Quantitative ethnobotanical evaluation of medicinal plants in District Karak, KP, Pakistan

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Research

Abstract

Background: The opulent vegetation of District Karak, boasting an array and exotic medicinal plants is still unexplored. This study focused on the ethnomedicinal knowledge of uncharted sites of District Karak. Medicinal plants help to identify pharmacognostically potent species. This study will help in drug discovery.

Methods: Field surveys based on semi-structured interviews were conducted with local informants and healers (a total of 100) to document the ethnomedicinal uses of plants. To evaluate the ethnomedicinal data various quantitative indices frequency citation (FC), relative frequency citation (RFC), fidelity level (FL), use value (UV), informant consensus factor (FIC), Jaccard index (JI) and relative importance level (RIL) were targeted to document the data.

Results: A total of 52 plant species belonging to 31 families were identified which were used for various purposes. The most commonly used plant species were *B. campestris, D. sissoo, S. arundinaceum, Z. jujuba, Z. nummularia, D. viscosa, S. mascatense S. suretenses, T. Angustata, V. negundo, F. cretica, H. controtus, J. maritimus, C. edulis Edgey, W. coagulana, A. adscendens* and *C. dactylon etc*. The categories of the informants, plant life form, part used, mode of preparation, rout of uses and ethnomedicinal uses were recorded. The highest RFC value was found for *Ziziphus jujuba* (0.15) followed by *Z. nummularia* (0.13), *A. vera* (0.09), *P. dactyliferous* (0.09), *and E. austrails* (0.07), *M. arvensis* (0.06) respectively. *Z. jujuba* was the most used medicinal plant species with the highest use value (0.18). The reported ailments were classified into 17 disease categories based on ICF values. The highest number of plant species was identified to treat kidney-related ailments (2.25). *M. longifolia* showed the maximum FL (89%), used against dermatitis disorders. The maximum Jaccard's similarity index (JSI) showed that Jandrai and Toor mirch had the highest similarity followed by Toor mirch and Turkha koi with JSI of (37.14%), (19.51%) and respectively. Since the three villages were part of the same ethnic and religious group they showed

significant variances in traditional ecological knowledge, which might be explained by socioeconomic differences and variability in the local environment.

Conclusion: The current study highlights the significance of traditional knowledge of ethnomedicinal plants in selected areas. The study suggested that these plant species have the potential to contribute to the development of new drugs and therapies emphasizing the need for future research and conservation reports.

Keywords: Ethnomedicinal, quantitative indices, informant consensus, Jaccard's similarity index, fidelity level, relative frequency citation, indigenous.

Background

The study of plant-human relationships is the need of life, including food, clothing, shelter, and the economy, as well as the impact of the plant on the environment and human society, is known as ethnobotany. The term ethnobotany was first used by John Hershberger in 1895 (Awan *et al.* 2021). Ethnomedicinal research has historically proven to be a very effective way to find out the traditional uses of local plants and where to get the botanical sources utilized to synthesize modern treatments (Ahmad *et al.*2021). Traditional knowledge can be very helpful, and the plant species that have been discovered may be employed in the future to make medication (*Hameed et al*. 2021). Tradition and ethnomedical records regarding the use of local plant species have, in fact, greatly benefitted pharmacological research. Currently, approximately 25% of all drugs are made from plants (Giri *et al.* 2023). Many medications are also produced using synthetic forms of substances derived from plants (Bano *et al.*2014a). Plant constituents are a significant source of traditional medicines that are used to treat a variety of ailments (Kimutai *et al* .2019). Organic chemicals found in medicinally important plants provide a source of medicines in the form of medicinal plants (Sufyan *et al*. 2018; Rubab *et al*. 2021). Since ancient times, people have used medicinal plants as medicine and in the treatment of many diseases (Mintah *et al.* 2019). Overall, ethnobotany, the study of plant-human relationships, is not merely an academic pursuit, but a vital endeavour that underpins human survival and well-being. It serves as an indispensable link between traditional knowledge and modern science, revealing the profound medicinal properties of plants (Sharif *et al*. 2022). The documented historical use of plants in traditional medicine forms a vast reservoir of information, directly contributing to the development of approximately 25% of modern pharmaceuticals, and indirectly through the synthesis of plant-derived compounds. This highlights the ongoing relevance of ethnobotanical research in driving medical innovation and addressing contemporary health challenges specifically in remote areas of Pakistan (Ashfaq *et al*. 2019). Furthermore, the systematic study of plant-human interactions is crucial for sustainable resource management, ensuring that these valuable natural resources are preserved for future generations. Given the immense potential for discovering novel medicinal compounds within the plant kingdom, ethnobotany remains a critical field, offering a fundamental pathway for accessing traditional wisdom, fostering pharmaceutical advancements, promoting sustainable practices, and unlocking the potential for future medical breakthroughs.

Approximately 80% of the global population receives their medical care from prehistoric systems (Mintah *et al.* 2019). Since ancient times people have used various medicinal plants to treat various diseases believing that they had fewer side effects and were easy to obtain. There are about 53,000 kinds of medicinal plants that are used to treat different types of illnesses (Gulzar *et al.* 2019). Pakistan has variations in climate, so rich medicinal plants are grown. People in rural areas rely on traditional medicine, and the Hakim use naturally produced medicinal plants. Pakistan has over 6000 species of flowering plants 400 of which are endemic to the country, and 600–700 types are medicinal plants (Alamgeer *et al.* 2018). Out of the 6000 species, 124 medicinal species that have been reported originated from the north, and less than 12–25% of medicinal plants are utilized for the treatment of various diseases. Approximately 40,000–50,000 local hakims treat a variety of illnesses using 600 herbs that are used in traditional recipes. According to a recent study, 25% of modern medications and 75% of new treatments for serious diseases come from natural plant sources. People have been using the native flora in their villages for medicinal and other reasons since ancient times. Ethnobotanical knowledge was traditionally transmitted verbally from one generation to the next. It is essential to preserve this knowledge and keep it preserved for future generations to prevent it from disappearing (Munir *et al.* 2022). In Pakistan's rural areas, traditional medicine is widely practiced (Benkhnigue *et al.* 2023). The use of plants is well-known to the people living in distant locations. Due to their simple accessibility and affordable treatment compared to expensive medications medicinal plants are preferred by local people. Through the traditional knowledge transmitted down from their ancestors, the local population reports the medicinal properties of plants against specific diseases (Dilbar *et al.* 2023). The field of ethnobotany has recently demonstrated the tendency to shift from a purely documenting process to one that is more practical and places a priority on the long-term usage of native medicinal flora. Approximately 53,000 medicinal plants are used to treat diseases (Gulzar *et al.* 2019). For the year 2002, the value of aromatic and medicinal plants was measured worldwide 62 billion; however, this value is expected to reach $5 trillion by the

year 2050 (Benkhnigue *et al.* 2023). Since the term "quantitative ethnobotany," which was first used by Prance *et al*. (1987), there has been an increasing interest in improving traditional ethnobotanical research by integrating quantitative research into data collection, processing, and interpretation of results (Zenderland *et al*. 2019). The cultural significance or use values for plants explain the relative importance of plant taxa across different human cultures. Various methodologies have been employed concerning measurement (Sikuku *et al.* 2023). A previous study by Turner (1988) established the cultural significance indices (CSI) as the sum of the various values obtained for every use of a plant. These values were the result of multiplying various estimates for each species' "quality of use, "intensity of use," and "exclusivity of use." With minor adjustments, other writers have used essentially the same framework. Likewise, (Pieroni, 2001) developed a specific Cultural Food Importance Index (CFSI) for wild food plants. In addition to frequency of use, listing frequency also looks at other factors such as number of plants, percentage of plants used, food consumption, satisfaction score and medication use. Approximately 600 different plant species are thought to be used medicinally in Pakistan (Ahmad *et al.* 2020). The bulk of these plants are found in the Himalayan regions of northern and western Pakistan. They have approximately 8000 species of blooming plants and are sites for floral biodiversity. Measuring the "importance" of plants and other vegetation to humans is a fundamental problem in quantitative ethnobotany. Indices are widely employed in the social and biological sciences to quantify otherwise qualitative data. In ethnobotany values for each folk or biological plant taxon are determined by applying relative cultural importance (RCI) indices such as the "use values" created by (Leonti *et al.* 2022). Determining the usage of plants as therapeutic plants can be helped by evaluating their ethno-medical uses. Furthermore, future drug development and discovery may benefit from the data gathered on ethno-medicinal plants. Knowledge can be preserved before it is lost forever with the use of timely data collection and documentation (Singh *et al.* 2018). Over the past three decades, quantitative significance measures have become increasingly common in the study of ethnobotany, motivated by these and other benefits (Zenderland *et al.* 2019). When these findings are properly understood and associated with relevant theoretical problems, they are most beneficial among the increasingly popular quantitative methods is the use value (UV) index which was introduced by (Phillips & Gentry 1993) and is extensively used to measure the relative importance of species.

Various ethnobotanical studies on traditional healthcare have been conducted by ethnobotanists in different parts of the Karak district. However, the Union Council of Jandrai has often been overlooked. People in this area place significant importance on home remedies derived from plants and trees for their medicinal uses. This study aims to address this gap by systematically analyzing the use of medicinal plants through an ethnomedicinal survey. Quantitative indices such as FC, RFC, FL, UV, FIC, JI, and RIL will be employed to identify the most prevalent species, particularly those that have not been widely reported or have limited documentation regarding their medicinal uses.

Materials and Methods

Study area

The Union Council Jandrai is located in Tehsil Karak District Karak, Khyber Pakhtunkhwa, Pakistan. The word Jandrai means watermill. Jandrai is situated at an altitude of 741 meters (2,434 feet) above sea level (2,434 feet) and 33º11'N 71º15'E. The total area of district Karak is about 3,372 square kilometres (Rahman *et al.* 2022). According to the 2023 census, Karak district has a current population of 815, 878. Union council Jandrai consists of many villages, but for the recent study, three villages were selected i.e., Jandrai, Tarkha koi, and Toor mirch. For these studies, three villages Jandrai, Tarkha Koi, and Toor Mirch were selected as the sample population (Fig. 1). These villages were chosen based on their geographical diversity, accessibility, and the presence of experienced traditional healers who actively use and preserve ethnobotanical knowledge. The selection was also influenced by resource constraints, time limitations, and the feasibility of conducting in-depth field research. While the sample size is relatively small, it allows for a detailed qualitative analysis of medicinal plant usage. Additionally, these findings provide a foundation for future, larger-scale studies across the district to further validate and expand upon this research. The climate of District Karak is generally arid and semi-arid with hot summers and moderate winters. The hottest month is June, with an average peak between 40 to 27 degrees Celsius. January is the coldest month with the highest and lowest temperatures at 18ºC and 60ºC respectively. The climate is extremely hot, however the average annual temperature in Union Council Jandrai is 29ºC, and the yearly rainfall is roughly 500 to 750mm (Siddique *et al.* 2016). The main wild flora of District Karak is khagal ghaz or Athel pine (*T. aphylla*), Kikar (*A. nilotica*), Karir (*C. decidua*), Vann or peeli (*S. oleoides*), date palm (*P. dactyliferous*), Toot or mulberry (*M. Alba*) etc. The whole district lacks horticulture because of the scarcity of water. *Z. jujuba (*Beer) is a famous tree of district karak due to its distinct characteristic of dry land. Maize, ground nuts, sorghum, and *peal millet* (bajra) are the main crops grown during the kharif (monsoon) season. The key crops grown during the Rabi season are bread, barley, chickpeas, and mustered (Rahman *et al.* 2022). The soil texture of Union Council Jandrai is medium clay, and loam and the annual rainfall is between 500 to 750mm. Also, the soil of Union Council Jandrai is mainly silty loam, developed in recent piedmont materials derived from the swalik rocks of the surrounding

mountains. When irrigation water is timely available all kinds of plants including fruits and vegetables can develop successfully (Khan *et al.* 2013).

