	Jarnich	2	0.003	
	<i>Silybum marianum</i> (L.) Gaertn.	Blessed thistle	Tawra	2	0.003	
<i>Brassicaceae</i>	<i>Mutarda nigra</i> (L.) DC.	Black mustard	Bouhamou	39	0.053	1.580
	<i>Lepidium sativum</i> L.	Ailean cress	Habe rechad	25	0.034	
	<i>Moricandia arvensis</i> (L.) DC.	Field cabbage	Jrjir	20	0.027	
	<i>Nasturtium officinale</i> R.Br.	Watercress	Grnouch	6	0.008	
	<i>Raphanus raphanistrum</i> subsp. <i>sativus</i> (L.) Domin	Radish	Fejal	2	0.003	
<i>Cactaceae</i>	<i>Opuntia ficus-indica</i> (L.) Mill.	Prickly pear	Zeaboul	63	0.085	1.080
<i>Capparaceae</i>	<i>Capparis spinosa</i> L.	Capparis	Kbar	56	0.076	0.960

Table 2. List of medicinal plants recorded in the Moroccan Central Plateau (continued...)

Family	Scientific name	Common name	Arabic or Amazigh name	FC	RFC	FIV (%)
<i>Caryophyllaceae</i>	<i>Spergularia rubra</i> (L.) J.Presl & C.Presl	Herass elhejer	Sabline rouge	79	0.107	
	<i>Corrigiola telephiifolia</i> Pourr.	Telephium-leaved corrigiola	Sarghina	46	0.062	2.520
	<i>Saponaria officinalis</i> L.	Soapwort	Tighchet	22	0.030	
<i>Cistaceae</i>	<i>Cistus creticus</i> subsp. <i>creticus</i> L.	Gum rockrose	Touzalt	50	0.068	1.660
	<i>Fumana viridis</i> (Pourr.) Pau	Cistus	Rbibit	17	0.023	
	<i>Cistus salviifolius</i> L.	Sage-leaved cistus	Boutour	30	0.041	
<i>Cucurbitaceae</i>	<i>Citrullus colocynthis</i> (L.) Schrad.	Colocynth	Hdaj	6	0.008	0.150
	<i>Ecballium elaterium</i> (L.) A.Rich.	Donkey cucumber	Fgouss lhmir	3	0.004	
<i>Cupressaceae</i>	<i>Tetraclinis articulata</i> (Vahl) Masters	Thuja	El'ar'ar	189	0.256	3.240
<i>Cyperaceae</i>	<i>Cyperus rotundus</i> L.	Piri piri	Tarra	2	0.003	0.030
<i>Ericaceae</i>	<i>Arbutus unedo</i> L.	Strawberry tree	Sassnou	24	0.033	0.410
<i>Euphorbiaceae</i>	<i>Euphorbia falcata</i> L.	Horned sickle-leaved spurge	Hayat noufous	2	0.003	0.480
	<i>Mercurialis annua</i> L.	Annual mercury	Hriga melsa	25	0.034	
	<i>Ricinus communis</i> L.	Castor	Krank	1	0.001	
<i>Fabaceae</i>	<i>Astragalus gummifer</i> Labill.	Episia	Ktira	2	0.003	2.040
	<i>Senna alexandrina</i> Mill.	Senna	Sana	2	0.003	
	<i>Ceratonia siliqua</i> L.	Carob	Slighwa	51	0.069	
	<i>Glycine max</i> (L.) Merr.	Soybean	Soja	1	0.001	
	<i>Glycyrrhiza glabra</i> L.	Licorice	Arek ssous	1	0.001	
	<i>Lathyrus oleraceus</i> (L.) D.C.	Pea	Jlbana baldia	6	0.008	
	<i>Trigonella foenum-graecum</i> L.	Fenugreek	Halba	57	0.077	
	<i>Vicia faba</i> L.	Broad bean	Foul	2	0.003	
<i>Fagaceae</i>	<i>Quercus rotundifolia</i> Lam.	Holm oak	Krouch	21	0.028	0.820
	<i>Quercus suber</i> L.	Cork oak	Fernan	27	0.037	
<i>Iridaceae</i>	<i>Crocus sativus</i> L.	Saffron	Za'frane lhor	30	0.041	0.510
<i>Juncaceae</i>	<i>Juncus acutus</i> L.	Rush	Ssmar	13	0.018	0.220
<i>Lamiaceae</i>	<i>Ajuga iva</i> (L.) Schreb.	Bugle ivette	Chendgûra	93	0.126	37.410
	<i>Clinopodium nepeta</i> (L.) Kuntze	Calamint	Maneta	48	0.065	
	<i>Lavandula angustifolia</i> Mill.	Common lavender	Khezama	179	0.243	
	<i>Lavandula stoechas</i> L.	French lavender	Helhal	75	0.102	
	<i>Marrubium echinatum</i> Ball	White horehound	Meriout	45	0.061	
	<i>Marrubium deserti</i> (de Noé) Coss.	Desert horehound	Jaâda	8	0.011	
	<i>Marrubium vulgare</i> L.	White horehound	Meriouet	114	0.155	
	<i>Mentha rotundifolia</i> (L.) Huds.	Round-leaved mint	Mressita	480	0.651	
	<i>Mentha pulegium</i> L.	Pennyroyal	Fliou	354	0.480	
	<i>Mentha piperita</i> L.	Peppermint	Nâanaâ abdi	34	0.046	

