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Ethnobotanical study of medicinal plants used to treat human ailments in Quara district, northwestern Ethiopia

Daniel Tadesse[1,2*], Getinet Masresha[1] and Ermias Lulekal[3]

Abstract

Background Ethiopia is recognized as one of the centers of origin for the diversity of many plant species, including medicinal plants. Throughout the country, a large proportion of the population relies on these therapeutic plant species for primary healthcare. While such traditional medicinal knowledge has been documented in some regions, there is a lack of information from the Quara district of northwestern Ethiopia. Therefore, this study aimed to document the indigenous and local knowledge of the use of medicinal plants among three ethnic groups residing in the area.

Methodology An ethnobotanical study was conducted from August 2022 to October 2023 in ten kebeles of the Quara district. Data were collected through semi-structured interviews, field walks, and focus group discussions with 286 informants using snowball, purposive, and random sampling techniques. Quantitative analyses included Rahman's similarity index (RSI), informant consensus factor (ICF), and direct matrix ranking (DMR). Descriptive statistics were used to analyze basic ethnobotanical data.

Results A total of 128 medicinal plant species from 112 genera and 50 families were documented and used to treat 14 disease categories. There was a 28% overlap in medicinal plant knowledge among the three ethnic groups studied. Fabaceae was the most represented family with 22 species. Trees accounted for the majority of the documented plants (37.5%), and leaves were the most commonly used plant parts (23.1%). Oral administration (56.7%) of plant extracts was the primary mode of remedy preparation and use. The highest ICF value (0.93) was recorded for circulatory and blood-related disorders. The study identified nine plants and 39 therapeutic uses not previously reported in Ethiopia. The RSI showed high overlap with neighboring areas and low similarity with distant areas. Top-ranked multipurpose plants were *Ziziphus spina-christi* and *Terminalia leiocarpa*, with agricultural expansion and fuelwood collection identified as major threats.

Conclusion The findings demonstrate the rich diversity of medicinal plants and associated traditional knowledge in the Quara district. The high ethnobotanical indices warrant further phytochemical and pharmacological investigations. Integrated conservation efforts are recommended to address the challenges facing these valuable plant resources.

Keywords Ethnobotany, Indigenous knowledge, Medicinal plants, Quara, Rahman's similarity index

*Correspondence:
Daniel Tadesse
kaleabfather@gmail.com
Full list of author information is available at the end of the article

Background

Humans have a long-standing relationship with plants, utilizing them for various daily needs such as food, shelter, fuel, medicines, and fodder [1]. Medicinal plants, in particular, have been integral to traditional healthcare systems, providing treatments for diverse human ailments [2]. The close interaction between man and nature has led to the accumulation of a wealth of traditional knowledge of medicinal plants. Traditional knowledge refers to the unique knowledge held by a particular culture or society, acquired over time through traditional practices [1]. The use of medicinal plants has been an integral part of traditional healthcare systems since antiquity.

The World Health Organization's Traditional Medicine Strategy 2014–2023 acknowledges the critical role of traditional medicine, with traditional remedies, practitioners, and herbs providing healthcare for millions of people [3]. Approximately 80% of the global population still relies on traditional herbal medicines [4], and in developing countries, this figure can range from 50 to 95% [5, 6]. Ethiopia, a developing nation, exemplifies this widespread use of medicinal plants to treat various diseases in both humans and domestic animals [7]. Traditional medicine serves as the primary healthcare source for around 80% of the Ethiopian population, with over 95% of medical preparations derived from plants [8]. However, the continued existence of these medicinal plants is threatened by various factors, including habitat destruction, urbanization, agricultural expansion, deforestation, firewood collection, and environmental degradation [9–11].

Ethiopia, renowned for its exceptional plant diversity, cultural richness, and ancient medical practices, is a hub for ethnomedicinal research [12, 13]. The northwestern lowland area of the country, home to several protected areas and communal forests, is particularly known for its diverse plant species [14–16]. Quara, a district in this lowland area, is inhabited by indigenous communities with diverse ethnic backgrounds, including Gumuz, Amhara, and Agew [17, 18]. Additionally, the district has experienced in-migration from different parts of the Amhara region of the country, driven by government resettlement programs [19] and through informal means driven by the search for agricultural and grazing lands [17].

The healthcare system in Quara includes various facilities such as a hospital, health stations, clinics, and pharmacies. However, this infrastructure is severely limited, with only 169 health professionals serving a population of 93,629 [20]. As a result, the local community continues to rely heavily on traditional medicinal plants and associated knowledge. The hot temperatures are prevalent across most of the kebeles in Quara leaving the population vulnerable to a range of diseases and insect-borne illnesses. The top ten human ailments recorded in the district in four successive years (2017/18-2020/21) included malaria, typhoid and paratyphoid, acute upper respiratory infections, pneumonia, functional intestinal disorder, fever of unknown origin, dyspepsia, helminthiases, amoebiasis and disorder of urinary system [20]. Adding to the burden of the inadequate healthcare system, the district experiences a high influx of seasonal agricultural laborers, further straining the limited resources. The remote location of Quara, its distance from major towns, and its proximity to the Sudanese border have facilitated the exchange of traditional medicinal plant knowledge across communities. This has likely led to the discovery of novel ethnobotanical findings in the area. Consequently, the local people have been compelled to rely on and share their knowledge of traditional medicinal plants to address their healthcare needs. However, there are growing concerns about the potential loss of this traditional knowledge and skill, primarily due to habitat degradation, modern education, acculturation, and the waning interest of younger generations [21, 22]. This problem is also prevalent in the lowlands of northwestern Ethiopia.

Despite numerous ethnobotanical studies conducted across Ethiopia in recent years, the traditional medicinal plant knowledge of the Quara district remains undocumented. Given the district's cultural diversity, rich vegetation cover, and other factors contributing to its reliance on traditional medicine, it is hypothesized that a wealth of valuable medicinal plant knowledge exists among the ethnic groups in Quara that warrants further study. Moreover, comparing the findings of such a study with the broader Ethiopian ethnobotanical medicinal plant database could provide valuable insights into the regional distribution and utilization of these plants, further enriching our understanding of Ethiopia's remarkable traditional plant-based healthcare system.

Given the unique cultural and ecological context of Quara, as well as the pressing need to document and preserve its traditional medicinal plant knowledge, the present study aims to (i) document the medicinal plants and associated indigenous knowledge used by the local communities, (ii) assess the major threats to the medicinal plants, and (iii) identify and report any new ethnomedicinal plant species data and usage information not previously recorded. The overarching goal of these research objectives is to contribute to the conservation and sustainable utilization of valuable plant resources in the unique cultural and ecological context of Quara.

Materials and methods

Description of the study area

The study was conducted in Quara district, located in the West Gondar Zone of the Amhara Region in northwestern Ethiopia (Fig. 1). The district is situated between 11°47′5.4″ and 12°31′3.6″ N latitude and 35°15′48″ to 36°48′51″ E longitude, with an altitude range of 530 to 1900 meters above sea level [23].

Quara district comprises 28 kebeles, which are the smallest administrative units. The average annual temperature in the district ranges from 25 to 35 °C, and the mean annual rainfall varies between 600 and 1200 mm [24]. The district experiences an unimodal rainfall pattern, with the rainy season starting in early May and ending in early October. The months between October and May are characterized by dry, hot weather conditions [23]. According to the Central Statistical Agency [25], the district had a total population of 94,106, with 50,021 (53.15%) men and 44,085 (46.85%) women. Of the total population, 89,375 (94.97%) resided in rural areas. The study area has a diverse ethnic composition, primarily consisting of the Amhara, Agew, and Gumuz communities. The predominant religion is Ethiopian Orthodox Christianity. The primary language spoken in the area is Amharic, with other locally known languages including Agewgna, Gumuz, and Datsien [17].