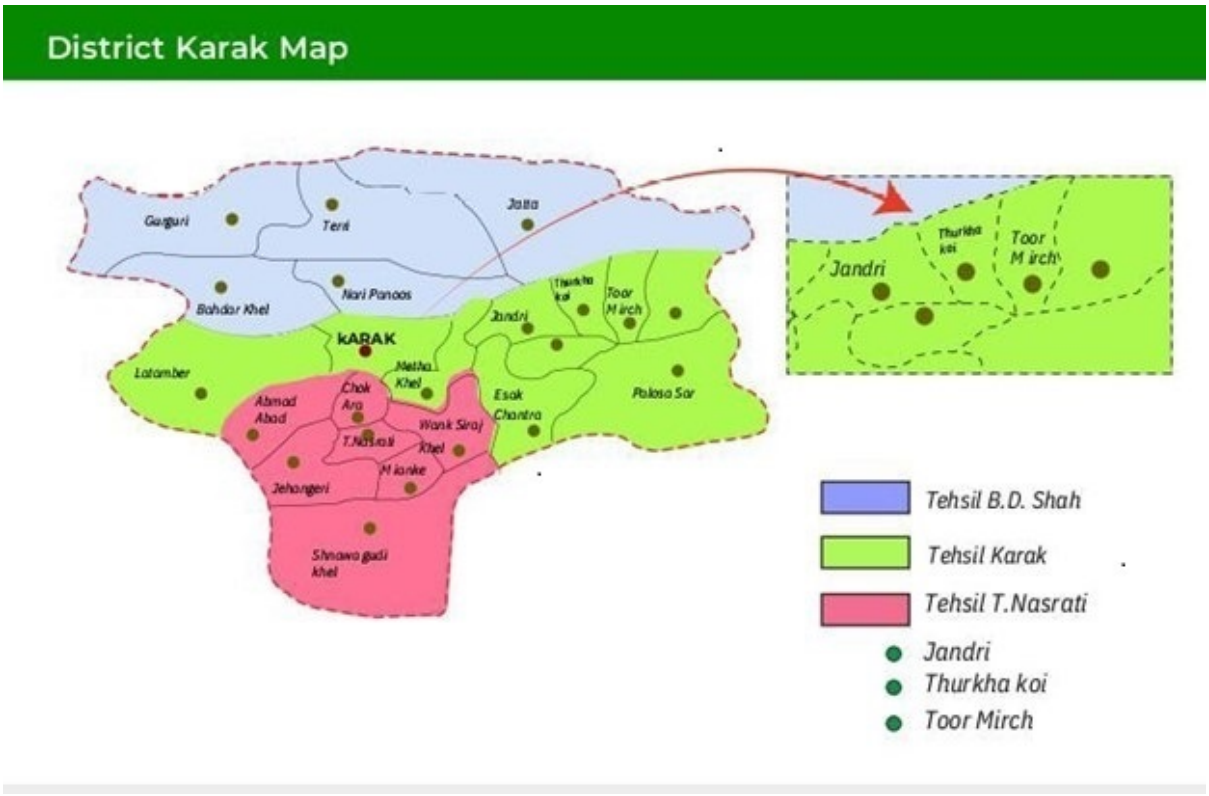

Figure 1. Map of the study area

Ethnomedicinal data collection and ethnographic composition

Field work was carried out in 2023–2024 during one year. Several ethnomedical uses were investigated through interviews with various informants. The informants were from three different villages of Karak i.e., Thurkha Koi, Toor Mirch, Jandrai. Due to the distances between these locations, the villagers utilize plants in various ways because these sites are far away from one another. Consequently, the presence of traditional healers and the amount of flora at these study sites are significant factors. Before starting the research work, general information about the study area was collected. Data was collected from different study sites and then organized and analyzed based on a structured questionnaire which contained predefined questions about therapeutic plants. Informants were questioned about the most frequently used plants their local names the ailments they treated, and the parts they used. To evaluate the reliability of the information acquired via surveys and learn more about the community's understanding of medicinal plants, we also organized group discussions. Interviews were performed by visiting each place and using the local language Pashto. The overall structure of the study including plant identification, data collection, and ethnobotanical categorization is presented in Fig. 2 which summarizes the study framework used for documenting and analyzing medicinal plant knowledge.

Based on data provided by local administrative authorities, about 100 native informants were selected as key sources for this study. Among them, 70 were elderly (40 to 88 years old), consisting of 35 males and 35 females. Additionally, 30 informants were younger (30 to 45 years old), including 15 males and 15 females. Out of the total 100 informants, 19 were specifically chosen for detailed ethnobotanical interviews comprising six males and thirteen females as shown in Table 1. These informants were selected due to their strong reputation and expertise in traditional medicine and medicinal plant usage within the community. They included housewives, farmers, social workers, and rural herbalists known as ‘Hakeems’ (Fig. 3). After collecting the information, a short group discussion was held with the primary informants in whom the objectives of the research were explained to them. Through their cooperation in maintaining the traditional knowledge of the study region and enhancing their confidence in their ability to provide precise data, the work was completed.

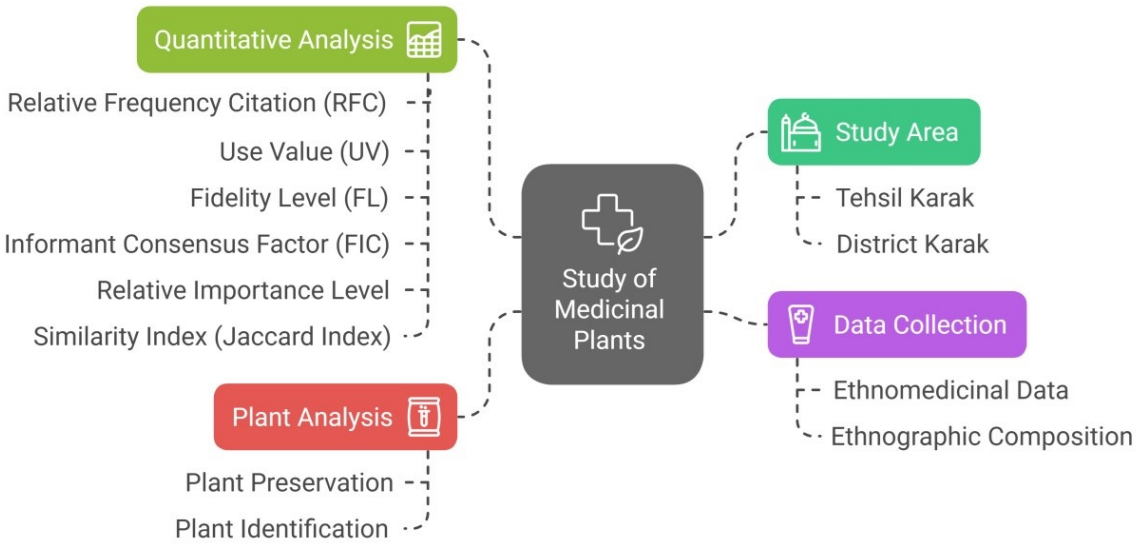

Figure 2. Study Framework

Table 1. Demographic Characteristics of Informants

Category	Informants	Age range	Gender distribution
Total Informant	100	30-88	50 males, 50 females
Elderly Informants	70	40-48	35 males, 35 females
Younger Informant	30	30-45	15 males, 15 females
Key Informants	19	13-88	6 males, 13 females

Plant preservation and identification

Different species of plants were gathered from the study area. Initially, the plant species were permitted to air dry in a ventilated area before being mounted on paper and compressed using a plant presser. The paper was changed every 24 hours until the plants dried completely. Plant species dried were pasted on herbarium sheets. The Latin scientific names, family names, and publishing authors' names were checked with the Flora of Pakistan (Ahmad *et al.* 2020). The investigated plant samples were placed for further study and kept in the Qurtuba University of Science and Information Technology Peshawar, Khyber Pakhtunkhwa, Pakistan. After accurate identification, the specimens were placed on the herbarium sheets. Concerning their botanical, local, and family names, the plant species were divided into three life forms i.e. trees, shrubs, and herbs.

Data analysis

Ethnomedicinal data will be calculated using indices such as FC, RFC, FL, UV, FIC, JI, and RIL to identify the most prevalent species that have not been widely reported or have limited documentation regarding their medicinal uses (Sulaiman *et al.* 2020). This study design offers an overview of ethnobotanical plants through a graphical representation focusing on their traditional and medicinal applications across various cultures.

Frequency Citation (FC)

The Frequency Citation (FC) index in ethnomedicinal studies measures how often a particular medicinal plant is mentioned by informants. It helps in assessing the importance and awareness of specific plant species within a community. The frequency of citation means the number of informants that cited the plant species for a particular use (Rehman *et al.* 2023). The following formula is used to calculate FC values.

$$FC(\%) = \frac{Number\ of\ informants\ who\ cites\ the\ species}{Total\ number\ of\ informants} \times 100$$

Relative Frequency Citation (RFC)

The Relative Frequency Citation (RFC) index is used in ethnomedicinal studies to measure the relative importance or popularity of medicinal plants based on how frequently they are cited by informants. The measure of relative frequency of citation (RFC) will be used to determine respondents' agreement regarding the medical usage of plants in the study area (Vijayakumar *et al.* 2015). It was calculated by applying the following formula:

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

Where; N is the total number of informants and FC is the number of informants reporting the use of a certain species. The most popular or widely used plants in the region are determined by this index.

Use Value (UV)

The Use Value (UV) index is used in ethnomedicinal studies to quantify the relative importance of plant species based on their reported uses. It helps researchers understand how widely and frequently a particular plant is utilized within a community. The importance of a plant species in traditional medicines is indicated by its usage value (Hussain *et al.*2022). These were determined by dividing the total number of informants (∑Ui) for a certain plant species by the total number of informants (N) who reported the plant species during the study (Rehman *et al.* 2023). The use value formula can be obtained by.

$$\textit{Use value = UV} = \Sigma \frac{UI}{N}$$

Fidelity Level (FL)

The Fidelity Level (FL) Index in ethnomedicinal studies is used to measure the degree of consensus among informants regarding the use of a specific plant species to treat a particular ailment. It helps identify which plants are most strongly associated with specific medicinal uses within a community. The fidelity level refers to the usage of a single species to treat a particular ailment. A large fidelity level indicates the most usage of a plant species for a particular disorder, whilst a small fidelity level indicates the minimal use of a plant species for a particular sickness (Rehman *et al.* 2023). These were computed using the following formula:

$$\textit{FL (\%)} = \frac{Ip}{Iu} \times 100.$$

Fidelity level means a single species used for curing a specific disease. Where IP means the number of informants who indicated the use of a species for the same major ailment and, IU= Total number of use reports.

Informant Consensus Factor (ICF)

The Informant Consensus Factor (ICF) is used in ethnomedicinal plant studies to measure the level of agreement among informants regarding the use of plant species for treating different diseases. It helps researchers understand how consistently a community or group selects specific plants for medicinal purposes based on shared knowledge. The plants with higher ICF values are more likely to be effective in treating ailments making them potential candidates for further pharmacological studies. The factor consensus informants (ICF) have been used to determine respondents' agreement with the use of plant species for the treatment of different types of diseases. The following formula is used to calculate it.

$$\textit{Fic} = \frac{Nur - Nt}{Nt - 1}$$

Where Nt = species utilized to treat different diseases in that group and Nur = use reports in the selected category of disorders. The values of the informant consensus factor (ICF) ranged from 0 to 1. A value near 1 indicates that plant species are selected based on clearly defined criteria or information and that informants transmit knowledge regarding these uses constantly. On the other hand, a value near 0 indicates that plant species are determined at random or that informants do not frequently share information about these uses (Kayani *et al.* 2015).