Table 2. List of medicinal plants recorded in the Moroccan Central Plateau (continued...)

Family	Scientific name	Common name	Arabic or Amazigh name	FC	RFC	FIV (%)
	<i>Ocimum basilicum</i> L.	Basil	Hbak	9	0.012	
	<i>Origanum compactum</i> (L.) Benth.	Oregano	Zaâtar	571	0.775	
	<i>Origanum majorana</i> L.	Marjoram	Mrededouche	57	0.077	
	<i>Salvia rosmarinus</i> Spenn.	Rosemary	Azir	142	0.193	
	<i>Salvia officinalis</i> L.	Sage	Salmia	102	0.138	
	<i>Salvia verbenaca</i> L.	Verbena-leaved sage	Khayata	6	0.008	
	<i>Teucrium polium</i> L.	Grayish-white germander	Jaâda	2	0.003	
	<i>Thymus maroccanus</i> Ball	Thyme	Zeitra	177	0.240	
	<i>Thymus zygis</i> L.	Thyme	Zeitra	172	0.233	
	<i>Vitex agnus-castus</i> L.	Chaste tree	Kharwaâ	50	0.068	
Lauraceae	<i>Camphora officinarum</i> Nees ex Wall.	Camphor tree	Kafour	2	0.003	0.860
	<i>Cinnamomum verum</i> J.Presl	Cinnamon	Karefa	41	0.056	
	<i>Laurus nobilis</i> L.	Bay laurel	Warekat sidna moussa	7	0.009	
Linaceae	<i>Linum usitatissimum</i> L.	Flax	Zerîât ktan	53	0.072	0.910
Lythraceae	<i>Lawsonia inermis</i> L.	Henna	Henna	1	0.001	0.120
	<i>Punica granatum</i> L.	Pomegranate	Reman	6	0.008	
Malvaceae	<i>Gossypium herbaceum</i> L.	Cotton	Ktam	2	0.003	0.150
	<i>Malva sylvestris</i> L.	Mallow	Khobiza	7	0.009	
Moraceae	<i>Morus nigra</i> L.	Black mulberry	Toute aswad	6	0.008	0.100
Myristicaceae	<i>Myristica fragrans</i> Houtt.	Nutmeg	Gouza	27	0.037	0.460
Myrtaceae	<i>Eucalyptus globulus</i> Labill.	Eucalyptus	Kalitous	82	0.111	3.770
	<i>Syzygium aromaticum</i> (L.) Merr. & L.M.Perry	Clove	Krenefel	30	0.041	
	<i>Myrtus communis</i> L.	Myrtle	Rihan	102	0.138	
	<i>Pimenta dioica</i> (L.) Merr.	Crowned pepper	Nwiwira	6	0.008	
Nitrariaceae	<i>Peganum harmala</i> L.	Harmel	Harmel	21	0.028	0.360
Oleaceae	<i>Fraxinus dimorpha</i> (Hiern) C.C.Huang	Ash	Lssan tér	5	0.007	1.110
	<i>Chrysojasminum fruticans</i> (L.) Kuntze	Shrubby jasmine	Jawhar	2	0.003	
	<i>Jasminum grandiflorum</i> L.	Large-flowered jasmine	Yassmin	2	0.003	
	<i>Olea europaea</i> L.	Oleaster	Zitoun	56	0.076	
Papaveraceae	<i>Papaver rhoeas</i> L.	Poppy	Belâaman	25	0.034	0.630
	<i>Papaver somniferum</i> L.	Opium poppy	Kherchacha	12	0.016	
Pedaliaceae	<i>Sesamum indicum</i> L.	Sesame	Zenjlane	4	0.005	0.070
Pinaceae	<i>Pinus sylvestris</i> L.	Pine	Tayda	13	0.018	0.220
Piperaceae	<i>Piper nigrum</i> L.	Pepper	Ibzar	38	0.052	0.650