In terms of topography, the district is characterized by flat to undulating plains that slope from south to north. The landscape features valleys, streams, scattered hills, and seasonal wetlands in the lowlands. As the terrain

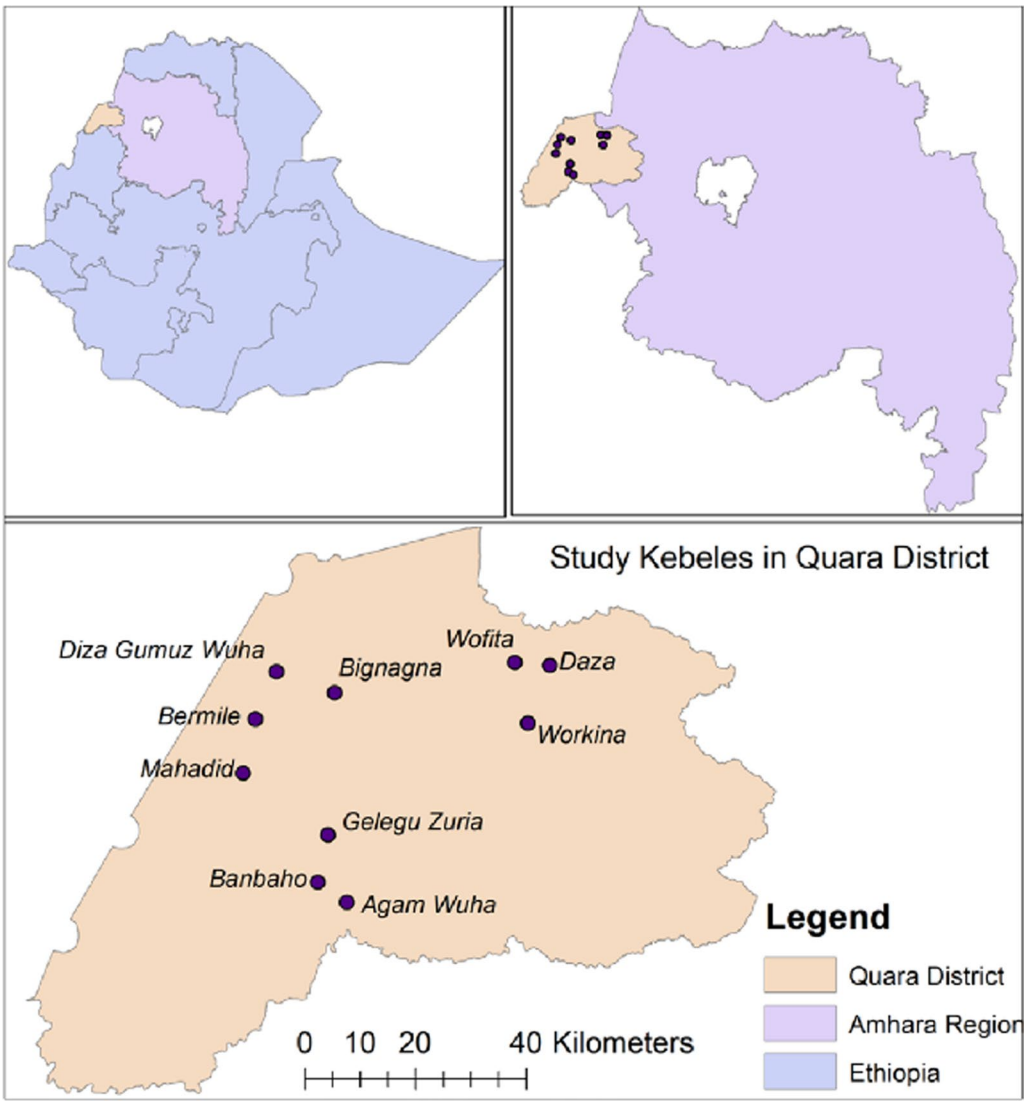

Fig. 1 Map of Ethiopia showing the Amhara region and the study sites

Table 1 Description of study kebeles of data collection within the study area, highlighting key geographical and demographical attribute

Study kebele	GPS coordinates		Elevation (m)	Ecology	Total number of HH	Number of interviewees	Gender		Informant type		Ethnicity			Age			Occupation			Religion	
	Latitude	Longitude					M	F	GI	KI	A	G	Ag	20–39	40–59	> = 60	Il	RW	FE	Ch	Mu
Gelegu Zuria	12°08′28"N	35°55′45"E	761	Lowland	4150	40	28	12	34	6	36	0	4	8	22	10	13	16	11	38	2
Mehadid	12°17′52"N	35°45′49"E	585	Lowland	1721	16	10	6	8	8	0	16	0	4	5	7	8	6	2	1	15
Bermil	12°23′32"N	35°44′13"E	575	Lowland	2235	21	14	7	19	2	21	0	0	7	10	4	10	2	9	21	0
Diza Gumuz Wuha	12°24′45"N	35°45′34"E	556	Lowland	3107	30	27	3	27	3	30	0	0	8	20	2	14	5	11	28	2
Agam Wuha	12°04′44"N	36°00′35"E	787	Lowland	1608	15	9	6	10	5	0	0	15	4	5	6	7	4	4	15	0
Bignagna	12°23′42"N	35°50′27"E	586	Lowland	1948	19	14	5	13	6	0	19	0	7	7	5	11	4	4	8	11
Daza	12°16′30"N	36°13′30"E	1764	Midland	5032	48	26	22	40	8	48	0	0	16	21	11	25	17	6	46	2
Wofta	12°17′54"N	36°13′19"E	1733	Midland	3287	32	24	8	24	8	32	0	0	13	7	12	13	16	3	32	0
Workina	12°16′10"N	36°11′48"E	1517	Midland	2034	20	13	7	16	4	20	0	0	10	7	3	6	7	7	20	0
Bambaho	12°05′03"N	35°56′12"E	735	Lowland	4670	45	30	15	37	8	35	1	9	11	20	14	31	10	4	42	3
Total					29792	286	195	91	228	58	222	36	28	88	124	74	138	87	61	251	35

Household = HH; Gender (Male, M; Female, F); Informant type (General Informant, GI; Key Informant, KI); Ethnicity (Amhara, A; Gumuz, G; Agew, Ag); Occupation (Illiterate, Il; Read and Write, RW; Formal Education, FE); Religion (Christian, Ch; Muslim, Mu)

transitions to the midland agroecology, it becomes steep, rugged, and scenic. The lowland area of the district is widely used for investment in Ethiopia, and the main sources of income are mixed crop-livestock systems. These systems involve the production of sesame, sorghum, maize, and cotton, as well as the rearing of livestock such as cattle, goats, and equines [23]. The district's vegetation is categorized under the *Combretum-Terminalia* woodland and wooded grassland vegetation type [26]. Additionally, the area contains other diverse ecosystem complexes, including intact scrublands, riverine vegetation, seasonal wetland vegetation, open wooded grasslands, and hilly area woodlands [27].

Research design

Reconnaissance survey and site selection

The researchers obtained a formal letter from the Vice President for Research and Technology Transfer of the University of Gondar to conduct the study with clearance number 1059/2022. Then, we presented this letter to the Quara district administration office and received permission to proceed with a reconnaissance survey and select sample kebeles for the actual study. The reconnaissance survey was carried out from July 15–22, 2022, in the Quara district.

After the reconnaissance survey, ten kebeles were selected through stratified random sampling, based on the recommendations of district administrators, local authorities, and elders. The selected sample kebeles represented 35.7% of the total 28 kebeles in the Quara district. The criteria for selecting the sample kebeles included the presence of traditional healers, agroclimatic conditions (lowland and midland), ethnic distribution (Amhara, Agew, and Gumuz), and settlement history (local inhabitants and settlers).

Sample size determination and informant selection

To determine representative samples for the study area, Cochran's formula [28] as cited in [29] was used. Accordingly, a total of 286 informants (195 males and 91 females) were chosen (Table 1). Among them, 58 were key informants, while 228 were general informants. The key informants were purposefully selected in consultation with local authorities and elders, as well as using the snowball sampling method. The general informants were selected through a random sampling method, considering factors such as age, sex, cultural background, settlement history, and agroecology.

Data collection

Ethnobotanical information was collected through face-to-face interviews with informants. For this purpose, pre-planned semi-structured questionnaires, and standardized data collection protocols [30–32] were used. Extensive field trips, accompanied by informants, were conducted from August 2022 to October 2023 to identify and collect therapeutic plant species used in the district. The interviews were primarily conducted in the Amharic language, which is the common language of the study area. However, when informants spoke other languages, local translators were engaged. Subsequently, all the documented data were translated into English. The checklist contained questions focused on local names of medicinal plants, their habits, parts used, diseases treated, and mode of preparation and administration.