Relative Importance Level (RIL)

The Relative Importance Index (RIL) in ethnomedicinal plant studies helps determine the overall significance of a plant species based on how frequently it is cited by informants and how many different medicinal uses it has. This index provides a standardized way to compare the importance of various plants within a study. RIL helps identify which plant species are most valued in traditional medicine by combining both citation frequency and diversity of uses. Plants with higher RIL values are considered more versatile as they are used to treat multiple diseases. Pardo-de-Santayana developed this index by

analyzing the species' use categories; it excludes the usage's subcategories. The relative frequency of citations over the maximum is represented by RFC (max) in the equation, while the relative value of the usage categories over the maximum is represented by RNU (max) (Zenderland *et al.* 2019). This index has a range from 0 to 1, where 0 indicates no one usage the species and 1 indicates that all respondents utilize the plants in all usage categories.

$$RIL_s = RFC_{s\ (max)} + RNU_{s\ (max)}/2$$

where RFCs (max) is the relative frequency of citation over the maximum, i.e., it is obtained by dividing FCs by the maximum value in all the species of the survey $[RFCs(\max) = \frac{\text{FCs}}{\max(\text{FC})}]$ and RNUs (max) is the relative number of use-categories over the maximum, obtained by dividing the number of uses of the species $\text{NUs} = \sum_{u=u}^{u=uNC} \text{URu}$ by the maximum value in all the species of the survey$[RNs(\max) = \frac{\text{NUs}}{\max(\text{NU})}]$.

For example, *Justicia adhatoda* was mentioned as used by 1 informant while the maximum number of informants citing any species was 15 for *Z. jujuba*. It was used for a single-curing disease (Blood purifier). The maximum number of use categories mentioned for a species in the survey was 0.01. So, the $RIL_{Justicia\ adhatoda}$ = [1/15+0.01/0.15]/2=0.09 RFCmax value of *Justicia adhatoda* is (0.09). The RIL index theoretically varies from 0, when nobody mentions any use of the plant was the most frequently mentioned as useful and in the maximum number of use categories of diseases (Diabetes, gastrointestinal problems, heart diseases etc).

Similarity Index (Jaccard Index)

The Jaccard Index (JI) is used to measure the similarity between two sets of medicinal plant species in different regions. It helps researchers evaluate how much plant knowledge or biodiversity is shared between two areas. Through this index, the researcher determines how much overlap exists between different areas in terms of medicinal plant species. Identifies unique and common plant species, which can guide conservation efforts for regionally important medicinal plants. The statistic used for evaluating the similarities and differences of sample sets is the Jaccard index also called the Jaccard similarity index. The following formula is used to determine the novelty index.

$$\text{JI} = \frac{C}{a + b - c} \times 100$$

Where, the parameters a, b, and c represent the number of species in region A, b is the number of species of the area B, and c is the number of species common to A and B (Bibi *et al.* 2024).

Result and Discussion

Medicinal plant diversity

Twenty plants were collected from Jandrai, nineteen plants from Turkha Koi and thirteen from Toor Mirch. The informants' ages ranged from 18 to 80. Most informants (23%) were between the ages of 60 and 80. Out of 52 ethnomedicinal plants 31 families were identified in which Zygophyllaceae was the dominant family. Social workers, farmers, housewives, and Hakeems, or rural herbalists, were included as these informants. In the present study, the inhabitants utilized herbs mostly for different ailments. Similarly, *Z. jujuba* plant was highly used in the study area for different ailments. Leaves were the most frequently utilized part in the present study. The most highly used remedy preparation method in the study area is dermal (topical) application, which comprises 30% of the total preparations. In Table 3 the highest use value of 0.18 was recorded for *Z. jujuba* while the smallest use value of 0.01 was recorded for *A. viridis*. People in the area use medicinal plants to treat a variety of disorders and ailments, including kidney, gastrointestinal, and reproductive health problems.

Traditional medical systems have used ethnomedical plants extensively to deal with a variety of disorders. Approximately 80% of people in developing nations use medicinal plants to heal ailments, preserving and enhancing their generation's standard of life (Tuasha *et al.* 2018). The abundant resources of nature and the widespread cultural heritage of traditional knowledge have been collected by indigenous tribes through oral tradition and transmission practices (Ouelbani *et al.* 2016). Indigenous traditional knowledge is essential in developing herbal medicines and identifying bioactive ingredients that serve as building blocks for semisynthetic medications (Abbas *et al.* 2017). For the treatment of infertility, women often go to traditional healers first (Ogunlakina *et al.* 2019). Although male healers treat fertility issues to a lesser degree, women healers often handle these issues. One of the primary causes of the variation in respondents' and women's knowledge of medicinal

plants is the source of that knowledge (Ohemu *et al.* 2024). Because traditional knowledge in the family or community is passed through male parents to their firstborn sons, women learn from their mothers or fathers through routine observations, whereas men learn from their fathers in addition to normal observations (Quinlan *et al.* 2016). They are experts in the field of medicinal plants and have a solid reputation in the community for their understanding of traditional medicine. The prevalence of herbs and shrubs aligns with various studies conducted in Ethiopia (Alemu *et al.* 2024). It was also noted that many plants of the Asteraceae, Lamiaceae, and Rosaceae families were utilized medicinally (Hussain *et al.* 2018a).

In Asia research on medicinal plants keeps on getting a lot of national and international attention, particularly given their many applications in improving healthcare and decreasing inequality (Aziz *et al.* 2018). Aromatic and traditional medicinal plants have long been utilized for medical purposes worldwide, and this use is still widely promoted today (Bahadur *et al*. 2022). The use of medicinal species has been documented in numerous studies, and ethnomedicinal research supports the plants' potential medical use (Riaz *et al.* 2021; Bahadur *et al*. 2023). Similarly, our study is in line with the study carried out in tribal communities of Gokand Valley District Buner (Sulaiman *et al.* 2020). According to (Sulaiman *et al.* 2020) a total of 109 species belonging to 64 families were reported to be used in the treatment of different disorders. It included three families (four species) of pteridophytes, 58 families (99 species) of angiosperm, one family (three species) of gymnosperms, and two families (three species) respectively. Asteraceae (six species) was the most prominent family in terms of the largest number of reported taxa, followed by Lamiaceae, Moraceae, and Rosaceae (five species each). The research verified that the most well-known therapeutic families were Asteraceae, Lamiaceae, Moraceae, and Rosaceae (Sulaiman *et al.* 2020). A quantitative ethnobotanical study among indigenous communities in Mauritius (Mahomoodally *et al.* 2014) found FIC value for digestive system disorders, including gastritis, diarrhea, ulcers, constipation, digestive aid, piles, carminative, flatulence, indigestion, colic, and anthelmintic. Table 1 indicates the total plants included in the recent study from Union Council Jandrai their local name, botanical name family name, the life form of the plant, partly used for medicinal purposes, route of administration and ethnomedicinal uses of plants.

The ethnobotanical data collected from the study area were systematically categorized based on local name, botanical name, plant family, life form, parts used, and route of administration and ethnomedicinal uses as illustrated in Fig. 3.

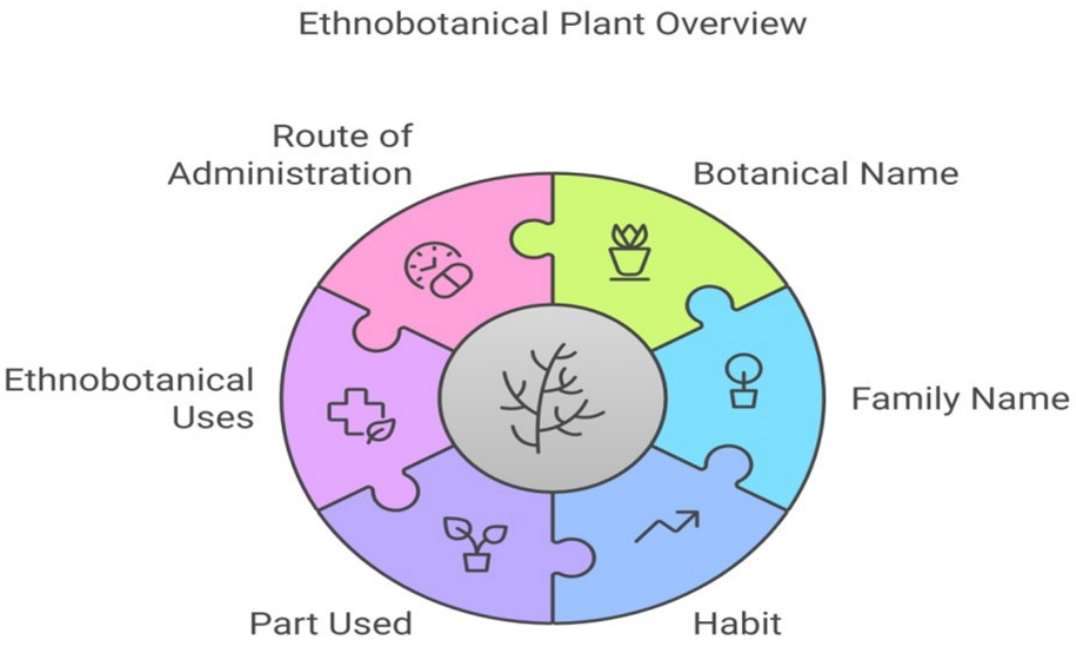

Figure 3. Ethnobotanical overview of plants

Table 2. List of ethnomedicinally important plant species and mode of administration of Union Council Jandrai District Karak

Scientific name	Family Name	Local name	Habit	Part used	Ethnobotanical uses of Plants	Rout of Administration
Justicia adhatoda L.	Acanthaceae	Baza	S	L	For three days, 200 g of crushed leaves are taken orally with black tea in the evening to treat cough and organ inflammation. Blood purifier	Orally, Extract
Achyranthes aspera L.	Amaranthaceae	Sapyboty	H	L, F	Used for diabetes, cough, gastrointestinal problem.	Orally, Paste
Aerva javanica (Burm.f.) Juss. ex Schult.	Amaranthaceae	Khursasa	S	WP	One liter of water is used to boil 250 grams of plant material for 30 minutes. For kidney problems and as a demulcent, a half-glass of the decoction is taken orally in the morning on an empty stomach.	Orally
Amaranthus viridis L.	Amaranthaceae	Ranzaka	H	L	The leaves are grinded to make powder. Take 3 g powder in night with green tea for gastro-intestinal problems.	Orally, Decoction
Chenopodium murale L.	Amaranthaceae	Sorma	H	L	Leaves are used as salad for Laxative	Orally
Caralluma edulis (Edgew.) Benth. ex Hook.f.	Apocynaceae	Pawana	H	WP	Decoction or used as salad for diabetes, stomach pain, digestive system.	Orally
Nerium oleander L.	Apocynaceae	zerawana	S	WP	After boiling 200g of leaves in water, a tiny bit of sugar is added. For digestive issues, have one cup of tea in the morning on an empty stomach.	Grinded form
Nannorrhops ritchieana (Griff.) Aitch.	Arecaceae	Mazaray	H	L	One liter of water is used to bail 250 grams of leaf powder. Boil until 1/2L of the decoction is left. For toothaches and gastrointestinal issues, take 1 teaspoon honey with 1 cup of this concoction at night.	Orally, Paste
Phoenix dactylifera L.	Arecaceae	Khajora	T	L, F	Drink two to three fruits of *Phoenix dactylifera* mixed with milk at night to aid in digestion. Wound healing and laxative	Orally, Extraction
Aloe vera (L.) Burm.f.	Asclepiadaceae	Zargia	H	L	Leaves are boiled in water. Add small amount of sugar for taste. Drink 1 teacup of decoction of in night for anti-arthritis, backache, hepatitis and acne. Also used for Sexual problem. Skin problem	Orally, Topical
Asphodelous tenuifolius Cav.	Asclepiadaceae	Pyazakay	H	L, S	Leaves or seeds approximately 250g are ground into a powder. Add two spoons of Desi ghee and the necessary amount of flour. After 5 minutes of	Orally, Darmal