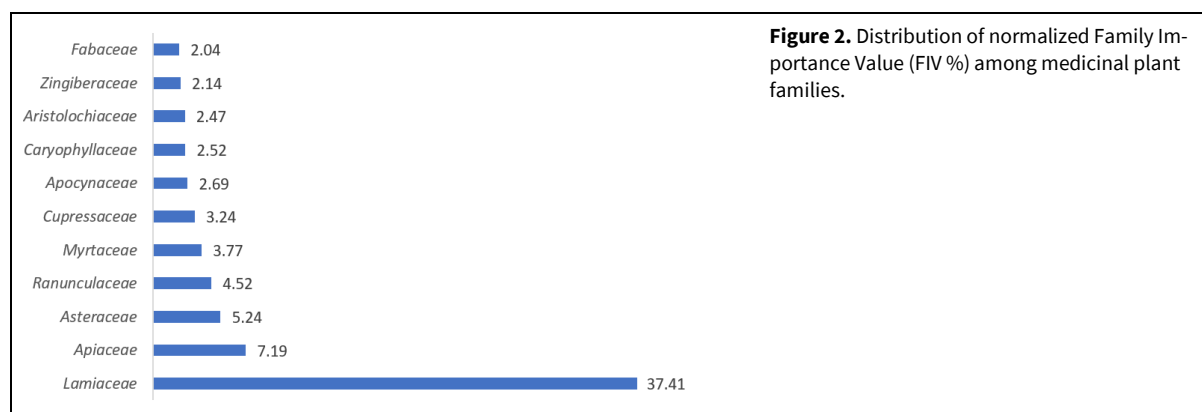
Table 2. List of medicinal plants recorded in the Moroccan Central Plateau (continued...)