In addition, for on-site data collection, guided field walks with the informants were carried out, during which notes were taken on local names, plant specimens were collected, and information on habits, habitats, status, and other relevant details of the therapeutic plant species were recorded. Moreover, four focus group discussions were held with seven key informants in each discussion. These discussions covered various topics, such as threats to medicinal plants, conservation practices, antidotes, and dosage following the approach outlined by [33]. The focus group discussions helped to validate the data collected from the informants.

Specimen identification

The collected voucher specimens were authenticated using taxonomic literature, reference voucher specimens, and various books on the Flora of Ethiopia and Eritrea. The identification of the specimens was conducted at the National Herbarium (ETH) of Ethiopia, Addis Ababa University, and at the Herbarium of University of Gondar with the guidance of an expert. The species, genus, and family names were further validated using the Plants of the World Online (https://powo.science.kew.org.) website. Finally, the identified plant specimens were dried, pressed, mounted on herbarium sheets, and deposited at the Herbarium of the Department of Biology, University of Gondar, Gondar, Ethiopia.

Data analysis

For this study, a combination of qualitative and quantitative ethnobotanical methodologies was employed, as proposed by [33, 34]. The ethnobotanical data were entered into an Excel spreadsheet, version 2013, and subjected to comprehensive analysis using descriptive statistical methods, such as percentages, proportions, and frequencies. To determine the impacts of socio-demographic factors on ethnobotanical knowledge, the variables gender, age, education level, healing experience, settlement history, and ethnic background were analyzed using SPSS, version 29 software. The Kruskal–Wallis H test, a nonparametric alternative to

the one-way ANOVA, was performed to examine the relationships among age, education level, and ethnic background categories. The Mann–Whitney U test, a nonparametric alternative to the independent sample t-test, was carried out to compare gender, healing experience, and settlement history. Medicinal plant knowledge was determined in terms of the number of medicinal plants mentioned by different respondents. The quantitative analyses included calculating ethnobotanical indices as described below:

Informant consensus factor (ICF)

The informant consensus factor (ICF) is used to assess the consensus or homogeneity of ethnobotanical information provided by participating informants [35]. The ICF is calculated using the following formula:

$$\mathrm{ICF} = \frac{\mathrm{Nur} - \mathrm{Nt}}{\mathrm{Nur} - 1}$$

where Nur represents the total number of use reports cited for each disease category, and Nt represents the number of species used in that disease category. The ICF value can range from 0 to 1, with 0 indicating no exchange of use information among informants and 1 suggesting a high level of knowledge exchange.

Rahman's similarity index (RSI)

The Rahman's similarity index (RSI) is used to measure the cultural similarities of indigenous knowledge among different communities in various areas. It is based on the common plant species found in those areas and their uses [36]. The RSI is calculated using the following formula:

$$\mathrm{RSI} = \frac{d}{a + b + c - d}$$

where "*a*" is the number of unique species in area *A*; "*b*" is the number of species unique in area *B*; "*c*" is the number of common species in both areas *A* and *B*; and "*d*" is the number of common species used for similar ailments in both areas *A* and *B*. Please note that "*a*" and "*b*" cannot be zero, and "*c*' and "*d*' must be greater than or equal to zero.

To determine the percentage of common uses between two areas, the formula can be expressed as

$$\mathrm{RSI} = \frac{d}{a + b + c - d} \times 100$$

Using a similarity index, the findings of the present work were compared with 32 other similar studies conducted previously with similar vegetation coverage.

Direct matrix ranking (DMR)

To compare multipurpose medicinal plants commonly reported by informants, a direct matrix ranking (DMR) exercise was used. The DMR method, as described by [33, 34], was employed to score the use diversity of selected medicinal plants. Accordingly, eight multipurpose plant species were selected based on their use citations. Of the many multipurpose uses of medicinal plants, eight common uses in the study area were selected for the exercise. A total of twelve key informants were chosen to independently assign use values (5 = best, 4 = very good, 3 = good, 2 = less used, 1 = least used, and 0 = not used). Based on the data obtained from each of the key informants, the given values for each species and use category were added and averaged. Finally, the values for each species and use category were summed and ranked.

Results

Socio-demographics of the informants

The socio-demographic characteristics of the informants were analyzed using statistical tests (Table 2). The Mann–Whitney *U* Test revealed a significant difference ($p < 0.05$) among gender, healing experience, and settlement history. Specifically, the males, key informants, and local inhabitants mentioned a greater number of medicinal plants than females, general informants, and settlers, respectively. The Kruskal–Wallis *H* test revealed a significant difference ($p < 0.05$) among the age categories, education level, and ethnic background. The older members reported more medicinal plants than other age groups. Education-wise, those who could read and write reported a greater number of medicinal plants compared to the other educational categories. Regarding ethnic background, the Gumuz listed more medicinal plants than the other ethnic groups.

Medicinal plant diversity

A total of 128 species of medicinal plants were found in the Quara district for treating human ailments. These species were distributed across 112 genera and 50 families (See Supplementary Material 1). Of the total number of families, 23 families (46%) had two or more species, while the remaining 27 families (54%) had only one species each. The family with the greatest number of species was Fabaceae (22 species), followed by Malvaceae (9 species) and Combretaceae (7 species). In terms of plant habit, trees accounted for 37.5% of the species, whereas climbers (4.7%) had the lowest proportion (Fig. 2).

Plant parts and conditions for preparing remedies

Different plant parts were reported to be used in remedy preparation in the district (Fig. 3). The leaf was the

Table 2 Medicinal plant knowledge of the informants in Quara district (n = 286)

Parameter	Categories	Number	Mean rank	Chi-Square	*P* value
Age	20–39	88	129.50	43.67	0.000*
	40–59	124	121.27		
	> = 60	74	197.41		
Education level	Illiterate	138	140.63	11.430	0.003*
	Read and write	87	164.98		
	Formal education	61	119.35		
Ethnic background	Amhara	222	126.06	48.425	0.000*
	Gumuz	36	221.00		
	Agew	28	182.13		
Gender	Male	195	152.79	7.87	0.005*
	Female	91	123.58		
Settlement history	Local	106	171.16	19.17	0.000*
	Settlers	180	127.21		
Healing experience	Key Informants	58	255.41	135.55	0.000*
	General Informants	228	115.03		

* Shows a significant difference at ($p < 0.05$)

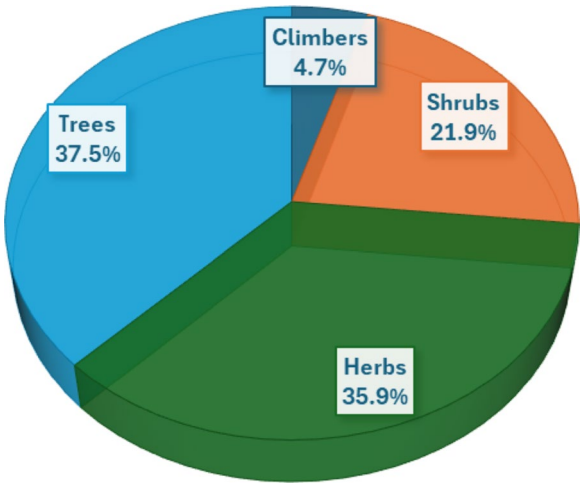

Fig. 2 Habits of medicinal plants in Quara district

most used plant part (23.1%), followed closely by the root (22.8%). Other plant parts like bulb, stem, root bark, flower, resin, seed pod gum, and tuber, accounted for a total of 8.6%. Most of the remedies were prepared using freshly collected plant parts (61.6%), followed by either fresh or dry parts (19.6%), or dry parts (18.8%).

