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Original article

Prospects of the sustainability of traditional and ethnic foods and their applications for basic health care in human society

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ABSTRACT

Background: Traditional and ethnic foods, rooted in centuries-old practices, have long been revered for their potential health benefits. In contemporary society, the sustainability and application of these foods for basic health care are garnering increased attention, offering promising prospects for holistic well-being.
Methods: In our research, we aimed to document the medicinal plants utilized by the indigenous community residing within the study area. Between 2021 and 2022, interviews were conducted with 457 participants, with 100 of them being identified as key informants. The snowball sampling technique was utilized to identify respondents. A group discussion was also held concerning the conservation and challenges associated with medicinal plants and traditional wisdom. The medicinal plants were assessed by applying various quantitative metrics, including Use Value (UV), Fidelity Level (FL), Informant Consensus Factor (ICF), Relative Frequency Citation (RFC) and Relative Popularity Level (RPL).
Results: The study identified 40 medicinal plant species from 22 different families that are employed to treat 33 unique human ailments. It was observed that perennial herbs accounted for 78% of these species in use. The leaves were shown to be the primary plant part in use, accounting for 35% and decoction was determined as the most prevalent preparation method. Some plants, such as *Polygonum plebejum* with the highest UV and RI values, and *Centaurium pulchelum* known for its use in treating jaundice with the highest RFC, were highlighted. In contrast to the findings presented in earlier literature, our study revealed a 14% concurrence rate, accompanied by a 6% disparity rate, and notably, 69% of the usages were newly documented.
Conclusion: This research serves as the inaugural quantitative investigation into ethnomedicinal practices within the study area, underscoring the importance of indigenous herbal treatments. The sustainability of traditional and ethnic foods offers promising prospects for the future of health care in human society. These foods, rooted in age-old wisdom, not only preserve cultural heritage but also present holistic health benefits. Embracing them can lead to more natural, accessible, and effective health solutions, bridging the gap between traditional wisdom and modern healthcare needs.

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1. Introduction

Exploration of ethnobotanical traditions is crucial for comprehending and addressing food and nutritional security challenges. Plants go beyond medicinal applications, offering essential nutrients that support underserved communities worldwide. Recognizing the significance of indigenous plant species through ethnobotanical studies can lead to the discovery of novel medicines. Therapeutic plants are indispensable to diverse populations globally. Worldwide, an estimated 35,000 to 70,000 plant species are employed in traditional healing practices. Due to their cost-effectiveness and safety, 60 to 80 percent of the global population resorts to plant-based remedies over allopathic treatments (Amjad et al., 2020). The WHO suggests that roughly 21,000 plant species have potential nutritional benefits (Bulut et al., 2017). Enhanced understanding of ethnobotany has amplified the efficiency of plant testing, fostering advances in food and medicine production. The rich indigenous ethnobotanical wisdom is under threat due to the current generation's decreasing plant knowledge (Raja et al., 2020). Research in ethnomedicine reveals modern medicines sourced from indigenous plant resources. Present-day pharmacopeias claim that 25 % of herbal medications originate from plants and numerous synthetic drugs are manufactured using compounds derived from these plants (Umair et al., 2017). All over the world, therapeutic plants are used for medicinal purposes. from their valuable therapeutic and medical components, practically every country has benefited. Plant remedies have played a distinctive role in healthcare systems from the stone age to the present. The Rigveda, written between 4500 and 1600 BCE, and Ayurveda, written between 250 and 600 BCE, both mention the first ethnomedicinal plant in subcontinental history (Siddique et al., 2021). Communities have relied on traditional food sources as the foundation of their diets. The World Health Organization defines indigenous food practices as a wealth of knowledge and skills grounded in the experiences and cultures of various communities, irrespective of their scientific validation· Important phytonutrients from food plants, such as flavonoids and tannins, have significant health benefits. With global health trends leaning towards natural food sources perceived as safer than processed foods, these plants hold economic promise (Qaseem et al., 2019). Modern diets derive a significant portion of their nutrients from these plants. Yet, the documentation and understanding of such traditional foods remain limited. In the ethnobotanical study, the identification of the plant and its parts to heal various diseases can be set out. Traditional medicinal plant practices are extremely important, and there is a need to preserve this knowledge to advance medication discovery and development in the future. Almost 88 % of people in poor nations, such as Pakistan, India, Thailand, Mexico and Nigeria rely on ethnomedicinal flora for the cure of various ailments. The flora of Mentha is generally found in North America, Europe, Africa, Australia and Asia among other natural therapeutic resources. Pakistan contains around 6,000 higher plant species, with just 12 % of them being used medicinally (Usman et al., 2021).

Medicinal herbs can be used to cure both human and animal problems. Women are the primary collectors of medicinal herbs followed by children. However, over-collection has resulted in the extinction of some species in the Hindu Kush-Himalayan region. Ethno-botanical surveys are frequently done to assess the complicated relationship between communities and wild plant species. These kinds of investigations aid experts in the identification of fresh medications derived from herbs (Usman et al., 2021). Since 1950, there's been a surge in discovering the nutritional value of new plant-based foods (Farooq et al., 2019). Many modern diets incorporate elements from traditional food sources. However, this knowledge, mainly passed down through oral traditions, is at risk of being lost, as younger generations show less inclination toward learning about it (Majeed et al., 2020). Hence, preserving this indigenous knowledge is vital not just for developing healthier diets but also for ensuring food security. The dissemination of information about these nutritional plants through literature and media plays a pivotal role (Farooq et al., 2019). Utilization of plants, habitat, life form, color, abundance, physical traits and combinations are all prevalent factors in this case (Gonfa et al., 2020). Numerous medicinal plants are extremely effective against respiratory diseases internationally and in other parts of Pakistan, therefore they naturally have a variety of advantages for people. Plants include internal and externally secreting secondary metabolites that are connected to antimicrobials and antibacterial, such as phenol, tannins, alkaloids, steroids, resins and gum (Afzal et al., 2021). It is commonly acknowledged that using conventional or allopathic medications incorrectly can have serious consequences but using herbal or botanical medications is thought to be more cost-effective, pure, accessible and safe (Majeed et al., 2020). *Arum maculatum* leaves are highly dangerous when eaten raw, but if prepared properly, they can be used in cooking to treat kidney stones, digestive problems and soreness in the muscles. Fresh roots of *Thymbra spicata* are frequently found at bazaars in the spring and its young leaves are pickled and used in salads, particularly for breakfast. Additionally, this herb is tasty and particularly powerful against digestive tract issues (Uzun and Koca, 2020). This herbal medicine refers to healing philosophies, practices and beliefs that combine manual treatments, dietary regimens, mind–body approaches, spiritual therapies and herbal medications to cure, diagnose and prevent disease and maintain health. This healing method also demonstrates the continuous relationship between Islamic medical practice and Prophetic teachings (Hadith), as well as the emergence of regional herbal remedies from specific geographic and cultural origins (Tounekti et al., 2019). Historically, it has been believed that for many years, medicinal herbs are the main resource for both the prevention and therapy of illnesses in livestock. A lot of research has been done the research on use of the herbal medicines and their derivatives to treat various maladies in livestock (Siddique et al., 2021). Herbal medicine is a natural remedy used to treat and manage skin conditions. Herbal anti-skin medications have a variety of beneficial qualities, such as little side effects and affordable treatment options with high levels of efficacy. Particularly in many communities of poor nations where residents rely upon medicinal plants for the cure of different diseases. Because of the geographic location of Pakistan, this area has a diverse range of therapeutic plants, that the locals use to treat their cattle. The bulk of people are rural dwellers who rely on agriculture and ethno-medical herbs as their main source of income (Afzal et al., 2021). Ethno-medicinal knowledge is a vital cultural legacy of a region which includes knowledge about how man uses and manages floral diversity pharmacologically. World Health Organization (WHO) defines traditional medicine is defined as the skills, knowledge, beliefs and procedures employed by any community to treat illness. The use of herbal medicines as complementary therapies to traditional medicine has grown globally (Saleem et al., 2017). Modern medicines are made up of about 25 % of medicinal herbs. Due to the incomplete studies and inventory of herbal medicines utilized by locals, traditional and ethnic medicinal plant information is extremely insufficient. Since 1950, the Food and Drug Administration (FDA) has approved around 1200 new drugs (Tamang et al., 2021).

A biodiversity hotspot for medicinal plant species is the Himalaya region, which comprises parts of Pakistan, Bangladesh, Afghanistan, China, Myanmar, Bhutan, Nepal, and India. Pakistan is Asia's seventh-largest producer of medicinal herbs. Over 75 % of the native population in Pakistan uses therapeutic herbs as their primary or only source of healthcare and there are about 600 species that are utilized in traditional medicine there (Hussain et al., 2022). Pakistan, with its rich ecological diversity, holds a plethora of plants that can address both nutritional and medicinal needs. The country exports numerous herbs while trading in various plant-based foods. Remarkably, 85 % of these plants are sourced from the wild (Shaheen et al., 2014). Tehsil Fort Abbas, in southern Punjab, is known for its diverse ecosystems, from the Cholistan desert to fertile lands, all rich in plant species. This study aims to document and highlight the plants of the Tehsil Fort Abbas region that traditionally contribute to the diets of its inhabitants. Our objectives encompass (i) identify and enlist the medicinal plants, their modes of consumption, the

parts utilized and preparation methods **(ii)** Our objective is to explore the connection between the plants and traditional knowledge and to compare our results with the current literature.

2. Materials and methods

2.1. Study area

The present research was carried out in Fort Abbas, Tehsil of District Bahawalnagar, Pakistan, over a 2536-square-kilometer region. It is well known for its Cholistan desert. Deserts, woodlands, and agriculture surround the city (Fig. 1 a-e). There was also a river flowing toward the eastern side of Fort Abbas known as the Ghagra River, which has long since dried up. The eastern edge of the city is about 5 to 6 km from the Indian border. The primary water supply in the region is the Hakra Canal. The area around Fort Abbas is very fertile.

2.2. Ethno-botanical survey, data collection and preservation of plant specimens

The first objective of our research was to collect and identify wild flora in Tehsil Fort Abbas. During data collection, ethical and moral parameters were strictly followed. First of all, a brief introduction as a researcher was given and after getting the respondents in confidence, interviews were started. As a majority of informants, such as farmers, housewives, and hakims, do not speak English, a questionnaire was translated into their local language (Punjabi) and after that, their responses were recorded. Locals provided the following information: local name, recipe, local usage, part of the plant used, and their involvement in the collection of data (Gonfa et al., 2020). The local names and growth characteristics of each plant species with therapeutic properties were recorded. After each interview, the systematic process of numbering, pressing, and drying sample specimens was undertaken to enable their subsequent identification. Pakistan e-flora was utilized as a valuable reference source for the identification.