Family	Scientific name	Common name	Arabic or Amazigh name	FC	RFC	FIV (%)
<i>Plantaginaceae</i>	<i>Plantago major</i> L.	Great plantain	Messassa	2	0.003	0.030
<i>Poaceae</i>	<i>Agropyrum repens</i> (L.) Beauv.	Couch Grass	Nejam	8	0.011	0.810
	<i>Avena sativa</i> L.	Cultivated Oats	Khertal	3	0.004	
	<i>Hordeum vulgare</i> L.	Barley	Cheir	6	0.008	
	<i>Panicum miliaceum</i> L.	Common Millet	Ilane	4	0.005	
	<i>Phragmites australis</i> (Cav.) Trin. ex Steud.	Reed	Kssab	2	0.003	
	<i>Sorghum bicolor</i> (L.) Moench	Sorghum	Douchen	20	0.027	
	<i>Triticum aestivum</i> L.	Soft wheat	Farina	6	0.008	
	<i>Triticum turgidum</i> L.	Durum wheat	Gmah	6	0.008	
	<i>Zea mays</i> L.	Corn	Ouli kbal	16	0.022	
<i>Polygonaceae</i>	<i>Polygonum maritimum</i> L.	Sea knotweed	Zyata	4	0.005	0.450
	<i>Rumex acetosa</i> L.	Sorrel	Hamida	22	0.030	
<i>Polypodiaceae</i>	<i>Pteridium aquilinum</i> (L.) Kuhn	Eagle fern	Afressko	1	0.001	0.020
<i>Ranunculaceae</i>	<i>Staphisagria macrosperma</i> Spach	Daphne	Habat rass	32	0.043	4.520
	<i>Ranunculus bullatus</i> L.	Buttercup	Wdan lhalouf	169	0.229	
	<i>Nigella sativa</i> L.	Black cumin	Sanouj	63	0.085	
<i>Rhamnaceae</i>	<i>Rhamnus alaternus</i> L.	Alaterna	Amlils	16	0.022	0.630
	<i>Zizyphus lotus</i> (L.) Lam.	Jujube	Sedra	15	0.020	
	<i>Zizyphus vulgaris</i> Lam.	Zizyphus	Zefzouf	6	0.008	
<i>Rosaceae</i>	<i>Crataegus laevigata</i> (Poir.) DC.	Hawthorn	Zaârou	2	0.003	1.080
	<i>Eriobotrya japonica</i> (Thunb.) Lindl.	Japanese medlar	Mezah	4	0.005	
	<i>Malus domestica</i> Borkh.	Apple tree	Tefah	2	0.003	
	<i>Prunus domestica</i> L.	Plum tree	Barkouk	6	0.008	
	<i>Rosa damascena</i> Mill.	Damask rose	Wared	39	0.053	
	<i>Rubus ulmifolius</i> Schott	Bramble	Aalik	10	0.014	
<i>Rubiaceae</i>	<i>Rubia tinctorum</i> L.	Madder	Foua	47	0.064	0.810
<i>Rutaceae</i>	<i>Citrus aurantium</i> L.	Bitter orange	Rang	2	0.003	0.700
	<i>Citrus sinensis</i> (L.) Osbeck	Sweet orange	Limon	2	0.003	
	<i>Ruta montana</i> L.	Wild rue	Figel	37	0.050	
<i>Salicaceae</i>	<i>Populus alba</i> L.	White poplar	Safsaf	4	0.005	0.340
	<i>Salix alba</i> L.	Willow	'od l-ma	2	0.003	
	<i>Salix babylonica</i> L.	Weeping willow	Aicha mousswalef	14	0.019	
<i>Santalaceae</i>	<i>Osyris alba</i> L.	Osyris	Marghata	2	0.003	0.030
<i>Scrophulariaceae</i>	<i>Verbascum sinuatum</i> L.	Mullein with sinuate leaves	Moslih ndar	8	0.011	0.140

Table 2. List of medicinal plants recorded in the Moroccan Central Plateau (continued...)