Ailments treated with medicinal plants

The study found that a total of 76 human ailments were treated using the 128 medicinal plant species identified in the district (see Supplementary Material 1). Of the total medicinal plant species, the majority (101 species, 79%) were able to treat two or more ailments, while 27 species (21%) were used to treat single ailments. Some of the plants that demonstrated particularly broad medicinal application included *Ximenia americana, Moringa stenopetala,* and *Terminalia leiocarpa*, each of which was able to treat ten different ailments. Another plant, *Solanum incanum*, was used to treat nine ailments. In addition to using individual plant species, the traditional healers in the study area also combined multiple parts to create remedies for various ailments. A total of 28 plant species were used in two or more combinations for this purpose. For instance, the mixture of the roots of *Securidaca longepedunculata*, *Allium sativum*, *Capparis tomentosa*, *Withania somnifera,* and *Cucumis ficifolius* was powdered and smoked to treat the evil eye. A drink was prepared using a combination of the roots of *Carissa spinarum*, and *Ruta chalepensis,* along with the bulb of *Allium sativum*, to treat snakebites.

Methods of preparation and route of administration of remedies

The communities in the study area utilized a variety of methods to prepare and administer traditional medicinal remedies. The most common preparation methods were extraction (17.5% of preparations), decoction (13.4% of preparations), and paste (10.2% of preparations). Additionally, seven other preparation methods accounted for a total of 5.2% of the remedies (Fig. 4). In terms of routes of administration, over half of the remedies (211 preparations, 56.7%) were administered orally. This was followed by topical application, which accounted for 32.5% of the preparations (121 in total) (Fig. 5).

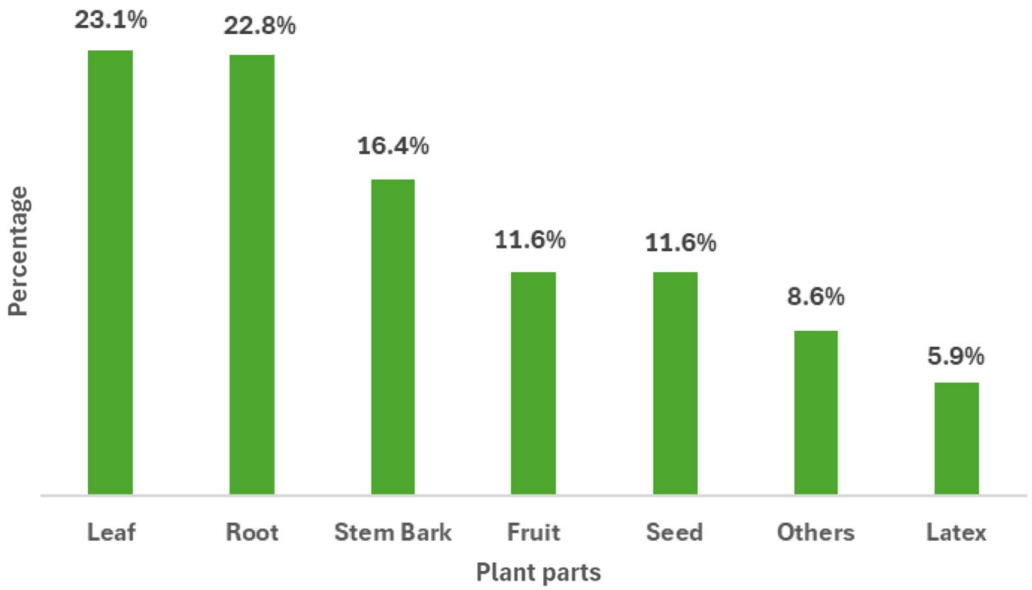

Fig. 3 Plant parts used for remedy preparation in Quara district

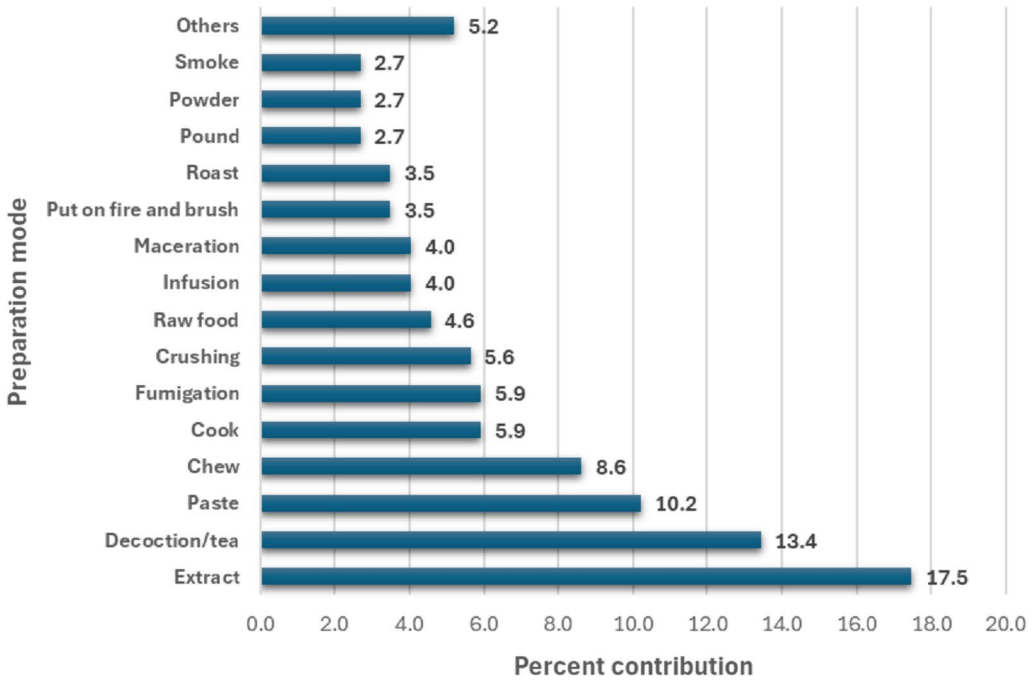

Fig. 4 Methods of remedy preparation in Quara district

Ethnobotanical knowledge distribution among ethnic groups

The study examined the ethnobotanical knowledge and use of medicinal plants across the three main ethnic groups in the district—the Amhara, Agew, and Gumuz using the Venn diagram (Fig. 6). Among the three ethnic groups, 57 plant species were reported by the Agew ethnic group, 70 by the Gumuz, and 107 by the Amhara ethnic groups. Analysis of the distribution of plant resources revealed that 28% of the plants studied overlapped among the three ethnic groups. The pairwise comparisons showed that the Amhara and Gumuz ethnic groups

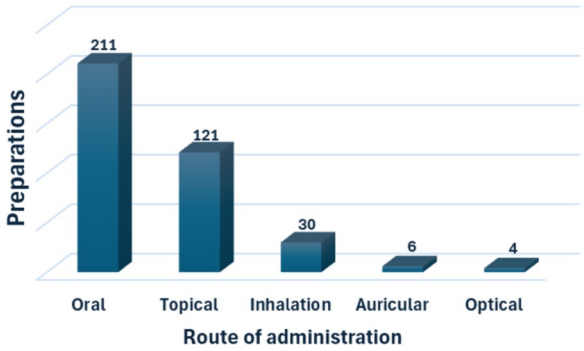

Fig. 5 Route of administration of medicinal plants in Quara district

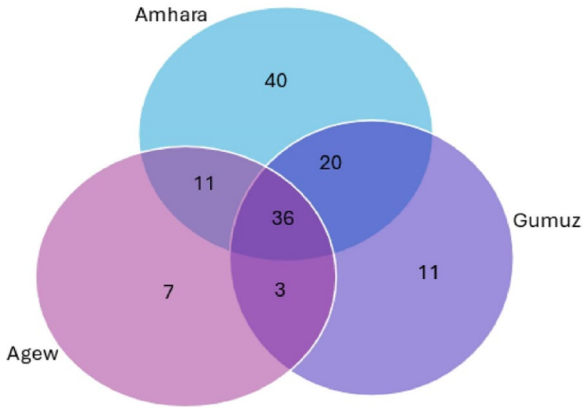

Fig. 6 Venn diagram of medicinal plants among the studied ethnic groups in Quara district

had the highest degree of similarity, sharing 15.63% of their medicinal plant species., followed by the Amhara and Agew groups (8.6%), and the Agew and Gumuz ethnic groups had the lowest overlap, sharing only 2.34% of their medicinal plant species. In total, the three ethnic groups collectively utilized 36 species of medicinal plants in common across the district.