2.3. Methods of quantitative ethnomedicinal data analysis

The data was evaluated using descriptive statistics as well as qualitative and quantitative analysis methods.

2.3.1. Family importance value (FIV)

The relative significance of families was assessed using the FIV, which was calculated by dividing the number of informants who mentioned the family by the total number of informants, as described by Heinrich et al. (2006):

$$\mathrm{FIV} = \frac{FC(family)}{N} \times 100$$

Where 'FC' is the number of informers revealing the family, while 'N' is the total number of informants who participated in the research.

2.3.2. Popular therapeutic use value (POPUT)

The metric known as POPUT is employed to assess the significance of a plant species for medicinal and therapeutic purposes. Following formula was used to calculate POPUT (Bulut et al., 2017):

$$\mathrm{POPUT} = \frac{\mathrm{NURIT}}{\mathrm{TUR}}$$

Where 'NURIT' refers to the number of use reports for each sickness or treatment effect. 'TUR' is the total number of use reports.

2.3.3. Informant consensus factor (ICF)

The ICF was determined based on the consensus among informants about the specific treatment for each disease category, using the given formula (Heinrich et al., 2006):

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

Where 'Nur' is the total use reports for each category, while 'N_t' is the number of taxa (species) used for a particular plant-use category by all informants.

2.3.4. Plant part value (PPV)

The value of plant parts is assessed as a measure of the relative importance of various plant components in traditional medicines. PPV was calculated as (Farooq et al., 2019)

$$\mathrm{PPV}\,(\%) = \frac{\varepsilon RU(plantpart)}{\varepsilon RU} \times 100$$

Where $\in \mathrm{RU}(\text{plant part})$ explain the sum of uses reported per part of the plant and $\in \mathrm{RU}$ = total number of uses reported of all parts of the plant.

2.3.5. Relative frequency citation (RFC)

The formula below was employed to calculate the index of the relative frequency of citations (Farooq et al., 2019):

$$\mathrm{RFC} = \frac{FC}{N}$$

Where FC is the number of informants who reported using a species and N is the total number of informants.

2.3.6. Use value (UV) of plant species

UV is a quantitative measure indicating the relative importance of a plant species based on its frequency of use by informants in a community. It was calculated using the formula (Ahmad et al., 2021):

$$\mathrm{UV} = \sum \frac{\mathrm{Ui}}{\mathrm{N}}$$

Where 'UV' denotes each species' use value, 'Ui' indicates the number of uses recorded by each informant for a specific species, and 'N' is the total number of informants.

2.3.7. Relative importance (RI)

The rating of each plant species' use and the body organ systems it treats is determined according to their RI, as stated by Farooq et al., (2019):

$$\mathrm{RI} = \frac{(R.Ph + R.BS)}{2} \times 100$$

Where 'R. Ph' denotes relative pharmacological traits. 'R. Ph' is determined by dividing the number of uses (U) by the total number of use reports in the whole study. 'R. BS' indicates relative body systems treated. The 'R. BS' value is obtained by dividing the number of body systems treated by a plant species by the total number of body systems studied.

2.3.8. Fidelity Level (FL)

The fidelity level was determined to assess the value of the species associated with medicines (Farooq et al., 2019):

$$\mathrm{FL}\,(\%) = \frac{\mathrm{Np}}{\mathrm{N}} \mathrm{x}100$$

'Np' is the number of species in a particular category. 'N' is used to accurately total consumption for specific species.

2.3.9. Relative popularity Level (RPL)

Relative Popularity Level (RPL) is a metric used in ethnobotanical studies to assess the popularity or preference for a particular plant species in treating ailments within a community, based on the consensus among informants (Umair et al., 2017).

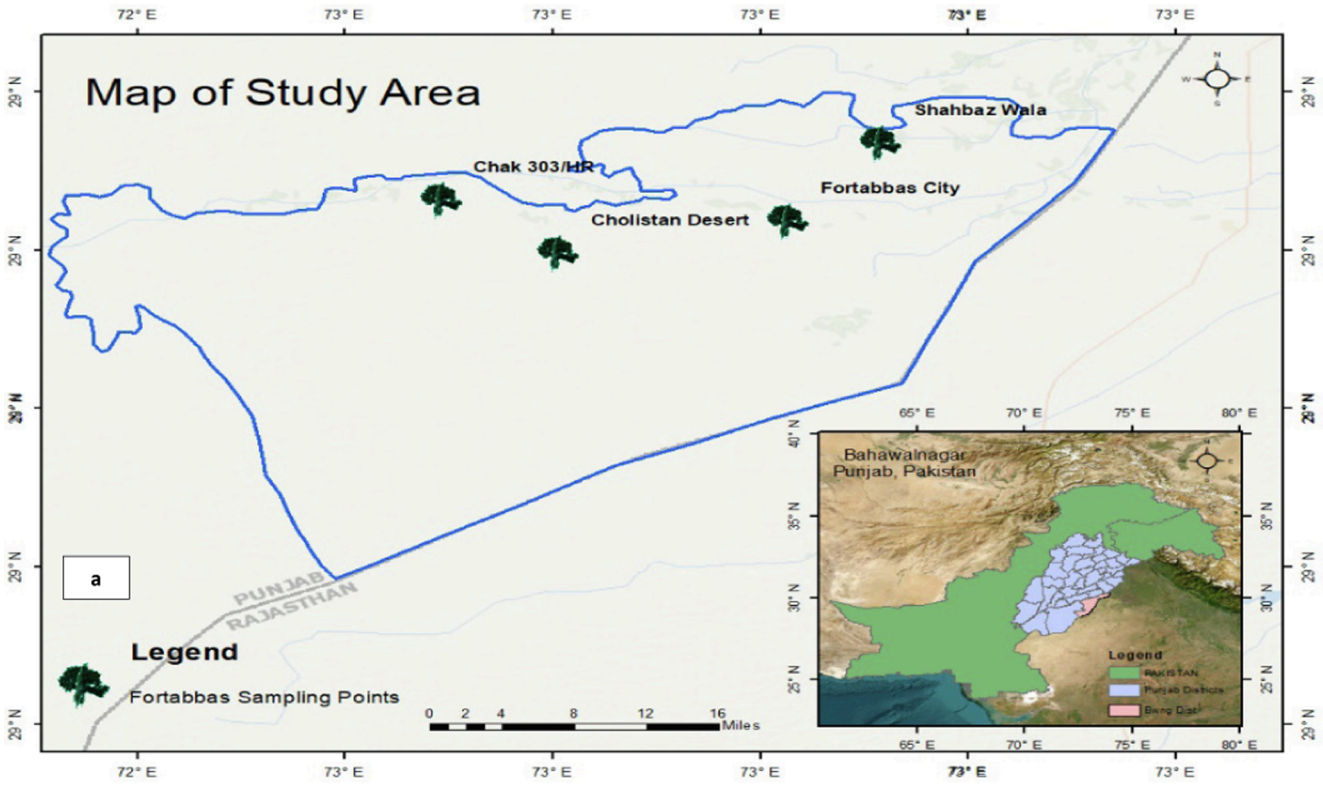


Fig. 1. (a) Map of the study area (b) Shehbaz wala (c) Cholistan (d) Fort Abbas city (e) Marot.

2.3.10. Rank order priority (ROP)

The proper ranking of plant species with varying fidelity levels (FL) and Relative Popularity Level (RPL) values is achieved through the utilization of a correction factor referred to as ROP. The ROP is derived from the FL by multiplying the RPL and ROP values (Umair et al., 2017):

$$ROP = FL \times RPL$$

2.3.11. Frequency index (FI)

The FI was determined through the application of the following formula for the quantitative analysis of the ethnomedicinal plants (Rajbanshi and Thapa, 2019):

$$FI = \frac{FC}{N} \times 100$$

Where 'FC' is the number of traditional healers who mentioned the use of species and 'N' is the total number of respondents.

2.3.12. Cultural significance index (CSI)

The CSI was employed to assess the alignment of informant knowledge with the utilization reports for a specific species, with the following formula being utilized for its calculation (Majeed et al., 2020):

$$CSI = \sum(i \times e \times c) \times CF$$

While 'i' refers to the management of species that significantly affect the community, 'e' indicates the informant's preference for one plant species over another for a specific purpose (value 2 for preferred species and value 1 for non-preferred species) and the letter 'c' denotes the frequency of use of a plant species (a species that is cultivated, managed, or operated in any way receives a score of 2 and a score of 1 if the species is still free of any kind).

2.3.13. Family use value (FUV)

The significance of plant families is determined by calculating the FUV, which is quantified using the following formula (Bouafia et al., 2021):

$$FUV = \frac{\Sigma UVs}{ns}$$

Where 'ns' is the overall number of species within a family and 'UVs' is the total usage value of all the species within that family.

2.3.14. Preference ranking (PR)

To ascertain the most suitable medicinal plant for each type of disease, a preference rating exercise was employed. In this activity, the medicinal plant deemed by participants to be the most effective in treating the specified ailments was assigned the highest value, while the one considered the least efficacious was assigned the lowest value. The scores for each species were aggregated to determine their ranking. This allowed for the identification of plants that are utilized by the local community to address frequently reported health conditions (Temam, 2016).

2.4. Jaccard index

The JI is utilized to compare study data with other ethnobotanical studies conducted in various countries across the globe, as well as among indigenous groups in the examined locations. The formula for calculating the JI was provided by Umair et al., (2017):

$$JI = \frac{c \times 100}{(a + b) - c}$$

where 'a' is the recorded number of species of the study area 'A,' 'b' is the documented number of species of the area 'B' and 'c' is the common number of species in both areas' 'A' and 'B.'