Family	Scientific name	Common name	Arabic or Amazigh name	FC	RFC	FIV (%)
Solanaceae	<i>Capsicum annum</i> L.	Bell pepper	Felfla hamera	16	0.022	1.280
	<i>Capsicum frutescens</i> L.	Hot pepper	Flifla	15	0.020	
	<i>Datura stramonium</i> L.	Datura	Chedak jmal	28	0.038	
	<i>Mandragora autumnalis</i> Bertol.	Mandrake	Bîid el-ghol	12	0.016	
	<i>Withania frutescens</i> (L.) Pauquy	Physalis	Chejra hbila	4	0.005	
Tamaricaceae	<i>Tamarix aphylla</i> (L.) Karst.	Tamarisk	Takawet	2	0.003	0.030
Thymelaeaceae	<i>Daphne gnidium</i> L.	Garou	Lzaze	18	0.024	0.340
	<i>Thymelaea hirsuta</i> (L.) Endl.	Hedgehog passerine	Mtnane	2	0.003	
Tuberaceae	<i>Terfezia leonis</i> (Chatin) Chatin	White truffle	Terfass	2	0.003	0.030
Verbenaceae	<i>Aloysia citrodora</i> Paláu	Verbena	Louiza	64	0.087	1.180
	<i>Verbena officinalis</i> L.	Common verbena	Baymout	5	0.007	
Vitaceae	<i>Vitis vinifera</i> L.	Vine	Dalia	27	0.037	0.460
Xanthorrhoeaceae	<i>Asphodelus fistulosus</i> L.	Asphodel	Brewag	29	0.039	0.500
Zingiberaceae	<i>Alpinia officinarum</i> Hance	Galangal	Khedanjel	47	0.064	2.140
	<i>Curcuma longa</i> L.	Turmeric	Kharkoum	7	0.009	
	<i>Zingiber officinale</i> Roscoe	Ginger	Zanjabil	71	0.096	
Zygophyllaceae	<i>Zygophyllum gaetulum</i> Batt.	Zygophyllum	Äakaya	4	0.005	0.070

Scientific names and family were verified from Word Flora Online (<https://www.worldfloraonline.org/>).

**Figure 2.** Distribution of normalized Family Importance Value (FIV %) among medicinal plant families.

The predominant botanical families recorded in the study area

To determine the relative importance of the medicinal plant families, we computed the Family Importance Value (FIV). In order to calculate each family's FIV brut (%), the citation frequencies (FC) of all of its species were added, divided by the total number of informers (N = 737), and then multiplied by 100. The comparison of families was then made possible by the normalization of these values. The FIV brut was divided by the sum of all the FIV bruts and multiplied by 100 to determine the FIV normalized (%) for each family. Families with a high normalized FIV indicate a

greater significance of ethnobotany in the area under study.

According to El Hassani's (2020) observations, the *Lamiaceae* (FIV = 37.41%) stand out among the surveyed families as the most prevalent, contributing significantly to the region's floristic diversity. The *Apiaceae* (FIV = 7.19%), *Asteraceae* (FIV = 5.24%), *Ranunculaceae* (FIV = 4.52%), *Myrtaceae* (FIV = 3.77%), *Cupressaceae* (FIV = 3.24%), *Apocynaceae* (FIV = 2.69%), *Caryophyllaceae* (FIV = 2.52%), *Aristolochiaceae* (FIV = 2.47%), *Zingiberaceae* (FIV = 2.14%) and *Fabaceae* (FIV = 2.04%) have a moderately significant contribution to the global floristic diversity (Fig. 2).

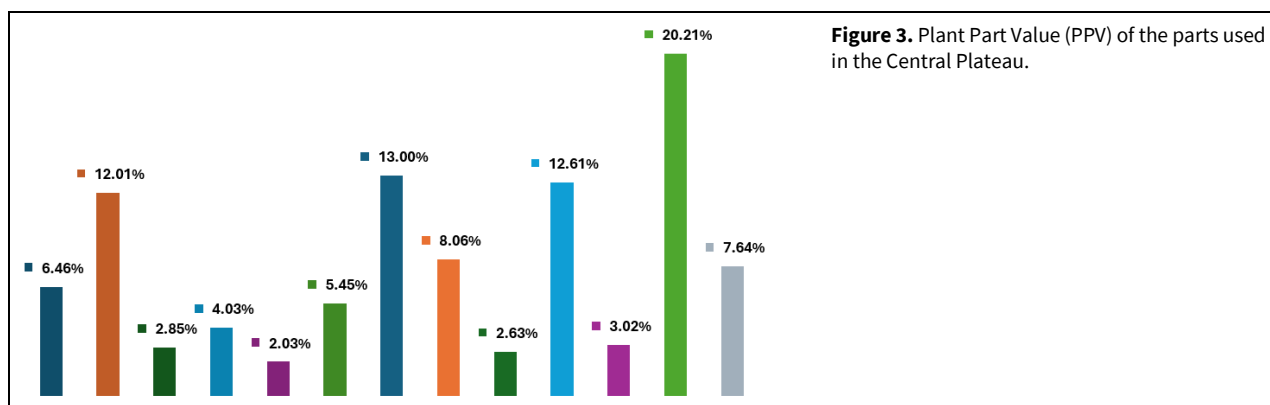


Figure 3. Plant Part Value (PPV) of the parts used in the Central Plateau.