Informant consensus factor

The study calculated the ICF to identify the most effective medicinal plants for treating common ailments in the district. The ICF values were calculated based on disease categories, which were determined using the International Classification of Diseases [37] with some modifications. Overall, 14 disease categories were identified, with ICF values ranging from 0.75 to 0.93 out of a maximum of 1.0 (Table 3). The diseases categories with the highest ICF values were diseases of the circulatory system and blood/blood-forming organs (ICF = 0.93), followed closely by infectious and parasitic diseases, and symptoms, signs, and clinical findings not elsewhere classified both with an ICF value of 0.92.

When analyzing the ICF in terms of the number of use citations and plant species mentioned, the data shows that the diseases and symptoms involving infectious and parasitic diseases (639 use citations, 54 species), diseases and symptoms involving the nervous system (553 use citations, 48 species), and diseases and symptoms involving the digestive system (500 use citations, 60 species) had a greater number of use citations and species compared to other disease categories.

Rahman's similarity index

The present ethnobotanical findings from the Quara district were compared to 32 previously published studies conducted in various parts of Ethiopia using the RSI. The RSI percentage values ranged from 0 to 12.93 across the different studied areas that were compared (Table 4).

Direct matrix ranking exercise

A direct matrix ranking (DMR) exercise was conducted in the Quara district to assess and prioritize the most important medicinal plant species utilized by the local communities (Table 5). The results of the DMR exercise showed that *Ziziphus spina-christi*, *Terminalia leiocarpa,* and *Ficus sycomorus* were the top-ranked medicinal plant species. Furthermore, the DMR exercise also evaluated the various use categories for these plants in the district. Accordingly, use as medicine, livestock forage, and a source of food were the most common use categories in the district.

Novel ethnobotanical findings

The current ethnobotanical study in the Quara district has uncovered several novel findings. Specifically, the research team identified nine medicinal plant species that were reported for the first time in Ethiopia through this study (Table 6). Of these nine newly documented medicinal plants, seven have been previously reported to have medicinal uses in other parts of the world. However, two species–*Dracaena forskaliana* and *Ipomoea biflora*–had not been associated with any known medicinal applications prior to this study. Additionally, the study reported 39 new use cases for medicinal plant species compared to what had been previously documented in other ethnobotanical studies published in Ethiopia (see Supplementary Material 2).

Threats to medicinal plants and conservation efforts

The ethnobotanical study in the Quara district revealed several threats to the sustainability of medicinal plant resources and indigenous knowledge in the area. During group discussions, participants prioritized seven key threats to medicinal plants: use of herbicides/insecticides, human-induced fires, agricultural land expansion,

Table 3 ICF values of plants for treating human ailments in Quara district

Disease categories	Reported diseases	No. of species	Use citations	ICF
Diseases of the circulatory system and blood and blood-forming organs	Hypertension, Anemia	7	86	0.93
Infectious and parasitic diseases	Rabies, tapeworm, amoebiasis, typhoid fever, malaria, athletes' foot, boil, gonorrhea, intestinal parasite, ring worm, scabies, uvulitis, wart, bacterial infection on the tip of a finger, dandruff	54	639	0.92
Symptoms, signs, and clinical findings not elsewhere classified	Sexsomnia, snake repellent, evil eye, evil spirit, hit by the devil	18	215	0.92
Diseases and symptoms involving the nervous system	Headache, snakebite, scorpion sting, spider poison, febrile illness, dizziness	48	553	0.91
Diseases and symptoms involving the digestive system	Toothache, stomachache, constipation, sudden sickness, abdominal bloating, dental caries, gastritis, indigestion, diarrhea, gum bleeding, dysentery, jaundice	60	500	0.88
Diseases of the musculoskeletal system or connective tissue	Bone fracture, gout, rheumatism, back pain, stabbing pain	10	67	0.86
Diseases of the ear or mastoid process and visual system	Ear infection, eye infection, night blindness	5	25	0.83
Diseases and symptoms involving the respiratory system	Asthma, cough, common cold, pneumonia, tonsilitis	20	106	0.82
Injury, poisoning, and certain other consequences of external causes	Food poisoning, stop bleeding, circumcision wound, ear pest, grass seed getting inside ear, swelling on the body, wound healing	35	195	0.82
Conditions related to sexual health	Erectile dysfunction, improves sexual desire	4	17	0.81
Mental, behavioral, or neurodevelopmental disorders	Intoxication, to become brave	3	11	0.80
Pregnancy, childbirth, and the puerperium	Retained placenta, breast engorgement, miscarriage, abdominal bloating after giving birth, uterus sore	7	31	0.80
Diseases of the genitourinary system	Urinary bladder pain, dysuria, kidney stone	3	10	0.78
Endocrine, nutritional, and metabolic diseases	Diabetes	4	13	0.75

construction activities, collection of fuel wood, use of plants for farm implements, and overgrazing. Additionally, the participants mentioned other threats such as the use of medicinal plants for house utensils, informal cross-border trade to neighboring Sudan, deforestation, seasonal migration patterns, and climate change-induced events like drought. The group participants also noted that there were minimal management practices in place for medicinal plants.

To further understand the severity of these threats, we conducted interviews with 12 key informants, who were asked to rank the seven prioritized threats to medicinal plants. The results showed that agricultural expansion was considered the primary threat, followed by the collection of fuel wood and its use for construction purposes (Table 7).

The ethnobotanical study in Quara district has highlighted the significant threats facing several important medicinal plant species due to their extensive and unsustainable utilization. *Ximenia americana* is a vital medicinal plant in the region, with its root used to treat spider bites and diarrhea, and its stem bark used for jaundice and uvulitis. However, the excessive harvesting of the root and stem bark is leading to a concerning decline in the plant's population. Similarly, *Carissa spinarum* is an important medicinal resource, with its root used to treat a variety of common illnesses, including snakebites, evil spirits, and the evil eye. The reported decline in the *Carissa spinarum* population in the area is particularly alarming. *Securidaca longepedunculata* is another highly sought-after medicinal plant, with its root extensively used to treat snakebites, the evil eye, and febrile illnesses. The root of this plant is commonly found in local markets and has even been reported to be illegally exported to neighboring Sudan for medicinal purposes, further exacerbating the threats to its population. *Boswellia papyrifera* is also facing threats due to the utilization of its stem bark for the treatment of scorpion stings, spider bites, and uvulitis, coupled with the various diseases affecting the plant, leading to a decline in its population.

Discussion

Socio-demographics of the informants

The ethnobotanical study conducted in the Quara district has yielded valuable insights into the socio-demographic factors influencing the knowledge and

Table 4 Rahman's similarity index between the present study (Quara district) and previous studies

Study area	NRPAA	PLOAA	PLOOSA	CPBA	CPSU	RSI %	References
Northwest Ethiopia							
Baso Liben and Debre Elias Districts	153	133	108	20	18	7.41	[38]
Zegie Peninsula	67	53	114	14	13	7.74	[39]
Dibatie and Guangua Districts	76	68	120	8	7	3.70	[40]
Enarj Enawga District	111	103	120	8	1	0.43	[41]
Chilga District	44	32	116	12	11	7.38	[42]
Metema district	29	3	102	26	15	12.93	[43]
Northern Ethiopia							
Kilte Awulaelo District	107	88	109	19	18	9.09	[44]
Asgede Tsimbila District	68	53	113	15	12	7.10	[45]
Adwa District	115	80	93	35	18	9.47	[46]
Erob and Gulomahda Districts	114	95	109	19	19	9.31	[47]
Delanta District	82	67	113	15	12	6.56	[48]
Raya Kobo District	71	45	102	26	10	6.13	[7]
Northeast Ethiopia							
Asagirt District	98	76	106	22	12	6.25	[49]
Kalu and Bati Districts	129	121	120	8	6	2.47	[50]
North central Ethiopia							
Habru District	134	105	99	29	24	11.48	[51]
Southern Ethiopia							
Amaro and Gelana Districts	112	98	114	14	12	5.61	[52]
Suro Barguda District	87	70	111	17	4	2.06	[13]
South Central Ethiopia							
Anlemo, Duna, Gibe, Gombora and Yem Districts	166	147	109	19	18	7.00	[53]
Hawassa, Shashemene, and Dilla Districts	189	147	86	42	25	10.00	[54]
Southwest Ethiopia							
Seven Districts	274	238	92	36	16	4.57	[55]
Southeast Ethiopia							
Dheeraa'Town	83	74	119	9	6	3.06	[56]
Nensebo District	112	102	118	10	8	3.60	[57]
Western Ethiopia							
Jibat, Chalia and Dendi Districts	172	160	116	12	10	3.60	[58]
Kaba district	129	117	116	12	9	3.81	[59]
Mandura District	60	49	117	11	7	4.12	[60]
Menge and Komehsa Districts	40	35	123	5	3	1.88	[61]
Central Ethiopia							
Basona Werana District	70	66	124	4	2	1.04	[62]
Ensaro District	101	88	115	13	12	5.88	[63]
Tarmaber District	97	85	116	12	11	5.45	[64]
Zay People	33	28	123	5	4	2.63	[65]
Artuma Fursi District	82	54	100	28	11	6.43	[66]
Mojana Wadera District	52	45	121	7	0	0.00	[67]