					heating, a paste is created. On the wound, paste is applied till it heals.	
Calotropis procera (Aiton) W.T.Aiton	Asclepiadaceae	Spalmaka	S	WP	Dried leaves are crushed to make and boiled. Drink one teacup in morning and night for three days for cough, muscle pain and tumor.	Orally, Darmal
Calendula arvensis L.	Asteraceae	Zirgulay	H	L	Drink one glass decoction of leaves in morning on empty stomach for hepatitis and spleen enlargement control.	Orally, Granded
Launaea nudicaulis (L.) Hook.f.	Asteraceae	Peshtlari	H	L	Grind the leaves and mix one egg and small amount of ghee paste are formed. Apply the paste on wound until recover.	Orally
Parthenium hysterophorus L.	Asteraceae	Livanay banga	H	L	Drink one glass decoction of leaves in morning on empty stomach for hepatitis and spleen enlargement control.	Topical, orally
Xanthium strumarium L.	Asteraceae	Qurashka	S	R, L, Fl, R	Decoction is used to treat many diseases, such as rhinitis, nasal sinusitis, headache, gastric ulcer, urticarial, rheumatism bacterial, fungal infections and arthritis. Blood Purifier	Orally
Heliotropium bacciferum Forssk.	Boraginaceae	Markondi	H	S	Ground the seeds to make powder and take one teaspoon with milk in night for pain in backache.	Orally, Extract
Brassica campestris L.	Brassicaceae	Sharsham	H	WP	Camphor 5g massage for 10 to 15 minutes to prevent lice. Oil is used to treat skin conditions; wash your hair after 15 minutes.	Oral, Oil, Darmal
Gymnosporia royleana (Wall. ex M.A.Lawson) M.A.Lawson	Celasteracea	Hrazanka	S	L	Root of *Gymnosporia royleana* is used as brush for toothaches. Decoction of leaves is used for rheumatism, influenza and cancer disorders.	Orally, Extract
Convolvulus arvensis L.	Convolvulaceae	Parwata	H	WP	The root cuts into small pieces and boiled in 2-glass water until one glass of water remains. Drink one teacup in night for laxative, skin diseases and asthma.	Orally
Euphorbia helioscopia L.	Euphorbiaceae	Zarobotay	H	WP	Boiled the required amount of *Euphorbia helioscopia* in 3L water. This water is sprinkled in room's edges to cause death in poisonous insects.	Orally
Acacia nilotica (L.) Delile	Fabaceae	Kikar	T	WP	Bark is used to treat problems with digestion. Seed is a stimulant and a demulcent. The plant is utilized to	Orally, Paste

					make furniture, fuel, feed, and agricultural implements.	
Albizia lebbeck (L.) Benth.	Fabaceae	Sreen	T	B, F	Used for gastrointestinal Problem.	Orally
Astragalus adscendens Boiss.	Fabaceae	Kookarai	S	L, St.	Poultice of the leaves is applied on wound.	Orally
Dalbergia sissoo DC.	fabaceae	Shawa	T	WP	Used for dermal problem.	Decoction
Senegalia greggi (A.Gray) Britton & Rose	Fabaceae	Wanna	T	L, St.	Gum of *Senegalia greggii* is used for gynecological problem.	Orally
Fumaria indica (Hausskn.) Pugsley	Fumariaceae	Livanaygajara)	H	WP	The decoction of leaves is used for antipyretic and anthelmintic.	Orally
Juncus maritimus Lam.	Junacaceae	Chosa	S	WP	Decoction is used for laxative and antibacterial.	Orally
Fagonia indica L.	Lamiaceae	Azghakey	S	WP	Ground the leaves paste is formed and applies on wound.	Dermatitis
Mentha arvensis (Falc.) A. DC.	Lamiaceae	Podina	S	WP	Used for skin diseases such as scars, acne, Stomach problem	Topical
Otostegia limbata (Benth.) Boiss.	Lamiaceae	Spinazghi	S	WP	Powder of leaves is used with milk for Analgesic	Orally
Malva parviflora L.	Malvaceae	Puskay	H	L	Leaf decoctions are utilized for digestive problems. Laxatives are another use of it.	Orally, Topical
Melia azedarach L.	Meliaceae	Bakanra	T	L, S	Leaves are antiseptic. Grind the Seeds to make powder. Add small amount of sugar. Eat one teaspoon in morning to control high blood pressure.	Orally, Syrup
Eucalyptus lanceolatus Link	Moraceae	Lochay	T	B, F	Fruit is a digestive and laxative. For teeth ache, hedging, and sheltering, branches are utilized.	Orally
Morus nigra L.	Moraceae	Toot	T	B, F	Fruit is used for laxative.	Orally
Olea cuspidate Wall. ex G.Don	Oleaceae	Zaitoon	T	L, F	Leaves are used as antiseptic. Used for heart problem. Stomach problem	Orally
Cynodon dactylon (L.) Pers.	Poaceae	Osha	H	L	Fresh roots of Cynodon dactylon are cut into small pieces and boiled in water drink one teacup in night for Laxative and antibacterial infection in abdominal cavity.	Orally
Heteropogan contortus (L.) P.Beauv. ex Roem. & Schult.	Poaceae	Sermal	S	R	Grind the plant material pasty substances are massage on teeth for toothache.	Orally
Saccharum arundinaceum Retz.	Poaceae	Muskanray	S	L	Roots are cuts into small pieces and boiled in water. Drink one teacup in morning for three days for urine blockage.	Paste, Decoction

Emex australis Steinh.	Polygonaceae	Markonda	H	F, L	Used for gynecological problem.	Dermal
Punica granatum L.	Punicaceae	Anar	T	F, B	Fruit is used for iron deficiency. Bark is used for nasal inflammation	Orally, Grinded form
Ziziphus jujuba Mill.	Rhamnaceae	Bera	T	WP	Leaves are used for digestive problem. Also, the used for dermal ailments.	Grinded, Extract
Zizyphus nummularia (Burm.f.) Wight & Arn.	Rhamnaceae	Karkanra	T	WP	The fruit has digestive and tonic properties. Young leaves are used as a diabetes.	Orally
Monotheca buxifoliaL.	Sapotaceae	Gurgura	T	WP	Fruit is Laxative, digestive and are used for iron deficiency.	Orally
Verbascum densiflorum Bertol.	Scrophulariaceae	Darsholon	H	L	Used for gynecological purposes, used for swelling, reduce pain.	Syrup
Datura innoxia Mill.	Solanaceae	Randa	S	L	Plant leaves are used as a laxative and anti-inflammatory.	Orally
Solanum surattenses Burm.f.	Solanaceae	Kandyari	H	L, R	Extract of plant is used as expectorant. Laxative	Orally,
Withania coagulans (Stocks) Dunal	Solanaceae	Shapyanga	H	L, St	Two to three seeds are taken orally to relieve stomach discomfort and act as a laxative.	Dermal
Typha angustifolia Bory & Chaub.	Typhaceae	Dela	S	L	The plant is used for fuel purpose. Skin problem	Orally
*Vitex negundo*L.	Verbenaceae	Warmandai	S	L, R	Once cooked in oil, leaves are applied topically to treat wounds. Roots are used to treat backaches,	Orally
*Fagonia cretica*L.	Zygophyllaceae	Spelaghza	H	WP	Plant extract is used to purify blood and treat diabetes mellitus. It also has anti-inflammatory and anti-scabic properties.	Orally
*Pegnum harmala*L.	Zygophyllaceae	Sponda	H	F, R	Fruit is used for heart problem.	Orally

Note: Part Used, L (Leaves), R (Root), **S** (Seed), **St** (Stem), **WP** (Whole Plant), **F** (Fruit), **Fl** (Flower), **B** (Bark) **Habit**: (Herb), **S**(Shrub), **T**(Tree).

Occupation and education of the informants

The current study data was mostly collected by farmers (8%), followed by housewives (27%), teachers (22%), and doctors (2%) respectively (Fig. 4). Most people who use medicinal herbs are illiterate (40%) and primary level education comprise (20%), matric level is (15%) On the other hand, just 13% and 12% of people with secondary or university degrees, respectively reported frequently utilizing therapeutic plants (Fig. 5).

Similar research was conducted in the Jhelum Valley of Azad Jammu Kashmir in which their informant included practitioner farmers, teachers and laborers from different localities (Awan *et al.* 2021). Another similar work was conducted in Mandi Ahmad Abad District Okara involved 94 informants comprising men, women, farmers, hakims, shepherds, herdsmen, school students and others with substantial local knowledge of plant uses (Munir *et al.* 2022). According to (Abbas *et al.* 2022) local traditional healers have an extensive knowledge of the therapeutic qualities of plants and how to use them to heal different kinds of disorders. A similar survey was carried out in Pakistani culture Himalayan region, which revealed that 41.7% of people were farmers, 29.5% were herders, and 6.3% were traditional healers. Shopkeepers make up 6.3%, students make up 4.2%, and employees make up 2.1% (Khan *et al.* 2022). The literate people possessed less knowledge as compared to those engaged in typical rural and traditional occupations such as farming, pastoralism etc. The most significant difference in knowledge was observed for the socioeconomic status of the informants such as herbal healers holding sufficient and diverse knowledge regarding medicinal plants (Fahim *et al.* 2023). The variations in the traditional applications of medicinal plants can be explained in a variety of ways. The different study locations could be one of the causes. The cultural and traditional practices of the local communities differ, which is another factor. The transmission and preservation of traditional knowledge about medicinal plants is another important function of herbalists (Ahmad *et al.* 2020).

This finding correlates with previous studies that showed illiterate people possess traditional knowledge (Benamar *et al.* 2023). The data shows that traditional herbalists are illiterate 54.49%, elementary level comprise 23.03% and secondary level 19.10%. Only 3.37% of herbalists have completed higher education (Fahim *et al.* 2023). These findings support the findings from various national studies and demonstrate that individuals without higher education continue to have the right to utilize medicinal plants (Liaqat *et al.* 2023). Among others, maximum informants having traditional knowledge regarding the use of medicinal plants were in secondary school education level or even below this and often spoke only Punjabi language (Subba *et al.* 2023). A similar study was conducted in the Okara region of Pakistan which found that 48.1% of traditional herbalists were illiterate, 26.5% had elementary-level education and 20.4% had secondary-level education (Jabeen *et al.* 2024). The consistency in findings across different studies highlights the importance of recognizing the value of traditional knowledge possessed by illiterate individuals and those with lower levels of education. These all findings show different results because these studies were conducted in different regions. Therefore, these regions have different cultural, social and economic contexts which may influence the level of education among traditional herbalists.