3. Results and discussion

3.1. Socio-demographic features of informants

In the current study, the understanding and utilization of plants and their parts in traditional medicine for various ailments were assessed through interviews with 457 participants. It was observed that a deeper familiarity with medicinal plants was exhibited by men, with 357 male participants and 100 female participants, constituting 78 % and 22 % of the respondents, respectively. The majority of medicinal knowledge was acquired from individuals aged 51–60 (40 %), followed by those aged 41–50 (34 %), 31–40 (13 %), and those above 60 (13 %). Valuable insights were obtained from various knowledgeable community members, including Hakims (21 %), Pansars (12 %), herbalists (26 %), and a combination of farmers and other locals (41 %), through structured questionnaires and interviews. Regarding education levels, the study revealed that 16 % of respondents were uneducated, 23 % had primary education, 19 % had middle school education, 26 % had completed matriculation, and 16 % possessed education beyond matriculation (Table 1). In Jhelum Valley, 152 respondents, aged between 25 and 70 years and from different ethnic backgrounds were interviewed. Of these, 52 were men and 100 were women (Awan et al., 2021). In central Kurram, a total of 152 individuals were examined who were represented by different ethnic groups and were aged between 25 and 70. Hundred women (65.77 %) and 52 men (34.21 %) were found among them (Hussain et al., 2022). In Khyber Pakhtunkhwa, it was identified that 95 of the informants were elderly (80 males and 15 females) aged between 58 and 72, while the remaining 20 were ascertained to be between the ages of 42 and 48 (Shuaib et al., 2019).

3.2. Growth habits of wild ethnomedicinal flora

In this study, 40 different plant species belonging to 22 families were identified in Tehsil Fort Abbas. It was asserted that these 40 species were utilized for the treatment of various illnesses. The prevailing life span was found to be perennial. Based on data collected in the current year, it was determined that 68 % of the species were perennials, 30 % were annuals, and 2 % were biennials (Fig. 2a). In the current study, the majority of the wild species were categorized as herbs (31 species, 78 %), while some were classified as trees (6 species, 15 %), and a small number were characterized as shrubs (3 species, 7 %) (Fig. 2b). Among the plant species, sedges, grasses, forbs, shrubs, and tree species are included. In District Sawat, the plant habit percentages were found to be 65 % herbs, 20 % shrubs and 14 % trees (Hassan et al., 2020). Of all the reported species, 25 % were constituted by trees, while shrubs made up only 13 % (Gulzar et al., 2019).

Table 1
Socio-demographic features of informants.

Variables	Demographic categories	Number of people	Percentage (%)
Gender	Male	357	78
	Female	100	22
Age	31–40	54	13
	41–50	142	34
	51–60	151	40
	Above-60	75	13
Education	Illiterate	74	16
	Primary	103	23
	Middle	89	19
	Matric	118	26
	Above matric	73	16
Occupation	Herbalist	95	21
	Farmer	120	26
	Pansar	54	12
	Others	188	41

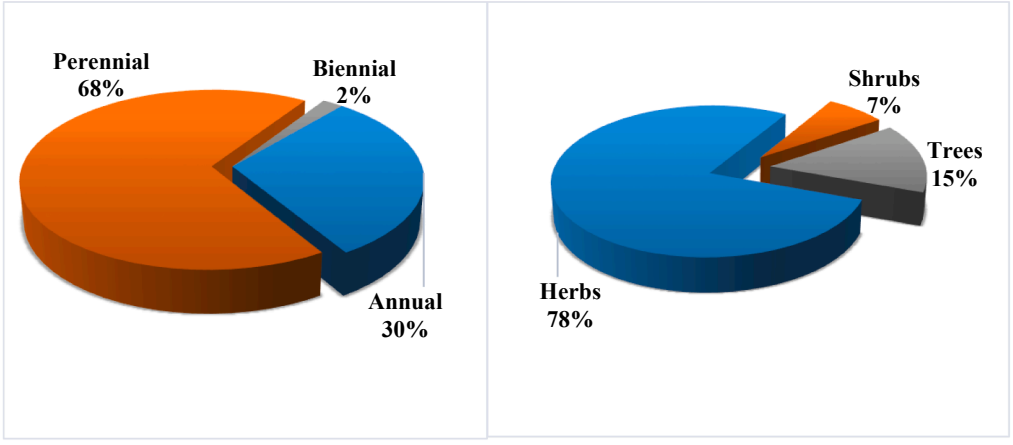
3.3. Method of preparation

A variety of herbal preparation methods are utilized by local informants in the research area. Among these methods, decoction was found to be the most commonly employed (24 %), followed by powder (21 %), infusion (10 %), herbal tea (7 %), paste (6 %), and juice (2 %). Additionally, a range of other methods, including raw, oil, poultice, and extract, were collectively used in 30 % of cases (Fig. 2c). Furthermore, herbal remedies were crafted from either single plant parts or combinations of multiple plant parts. In Central Kurram, Khyber Pakhtunkhwa, resin, nuts, and latex were the least documented plant parts being used only 1 %, as reported by Hussain et al., (2022). The most popular method of preparation, decoction, was used 39 %, while vegetable was used 10 %, juice 9 %, and straight 8 %. Based on the ethnopharmacological survey by Shah et al. (2021), 32 % of the herbal formulations were made up of plant extracts and 11 % were made up of decoctions. Food (10 %), oil (10 %) and fresh plant material (6 %) were contained in some herbal treatments. Additionally, 5 % of the herbal formulations were reported to involve cooking in the form of food.

3.4. Quantitative ethnobotanical data analysis

3.4.1. Family importance value (FIV)

The most frequently encountered family in area was Fabaceae (6 species). This prevalence may be attributed to the wide distribution of Fabaceae plant species and their well-documented traditional uses known to indigenous tribes worldwide (Fig. 3). Other species examined in the research area belong to various families, including Asteraceae (5 species), Poaceae (4 species), Amaranthaceae (3 species), Solanaceae, Euphorbiaceae, Verbenaceae and Polygonaceae (2 species each) while all other families were represented by only one species. The wild flora of Fort Abbas was studied and it was found that 71 species and 28 families are represented there. In the study, 69 plant species (85 %), 5 tree species (6 %), and 7 shrubs (9 %) were also identified. The four families with the most represented species were Poaceae (15 species), Euphorbiaceae (8 species), Asteraceae (7 species) and Amaranthaceae (7 species). Plants without leaves, specifically *Cuscuta campestris* with *Haloxylon salicornicum* were mentioned (Anwer et al., 2020). In Hafizabad, medicinal plant species from 71 genera and 34 families were documented. The Fabaceae was found to have the most species with



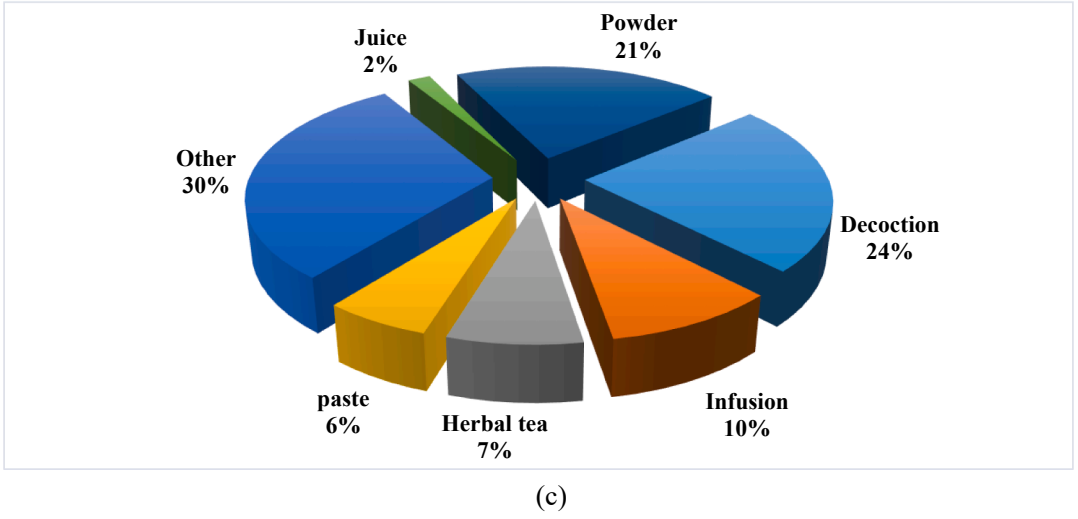


Fig. 2. (a) Life span (b) life form (c) Percentage distribution of various modes of preparation utilized for disease treatment.

Fig. 3. Percentage of family importance value (FIV).

Table 2
Comparison of popular therapeutic use value and informant consensus factor for various ailments.

Ailments	POPUT	ICF
Animals' bites	0.02	0.9
Asthma	0.05	0.78
Blood pressure	0.006	1.0
Cancer	0.01	0.87
Cholesterol	0.006	1.0
Constipation	0.07	0.78
Cough	0.05	0.78
Diabetes	0.03	0.81
Diarrhea	0.07	0.82
Enhance appetite	0.008	1.0
Eye disease	0.004	1.0
Fever	0.1	0.81
Flue	0.02	0.83
Gastro-intestinal disorder	0.01	0.83
Headache	0.004	1.0
Heart problem	0.006	1.0
Hepatitis	0.03	0.81
Inflammatory diseases	0.01	1.0
Jaundice	0.05	0.82
Joint pain	0.03	0.81
Liver disorders	0.06	0.81
Lung's infection	0.03	0.81
Purify blood	0.05	0.73
Relieve pain	0.04	0.8
Sexual illness	0.04	0.76
Skin diseases	0.08	0.84
Stomach disorder	0.03	0.84
Stop bleeding	0.02	0.77
Throat infection	0.008	1.0
Toothache	0.01	0.87
Urinary disorder	0.01	0.83
Vomiting	0.03	0.86
Wounds	0.03	0.78

eight, followed by the Moraceae and Euphorbiaceae with six each, the Chenopodiaceae with five, the Malvaceae and Solanaceae with four each, the Amaranthaceae with three and the Meliaceae with two species. The use of medicinal plant species from the Asteraceae and Poaceae families was found to be widespread, similar to ethnomedicinal flora reported in other regions of Pakistan (Umair et al., 2017).

3.4.2. Popular therapeutic use value (POPUT)

POPUT is ranged from 0.004 to 0.1 (Table 2). In our study area, out of 40 plant species, 9 species were employed in the treatment of fever. Fever is treated with the following plants: *Convolvulus arvensis, Achyranthes aspera, Imperata cylindrica, Mazus pumilus, Aerva persica, Bauhinia variegate, Alhagi maurorum, Seteria viridis,* and *Xanthium strumariam*. According to the responses, the minimum POPUT value was observed for eye diseases (0.004) and headaches (0.004). The highest POPUT value was recorded for fever (0.1) in the study area. Fever was identified as the most prevalent ailment in the research area and the awareness of various herbs that could be utilized for fever treatment was widespread among the population. In this study, POPUT values of 0.08 and 0.07 were calculated for wound healing and stomach issues. A POPUT value of 0.04 was shown by diabetes (Umair et al., 2017), while 0.03 was shown in the current study. POPUT values of 0.14 for stomach illnesses, 0.06 for colds, 0.05 for coughs, and 0.04 for eczema and rheumatism were presented by Bulut et al., (2017). In the current study, 0.05 was shown for cough, which was similar to the value in the studied area; 0.03 was shown for stomach illness, which was the lowest value from the studied area. Similarly, 0.05 was shown for cough in the present study, aligning with the value in the studied area (Bulut et al., 2017).