NRPAA: number of reported plants in the aligned areas, PLOAA: Plants listed only in the aligned areas (a), PLOOSA: Plants listed only in our study area (b), CPBA: Common Plants in Both Areas (c), CPSU: Common Plants with Similar Uses (d), % RSI: % of Rahmna's similarity index

utilization of medicinal plants in the local community. Accordingly, the study found that men were more knowledgeable about medicinal plants than women. In the study area, men were more likely to be exposed to social affairs, which facilitates their acquisition of knowledge. Our data support the findings of [75, 76] who reported similar outcomes.

Table 5 DMR of eight multipurpose medicinal plant species in the Quara district

Medicinal plants	Use categories								Total	Rank
	Co	Fu	LF	Md	Fo	FW	FI	Fe		
Azadirachta indica	1.7	0.8	0.4	4.8	1.6	2.3	1.3	2.0	14.8	8th
Stereospermum kunthianum	2.0	1.8	2.0	3.9	0.0	2.0	3.6	2.6	17.9	6th
Terminalia leiocarpa	4.8	3.6	4.1	2.8	0.0	4.7	3.2	4.8	27.8	2nd
Ficus sycomorus	0.8	2.5	4.3	2.9	4.3	3.2	1.8	2.3	22.2	3rd
Carissa spinarum	0.9	0.7	2.3	4.6	4.3	2.8	0.4	4.0	19.8	4th
Ziziphus spina-christi	2.5	4.2	5.0	3.8	4.6	3.9	3.3	4.8	32.0	1st
Ximenia americana	0.3	1.4	2.6	3.3	4.9	3.1	2.3	1.5	19.4	5th
Moringa stenopetala	0.0	0.3	4.3	4.9	3.7	1.0	0.3	0.4	14.9	7th
Total	13.1	15.3	24.9	30.8	23.3	22.9	16.3	22.3		
Rank	8th	7th	2nd	1st	3rd	4th	6th	5th		

N.B. Scores in the table indicate average values of ranks given to medicinal plants based on their use diversity. Co = Construction, Fu = Furniture, LF = Livestock forage, M = Md, Fo = Food, FW = Fuel wood, Farm implements = FI, Fence = Fe

Table 6 Plants reported to treat ailments in Quara district for the first time in Ethiopia

Scientific name	Ailments treated in the current study	Reports from other parts of the world
Abelmoschus ficulneus	Constipation, intestinal parasite, back pain	Indigestion [68]
Combretum hartmannianum	Malaria, amoebiasis	Underweight [43], Wound healing, urinary tract infections, rheumatism, headache [69] Eczema,
Dioscorea praehensilis	Diarrhea	Diabetes [70]
Dracaena forskaliana	Ear infection	–
Grewia flavescens	Swelling on the body, constipation	Malaria and diabetes [71]
Ipomoea biflora	Gastritis	–
Keetia gueinzii	Scabies	Asthma, pneumonia, coughing, allergy [72]
Sterculia setigera	Scorpion sting	Stomachache, heart trouble, and cough [73]
Strychnos innocua	Snakebite, stomachache	Skin infections, candidiasis [74]

Table 7 Ranking of threats to medicinal plants in Quara district

Threats	Key informants												Total score	Rank
	KI1	KI2	KI3	KI4	KI5	KI6	KI7	KI8	KI9	KI10	KI11	KI12		
Use of herbicides/insecticides	1	1	2	2	1	2	1	1	1	2	2	1	17	7th
Human-induced fire	2	2	1	1	2	1	3	3	3	1	1	2	22	6th
Agricultural land expansion	7	7	7	7	7	7	7	7	7	7	7	7	84	1st
Construction	5	4	5	4	5	5	5	5	5	4	4	5	56	3rd
Fuel wood	6	6	6	6	6	6	6	6	6	6	6	6	72	2nd
Farm implements	4	5	4	5	3	3	2	2	2	3	5	4	42	5th
Over grazing	3	3	3	3	4	4	4	4	4	5	3	3	43	4th

It was also found that older informants, aged 60 years and above, demonstrated a higher level of knowledge of medicinal plants compared to the younger age groups (20–39 years and 40–59 years). This aligns with the findings of previous research [46], which suggest that the older generation's extended cultural exposure, exchange, and practical experience contribute to their greater knowledge in this domain. Studies also identified a concerning trend that the indigenous knowledge on the use of medicinal plants is deteriorating due to the passing away of the knowledgeable older generation before they can effectively transfer their knowledge to the next generation [49, 77, 78]. This challenge is exacerbated by the younger generation's lack of interest in learning from

their elders. As a result, there is a risk of losing this invaluable indigenous wisdom as the older members of the community pass away.

Among the three informant groups categorized by educational level, those who could read and write cited the highest number of medicinal plants, followed by illiterate informants, and those with formal education. This finding is consistent with other studies [49, 78], which suggest that lower levels of education are associated with greater knowledge of medicinal plants, possibly due to the impact of modern education [10]. The ability of those who can read and write to recall and utilize the medicinal plants they are familiar with may be connected to their overall higher level of knowledge compared to the illiterates. This finding highlights the complex interplay between formal education, literacy, and the retention and application of traditional medicinal plant knowledge.

Key informants, such as herbal practitioners, cited more medicinal plants than the general informants, reflecting their full-time experience in utilizing these plants for treatment, as supported by previous research [49]. Although settlers (both formal and informal) and local inhabitants coexist harmoniously, the local inhabitants mentioned a larger number of medicinal plants compared to settlers. This could be because local inhabitants have lived in the area for a longer period and are therefore more familiar with the plants that grow there. The Gumuz ethnic group was found to be the most knowledgeable about medicinal plants compared to other ethnic groups in the study area. This can be attributed to the Gumuz people's heavy reliance on flora and fauna for their health and everyday survival, as well as the exchange of indigenous knowledge, particularly medicinal plant knowledge, within their community and with neighboring Sudan.

Medicinal plant diversity

The study identified a rich diversity of medicinal plants used to treat human ailments in the Quara district, with a total of 128 medicinal plant species documented. This figure exceeds the counts reported in recent ethnobotanical studies conducted in other parts of Ethiopia. As an example, studies in the Raya Kobo [7], Suro Barguda [13], Artuma Fursi [66], Asagirt [49], and Ensaro [63] districts recorded 74, 98, 92, 103, and 101 medicinal plant species, respectively. Several factors may contribute to the greater number of medicinal plants utilized in the Quara district. These include ethnic diversity in the area, and the influx of settlers from different parts of the Amhara region; the rich plant diversity, particularly due to the presence of communal forest areas; the district's proximity to Sudan, which has facilitated the exchange of indigenous knowledge; the remote location of the area and inadequate access to formal healthcare, leading the community to rely more on traditional medicine; and the prevalence of various human ailments, such as febrile illness, evil eye, evil spirit, snakebite, spider sting, tonsillitis, wound healing, intestinal parasites, diarrhea, and amoebiasis, which may necessitate the use of a broader range of therapeutic plant species (see Supplementary Material 1). Furthermore, the large number of recorded medicinal plant species emphasizes the continued relevance and indispensability of plant-based remedies in fulfilling the primary healthcare requirements of the population, particularly in areas with limited access to conventional medical services.