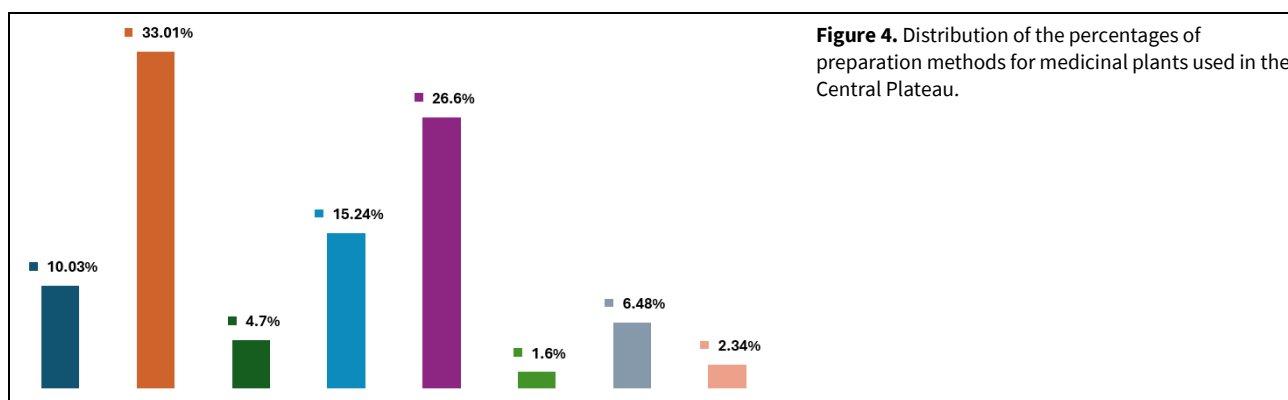


Figure 4. Distribution of the percentages of preparation methods for medicinal plants used in the Central Plateau.

Use of medicinal plants in the treatment of diseases

Plant parts used

In phytotherapy, various plant parts are used, each offering distinct therapeutic properties. These include leaves, roots, fruits, seeds, flowers, rhizomes, inflorescences, and bark, with the entire plant sometimes being utilized. The selection of the plant part depends on its medicinal application, and the quantities used can vary considerably.

In the studied region, leaves (PPV=20.21%) are the most commonly used parts for therapeutic purposes, consistent with the findings of Laouali et al. (2020). The whole plant (PPV=13.00%), seeds (PPV=12.61%), and aerial parts (PPV=12.01%) are also widely utilized, while fruits, roots, and other organs (stems, inflorescences, silks, bark, rhizomes, flowers and cones) are used more marginally (Fig 3).

Field studies have shown a tendency for non-selective harvesting of medicinal plants. Instead of focusing on the specific organ of interest, users often collect the entire plant, including roots and rhizomes. This unsustainable harvesting practice, which negatively affects the plant's reproductive capacity, poses a threat to the long-term survival of these valuable species.

Preparation method

The extraction of active compounds from medicinal plants requires specific preparation techniques. Depending on the therapeutic purpose, various methods such as infusion, decoction, poultice preparation, maceration, fumigation, or powdering can be used. In the central plateau, infusion is the most widely practiced method (33.01%), followed by powder preparation (26.6%) and decoction (15.24%), while other techniques are used less frequently (Fig 4).