3.4.3. Informant consensus factor (ICF)

Approximately 40 plant species were utilized and reported by the inhabitants of the field area, which were further categorized into 22 plant families. The ICF values, ranging from 0.73 to 1, were observed. Notably, the highest ICF values were recorded for the treatment of various health issues, including heart problems (1.00), blood pressure (1.00), cholesterol (1.00), throat infection (1.00), enhanced appetite (1.00), eye diseases (1.00), inflammatory diseases (1.00) and headache (1.00). It was noted that these health concerns were reportedly alleviated using individual plant species sourced from the field area, as indicated in Table 2. Conversely, the lowest ICF values were calculated for fever, which was employed for blood purification (0.73) and for the treatment of sexual illnesses (0.76). Noteworthy plant species used in addressing skin issues encompass *Convolvulus arvensis, Euphorbia prostrata, Azadirachta indica, Momordica charentia, Senna occidentalis, Phyla nodiflora*, and *Alternanthera caracasana*. In District Hafiz Abad, an ICF value for skin diseases of 0.39 was reported by Umair et al., 2017. This is about 50 percent less than the ICF value for skin diseases calculated from our study area, and at 0.84, it is significantly higher than the ICF value for skin diseases in Hafiz Abad. It may be due to that the locals of Tehsil Fort Abbas were not fully informed that various plants could be used to treat skin diseases, leading them to agree on treating skin ailments with only a few plants. The highest ICF value was reported for wound healing at 0.87 (Tufail et al., 2020). A value of 0.78 was calculated for wounds in the current study, which was less than the value from that study. In District Sheikupura, the highest ICF value reported for urinary diseases was 0.82, while the lowest for fever was 0.02. In the current study, the ICF value for urinary issues was 0.83, closely matching the value from the aforementioned study. However, the value for fever was 0.81 in our study, considerably higher in our area, indicating a reduced variety of plants used in fever treatment.

3.4.4. Plant part value (PPV)

In the research region for human ailments, several plant parts were used by locals (either in combination or independently). It was stated that leaves constituted the largest percentage (35 %) of plant parts used to make herbal drugs, followed by the whole plant (25 %), fruit (14 %), roots (8 %), seeds (7 %), flowers (6 %), stem (3 %), bark and rhizome (1 % each). Leaves, which are abundant in bioactive secondary metabolites are frequently employed in herbal treatments (Fig. 4). Aerial parts, bark, branches, stems, latex, and other plant parts were accounted for by less than 5 % of the total plant parts used, with leaves being accounted for by

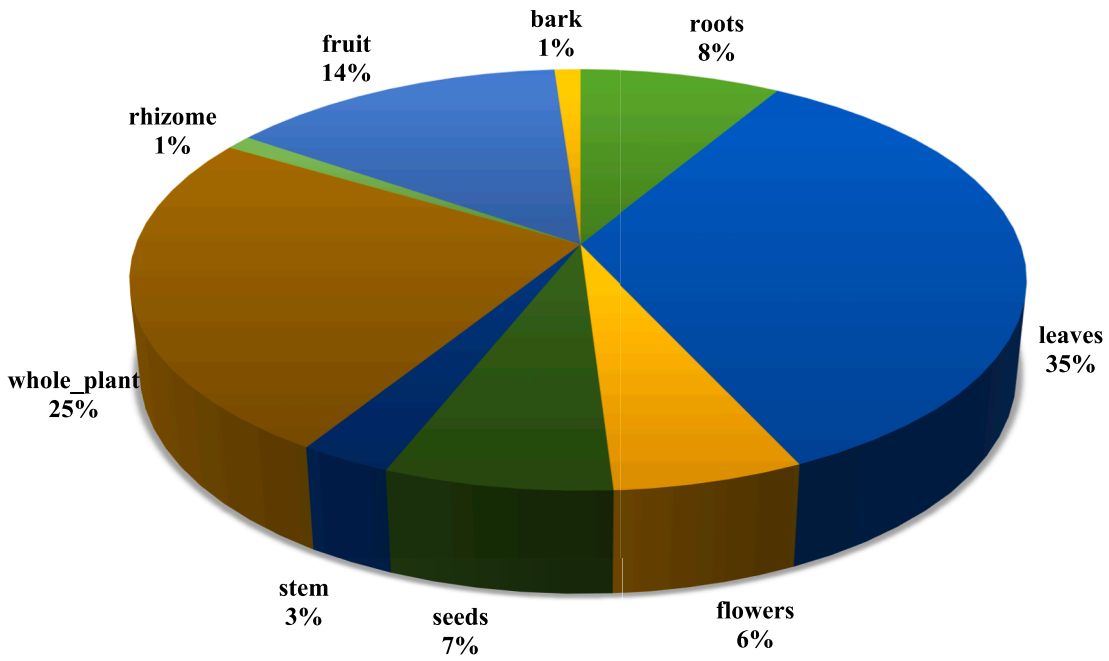


Fig. 4. Percentage distribution of various plant parts used in ethnomedicinal applications.

29 % of the total. Whole plants were followed by 21 %, roots by 13 %, fruit by 8 %, seeds by 6 %, and flowers by 5 %. In the current analysis, 38 % of applications in traditional medicinal formulations were represented by leaves, making them the plant component used most often. The whole plant was followed by 14 %, the root by 10 %, the stem by 8 %, and fruit, seed, and flower by 7 % each. The bark was represented by 5 %, and shoot and rhizome were accounted for by 2 % each. All other plant components were cited by (Umair et al., 2017). However, in the majority of places examined, treatments' composition was primarily constituted by leaves. In our study area, similar findings were observed.

3.4.5. Relative frequency citation (RFC)

In scientific research, the relevance of a specific plant species is determined by RFC values. RFC values ranging from 0.017 to 0.037 are reported (Table 3). The highest RFC value for *Centaurium pulchelum* (0.037) was reported by respondents in the tehsil Fort Abbas, indicating its significance in the research. This was followed by the RFC values for *Xanthium strumarium* (0.035), *Convolvulus arvensis* (0.035), *Echinops echintus* (0.032), *Acyranthes aspera* (0.032), *Conyza bonariensis* (0.032), *Dalbergia sisso* (0.03) and *Dichanthium annulatum* (0.028). On the otherhand, plants such as *Gisekia pharnaceoides, Lasiurus scindicus* and *Alternanthera caracasana*, which have lower RFC values, were cited less frequently in the research area. The highest RFC values were found for *Mentha arvensis* (0.88), *Berberis lycium* (0.86), *Achyranthes aspera* (0.85), *Taraxacum oficinale* (0.85), *Zanthoxylum alatum* (0.82), *Pinus roxburghii* (0.80), *Pyrus malus* (0.80), *Achillea millefolium* (0.77) and *Prunus persica* (0.77). It was indicated by these high RFC values of these species that they are closely associated with the locals in the research area and are frequently used by them to address various ailments, as reported by Farooq et al., (2019). In Lahore, the highest RFC was attributed to *Rosa indica*, while the lowest values were associated with *Deutzia scabra* and *Euonymus japonicus*, as documented by Shaheen et al., 2014. Plants that were noted to have lower RFC values included *Gisekia pharnaceoides*, *Lasiurus scindicus*, and *Alternanthera caracasana. Solanum surattense* (0.17), *Eclipta alba* (0.15) and *Triticum aestivum* (0.15).

3.4.6. Use value (UV) of plant species

Statistical information on the relative importance of plant species, as indicated by residents, is provided by the UV. The species from our study area have use values ranging from 0.16 to 0.5, as shown in Table 3. The highest UV was reported to be for *Polygonum plebejum* (0.5), *Phoenix dactylifera* (0.45), *Imperata cylindrica* (0.45) and *Pentatropis spiralis* (0.44). Diseases like constipation, asthma, liver disorders and skin issues were treated using these species, and they were also utilized as blood purifiers. Meanwhile, the lowest use values were reported to be for *Alhagi maurorum* (0.17) and *Euphorbia prostrata* (0.16). UV is determined by how extensively it is used locally when it is high; conversely, when the value of UV is low, it is less frequently used in specific areas. The highest use value (0.92) was attributed to *Allium sativum* (Ahmad et al., 2021). It was reported by District Okara, Pakistan that the highest use value for *Azadirachta indica* was (0.22), whereas the minimum use values of 0.01 were attributed to *Alhagi maurorum*, *Eclipta rostrata* and *Trianthema potulacastrum* (Munir et al., 2022). In our research, a use value of 0.5, the highest for *Polygonum plebejum*, was identified for conditions like diarrhea, asthma, vomiting, sexual diseases and purifying the blood. In Southern Punjab, Pakistan, the highest use value of 0.58 was reported for *Conyza canadensis*. An ethnobotanical study in the Bandarban District of Bangladesh was undertaken, revealing that the indigenous tribes' ethnomedicinal use of medicinal plants had Use Values ranging from a high of 0.43 to a low of 0.03 (Faeuque et al., 2018). In the District of Bhimber Azad, Jammu, and Kashmir, Pakistan, use values of 0.40, 0.67, 0.56, 0.42, and 0.56 were reported for *Achyranthus aspera*, *Azadirachta indica*, *Echinops echinatus*, *Euphorbia helioscopia* and *Bauhinia variegata* respectively (Majeed et al., 2022).

3.4.7. Relative importance (RI)

The relative importance values ranged from 3.90 to 8.88. The plants species identified as the most important with the highest RI values are *Polygonum plebejum* (8.88), *Momordica charentia* (8.66) and *Phoenix dactylifera* (8.66). Other species with relatively high RI values are *Imperata cylindrica* (8.56), *Xanthium strumarium* (7.81), *Achyranthes aspera* (7.70) and *Conyza bonariensis* (7.70) which are believed to have a significant ecological impact. However, species with lower RI values, such as *Ranunculus sceleratus* (4.12), *Rumex crispus* (4.12) and *Lasiurus scindicus* (3.90) are considered less significant in terms of ecological impact, but they are nonetheless thought to play a significant role in the indigenous ecosystem (Table 3). The greatest RI was shown by *Tabernaemontana divaricata,* while the lowest was had by *Garcinia aristata* (Shaheen et al., 2014). High RI values were also possessed by *Curcuma longa* (59.72), *Elaeagnus angustifolia* (63.89) and *Matricaria chamomilla*

Table 3
List of wild medicinal plants investigated with their related information.