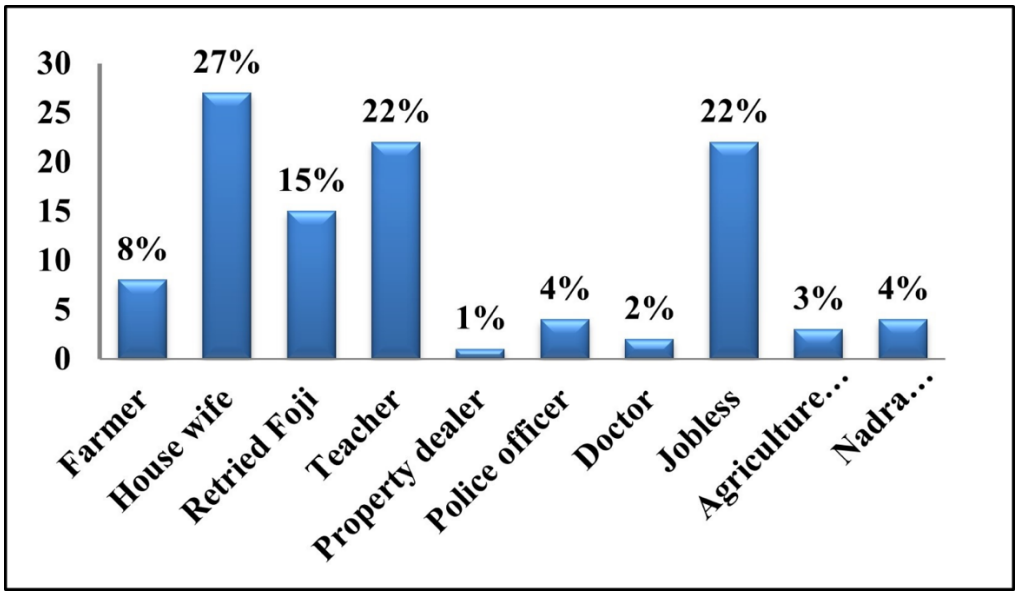

Figure 4. Occupation of the informants

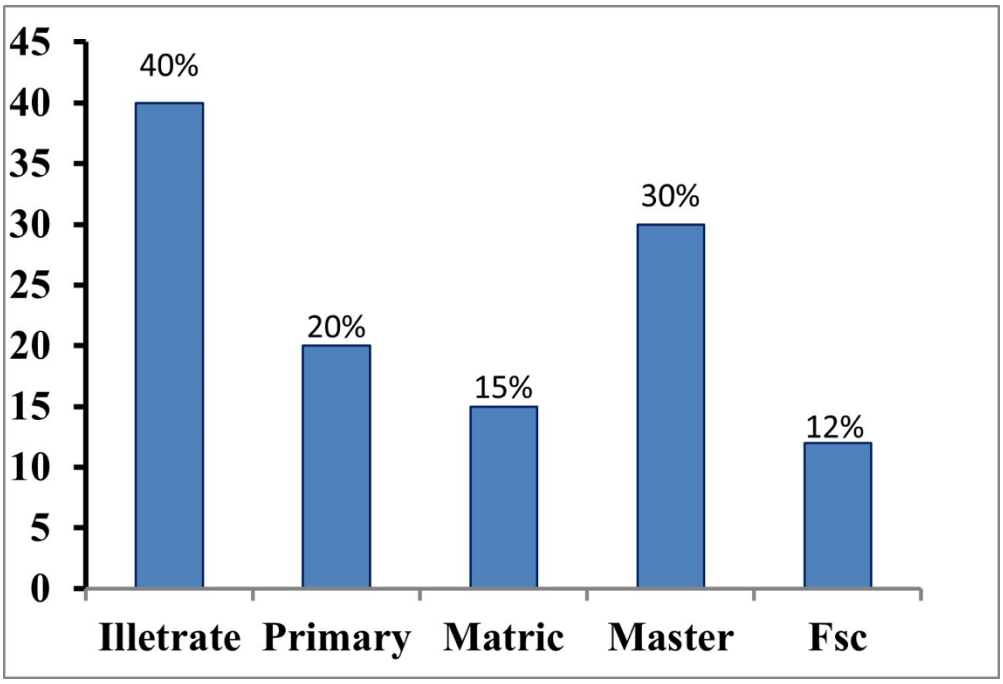

Figure 5. Use of plants according to education level

Plant family-wise distribution according to medicinal uses

The current research survey provides data on 52 medicinal plants from 31 families however, the family percentage was observed high for Zygophyllaceae (11%), Rhamnaceae (9%) followed by Asclepiadaceae (8%), Poaceae (8), Asteraceae (7%), Punicaceae (7%), Solanaceae (5%) while the remaining families showed percentage less than (5%) (Fig. 6).

In contrast, the current findings align with a similar study conducted in a different region of Pakistan. The Tehsil Kabal district in Swat shows that medicinal plant diversity is concentrated in a total of 27 families, with the most highly represented families being Lamiaceae, which contributes 6 species, followed by Asteraceae with 5 species, and Poaceae with 4 species (Khan *et al.* 2015). The remaining families contain fewer than 3 species each. A similar study in the tribal communities of the Central Kurram region of Pakistan reported that most medicinal plants belonged to the Asteraceae family (12%), followed by Poaceae (10%) and Fabaceae (9%) (Hussain *et al.* 2018b). The use of medicinal plant species from the Asteraceae and Poaceae families aligns with ethnomedicinal flora reported from other regions of Pakistan and globally. This may be attributed to the wide distribution of species from the Asteraceae and Poaceae families and their traditional uses known to indigenous communities in Tehsil Arifwala, Punjab, Pakistan (Ramazan *et al.* 2024). Similarly, some studies in Ethiopia by Asfaw *et al.* (2021) indicated that Fabaceae was the dominant family while other studies by Michel *et al.* (2020) reported Asteraceae as the most prevalent one. However, the current study also highlights some differences in the distribution of medicinal plant families. For instance, this study found that Zygophyllaceae was the most highly represented, whereas the study by (Wali *et al.* 2019) reported Asteraceae as the most prominent. A similar study conducted in Uganda documented a total of 165 species belonging to 62 families traditionally used for wound treatment, with the most cited families being Asteraceae (14%), Fabaceae (10%), and Euphorbiaceae (7%). The least cited families, each with only one species, were categorized as others (38%) (Gang *et al.* 2024). These discrepancies may be attributed to different geographic locations and the traditional uses recognized by local informants. All these differences underscore the importance of documenting and preserving traditional knowledge of medicinal plants in Pakistan. The common use of plant species from Asteraceae and Fabaceae for treatment may be due to the high number of bioactive compounds and their prevalence, which in turn renders them superior (Khalfa *et al.* 2024).

Habit-wise distribution of medicinal plants

In the current study, out of the 52 medicinal plants, the primary source of medicine was identified, as herbs 23% was the highest life form Shrubs in second with 15% and trees at 14% (Fig. 7). This distribution highlights the prevalence of herbaceous plants as a key source of traditional medicine, likely because they are easily accessible and abundant in the study area. The special presence of shrubs and trees further underscores their supportive role in traditional healing practices.

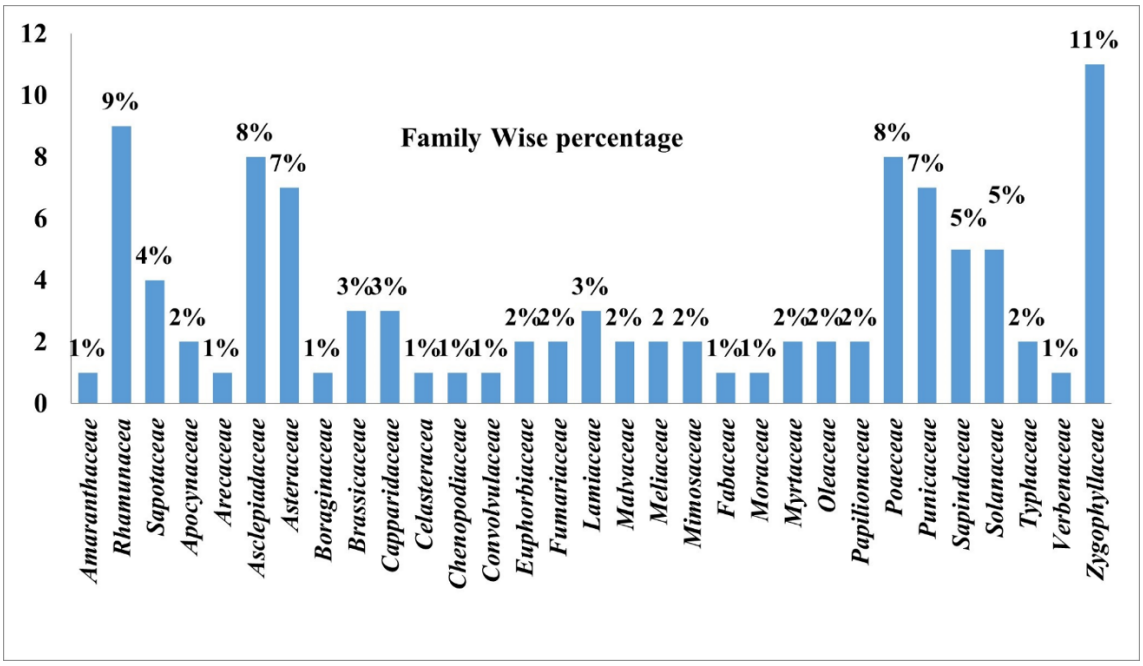

Figure 6. Plant family wise distribution according to ethnomedicinal uses

Inhabitants of District Karak, on the other hand, use 161 plants from 136 genera, 57 families, including 22 trees, 23 shrubs, 104 herbs, and 9 grasses, which were among the significant ethnobotanical plants (Siddique *et al.* 2016). A similar study was conducted in another region of Pakistan where the main sources of medicine are herbs (41%), shrubs (37%), and trees (22%) (Rashid *et al.* 2015). The research area had a rich supply of herbs, which is typical of sub-alpine and alpine environments. This finding was supported by fieldwork, as residents noted a rise in the use of herbs due to their plentiful availability (Kayani *et al.* 2015). Additionally, the extraction and preparation of herbal bioactive substances are relatively straightforward (Stéphane *et al.* 2021). The prevalence of herbs and shrubs aligns with various studies conducted in Ethiopia (Alemu *et al.* 2024). Similar findings were reported in studies on medicinal plants in rural communities, where trees were found in lower percentages due to factors such as high altitude, strong winds, and other climatic and geographic conditions (Anwar *et al.* 2024). Wild and cultivated trees contribute 17% and 10%, respectively, while wild grass accounts for 8%, wild and cultivated shrubs for 9% and 7%, respectively, cultivated herbs for 4%, and cultivated grasses for 1%, in descending order. These findings are consistent with previous reports (Bhat *et al.* 2021). The frequent use of herbs by indigenous communities may stem from their accessibility and effectiveness in treating diseases compared to other life forms (Pan *et al.* 20214). It is well-known that perennial medicinal plants require a prolonged growth period of about 6 to 8 years, depending on the species. Consequently, the perennial life cycle is more prominent in medicinal plant species than in annual ones (Ur-Rahman *et al.* 2019). In terms of the life forms of the medicinal plants reported by the respondents, the study revealed that trees (28 species) were the most used, followed by herbs (15 species), shrubs (10 species), and climbers (4 species) in that order (Waheed *et al.* 2022). The higher prevalence of herbs can be linked to their abundance, diversity, and therapeutic properties, which include antidiabetic, antimalarial, antipyretic, and antiulcerogenic effects, as well as benefits for blood purification, skin soothing, and conditions like high blood pressure, hepatitis, stomach pain, and itching (Anand *et al.* 2019).

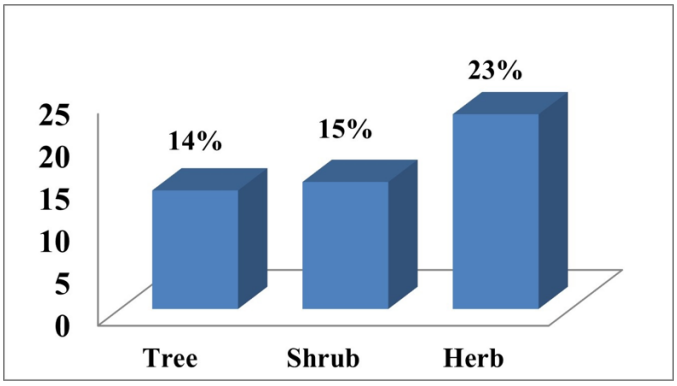

Figure 7. Habit Wise Distribution of Plants Species

Plant parts used for various ailments

Almost every aspect of the various species was found to be used in the current survey to treat prevalent ailments. The most utilized plant part for herbal medicines was the leaf (25%) and were followed by fruits (18%), roots (16%), entire plants (16%), seeds (11%), stems (7%), flowers (4%), and bark (3%) (Fig. 8).