Previous ethnobotanical surveys conducted in other areas of Morocco indicate that most participants in this study would prefer to prepare remedies by infusion or decoction (Salhi et al., 2010; Slimani et al., 2016). This highlights that the cultural practice of knowledge exchange regarding the use of aromatic and medicinal plants is alive among Moroccans. In addition, infusion and decoction are considered the two basic methods of preparation across the continent (Okello et al., 2009; Stangeland et al., 2011; Yetein et al., 2013).

The data collected from informants further emphasize the absence of standardized methods for preparing plant-based remedies. The lack of precise guidelines, both for ingredient proportions and for preparation parameters (including solvent type and extraction duration), constitutes a significant shortfall.

Dose used in phytotherapy

The surveys indicated that many medicinal plant users seem to be unaware of the importance of following recommended dosages and the potential risk of toxicity from overdosing. It is important to stress that not all plants are harmless, and a medicinal plant can become toxic if usage instructions are not followed. Furthermore, some plants, even when used frequently, can pose risks with prolonged and repeated consumption. Therefore, caution and accurate information are vital. These results are in agreement with the study by Benkhniue et al. (2010) conducted in the Mechraâ Bel Ksiri region.

Therapeutic indications of medicinal plants

Types of diseases treated with medicinal plants

The ethnobotanical survey conducted among residents of the Central Plateau identified 246 medicinal plant species used to treat various ailments (Table 3).
Notably, our findings align with ethnobotanical studies conducted in several parts of Morocco, particularly in the Essaouira province (Mehdioui & Kahouadji, 2007), in the Zaër region (Lahsissène et al., 2009), and in the Rabat region (Hseini et al., 2011). These studies all have 256 highlighted the most

common use of medicinal plants in the treatment of digestive system disorders 257 (30.16%) (Table 3).
Respiratory infections are the second most frequently treated condition, followed by genital system and skin-related disorders. Neurological conditions represent a smaller share of cases. The remaining cases encompass a diverse range of health issues, such as oral diseases, diabetes, musculoskeletal problems, cardiovascular conditions, immunological disorders, hearing impairments, urinary and renal issues, visual and circulatory disorders, as well as liver and biliary diseases.

CONCLUSION

This study identified 170 medicinal plant species used by the inhabitants of Morocco's Central Plateau, with *Lamiaceae* emerging as the most culturally significant family. Leaves were the most utilized plant part, and infusion was the primary preparation method. Traditional knowledge was largely preserved among the elderly and female populations, suggesting a risk of knowledge erosion. Further pharmacological and phytochemical analyses are recommended, particularly for the most-cited species, to support evidence-based conservation and drug-development strategies.

Table 3. Therapeutic indication domain.

Phytotherapeutic action	Number of citations
Digestive disorders	1945
Respiratory infections	1384
Gynecological diseases	885
Dermatological diseases	634
Neurological diseases	321
Oral diseases	189
Diabetes	180
Osteoarticular diseases	175
Cardiovascular diseases	140
Immunological diseases	120
Hearing diseases	117
Urinary diseases	115
Renal diseases	104
Visual disorders	41
Circulatory diseases	41
Liver and biliary tract diseases	31
Others	27

CONFLICT OF INTEREST

The research was conducted entirely free from any involvement in commercial, financial, or personal matters that might be perceived as a possible conflict of interest or that could have influenced the outcomes or interpretation of the study.

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GENERATIVE ARTIFICIAL INTELLIGENCE (AI)

The authors used ChatGPT (OpenAI) to improve the language and readability of the manuscript. The authors reviewed and edited the content and take full responsibility for its accuracy. No images were generated or manipulated using AI tools.

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154–163.

AUTHOR CONTRIBUTION:

Contribution	El Hilah F	Ben Akka F	Benkhniq O	Salhi S	Hmouni D	Zidane L
Concepts or ideas	x					x
Design	x	x	x	x		x
Definition of intellectual content	x	x			x	
Literature search	x	x	x	x		
Experimental studies	x					x
Data acquisition	x				x	x
Data analysis	x					
Statistical analysis	x					
Manuscript preparation	x	x	x	x	x	
Manuscript editing	x					
Manuscript review	x	x	x	x	x	x

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