BN	LN	Family	LF	PU	Rec	App	Uses	RFC	UV	RI	FL	RPL	ROP	FI	CSI	Previously reported uses and references
Achyranthus aspera L.	Puthkanda	Amaranthaceae	Perennial Herb	Whole plant	Decoction, herbal tea and powder	Oral	Used for asthma, fever, *lungs infection and gastrointestinal diseases	0.032	0.25	7.7	38	0.25	9.5	3.5	3.76	Ψ1 ⁑2 Ψ3 Ψ4 Ψ5 φ 6 ⁑7 φ8 Ψ9 ⁑10
Adiantum capilus veneris L.	Khoo_boti	Pteridaceae	Perennial herb	Whole plant	Decoction, paste, and powder	Oral, topical	*Lungs infection, animal bites and flue	0.024	0.25	5.74	42	0.25	10.5	2.6	2.58	⁑1 ⁑2 ⁑3 ⁑4 ⁑5 Ψ6 ⁑7 ⁑8 ⁑9 ⁑10
Aerva persica (Burm. Fil.) Merr.	Bhoe	Amaranthaceae	Perennial herb	Fruit leaves and stem	Decoction and powder	Oral	Used for *diarrhea and fever	0.024	0.18	4.23	55	0.18	10	2.4	2.58	⁑1 Ψ2 ⁑3 ⁑4 ⁑5 ⁑6 ⁑7 ⁑8 ⁑9 ⁑10
Alhagi maurorum Medik	Jawasa	Fabaceae	Perennial shrub	Whole plant	Powder, herbal tea and decoctions	Oral	Used for fever, diarrhea and vomiting	0.026	0.17	5.85	41	0.17	7.23	3.7	4	Ψ1 ⁑2 Ψ3 ⁑4 φ 5 ⁑6 ⁑7 φ 8 ⁑9 φ 10
Alternanthera caracasana Kunth.	Khaki_weed	Amaranthaceae	Perennial Herb	Whole plant	Decoction	Oral, topical	*Used for headache, vomiting, skin diseases and animals bite	0.02	0.4	7.04	40	0.4	16	2.1	1.17	⁑1 ⁑2 ⁑3 ⁑4 ⁑5 ⁑6 ⁑7 ⁑8 ⁑9 ⁑10
Azadirachta indica A. Juss.	Neem	Meliaceae	Perennial Tree	Seeds, fruit leaves and seeds	Powder and infusion	Oral, Topical	Used to purify the blood, used for skin diseases, toothache, and gastrointestinal diseases	0.022	0.36	5.63	40	0.36	14.5	2.4	2.58	φ 1 ⁑2 Ψ3 ⁑4 ⁑5 ⁑6 ⁑7 Ψ8 Ψ9 ⁑10
Bauhinia variegata L.	Kachnaar	Fabaceae	Perennial Tree	Flowers, leaves, roots and fruit	Decoction, powder, and herbal tea	Oral	Used for blood pressure stomach disorder, throat infection and diarrhea	0.022	0.4	7.15	40	0.4	16	2.1	2.35	⁑1 ⁑2 ⁑3 ⁑4 ⁑5 ⁑6 ⁑7 φ 8 ⁑9 ⁑10
Centaurium pulchelum (Sw.) Druce	Barik_chirayata	Gentianaceae	Biennial *herb*	Leaves	Powder and Decoction	Oral	Used for *jaundice and fever	0.037	0.22	4.89	67	0.22	14.8	1.9	0.52	⁑1 ⁑2 ⁑3 ⁑4 Ψ5 ⁑6 ⁑7 ⁑8 ⁑9 ⁑10
Convolvulus arvensis L.	Hiran_khuri	Convolvulaceae	Perennial Herb	Leaves, roots, flowers	Infusion, herbal tea and paste	Oral, massage	Used for skin diseases, Constipation and purify blood	0.035	0.2	6.29	47	0.2	9.4	3.2	3.52	Ψ1 ⁑2 φ 3 ⁑4 φ 5 Ψ6 7 φ 8 ⁑9 ⁑10
Conyza bonariensis L.	Beili	Asteraceae	Perennial Herb	Fruit, leaves, flowers	Herbal tea and infusion	Oral. Topical	Used for diarrhea, stop bleeding, cough and hepatitis	0.032	0.26	7.7	40	0.26	10.6	3.2	3.52	⁑1 ⁑2 Ψ3 ⁑4 ⁑5 ⁑6 ⁑7 ⁑8 ⁑9 ⁑10
Dalbergia sisso Roxb. Ex. DC.	Tali/shisham	Fabaceae	Perennial Tree	Fruit and leaves	decoction and powder	Oral, topical	Used for sexual illness, Asthma, purify blood and eye diseases	0.03	0.4	7.59	40	0.4	16	2.1	2.35	φ 1 ⁑2 Ψ3 ⁑4 ⁑5 ⁑6 ⁑7 ⁑8 ⁑9 ⁑10
Dichanthium annulatum (Forssk.) Stapf	Khew/khurd	Poaceae	Annual herb	Leaves and stem	Infusion and powder	Oral	Used for diarrhea and *Sexual illness	0.028	0.18	4.45	64	0.18	11.6	2.4	2.58	⁑1 ⁑2 Ψ3 ⁑4 Ψ5 ⁑6 ⁑7 ⁑8 ⁑9 ⁑10
Echinops echinatus Roxb.	Unt_katara	Asteraceae	Perennial Herb	Whole plant	Decoction, herbal tea, and powder	Oral	Used for jaundice, liver disorders, *Flue and hepatitis	0.032	0.25	7.7	44	0.25	11	3.5	3.76	⁑1 ⁑2 ⁑3 ⁑4 Ψ5 ⁑6 ⁑7 ⁑8 ⁑9 Ψ10
Euphorbia heliscopia L.	Dadar_boti	Euphorbiaceae	Annual herb	Whole plant	Herbal tea and powder	Oral	Used for cough, Constipation and cancer	0.02	0.27	5.53	45	0.27	12.2	2.4	2.58	⁑1 ⁑2 Ψ3 ⁑4 5 ⁑6 ⁑7 ⁑8 ⁑9 ⁑10

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Table 3 (*continued*)

BN	LN	Family	LF	PU	Rec	App	Uses	RFC	UV	RI	FL	RPL	ROP	FI	CSI	Previously reported uses and references
Euphorbia prostrata Aiton	Dodhak	Euphorbiaceae	Annual Herb	Whole plant	Decoction, powder and paste	Oral, topical	Used for skin diseases and Cough	0.024	0.16	4.23	67	0.16	11.1	2.6	2.82	⁑1 ⁑2 φ 3 ⁑4 Ψ5 φ 6 ⁑7 ⁑8 ⁑9 Ψ10
Fagonia cretica L.	Dhamasa_ Boti	Zygophyllaceae	Perennial herb	Whole plant	Decoction, powder and infusion	Oral	Used for jaundice, purify blood and asthma	0.026	0.27	5.85	45	0.27	12.2	2.4	2.58	⁑1 ⁑2 ⁑3 ⁑4 φ 5 ⁑6 ⁑7 ⁑8 ⁑9 Ψ10
Ficus religiosa L.	Peepal	Moraceae	Perennial tree	Fruit, bark and seeds	Powder, paste	Oral, Topical	Used for vomiting, relieve pain and diabetes	0.024	0.27	5.74	45	0.27	12.2	2.4	2.58	Ψ1 ⁑2 φ 3 φ 4 ⁑5 ⁑6 ⁑7 Ψ8 ⁑9 ⁑10
Gisekia pharnaceoides L.	Balu ka sag	Aizoaceae	Annual herb	Whole plant	Decoction, powder and infusion	Oral, Topical	Used for constipation, relieve pain and sexual diseases	0.019	0.33	5.49	40	0.33	13.3	1.9	1.05	Ψ1 ⁑2 ⁑3 ⁑4 ⁑5 ⁑6 ⁑7 ⁑8 ⁑9 φ 10
Imperata cylindrica (L.) P.Beauv.	Khans	Poaceae	Perennial herb	Whole plant	Powder, decoction and infusion	Oral	Used for heart problems, Wounds, *Fever, urinary disorder and diarrhea	0.02	0.45	8.56	36	0.45	16.3	2.4	1.29	⁑1 ⁑2 Ψ3 ⁑4 5 ⁑6 ⁑7 ⁑8 ⁑9 Ψ10
Lantana camara L.	Pit_syapa	Verbenaceae	Perennial shrub	Whole plant	Decoction, paste, and infusion	Oral, topical	Used for jaundice, *Stomach disorders, joint pain and toothache	0.022	0.33	7.15	42	0.33	14	2.6	2.82	⁑1 ⁑2 φ 3 ⁑4 φ 5 ⁑6 ⁑7 ⁑8 ⁑9 ⁑10
Lasiurus scindicus Henrard	Ghorka	Poaceae	Perennial herb	Whole plant	Paste, powder and decoction	Oral, Topical	Used for cough and *Skin diseases	0.017	0.22	3.9	56	0.22	12.4	1.9	0.52	⁑1 ⁑2 ⁑3 ⁑4 φ 5 ⁑6 ⁑7 ⁑8 ⁑9 ⁑10
Launaea mucronata (Forssk.) Muschl.	Desert Grass	Asteraceae	Perennial Herb	Roots, leaves and stem	Powder and decoction	Oral	*Used for stomach disorders and liver diseases	0.024	0.25	4.23	62	0.25	15.5	1.7	0.47	⁑1 ⁑2 ⁑3 ⁑4 ⁑5 ⁑6 ⁑7 ⁑8 ⁑9 ⁑10
Lepidium didymum L.	Afsanteen	Brassicaceae	Annual herb	Leaves and flowers	Decoction and powder	Oral, topical	Used to purify blood and used for liver disorder, wounds and stop bleeding	0.022	0.4	7.15	30	0.4	12	2.1	2.35	⁑1 ⁑2 Ψ3 ⁑4 ⁑5 ⁑6 φ 7 ⁑8 ⁑9 ⁑10
Mazus pumilus (Burm. F.)		Mazaceae	Annual herb	Whole plant	Decoction and powder	Oral	Used for fever and *Sexual illness	0.022	0.2	4.12	60	0.2	12	2.1	1.17	⁑1 ⁑2 ⁑3 ⁑4 Ψ5 ⁑6 ⁑7 ⁑8 ⁑9 ⁑10
Medicago polymorpha L.	Maina	Fabaceae	Annual herb	Leaves, fruit and stem	Powder and infusion	Oral,	Used for liver disorder and hepatitis	0.024	0.2	4.23	50	0.2	10	2.1	2.35	⁑1 ⁑2 ⁑3 ⁑4 φ 5 ⁑6 ⁑7 ⁑8 ⁑9 ⁑10
Momordica charentia L.	Jangli Karela	Cucurbitaceae	Annual herb	Fruit	Decoction and raw	Oral, Topical	Used for diabetes, skin diseases, jaundice, cholesterol and inflammation	0.022	0.35	8.66	36	0.35	12.8	3.0	3.29	⁑1 ⁑2 ⁑3 ⁑4 ⁑5 ⁑6 ⁑7 Ψ8 ⁑9 ⁑10
Pentatropis spiralis (Forssk.) Decne.	Hiran boti	Asclepiadaceae	Perennial herb	Whole plant	Herbal tea and powder	Oral	Used for wounds, *Stop bleeding, stomach disorder and inflammation	0.024	0.44	7.26	44	0.44	19.5	1.9	1.05	⁑1 ⁑2 ⁑3 ⁑4 ⁑5 ⁑6 ⁑7 ⁑8 ⁑9 Ψ10
Phoenix dactylifera L.	Khajoor	Areaceae	Perennial tree	Fruit and leaves	Raw and decoction	Oral	Used for constipation, throat infection, sexual illness,	0.022	0.45	8.66	36	0.45	16.3	2.4	2.58	⁑1 ⁑2 ⁑3 Ψ4 ⁑5 ⁑6 ⁑7 φ 8 ⁑9 ⁑10