Numerous studies have reported that the leaves of ethnomedicinal plants are the primary plant part used to treat various diseases (Amjad *et al.* 2020). Fruits are also noted as a significant and commonly used component in traditional medicine (Imran *et al.* 2023). This information can pave the way for a scientific evaluation of traditional medicines; potentially leading to advancements in drug development (Chunarkar *et al.* 2024). Throughout history and prehistory, botanically derived medicinal plants have played a crucial role in human societies. The traditional use of these plants is closely linked to the physiological and pharmacological effects of their active ingredients. The most used parts of plants include bark, leaves, roots, branches, stems, fruits, and seeds (Haq *et al.* 2023). Additionally, some plants possess medicinal properties in their flowers, rhizomes, tubers, and wood. In certain instances, the entire plant, including the roots, is utilized). Most ethnobotanical studies have confirmed that leaves are the predominant part of the plant used for treating diseases (Khajuria *et al.* 2021). The frequent use of leaves in traditional herbal remedies has also been documented in earlier ethnobotanical research. Leaves are the primary photosynthetic organs in plants and are often referred to as nature's pharmacy due to their ability to synthesize many active compounds that are pharmacologically effective against various diseases (Ozyigit *et al.* 2023). Similar to previous studies, this research also highlights those roots are commonly used, followed by leaves (Gillani *et al.* 2024). In the Chail Valley, the local population widely utilizes fruits after leaves and roots which aligns with findings by Ahmad *et al.* (2014), who documented a rich diversity of edible wild fruits with medicinal properties in the Swat region of northern Pakistan. Other researchers have also recorded the use of various plant parts, including leaves, roots, fruits, seeds, and whole plants, for preparing herbal remedies (Zamin *et al.* 2024). Earlier ethnobotanical studies have noted predominance in the use of leaves, the biological form of herbs, the preparation method of decoction, and oral administration (Alemu *et al.* 2024). The higher utilization of fruits could be linked to their nutritional benefits (Hasan *et al.* 2024). Aerial parts of herbaceous plants are often collected in large quantities for medicinal purposes, and many recipes incorporate multiple plant parts. However, the harvesting of roots, rhizomes, and whole plants poses a significant threat to the regeneration of these medicinal plants (Jalali *et al.* 2024).

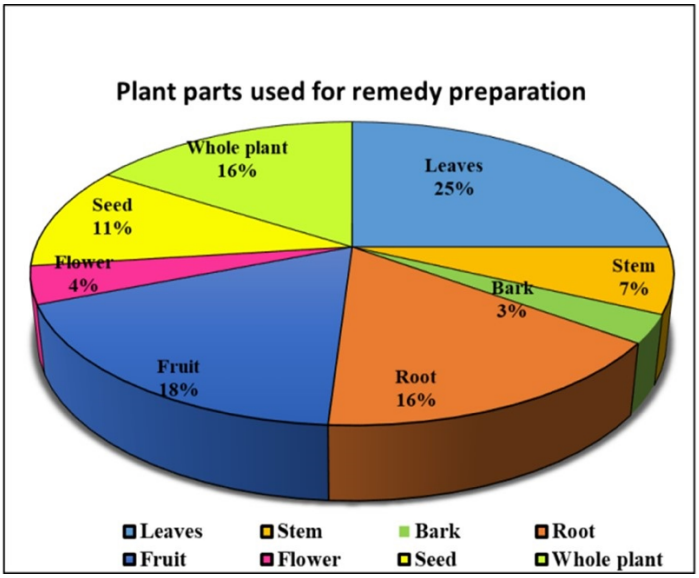

Figure 8. Plant Part Used for Various Ailments

Use and mode of preparation of plants for different ailments

The community that lives in the area of study prepares recipes for the treatment of a variety of ailments using a variety of methods, such as decoction, extract, juice, powder, paste, infusion, skin inflammation, crushed, sap, syrup, and oral. The most used mode of preparation of plants remedies was Skin Inflammation which comprised (30%), then oral (20%), syrup (15%), crushed (10%), paste (9%), and sap (8%) (Fig. 9) while the current study it was found that the primary method of remedy preparation was through dermal use, as indicated by ethnopharmacological studies from other regions (Jalali *et al.* 2024). We were fortunate to gather significant information regarding the preparation of remedies and their administration methods for all the plants reported. However, the therapeutic potential of some plants is linked to how they are used. The

crushed leaves of *J. adhatoda* are mixed with black tea and taken orally for three days to treat cough and inflammation of the organs.

Furthermore, reports from other regions of Pakistan have previously mentioned a similarly broad range of preparation techniques (Umair *et al.* 2019). The leaf of *A. Vera*, which contains a viscous juice, is scratched and used as a dressing for wounds. The latex from *C. procera* is combined with flour and then applied topically to promote wound healing (Dharani *et al.* 2022). An infusion made from the inner septa of *C. fistula* fruit is prepared to alleviate stomach pain and provide relief from colic in children. The fruit of *C. colocynthis*, when boiled in water, is consumed to help manage diabetes (Vidhya *et al.* 2024). Grains of *H. Vulgare* are soaked in water for a day, and the resulting extract is used for diabetes treatment. A decoction made from the shoots of *S. kurramensis* serves as an anti-helminthic and anti-malarial remedy (Kalauni *et al.* 2024). The leaves of *J. regia* are commonly used for dental hygiene and to prevent tooth decay. The roots of *P. wallichiana* are chopped into small pieces, and boiled, and the liquid extract is collected. A drop of this extract is mixed with a glass of milk and taken orally once a day as a blood purifier (Hussain *et al.* 2018b). Medicinal plants continue to be utilized in tribal and rural areas, where they are regarded as primary therapeutic agents for maintaining good health. These practices have been documented in ethnobotanical studies conducted throughout Pakistan, and their medicinal significance is supported by indigenous research from various regions of the country (Malik *et al.* 2015). Our findings align with the traditional uses of plants in the surrounding regions. Similarly, some plants in the present study like *B. campestris* and *E. helioscopia* are administrated tropically for the treatment of hair strength and used for anti-lice. *F. indica* is known for its blood-purifying properties, while a decoction of *H. vulgare* grains is used for diabetes. *S. nigrum* extract is used for jaundice, and *S. surattensis* fruit decoction is effective for coughs, as documented in the study (Table 1). Such correlations reinforce our findings and present a valuable opportunity to assess the therapeutic potential of these plants.

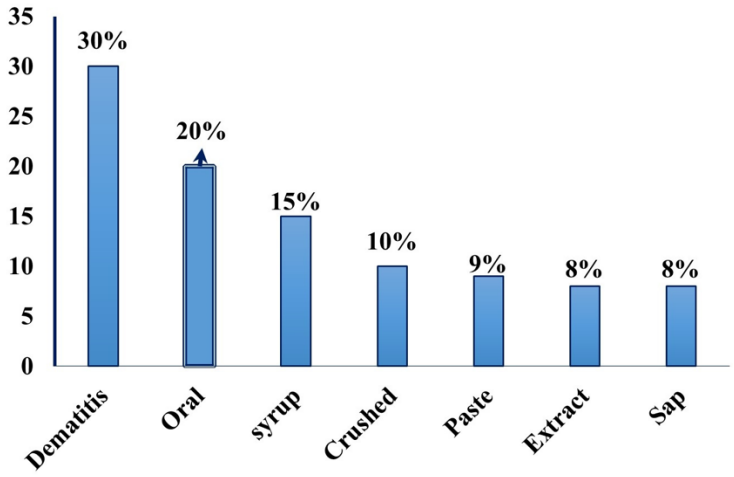

Figure 9. Mode of Preparation of Herbal Medicine

Quantitative Evaluation of Ethnomedicinal Data

This study is the first attempt to quantify the medicinal flora of the selected region, including recording parameters such as frequency citation, relative frequency citation, relative importance level, Jaccard index, and informant consensus factor. The chord diagram is provided (Fig. 10) to depict the multidimensional relationships between ethnobotanical indices (FC, RFC, FL, UV, RIL) and documented medicinal plant species. This graphical representation enables in depth evaluation of the cultural and therapeutic importance of individual species based on quantitative ethnobotanical indices.

Relative Frequency Citation

Out of 52 collected medicinal plants, 10 of these seem to be the most well-known to the local inhabitants as indicated by their RFC value (Table 3). The plant species included in this study had RFC values ranging from 0.01 to 0.15. Table 3 shows that the plants with the greatest RFC values were *Z. jujuba* (0.15), *Z. nummularia* (0.4), *A. vera* (0.09), *P. dactylifera* (0.09), *E. austrails* (0.04), and *Z. jujuba* plant that can easily be cultivated within unfavorable conditions believed to be potential for health and beauty products. All parts and components derived from the plant have been used to alleviate various ailments in traditional medicine. Wide availability makes it excellent potential for growth in the economy and health & nutrition sector in a developing country. It is very rich in healthy antioxidant and bioactive compounds. It can cure skin infections and sores.

All other plant species exhibited values less than 0.05. The high level of ethnomedicinal richness in the study areas can be attributed to the diverse range of medicinal plants that local communities traditionally use. Furthermore, the RFC values highlight the significance of these species about the number of local informants involved in this study. This underscores the deep and enduring connection that residents have with the plants in their environment.

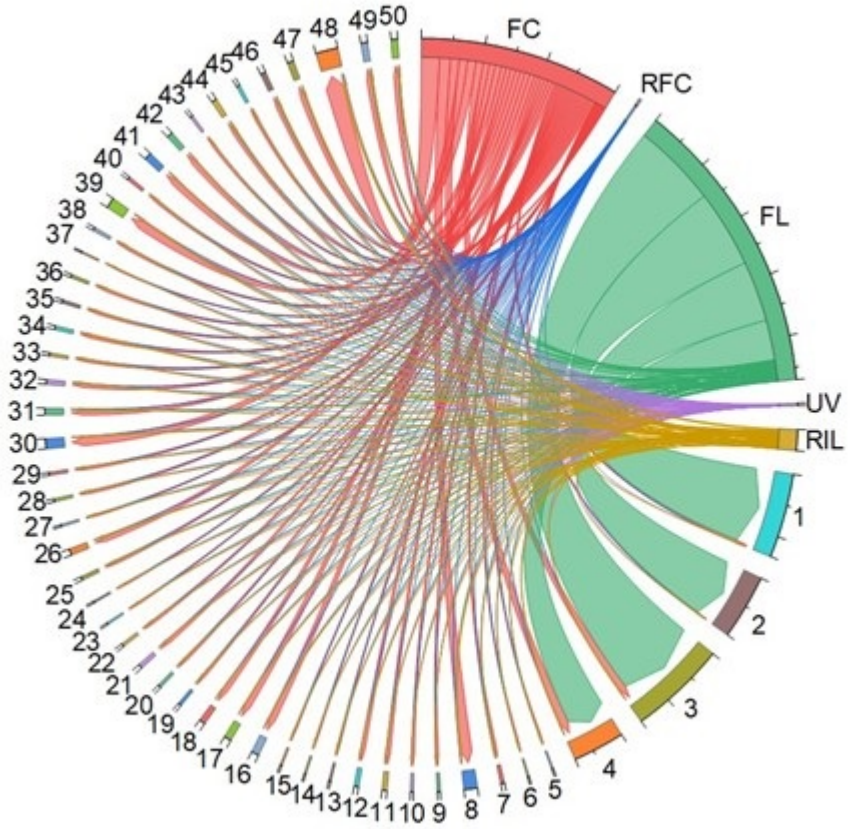

Figure 10. Chord diagram showing the links between ethnobotanical indices and species