The dominance of the Fabaceae family among the medicinal plants identified can be attributed to the evolutionary adaptations of this plant family in the local environment. The ability of Fabaceae species to form symbiotic relationships and thrive in nitrogen-deficient soils, as well as their capacity to develop extensive root systems and outcompete other plants for resources, provides them with a competitive advantage in the area [79, 80]. This finding is consistent with previous ethnobotanical studies conducted in Ethiopia [49, 78, 81], and other parts of the world [82–84].

Regarding the habit of medicinal plants, the study found that the people of the Quara district utilized trees and herbs in nearly equal proportions. This observation aligns with the findings of a previous ethnobotanical study conducted in Ethiopia [78, 85], where a similar pattern was reported. However, it is important to note that in some other ethnobotanical studies, shrubs were reported to be the most widely used medicinal plant habit [13, 66, 75]. This variation may be attributed to differences in the local plant community composition and ecological conditions. Lowland areas with sufficient rainfall, like the Quara district, are typically dominated by woody species, forming woodlands, which could explain the prominence of trees and underneath herbs as medicinal plants in the present study.

Plant parts and the conditions for preparing remedies

The study found that the most commonly used plant parts for remedy preparation were leaves, followed closely by roots. This observation is consistent with the findings of many other ethnobotanical studies conducted in Ethiopia [13, 46, 77, 78] and globally [83, 86]. The predominant use of leaves for remedy preparation in the study area can be attributed to several factors such as easy accessibility, abundantly availability, and their primary site for the accumulation of many bioactive compounds. Furthermore, picking leaves has less effect on the plant species' survival. While roots have been reported as the most frequently used plant parts in a few other

studies [75, 82, 87], the extensive use of roots can pose a risk to the long-term survival of medicinal plant populations [8, 88].

Consistent with previous studies conducted in Ethiopia [10, 49, 89], the majority of the remedies in the Quara district were prepared using fresh plant parts. The use of fresh plant materials is generally associated with higher efficiency of the bioactive components [75]. However, the fact that most of the medicinal plants in the study area were trees, and the fresh parts were primarily collected, suggests that the availability of remedies may have been limited to certain seasons of the year, as many trees shed their leaves during the dry season.

Ailments treated with medicinal plants

The analysis of the data on the diversity of medicinal plant use revealed that more than three-quarters of the identified species were employed to treat multiple diseases. This finding suggests a widespread adoption and utilization of these medicinal plants by the local community, which agrees with [90]. The versatility of many medicinal plants reported in this study for treating different health conditions may be attributed to the combined action of the various bioactive constituents present in these plants. In association with this finding, [91] reported that the synergistic effects of the different medicinal components can potentially enhance the catalytic activity and facilitate the absorption of the beneficial compounds in the human body. These findings highlight the need for further scientific investigation into the phytochemical profiles and pharmacological properties of these versatile medicinal plants. Unraveling the underlying mechanisms that enable certain medicinal plants to treat a diverse array of ailments can contribute significantly to the development of more effective and holistic traditional medicine practices. This knowledge can be instrumental in improving the overall health and well-being of the local population.

Methods of preparation and route of administration of remedies

The study found that the most frequent methods of preparing medicinal remedies in the Quara district were extraction, decoction, paste, and chewing. These preparation methods align with the findings of previous ethnobotanical studies conducted in different regions [51, 92, 93]. The informants reported that there was no standardized approach to administering the remedies, and the method varied depending on factors such as the patient's age and health condition. This observation is consistent with the findings of other studies [94], indicating the flexibility and patient-specific nature of traditional medicine practices. Oral administration was identified as the primary route of delivering herbal remedies in the Quara district. This observation is in line with the findings of other ethnobotanical studies, which have also reported the oral route as the predominant mode of administration for traditional medicines [49, 95]. The diversity of preparation techniques and administration routes observed in the study highlights the depth of traditional knowledge within the local community. Healers and practitioners likely adjust their approaches based on the specific needs and conditions of the patients, drawing from a wealth of experiential knowledge accumulated over generations.

Ethnobotanical knowledge distribution among ethnic groups

The study found that more than a quarter (28%) of the medicinal plants were mentioned across all three ethnic groups. However, the Amhara ethnic group reported a greater number of medicinal plants compared to the other groups. The higher mention of medicinal plants by the Amhara is likely due to their large population size and extensive agricultural land coverage in the area. Additionally, the seasonal movement of the Amhara people from neighboring highland districts to Quara for farming and livestock rearing may have facilitated the sharing of medicinal plant knowledge within their community. In contrast, the Agew ethnic group reported a smaller number of medicinal plants, possibly due to the secretive nature of their traditional knowledge, which is a common phenomenon observed in many traditional communities. The findings of this study, as well as several previous studies [96–98], emphasize that the diversity of medicinal plant knowledge is often influenced by the ethnicity and cultural background of the communities. These insights underscore the importance of considering the ethnic and cultural context when documenting and understanding traditional medicinal plant knowledge.

Informant consensus factor

The study reported ICF values ranging from 0.75 to 0.03 indicating a strong consensus among the informants regarding the therapeutic uses and efficacy of certain medicinal plant species, as described in [99]. The highest ICF value of 0.93 was observed for diseases related to the circulatory system and blood/blood-forming organs. This aligns with findings from other studies [100, 101] and suggests that the local community has confidence in the medicinal plants of the study area for treating these types of conditions. Specifically, hypertension and anemia were the two diseases highlighted in this high consensus category, with 71 and 15 use citations, respectively. Among the three species reported to treat hypertension, *Moringa stenopetala* had the most citations, with 67 use reports. The informants mentioned that hypertension can be

effectively treated by boiling the leaves of *Moringa stenopetala* and consuming the resulting decoction as tea.

The second-highest ICF value was recorded for the category of infectious and parasitic diseases. This finding is consistent with the results reported in [102], which found high ICF values for viral, fungal, bacterial, and other parasitic infections. Within this category, Malaria had the highest number of use reports, with a total of 118 use reports. *Azadirachta indica* was the most cited species for treating malaria. The highest use report of *Azadirachta indica* could be attributed to its ability to adapt to local environments and its effectiveness in conventional uses. Informants indicated that malaria can be treated by either boiling the plant parts or consuming the decoction once it has cooled or by crushing the stem bark, adding water, and drinking the resulting fluid.

The use of multiple species reported for diseases and symptoms related to the digestive system is likely attributed to factors such as malnutrition, poor hygiene, irregular dietary routines, and contaminated drinking water [103]. A high ICF can be an indication of potentially effective medicinal plants [35]. These findings indicate that the local community has a well-established and shared knowledge base regarding the therapeutic efficacy of certain medicinal plants, particularly for circulatory and blood-related conditions. This high level of consensus can help prioritize these medicinal plants for further phytochemical and pharmacological investigations, as well as inform the development of culturally relevant healthcare interventions.

Rahman's similarity index

The highest RSI of 12.93% was found in a study carried out in the Metema district of northwestern Ethiopia [43]. This was followed by studies in the Habru district of northcentral Ethiopia with an RSI of 11.48% [51] and in the Hawassa, Shashemene, and Dilla districts of southcentral Ethiopia with an RSI of 10% [54]. Northern Ethiopian districts like the Adwa (RSI = 9.47%) [46], the Erob and Gulomahda districts (RSI = 9.31%) [47], and the Kilte Awulalo district (RSI = 9.09%) [44] also had higher RSI values. The RSI gradually decreased from the northern, northwestern, northcentral, and southcentral regions to the western, southwestern, southern, southeastern, and northeastern regions of the country.

The high RSI between the current study and Metema district [43] can be attributed to the geographical proximity of these two neighboring districts. The similarities observed with other regions in the northwestern, northern, northcentral, and northeastern parts of Ethiopia can be explained by factors such as geography, cultural practice, and vegetation coverage [82, 104]. The gradual decrease in RSI from the northern to southern areas is likely influenced by the distance and geographical barriers that impede the exchange of information on the use of ethnomedicinal plants [82, 105]. These findings suggest that the use of traditional medicinal plants is more homogeneous in geographically proximate and culturally similar regions, while diversity increases with distance and geographic barriers. This highlights the importance of considering regional and cultural factors when studying traditional plant-based healthcare practices.