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Table 3 (*continued*)

BN	LN	Family	LF	PU	Rec	App	Uses	RFC	UV	RI	FL	RPL	ROP	FI	CSI	Previously reported uses and references
							toothache and asthma									
Phyla nodiflora (L.) Greene	Bukkan_boti	Verbenaceae	Perennial *herb*	Whole plant	Extract	Oral, Topical	Used for skin diseases, Cough and relieve pain	0.022	0.3	5.63	40	0.3	12	2.1	2.35	♣1 ♣2 ♣3 φ 4 Ψ5 ♣6 ♣7 φ 8 ♣9 ♣10
Polygonum plebejum	Charri_hatha	Polygonaceae	Annual Herb	Whole plant	Decoction and powder	Oral	Used for asthma, Diarrhea, sexual diseases, vomiting and *Purify blood	0.026	0.5	8.88	40	0.5	20	2.1	2.35	♣1 ♣2 φ 3 ♣4 Ψ5 φ 6 ♣7 ♣8 ♣9 Ψ10
Prosopis Juliflora (Sw.) DC	Jangli_keekar	Fabaceae	Perennial Tree	Leaves and stem	Decoction and powder	Oral, Topical	Used for skin diseases and cancer	0.022	0.2	4.12	60	0.2	12	2.1	2.35	♣1 ♣2 φ 3 ♣4 ♣5 ♣6 ♣7 φ 8 ♣9 Ψ10
Ranunculus sceleratus L.	Peeli_boti	Ranunculaceae	Perennial Herb	Leaves	Decoction	Oral, topical	Used for *relieve pain and purify blood	0.022	0.2	4.12	60	0.2	12	2.1	2.35	♣1 ♣2 φ 3 ♣4 φ 5 ♣6 ♣7 ♣8 ♣9 ♣10
Rumex crispus L.	Khaar_palak	Polygonaceae	Perennial Herb	Leaves and fruit	Herbal tea, decoction and infusion	Oral	Used for *liver disorder and gastrointestinal diseases	0.022	0.2	4.12	60	0.2	12	2.1	2.35	♣1 ♣2 ♣3 ♣4 φ 5 ♣6 ♣7 ♣8 ♣9 ♣10
Senna occidentalis (L.) Link	Kasondi	Fabaceae	Perennial Shrub	Whole plant	Decoction, powder and paste	Oral, Topical	*Used for skin diseases, joint pain and constipation	0.024	0.25	5.74	42	0.25	10.5	2.6	2.35	♣1 ♣2 ♣3 ♣4 ♣5 ♣6 ♣7 ♣8 ♣9 ♣10
setaria viridis (L.) P.	Sitti_ghaas	Poaceae	Annual herb	Seeds	Powder and infusion	Oral	Used for lungs infection, fever and *Constipation	0.024	0.18	5.53	44	0.18	8.25	3.5	2.82	♣1 ♣2 ♣3 ♣4 ♣5 ♣6 ♣7 ♣8 ♣9 ♣10
Solanum nigrum L.	Mako	Solanaceae	Annual herb	Whole plant	Decoction, juice and infusion	Oral, topical	Used for liver disorder, joint pain and diabetes	0.019	0.23	5.85	46	0.23	10.6	2.8	3.76	Ψ1 ♣2 φ 3 ♣4 φ 5 φ 6 ♣7 ♣8 ♣9 ♣10
Solanum surattense Burm. F.	Choti_kateri/ kanderi	Solanaceae	Perennial herb	Leaves, fruit, seeds and flowers	Powder, paste and infusion	Oral, topical	Used for asthma, diabetes and joint pain	0.026	0.27	5.63	45	0.27	12.2	2.4	3.05	♣1 ♣2 φ 3 ♣4 Ψ5 Ψ6 ♣7 ♣8 ♣9 Ψ10
sonchus asper (L.) Hill.	Didhi	Asteraceae	Perennial herb	Whole plant	Decoction, paste and powder	Oral, Topical	Used for constipation, *Wounds, cough and fever	0.022	0.4	7.26	40	0.4	16	2.1	2.58	♣1 ♣2 Ψ3 ♣4 Ψ5 Ψ6 7 Ψ8 9 ♣10
Veronica anagallis-aquatica L.	Pani wali boti	Plantaginaceae	Perennial herb	Leaves and roots	Decoction, powder and paste	Oral, Topical	*Used for urinary disorder and purify blood, used to enhance appetite	0.02	0.33	5.53	44	0.33	14.6	1.9	0.52	♣1 ♣2 ♣3 ♣4 ♣5 ♣6 ♣7 ♣8 ♣9 ♣10
Xanthium strumariam L.	Leedha	Asteraceae	Annual herb	Whole plant	Paste, decoction and infusion	Oral, topical	Used for fever, Flue, animal's bites and relieve pain	0.035	0.26	7.81	40	0.26	10.6	3.2	3.52	♣1 ♣2 φ 3 ♣4 Ψ5 Ψ6 ♣7 ♣8 Ψ9 ♣10

Abbreviations: **BN.** Botanical name, **LN.** Local name, **LF.** Life form, **PU.** Part used, **Rec.** Recipe, **App.** Mode of application, **UV.** Use value, **FL.** Fidelity level, **RFC.** Relative frequency citation, **ROP.** Rank order priority, **FI.** Frequency index, **CSI.** Cultural significance index **RI.** Relative importance, *Novel use (Ψ) = Plant with similar use; (φ) = Plant with dissimilar use; (♣) = Plant not reported in the previous study; 1: Saleem et al., 2017; 2: Chawla et al., 2012; 3: Umair et al., 2017; 4: Afzal et al., 2021; 5: Fatima et al., 2019; 6: Hussain et al., 2022; 7: Munir et al., 2022; 8: Tounekti et al., 2019; 9: Ali et al., 2023; 10: Usman et al., 2021.

(59.72) (Usman et al., 2021). The plants with the highest RI values were reported to be *Adhatoda zeylanica* (93.75), *Zanthoxylum alatum* (91.67), *Berberis lyceum*, *Juglans regia* (87.50 each), *Punica granatum*, *Olea ferruginea* (83.33 each) and *Solanum surattense* (79.17) (Qaseem et al., 2019). In Harighal, Azad Jammu Kashmir, species' diversity for treating various ailments was evaluated using the relative significance value. The plants found to have the highest RI values were *Mimosa pudica* (91) and *Galium aparine* (96) (Amjad et al., 2020). In district Lahore, the greatest RI was shown by *Tabernaemontana divaricata*, while the lowest by *Garcinia aristata*. In our study, the highest RI was recorded for *Polygonum plebejum* (8.88), and the lowest RI value was recorded for *Lasiurus scindicus* (3.9).

3.4.8. Fidelity Level (FL)

The range of FL values is set from a minimum of 30 % to a maximum of 67 % (Table 3). FL is varied based on the species and also based on the disease, as determined by the responses given by the locals of Tehsil Fort Abbas. The highest FL value was determined to be for *Centaurium pulchellum* (67 %) for the treatment of jaundice, followed by *Euphorbia prostrata* (67 %) for the treatment of skin diseases, *Dichanthium annulatum* (64 %) for diarrhea and *Launaea mucronata* (62 %) for liver disorders. FL value of 87 % was recorded for *Alderia modesta*, which was used for toothache and gastric problems (Anwer et al., 2020). Similarly, FL value of 82 % was observed for the *Chenopodium album*, which was used to treat intestinal issues. In the Chenab riverine area, Pakistan, the highest FL value for curing diabetes was reported to be found for *Caralluma tuberculate* (61.22 %) and *Artemisia scoparia* (55.56 %), with both plants being used to lower blood glucose levels (Umair et al., 2017). In the district Sheikupura, Pakistan, FL value of 66.14 % was reported for *Solanum americanum* (Zahoor et al., 2017). In Southern Punjab, Pakistan, the highest value was reported for *Azadirecta indica* (93.4 %) which was used for blood purification (Usman et al., 2021). In the current study, an FL value of 40 % was calculated for *Azadirecta indica* for blood purification purposes. It was shown in the current study that the FL value of this plant was low, indicating that this plant is used less frequently in our area compared to southern Punjab.