Similar research was conducted in different regions of Pakistan (Hassan *et al.* 2019). The distinctive and dominant species of the Skardu valley *H. rhamnoides* is crucial to the development of the interrelationships between humans and nature. The inhabitants of this valley commonly use different plants to cure a variety of conditions, including dermatitis, coughing, ulcers, jaundice, heart problems, and urinary tract infections. In contrast, other researchers (Belgica *et al.* 2021) reported that various parts of *C. dichotoma* plant used for different purposes, such as leaves, roots, seeds, bark, and fruit, have been reported for possessing immunomodulatory, antidiabetic, anthelmintic, anti-ulcer, anti-inflammatory, and analgesic activity. Hence, medicinal species with the highest use-value were commonly used by the local inhabitants in traditional medicine and can be found and wildly distributed in their community and available when needed (Nik-Salleh *et al.* 2020). Similarly, a study was conducted at indigenous communities of the Punjab region, Pakistan. The result showed that plants with high RFC values greater than 0.5 which were mainly utilized for many health-related disorders including *W. sominifera* (Ashwaganda) had RFC value of 0.73 indicating its high importance in traditional medicine (Ullah *et al.* 2023). A similar study was carried out in the Khyber Pakhtunkhwa region of Pakistan. It showed that plants with high RFC values exceeding 0.6 were commonly used for various disorders, such as *B. lycium* (Kashmiri barberry), which had an RFC value of 0.83 and was utilized for gastrointestinal issues, infections, and wounds (Khan *et al.* 2018). Another study in the Azad Jammu Kashmir region focused on medicinal plants with high RFC values, revealing that these plants had RFC values greater than 0.55 (Awan *et al.* 2021). Notably, *V. pilosa* (Wild Pansy) had an RFC value of 0.67 and was primarily used for treating diabetes, hypertension, and arthritis, highlighting its significant role in traditional medicine. These studies illustrate the effectiveness of RFC in assessing the citation frequency of medicinal plants in ethnomedicinal research in Pakistan. The findings can guide conservation efforts, promote the sustainable use of medicinal plants, and aid in the development of new medicinal products (Abaku *et al.* 2024). However, our findings regarding the most frequently used families, species, and diseases treated with medicinal plants in this region differ significantly from those in other parts of the world.

Use Value Index

The use value (UV) of the plants refers to species deemed most significant in the municipality based on their reports. In this study, the UV of the medicinal plant species ranged from 0.01 to 0.18. The highest UV was recorded for *Z. jujuba* (0.6), followed closely by *Z. nummularia* (0.17), *B. campestris* (0.11), *A. vera* (0.09), *P. dactyliferous* (0.09), *D. innoxia* (0.09), *E. australis* (0.07), and *M. arvensis* (0.06). The lowest UV was noted for *J. adhatoda* (0.05), *A. viridis*, and *A. javanica* (0.04), while *S. suretenses, X. strumarium, W. coagulana*, and other plant species had a UV below 0.04, as shown in Table 3.

A similar study on use value was conducted in various regions of Pakistan. *O. compactum*, with the highest UV of 0.553, was identified as the most frequently utilized species by local informants (Anywar et *al.* 2020). Locals refer to this aromatic and therapeutic plant as "zaâtar" and "sahthar." It has been traditionally used as a natural remedy in Morocco, with applications varying by region, including the treatment of various ailments, utilizing different parts of the plant, and preparing it in diverse ways. For instance, Moroccan people use parts of *O. compactum* to address gastrointestinal and lung issues. The leaves and stems of *O. compactum* are employed for treating various diseases, including heart conditions, diabetes, inflammation, hypertension, and digestive disorders (Bouyahya *et al.* 2017). A well-known *B. balsamifera* herbal plant in the Philippines is commonly used for medicinal purposes, including treating spasms, wounds, cuts, rheumatism, diarrhea, colds, and coughs. It is also effective for infected wounds, respiratory infections, and stomach pains, making it particularly popular among individuals with kidney issues due to its diuretic properties (Liang *et al.* 2023).

Consuming it as an afternoon tea can help maintain a healthy urinary tract and assist in flushing out uric acid. *M. paniculata* has been recognized for its ability to address various health conditions and shows promising preventative effects against issues like liver damage, infections, hyperglycemia, and cancer. Additionally, it serves as a remedy for stomach aches, fevers, pain relief, and intestinal disorders (Aziz *et al.* 2015) *P. amboinicus*is valued for its therapeutic and nutritional benefits, which are highly sought after in the pharmaceutical sector. Moreover, it possesses horticultural advantages due to its aromatic qualities and ability to produce essential oils (NikSalleh *et al.* 2020). The leaves of this plant are often consumed raw, used as flavoring agents, or included as ingredients in traditional dishes. The highest use value (UV) recorded was 0.48. *Z. officinale* also been noted in a study from Kurdistan, Iraq (Ahmed *et al.* 2016). This finding aligns with the results of the current study. The powdered fruit of *Z. jujuba* is employed to alleviate stomach pain, blood disorders, digestive issues, diabetes, and to serve as a heart tonic, immunological modulator and antibacterial agent (Rodriguez *et al.,* 2017). Similarly, the root of *Z. jujuba* is used for headaches, nausea, coughing, and chronic diarrhea (Ahmad *et al.* 2017). The next highest use value was found for *Z. nummularia*, which has five medicinal applications diabetes, malaria, fever, blood pressure issues, and urologic problems (Ullah *et al.* 2023). Among the other plants, *B. campestris* is used for diabetes, cancer, stomach issues, and as a blood purifier (Azam *et al.* 2013). The *C. fistula* is utilized for colic and stomach pain, as well as a carminative; and *T. linearis* is used for cough relief and as a carminative and appetite stimulant (Thakur *et al.* 2020). All these findings demonstrated that different plants exhibit varying use values due to their potential. In the present study, *Z. jujuba* showed the highest use value because it is abundantly found in the Union Council Jandrai. Additionally, it contains many bioactive compounds; the main biologically active components of this plant's fruit include vitamin C, phenolics, flavonoids, triterpene acids, and polysaccharides.

Relative Importance Level Index (RIL)

The relative importance level (RIL) indicates how significant each species *is* within the study site. To calculate the RIL value, the method used outlined by (Umair *et al.* 2019) was applied. This index is derived by dividing the number of respondents who identified a useful species (FC) by the total number of respondents for all species (FC). A relative importance level index (RII) is widely used metric in the cultural significance and traditional uses of medicinal plants (Loenti *et al.* 2022). The present work highlights that the highest relative importance level (RIL) statistics are recorded for *Z. jujuba* (1.5), followed by *B. campestris* (0.9), *C. procera, C. arvensis*, and *L. nudicaulis* (0.78), as well as *P. dactylifera*, *A. vera,* and *M. azedarach* (0.69), *N. oleander*, (*N. oleander* is highly toxic due to the presence of cardiac glycosides e.g., oleandrin and periodide. Despite its toxicity *N. oleander* has been used in traditional medicine in controlled doses for various ailments such as *Oleander* leaves and flowers are sometimes used in topical applications for treating skin infections, boils, and wounds. It is also used for cancer).

Other plants show RI values below 0.09. This finding concludes that the highest RI value is 1.5, while the lowest is 0.09, as shown in Table 3. In contrast, this study is consistent with another study which was conducted in another region of Pakistan which indicated that the most significant species used for various disease categories in the survey area is represented by the relative importance level. The RIL values for the following species are *A. lantago* (0.59), *B. lyceum* and *T. hirsuta* (0.61), *M. polymorpha* (0.64), *J. adhatoda* and *A. parviflora* (0.65), *C. procera* (0.69), and *R. communis* (0.62). Due to their use for a range of ailments, these species have been recognized by a considerable percentage of informants (Rahman *et al.* 2022).

Pakistan is the home of a diverse range of medicinal plants with a rich culture of traditional medicine. Recently published studies have employed the relative importance level (RII) to evaluate the cultural significance and traditional uses of medicinal plants in various regions of Pakistan (Shaheen *et al.* 2017). A study conducted in the Laki Marwat district of Pakistan showed that plants with high (RII) value (> 0.7) were primarily used for treating diseases such diarrhea, fever and respiratory infection (Ullah *et al.* 2014). A similar study was conducted in Kalash people in Pakistan (Hadi *et al.* 2024). The study found that high relative (RII) values (> 0.8) were mainly used for treating diseases such as skin infections, wounds and gastrointestinal disorders. Similarly, studies conducted in Swat Valley, Pakistan, documented that *O. indicum* exhibited the highest RI values, indicating it is the most valued and preferred medicinal plant for treating various diseases across several ailment categories (Shah *et al.* 2024a). The indigenous communities of the northern region in Pakistan which commented the (RII) values (> 0.7) were primarily used for treating diseases such as fever, skin disorder, and respiratory infections (Hussain *et al.* 2018a). Another study was carried out in the Eastern India-Pakistan borders. The result showed that plants with high (RII) values were used for many disorders such as heart disorders, diarrhea, constipation, and skin ailments (Fahim *et al.* 2023). Similarly, study was evaluated by the Balochi people in Pakistan which demonstrated the importance of medicinal plants in traditional medicine. The result showed that the high (RII) values of plants (> 0.8) were mainly used for treating gastrointestinal disorders, skin ailments, infections, and wounds (Siddique *et al.* 2021).

All these findings show different RI values for different plants which are documented in different regions in Pakistan. All the findings investigate the importance of medicinal plants and providing valuable insights into the complex relationships between plants, people and culture. Whliein the present study the relative importance (RI) highest value is observed for many plants such as *Z. jujuba, B. campestris*, *N. oleander*, *C. procera, C. arvensis*, and *L. nudicaulis, P. dactylifera*, *A. vera* and *M. azedarach* (0.69) due to their distinctive properties. Because they are found widely in Jandrai because this area is dry. The reason is that this plant contains different bioactive compounds which are used for different diseases. For example, *C. arvensis* flower is used for skin firmness, and decoction is used for insomnia.

Fidelity Level Index

In ethnomedical research, the fidelity level index (FL) is a useful tool for assessing the frequency with which traditional knowledge and the usage of medicinal plants are utilized by different informants (Albuquerque *et al.* 2024). The fidelity of plant species for specific diseases showed significant variation, ranging from 1% to 100% in the study area (Fig. 11). A high-fidelity level (FL) suggests that certain plant species are highly preferred for treating a disease, while a low fidelity level indicates that those species are less favored for specific treatments. High FL for a plant species suggests that they might contain valuable phytochemical compounds with pharmacological effects that have to be proven scientifically. The fidelity level (FL) in the present study ranged from 11% to 89%, *M. longifolia* (89%) was the most often used plant species in the research area for treating dermatitis, followed by *W. coagulana* (86% Diabetes), *V. densiflorum* (Gynological Disorder 75%), *C. dactylon* (analgesic 75%), *A. adscendens*, *A. Lebback* (respiratory disorder 70%), *Z. jujuba* (respiratory disorder 67%), *A. nilotica* (Stomach problem 64%), *H. controtus* (toothache 60%) and *C. murale* (Ulcer 60%), *Z. nummularia* (tonic 57%), and *J. maritimus* (analgesic 50%), while the remaining species show FL values less than 50%, as indicated in (Table 3).