Direct matrix ranking

The DMR exercise helped to determine the most heavily used multipurpose plant species in the Quara district, as well as the factors posing a threat to these plants. Accordingly, the top three most used multipurpose plant species were *Ziziphus spina-christi*, *Terminalia leiocarpa,* and *Ficus sycomorus*. These plants are currently exploited primarily for their medicinal properties rather than their non-medicinal uses. This finding aligns with previous research [106] that highlighted the use of medicinal plants for medicinal purposes as the primary threat among the five threats evaluated in the DMR exercise. The specific plant parts utilized for medicinal purposes play a crucial role in determining whether a plant is at risk. For instance, the root, root bark, and stem bark of *Ziziphus spina-christi* are used for various ailments, increasing the susceptibility of this plant to threats. Similarly, the stem and stem bark of *Terminalia leiocarpa* are utilized for treating different ailments, leading to its vulnerability. The findings from the DMR exercise suggest that the overexploitation of these multipurpose plants, particularly for their medicinal uses, poses a significant threat to their sustainability in the Quara district. This highlights the need for conservation strategies that consider the balance between medicinal and non-medicinal uses of these important plant resources.

Novel ethnobotanical findings

Out of the 128 medicinal plant species identified in the current study, 80 of them had been previously reported to have the same uses. This suggests a strong cultural exchange of traditional plant-based healthcare practices among communities across Ethiopia [55]. From the remaining 48 species, there were nine new reports of medicinal plants in Ethiopia, highlighting the incredible biodiversity of the area studied. Notably, two of these medicinal plants–*Dracaena forskaliana* and *Ipomoea biflora*–were not reported elsewhere in the world, making them novel global discoveries as well. The identification of these two species as new medicinal plants is particularly remarkable, as it suggests that the traditional health practices of the local communities in the Quara district encompass the utilization of plant resources that

have not been recognized for their medicinal properties elsewhere. These discoveries expand the existing knowledge of traditional medicinal applications of plants in the Quara district. In addition to the new medicinal plant species, the study also reported 39 new use cases for plants that were already known. For instance, the study revealed that the leaf of *Rumex nepalensis* is used to treat malaria, whereas previous studies had reported its use for 24 different ailments [29, 30, 39–42, 45–47, 49, 51, 58, 59]. Similarly, the study found that the root of *Albizia gummifera* is chewed for snakebite treatment, whereas earlier studies had reported its use for 23 different ailments [43, 46]. Furthermore, the present study identified *Amaranthus caudatus* as a medicinal plant used for treating anemia, in contrast to the nine previously reported uses, including constipation, wound healing, febrile illness, urinary problems, common cold, malnutrition, rheumatism, stomachache, and diarrhea [29, 45, 47, 50].

The researchers were able to uncover these previously unmentioned medicinal plants and discover new uses for known plants by performing ethnobotanical investigations from an ethnic-based perspective and exploring new areas. Similarly, another study [107] reported new medicinal plant species by taking an ethnic-based approach in an area previously not studied. The discovery of these previously unreported medicinal plants in the Quara district highlights the potential for further documentation and exploration of traditional ethnobotanical knowledge in Ethiopia. To validate the efficacy of these newly reported uses and plants, further phytochemical research is needed. This research has the potential to provide valuable insights into medical sciences [108] and strengthen the traditional medicinal practices that have been passed through generations [107].

Threats to medicinal plants and conservation efforts

The greatest threat to medicinal plants in the district is agricultural land expansion, consistent with previous research in Ethiopia [10, 106, 109]. Other reported threats include deforestation, habitat loss, drought, furniture production, informal export, settlement, land degradation, and encroachment on communal forests. The main drivers of this agricultural land expansion are population pressure and low land productivity. The unsustainable exploitation of specific medicinal plants, such as *Ximenia americana*, *Carissa spinarum*, *Securidaca longepedunculata*, and *Boswellia papyrifera*, threatens their status. To address this, it is crucial to implement awareness programs and conservation education involving stakeholders and local communities to prevent disruptions in the population dynamics of these threatened species. However, the study area currently has limited conservation and management practices for medicinal plants. The local community's reported conservation efforts include cultivating plants in home gardens and preserving them in agricultural lands.

Beyond their medicinal applications, the medicinal plant species documented in this study also serve a multitude of other vital purposes within the local communities. These plants are cultivated and utilized for their aesthetic value, as living fences, as sources of food, and shade, and as fuel for firewood. This diverse spectrum of uses underscores the deep cultural and ecological significance of these natural resources. Strengthening the existing conservation and management practices surrounding these medicinal plants is, therefore, essential for ensuring their long-term sustainability and continued availability to the local population. Safeguarding these invaluable natural resources is not only crucial for preserving traditional medicine knowledge and practices, but also plays a critical role in bolstering food security within the area. This study contributes to environmental protection by prioritizing the major threatening factors to the study area's natural resources. Identifying these key threats can help halt further degradation of the environment and enable the development of appropriate conservation and management strategies. This, in turn, will aid in protecting against the loss of species and other natural resources in the study area and similar environments.

Conclusion

This comprehensive study represents the first detailed exploration of indigenous ethnomedicinal knowledge in the Quara district of Northwestern Ethiopia. The documentation of 128 medicinal plants used to treat 76 common ailments across 14 disease categories highlights the rich diversity of plant resources employed for healthcare purposes. This finding underscores the importance of further exploring and preserving the indigenous knowledge of medicinal plant use.

The study also highlights the ethnic distribution of medicinal plant knowledge, with the Amhara, Gumuz, and Agew ethnic groups contributing to the documentation of medicinal plant species. This underscores the importance of cultural diversity and the role of different communities in preserving and sharing traditional knowledge. The high ethnobotanical indices of certain plants suggest the need for further phytochemical and pharmacological investigations to uncover their medicinal properties and potential use in drug development.

Furthermore, this ethnobotanical investigation in the Quara district has uncovered both new medicinal plant species as well as new use reports that were previously undocumented. This makes it a valuable contribution to the understanding of traditional plant-based healthcare

practices in Ethiopia, indicating the potential for further exploration and discovery of novel remedies. The comparison with previous studies in neighboring areas shows a high degree of use similarity, highlighting the shared traditional knowledge and practices in the region.

The findings of this study also have implications for conservation efforts. The identification of threats to medicinal plants, such as agricultural land expansion and fuelwood use, underscores the need for integrated conservation strategies. Protecting and sustainably managing these plant resources is crucial to ensure their availability for future generations and to address the challenges they face.

Overall, this ethnobotanical study provides valuable insights into the traditional use of medicinal plants in the Quara district, Northwestern Ethiopia. The documentation of plant species, their therapeutic uses, and the associated traditional knowledge contributes to our understanding of the local healthcare system and provides a foundation for further research and conservation efforts. The study highlights the importance of preserving cultural diversity, promoting interdisciplinary collaboration, and integrating traditional medicine with modern healthcare practices for the benefit of local communities and the broader field of medicine.

Abbreviations

DMR	Direct matrix ranking
QDOA	Quara district office of agriculture
ICF	Informant consensus factor
RSI	Rahman's similarity index

Supplementary Information

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Supplementary Material 1: List of medicinal plant species used by the communities of the Quara district, Northwestern Ethiopia.

Supplementary Material 2: New therapeutic uses of medicinal plants reported in this study.

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Author contributions

DT was involved in the proposal write-up, field data collection, specimen identification, investigation, and writing the first draft of the manuscript. GM helped in incorporating insight and valuable comments during the proposal write-up, field data collection, and the final manuscript preparation. EL helped in the proposal write-up, field data collection, specimen identification, and the final manuscript preparation. All the authors read and approved the final manuscript.

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Availability of data and materials

The necessary data collected for this study was analyzed and included in this manuscript, and its supplementary information files are attached as Supplementary Material 1, and Supplementary Material 2.

Declarations

Ethics approval and consent to participate

This research was approved by all the concerned bodies at University of Gondar, Ethiopia. All participants were informed about the purpose of this research and verbal consent was reached between the investigators and participants before conducting the research.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Author details

[1]Department of Biology, College of Natural and Computational Sciences, University of Gondar, Gondar, Ethiopia. [2]Department of Plant Sciences, College of Agriculture and Environmental Sciences, University of Gondar, Gondar, Ethiopia. [3]Department of Plant Biology and Biodiversity Management, College of Natural and Computational Sciences, Addis Ababa University, Addis Ababa, Ethiopia.

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