3.4.9. Relative popularity Level (RPL)

RPL indices for the 40 most predominant plants belonging to 22 families with high medicinal values in the study area were determined. A value between 0 and 1.0 is assumed by the RPL, with 0 indicating no ailments treated by a plant species and 1.0 indicating full popularity of a plant for significant ailments. RPL values ranging from 0.17 to 0.5 are shown in Table 3. The highest RPL was found to be for *Polygonum plebejum* (0.5), *Phoenix dactylifera* (0.45), *Imperata cylindrica* (0.45), and *Pentatropis spiralis* (0.44). The lowest use values were reported for *Aerva persica* (0.18), *Alhagi maurorum* (0.17), and *Euphorbia prostrata* (0.16). It is demonstrated that these plants were used for fewer diseases and were not popular. The highest RPL value (1.00) was found for *Phyllanthus emblica*, *Morus macruora*, *Justicia adhatoda*, *Melia azedarach* and *Ajuga bracteosa* each. It was proved by this that these plants were the most popular source of TEMs in the study area (Majeed et al., 2022). The most common plant species with a 1.0 RPL value were identified as *Solanum surattense*, *Triticum aestivum, Solanum nigrum, Withania somnifera, Ranunculus sceleratus* and *Calotropis procera* (Umair et al., 2017). The findings of the current study were noted to be different from the previous study because the highest RPL for *Polygonum plebejum* (0.5) was reported in the current study. In a survey of medicinal plants in the Palestinian territories conducted by Umair et al., (2017), *Alhagi maurorum* (for urinary disorders) and *Tamarix aphylla* (for eye disorders) were recognized as unpopular plant species due to their low RPL. In the current research, it was shown that *Aerva persica* (0.18), *Alhagi maurorum* (0.17) and *Euphorbia prostrata* (0.16) were used for fewer diseases and they were found to be unpopular.

3.4.10. Rank order priority (ROP)

The priority values are ranged from 7.23 to 20. The highest priority value of 20 is held by *Polygonum plebejum* suggesting that it is perceived as the most important or valuable plant while the lowest priority value of 7.23 is held by *Alhagi maurorum* indicating that it is considered the least important plant (Table 3). Based on the reports from locals, the highest value was given to *Polygonum plebejum* (20), followed by values given to *Pentatropis spiralis* (19.5), *Phoenix dactylifera* (16.3), *Imperata cylindrica* (16.3), *Sonchus asper* (16), *Bauhinia variegata* (16) and *Dalbergia sisso* (16). In District Hafizabad, the values of different plant species were shown to indicate their medicinal importance and their popularity among the locals (Umair et al., 2017). It was observed that many species had ROP levels greater than 75. The ROP index was utilized to rank plant species with differing FL values. In District Bhimber Azad Jammu and Kashmir, it was reported that the highest ROP value was held by *Ranunculus laetus* (18) while the lowest ROP value was held by *Convolvulus arvensis* (0.13). However, in another study, it was reported that *Polygonum plebejum* (20) had the highest ROP value, with *Alhagi maurorum holding* the lowest ROP value (Majeed et al., 2022).

3.4.11. Frequency index (FI)

FI value is reported by respondents to range from 1.6 to 3.7. *Alhagi maurorum* (3.7) has the highest FI value, suggesting that it is the most abundant plant species within the study area. It is also suggested by high FI values of 3.5 that *Echinops echinatus*, *Achyranthes aspera* and *Setaria viridis* are relatively abundant. The lowest value (1.6) is attributed to *Launaea mucronata* (Table 3). The frequency index of therapeutic plants was calculated during an ethnobotanical survey in Nepal to assess their ethnobotanical usage frequency (Rajbanshi and Thapa, 2019). *Ricinus communis* was found to have the highest value (86.41), while *Citrus limon*, *Camellia sinensis*, *Moringa oleifera*, *Artocarpus lakoocha* and *Dolichos lablab* were all determined to have the lowest values (1.223 each) (Heinrich et al., 2006). A frequency index of 14.81 was recorded for *Achyranthes aspera*; other species such *as Centella asiatica* (30.86), *Dioscorea bulbifera* (74), *Mimosa pudica* (13.58) and *Jatropha curcas* (7.40) were also recorded in the study region by Uzun and Koca (2020). The highest FI value was reported for *Elephantorrhiza elephantina* at 35 in South Africa, while the lowest was reported for *Aloe grandidentata* at 2 (Mudau et al., 2022). In the present study, the highest FI value was held by *Alhagi maurorum* at 3.7, suggesting its dominant presence in the study area, whereas the lowest value was attributed to *Launaea mucronata* at 1.6.

3.4.12. Cultural significance index (CSI)

The CSI values range from 0.47 to 4, with a higher number indicating that the plant is suggested to possess a stronger CSI (Table 3). Plants with a low CSI value, such as *Launaea mucronata* (0.47), were believed to be associated with low cultural relevance. Plants with a high CSI value, such as *Alhagi maurorum* (4) and *Setaria viridis* (3.6), were observed to be connected with significant cultural relevance. According to the data reported by the locals of Tehsil Fort Abbas, the highest cultural significance index value was reported for *Alhagi maurorum* (4), followed by *Setaria viridis* (3.6), *Achyranthes aspera* (3.76), *Echinops echinatus* (3.76) and *Convolvulus arvensis* (3.52). In Punjab, Pakistan, it was reported that *Triticum aestivum* had the highest value of CSI at 8.00, while *Lolium temulentum* had the lowest CSI value at 0.13 (Majeed et al., 2020). The RFC values of the reported species were found to range from 0.1 to 0.92. The highest RFC (0.92) was attributed to *Viola canescens*, followed by *Mentha arvensis* (0.88), *Berberis lycium* (0.86), *Achyranthes aspera* (0.85), *Taraxacum oficinale* (0.85), *Zanthoxylum alatum* (0.82), *Pinus roxburghii* (0.80), *Pyrus malus* (0.80), *Achillea millefolium* (0.77) and *Prunus persica* (0.77). In the district Lahore, it was reported by Shaheen et al., 2014 that *Rosa indica* had the highest RFC value, while the lowest values were observed for *Deutzia scabra* and *Euonymus japonicus*. Throughout the study, the highest RFC value of 0.037 was reported for *Centaurium pulchelum*, while plants with lower RFC values included *Gisekia pharnaceoides*.

Table 4
Family use value assessment of plant species.

Plant Families	FUV
Aizoaceae	0.33
Amaranthaceae	0.27
Areaceae	0.45
Asclepiadaceae	0.44
Asteraceae	0.28
Brassicaceae	0.4
Convolvulaceae	0.2
Cucurbitaceae	0.35
Euphorbiaceae	0.21
Fabaceae	0.27
Gentianaceae	0.22
Mazaceae	0.2
Meliaceae	0.34
Moraceae	0.27
Plantaginaceae	0.33
Poaceae	0.25
Polygonaceae	0.35
Pteridaceae	0.25
Ranunculaceae	0.2
Solanaceae	0.25
Verbenaceae	0.31
Zygophyllaceae	0.27

3.4.13. Family use value (FUV)

The highest FUV was found in Areaceae (0.45), followed by Asclepidaceae (0.44) and Brassicaceae (0.4). The lowest FUV was observed in Ranunculaceae, Convolvulaceae, and Mazaceae, each with a value of 0.2 (Table 4). It was observed that families with high FUVs are not necessarily represented by a large number of species in the research area.

The most species were found in Lamiaceae and Asteraceae (12 for each), followed by Cupressaceae (2 species) and Ephedraceae (1 species). The highest FUV was identified in Asteraceae (0.56), Ephedraceae (0.45), Asteraceae (0.36), and Lamiaceae (0.35). According to the current study, the Fabaceae (6 species) were identified as having the most species out of 22 families. However, the highest FUV was possessed by Areaceae (0.45), followed by Asclepiadaceae (0.44) and Brassicaceae (0.4). The potential absence of a large number of species in the research area representing families with high FUVs was indicated by our findings. It was established by Bouafia et al., (2021) that the inclination of the local population to use specific plant families more than others determined the use-value of families.

3.4.14. Preference ranking

Phoenix dactylifera (23) was identified as the most used plant for constipation; for fever, *Bauhinia variegate* (20) was identified as the most used plant. The plants most commonly used for blood purification were identified as *Convolvulus arvensis* (21), *Dalbergia sisso* (21), and *Fagonia cretica* (21). For liver disorders, the most frequently used plants were, *Echinops echinatus* (19) and *Centaurium pulchelum* (19); and for skin diseases, *Convolvulus arvensis* (21) was identified as the most used plant (Table 5). The highest overall score of 74 in the preference rating among the seven therapeutic plants used to treat high blood pressure was given to *Verbascum sinaiticum*, (Almeneh, 2021). In the study by Temam et al. (2016), it was stated that the condition most frequently mentioned in the

Table 5
Preference ranking of medicinal plants.

Species	Ailment	Respondents (R1-R8)									
		R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**Score**	**Ranking**
Phoenix dactylifera L.	Constipation	3	3	3	3	3	3	2	3	23	1st
Convolvulus arvensis L.		3	3	3	3	2	2	2	3	21	2nd
Senna occidentalis (L.) Link		2	2	3	3	3	3	2	3	21	2nd
Setaria viridis (L.) P		2	3	2	3	3	3	2	1	19	3rd
Rumex crispus L.		2	2	2	3	2	2	2	3	18	4th
Sonchus asper (L.) Hill.		2	2	2	3	2	2	2	1	16	5th
Euphorbia heliscopia L.		2	2	2	1	2	2	3	2	16	5th
Gisekia pharnaceoides L.		1	2	2	2	2	1	3	2	15	6th
Bauhinia variegate L.	Fever	3	2	3	2	2	2	3	3	20	1st
Aerva persica (Burm.Fil.) Merr.		2	2	2	2	3	3	2	3	19	2nd
Achyranthes aspera L.		3	2	2	3	2	3	2	2	19	2nd
Setaria viridis (L.) P.Beauv.		2	3	2	3	3	3	2	1	19	2nd
Imperata cylindrica (L.) P.Beauv.		2	2	1	3	2	2	3	3	18	3rd
Alhagi maurorum Medik.		2	1	3	2	3	2	3	1	17	4th
Mazus pumilus (Burm.f.) Steenis		2	2	3	2	3	2	1	2	17	4th
Sonchus asper (L.) Hill.		2	2	2	3	2	2	2	1	16	5th
Xanthium strumariam L.		2	2	2	3	2	1	1	2	15	6th
Convolvulus arvensis L.	Purify blood	3	3	3	3	2	2	2	3	21	1st
Fagonia cretica L.		2	2	3	3	2	3	3	3	21	1st
Dalbergia sisso Roxb. Ex. DC.		3	2	2	3	3	3	3	2	21	1st
Ranunculus sceleratus L.		2	2	3	3	2	2	2	2	18	2nd
Veronica anagallis-aquatica L.		3	2	2	2	3	1	2	3	18	2nd
Azadirachta indica A. Juss.		2	2	2	3	3	2	1	3	18	2nd
Lepidium didymium L.		2	2	3	2	2	2	3	2	18	2nd
Polygonum plebejum R.Br.		1	2	2	2	2	1	3	2	15	3rd
Echinops echinatus Roxb.	Liver disorders	3	3	3	2	2	2	2	2	19	1st
Centaurium pulchelum (Sw.) Druce		3	2	3	2	3	1	3	2	19	1st
Solanum nigrum L.		3	2	2	3	2	2	2	2	18	2nd
Lepidium didymium L.		2	2	3	2	2	2	3	2	18	2nd
Launaea mucronata (Forssk.) Muschl.		2	3	2	1	2	3	3	2	18	2nd
Medicago polymorpha L.		2	2	2	2	3	3	2	2	18	2nd
Rumex crispus L.		2	2	2	1	2	1	2	3	15	3rd
Momordica charentia L.	Skin diseases	2	3	3	3	2	2	3	3	21	1st
Senna occidentalis (L.) Link		2	2	3	3	3	3	2	3	21	1st
Convolvulus arvensis L.		3	3	3	3	2	2	2	3	21	1st
Azadirachta indica A. Juss.		2	2	2	3	3	2	1	3	18	2nd
Euphorbia prostrata Aiton		2	2	2	2	3	2	2	2	17	3rd
Phyla nodiflora (L.) Greene		3	2	2	1	2	1	2	3	16	4th
Prosopis juliflora (Sw.) DC		2	2	1	1	2	3	3	2	16	4th

Success rate of this plant for treatment 3 = high, 2 = average, 1 = low, R1-R8 = Respondents.

study area was stomach pain. After a preference ranking of six malaria-treating plants, *Allium sativum* was identified as the most potent medicinal plant for treating malaria. In our research, *Phoenix dactylifera* was identified as the plant most commonly used for constipation (23), while *Bauhinia variegate* was identified as the plant used for fever (20). For blood purification, the plants most commonly used were identified as *Convolvulus arvensis* (21), *Dalbergia sisso* (21) and *Fagonia cretica* (21); for liver disorders, it was *Echinops echinatus* (19); and for skin diseases, *Convolvulus arvensis* (21) was identified as the most used plant.

3.5. Jaccard index

The data from the study area was compared to that of 25 earlier published studies from the region spanning 2012 to 2023 (Table 6). By comparing the data from the study region to other areas, Jaccard index values were determined to range from a minimum of 0.0 to a maximum of 15.32. The highest Jaccard index value (JI: 15.32) was found for Tehsil Yazman Punjab, Pakistan, while the lowest value (JI: 0.0) was associated with China. The determining factor might be the existence of similar species or common uses of species in both study areas. The Jaccard index was determined in relation to various Pakistani regions such as Hafizabad (14.67), Chenab riverine (11.92), Head Maralla (11.18), Sargodha (9.52), Sialkot (9.21), Kotli, AJK (9.09), Thal desert (8.84), and Southern Punjab (7.69). For other countries, the Jaccard index was determined as follows: Saudi Arabia (1.86) and India (1.7). In this study, the unique species or unique uses of the species were reported by the respondents. Species that were found to be common between the study area and neighboring areas ranged from 0 to 21 species; the maximum number of common species was noted to be 21 species from Tehsil Yazman Bahawalpur (Fatima et al., 2019). The lowest count was determined by comparison with a study from China (Guo et al., 2022). The values of the Jaccard index, ranging from a minimum of 0.0 to a maximum of 15.32, were derived by comparing the data of the study area with other areas. The ethnomedicinal data collected from the study area was compared with 25 other studies, revealing that the percentage of species with common uses was between 0 % and 11.86 %. The lowest percentage (0 %) of species with common uses was determined for the areas of Malakand, KPK (Gulzar et al., 2019), Haripur (Siddique et al., 2021), and China (Guo et al., 2022). The maximum percentage of species with common uses was noted in Tehsil Yazman (Fatima et al., 2019), whereas the percentage of species with dissimilar uses was found to range between 0 % and 9.16 %. The minimum value of species with dissimilar uses was noted as 0 for China. The maximum percentage of species with dissimilar uses, calculated at 9.16 %, was attributed to the Thal desert (Shaheen et al., 2014). Upon comparison with this study, three plant species: *Boerhavia diffusa*, *Tribulus terrestris*, and *Peganum harmala* were identified as common between the two areas. Different uses in Sargodha were found for all these three species. The value of (JI) for this study, calculated at 6.67, reflected the very low similarity index between these two areas.

3.6. Novelty index

Seteria viridis seed powder was used for lung infections, fever, and constipation. *Veronica anagalis*, reported for the first time in Tehsil Fort Abbas, was employed for urinary disorders, blood purification, and appetite enhancement using various preparations. *Alternanthera caracasana*, also a new record from Tehsil Fort Abbas, was used for headaches, skin conditions, and animal bites. *Launaea mucronata* was introduced in the study area as a remedy for stomach and liver ailments. *Senna occidentalis*, another first-time report for Tehsil Fort Abbas, addressed skin issues, joint pain, and constipation. Other species like *Ranunculus sceleratus* and *Lantana camara*, among others, were documented with new uses and preparation methods in the region. In the study area, some species, including *Ranunculus sceleratus*, *Rumex crispus*, *Xanthium strumariam*, *Pentatropis spiralis*, *Polygonum plebejum*, *Echinops echinatus*, *Lantana camara, Launaea mucronata, Lasiurus scindicus*, were recorded. This time, novel uses and methods of preparation for these species were documented. For *Echinops Echinatus*, it was reported that a whole plant decoction, herbal tea, and powder were utilized to address flu and hepatitis. In a study by Fatima et al., (2019), it was stated that this plant had been previously used to treat liver disorders and jaundice. Decoction pastes and infusion from the whole plant of Lantana camara were reported to treat stomach disorders and toothaches. Fatima et al., (2019) previously indicated that this plant had been used for colds, coughs, and bacterial infections. Powders and decoctions derived from the roots, leaves, and stems of *Launaea mucronata* were utilized to address stomach disorders and liver diseases. A previous study by Abouzied (2021) noted the plant's use in treating lung cancer. Whole plant powder and herbal tea of *Pentatropis spiralis* were used in addressing stomach disorders. Ali et al. (2023) had previously stated its application in halting bleeding from ulcers and wounds. *Polygonum*

Table 6
Jaccard index values.

Author Citation	Study area, province	SY	TRSs	NPSU	NPDU	PPSU	PPDU	TSCBA	JI
Fatima et al., 2019	Yazman	2019	118	14	7	11.86	5.93	21	15.32
Umair et al., 2017	Hafizabad	2017	85	10	6	11.7	7.05	16	14.67
Iqbal et al., 2021	Head Maralla	2021	119	6	10	5.04	8.4	16	11.18
Qureshi *et al.*, 2012	Sargodha	2012	98	3	9	3.06	9.18	12	9.52
Shah et al. (2021)	Sialkot	2021	114	4	9	3.5	7.89	13	9.21
Qaseem et al., 2019	Kotli, AJK	2019	80	6	4	7.5	5	10	9.09
Shaheen et al., 2014	Thal desert	2007	120	2	11	1.66	9.16	13	8.84
Usman et al., 2021	Southern Punjab	2021	58	2	4	3.44	6.89	6	7.69
(Ali et al., 2023	Cholistan desert	2023	93	8	1	8.6	1.07	9	7.25
Hussain et al., 2022	Central Kurram	2022	106	5	4	4.71	3.77	9	6.56
Saleem et al., 2017	Bahawalnagar	2017	50	6	2	12	4	8	6.06
Raja et al., 2020	Muzaffarabad, AJK	2020	50	2	3	4	6	5	5.88
Afzal et al., 2021	Bahawalpur	2021	20	1	2	5	10	3	5.26
Parvaiz, 2014	Gujrat	2014	37	2	1	5.4	2.7	3	4.05
Ahmad et al., 2021	Thakht-e-Sulaiman Hills	2021	44	1	2	2.27	4.54	3	3.7
Siddique et al., 2021	Haripur	2021	40	0	2	0	5	2	2.56
Gulzar et al., 2019	Malakand, KPK	2019	50	0	2	0	4	2	2.27
Munir et al., 2022	Okara	2022	126	4	7	3.17	5.55	11	2.13
Tounekti et al., 2019	Saudi Arabia	2019	124	2	1	1.61	0.8	3	1.86
Tamang et al., 2021	India	2022	60	0	2	0	3.33	1	1.01
Guo et al., 2022	China	2022	121	0	0	0	0	0	0

key: **SY**. study area, **TRSS**. Total number of reported species, **NPSU**. Several plants with similar uses, **NPDU**. Several plants with dissimilar uses, **TSCBA**. Total number of species common in both areas, **PPSU.** Percentage of plants with similar uses, **PPDU**. Percentage of plants with dissimilar uses, **JI.** Jaccard index.

plebejum was documented to be used in its whole plant decoction and powder form to purify the blood. Prior uses, as cited by Ali et al. (2023), involved its application for cough, asthma, bronchitis, and vomiting. A decoction derived from the leaves of *Ranunculus sceleratus* was used for pain relief. Qaseem et al., (2019) had earlier cited the plant's application for blood purification. The leaves and fruits of Rumex crispus were transformed into herbal tea, decoction, and infusion for treating liver disorders and gastrointestinal diseases. Its former uses include addressing cutaneous disorders and viral infections as mentioned by Fatima et al., (2019). For *Xanthium strumariam*, the whole plant paste, decoction, and infusion were used to treat fever, flu, animal bites, and pain. Shah et al.. (2021) had reported its previous use in addressing smallpox, as an anti-malarial, and in cancer treatment.

4. Conclusion

The research highlights the rich ethnomedicinal heritage of Tehsil Fort Abbas, emphasizing the potential of traditional and ethnic therapies in contemporary health care. With 69 % of the medicinal uses documented for the first time, this study paves the way for future exploration and validation of these practices. Harnessing the power of these traditional remedies can foster a fusion between age-old practices and modern health necessities, promoting a sustainable and holistic approach to well-being.

Data availability

The original data is presented in the article. There is no supplementary data.

CRediT authorship contribution statement

Tauseef Anwar: Methodology, Supervision, Research design. **Huma Qureshi:** Review, and Editing. **Hafsa Naeem:** Experimentation, Validation, Writing. **Ejaz Hussain Siddiqi:** Software, Resources. **Asma Hanif:** Research design, Writing. **Sadaf Anwaar:** Statistical analysis, Validation. **Zobia Noreen:** Resources. **Javed Iqbal:** Research design, Validation. **Baber Ali:** Resources, Drafting. **Rashid Iqbal:** Statistical analysis. **Bilal Ahamad Paray:** Funding, Statistical analysis.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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