In contrast, our study is consistent with other work which are documented in another region. Exploring the bioactivity of medicinal plants, the traditional healer's value improves their acceptability for use in healthcare systems both domestically and internationally (Mofokeng *et al.* 2022). The study was conducted in indigenous communities living in the western hilly slopes of Dera Ghazi Khan, (Ahmad *et al.* 2020). A similar study was conducted by the Baochi people in Pakistan, which documented plants with high fidelity level values (> 80%) were mainly used for treating Pakistan to assess the traditional knowledge of medicinal plants. The result showed that plants with high fidelity level values (> 70%) were primarily used for treating diseases such as malaria, tuberculosis and skin infections diseases such as fever cough and diarrhea (Shah *et al.* 2024). Another study was carried out by local communities of Punjab people which documented those medicinal plants with high (FL) values (> 75%) were mainly used for treating different health ailments such as cancer, heart disorders, and skin infection (Ijaz *et al.* 2016). Furthermore, the result summarized that the medicinal plant species that are frequently used by local people to treat several ailments have less fidelity level value, while medicinal plants used to treat one or few ailments have 100% FL (Ullah *et al.* 2014). According to a study conducted in 2023, *B. lycium* had the highest fidelity level (89.9%) when used to treat ulcers and stomach pain. *D. blancoi* followed with a fidelity level of 62.2% for treating diarrhea and abdominal pain, while Sageretiathea and *S. nigrum* each had a fidelity level of 53.3% for treating hepatitis and blood purification, respectively (Haq *et al.* 2023). In contrast, *X. strumarium, C. longifolia*, and *A. grahamianus* exhibited the lowest fidelity levels. The fidelity levels ranged from 28% to 100%. The plant species most frequently used in the study area, achieving a 100% fidelity level, included *A. indica, A. viridis, A. scoparia, C. deodara, C. botrys, J. humile, M. sylvestris, L. chrysanthemoides, T. foliolosum,* and *U. dioica* (Murad *et al.* 2013). In the present study total 53 plants were documented

which belong to 31 families that are used total of seventeen different disease categories. For example, *O. limbata* is used for cancer and *A. lebback* is used for respiratory disorders *M. longifolia* was the most often used plant species in the research area for treating dermatitis, because these plants possess pharmacological efficacy. All the above studies show different fidelity level values due to different reasons. One of the most important reasons is that every region has its own beliefs and cultural practices. The other most important reason is that every region has different climatic conditions that are why plants possess different pharmacological compounds. Documenting and preserving traditional knowledge about indigenous medicinal plants is essential not just for the communities themselves, but also for ethnopharmacological research (Shuaib *et al*. 2021). Our findings could serve as foundational data to connect scientific communities with traditional health practitioners in the realm of new drug discovery. Therefore, there is a significant need for more scientific research on these medicinal plants, focusing on phytochemical, biological, and clinical studies

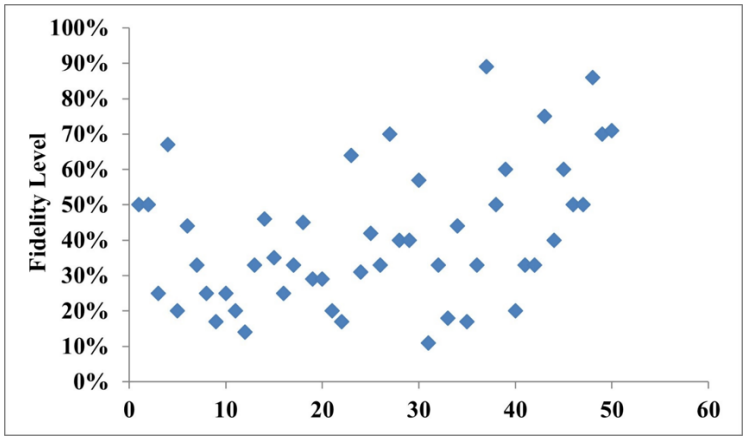

Figure 11. Fidelity Level Index of Ethnomedicinal Plant

Table 3. Medicinal uses of Wild plants of Jandrai, with FC, RFC, FL, UV, RIL

Plant Scientific Name	FC	RFC	FL value	Use value	RIL
Acacia nilotica	2	0.02	64%	0.05	0.2
Aerva javanica	1	0.01	50%	0.04	0.1
Albizia lebbeck	6	0.06	70%	0.04	0.6
Aloe vera	7	0.07	33%	0.09	0.7
Amaranthus viridis	1	0.01	25%	0.04	0.1
Asphodelous tenuifolius	1	0.01	25%	0.01	0.1
Astragalus adscendens	2	0.02	70%	0.05	0.2
Brassica campestris	9	0.09	46%	0.11	0.9
Calendula arvensis	2	0.02	25%	0.02	0.2
Calotropis procera	2	0.02	17%	0.02	0.2
Capparis decidua	3	0.03	35%	0.03	0.3
Caralluma edulis	3	0.03	20%	0.04	0.3
Chenopodium murale	1	0.01	60%	0.01	0.1
Convolvulus arvensis	1	0.01	33%	0.01	0.1
Dalbergia sissoo	1	0.01	40%	0.01	0.1
Datura anoxia	5	0.05	33%	0.09	0.5
Dodonaea viscosa	5	0.05	11%	0.05	0.5
Emix austrails	4	0.04	33%	0.07	0.4
Eucalyptus lanceolatus	2	0.02	42%	0.02	0.2
Euphorbia helioscopia	2	0.02	45%	0.02	0.2
Fagonia cretica	3	0.03	17%	0.03	0.3
Fumaria indica	2	0.02	29%	0.02	0.2
Gymnosporia royleana	1	0.01	25%	0.01	0.3
Heliotropium bacciferum	1	0.01	33%	0.01	0.1
Heteropogan controtus	2	0.02	60%	0.02	0.2
Juncus maritimus	4	0.04	50%	0.04	0.4

Justicia adhatoda	1	0.01	50%	0.05	0.1
Lunaea nudicaulis	2	0.02	20%	0.02	0.2
Malva parviflora	2	0.02	20%	0.02	0.2
Melia azedarach	7	0.07	17%	0.02	0.7
Mentha longifolia	4	0.04	89%	0.06	0.4
Monotheca buxifolia	3	0.03	44%	0.03	0.3
Morus nigra	2	0.02	31%	0.02	0.2
Nerium oleander	2	0.02	20%	0.02	0.8
Olea cuspidata	2	0.02	33%	0.02	0.2
Otostegia limbata	2	0.02	20%	0.02	0.2
Parthenium hysterophours	1	0.01	14%	0.01	0.1
Peganum harmala	2	0.02	33%	0.02	0.2
Phoenix dactylifera	7	0.07	44%	0.09	0.7
Sacchrum arundinacea	2	0.02	40%	0.02	0.2
Senegalia greggii	5	0.05	40%	0.04	0.5
Solanum surattensis	4	0.04	33%	0.04	0.4
Typha angustifolia	2	0.02	18%	0.02	0.2
Verbascum densiflorum	3	0.03	75%	0.03	0.3
Vitex negundo	2	0.02	44%	0.02	0.2
Withania coagulana	3	0.03	86%	0.04	0.3
Xanthium strumarium	4	0.04	50%	0.02	0.4
Ziziphus jujuba	15	0.15	67%	0.06	1.5
Cynodon dactylon	3	0.03	75%	0.03	0.3
Ziziphus nummularia	4	0.04	57%	0.17	0.4

Note: FC= frequency citation, **RFC**= Relative frequency citation, **UV**= Use value, **FL**= Fidelity level, **RIL**= Relative importance level

Informant Consensus Factor (FIC) or Efficacy of Medicinal Plants

Factors of informant consensus were calculated to assess the diversity of medicinal plant usage and to identify which plants are especially noteworthy in the quest for bioactive compounds. The local people used therapeutic plants for the treatment of 17 health problems (Fig. 12). The significant ailments include kidney disorder, Gastrointestinal disorder, Tonic, diabetes, dermatitis, blood-related disease, analgesic, reproductive disorders, snake venomous, dental disorder, antiseptic, respiratory disorder, cancer, boon disorder, spleen enlargement, brain disorder ulcer. To determine the informant consensus factor (FCI), all the reported ailments were first grouped into 17 different disease categories based on their use reports (Table 4). The uppermost FCI value is reported for Tonic (2.5), kidney disorder (2.2), respiratory disorder (2.1), blood-related diseases (1.3) bone disorder, snake venomous (0.05) and spleen enlargement (0.05) on the other hand the lowest FIC values is less than (0.5) respectively as shown in (Table 4). Similarly, previous study also described the same plants used for the same ailment in the Malakand region of Pakistan (Pedrollo *et al.* 2016). About 8% of plants were used to treat cancer and diabetes disorders, followed by reproductive disorders and analgesics (8%), while the lowest value of ICF shows tonic, ulcer and spleen enlargement (1%). According to (Hassan *et al.* 2019) they found that the highest levels of agreement between informants and the greatest percentage of medicinal plant citations for disease categories including respiratory and gastrointestinal infections could be related to the relatively high occurrence of these subsequent disorders in the region. The most commonly cited species for treating cuts, wounds, and bleeding are *M. cordata, C. dactylon,* and *C. tinctoria,* and many people use these plants for these purposes (Anand *et al.* 2019). The findings of this study align with those of (Kayani *et al.* 2015) who reported a high FIC value for cuts and wounds in their survey conducted in Northern Pakistan. A quantitative ethnobotanical study among indigenous communities in Mauritius (Mahomoodally *et al.* 2014) found a ICF value for digestive system disorders, including gastritis, diarrhea, ulcers, constipation, digestive aid, piles, carminative, flatulence, indigestion, colic, and anthelmintic. The hepatoprotective effects of the crude extract from the aerial parts of *A. scoparia* were studied against liver damage induced by carbon tetrachloride, with results indicating its protective properties (Ding *et al.* 2021). These results show that Tonic, kidney disorders and dermatological diseases are common in the study area. Similar findings have already been reported from other regions (Singh *et al.* 2018). Dermatological disorders concerning FIC ranked as the third category. The local people of the study area mostly prefer to use these plant-based treatments against skin diseases, insect bites, and scorpion stings (Umair *et al.* 2019). Likewise, Ralte *et al.* (2021) stated that species with a higher likelihood of possessing intriguing bioactive components require a high FIC value. The species to preserve in an environment having

medicinal significance are steadily disappearing, at high informant consensus factor is also a crucial consideration. The differences in FIC values may be attributed to the availability and diversity of medicinal plants, as well as the transmission of ethnobotanical knowledge across generations and regions. The ethnomedicinal information provided highlights the therapeutic significance of the plants mentioned. These plant species exhibit biological activities that indicate their potential therapeutic applications.

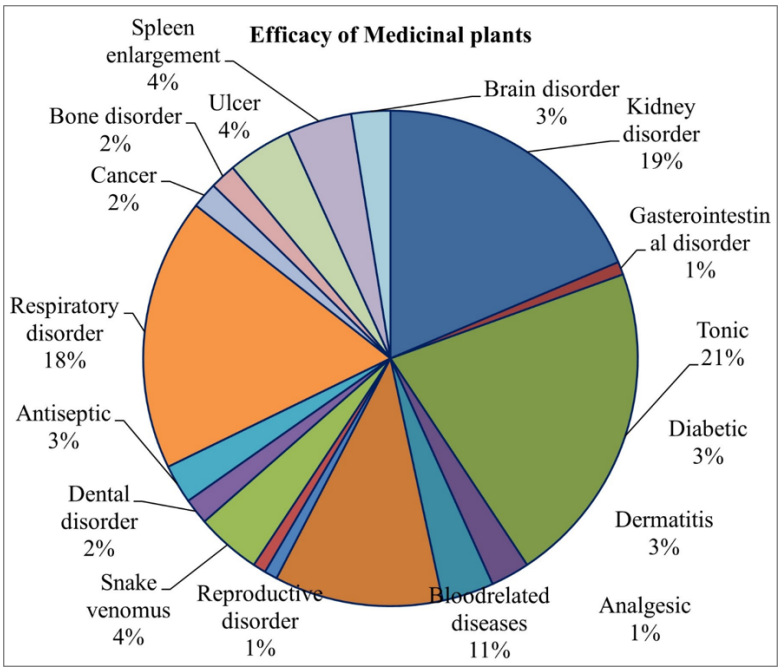

Figure 12. Efficacy of medicinal plants

Table 4 Informant Consensus Factor Index

Categories	(Nur)	(Nt)	Nur-Nt	Nt-1	FIC
Kidney disorder	14	5	9	4	2.2
Gastrointestinal disorder	21	18	3	17	0.1
Tonic	7	2	5	2	2.5
Diabetic	13	10	3	9	0.3
Dermatitis	26	19	7	16	0.4
Blood-related diseases	15	7	8	6	1.3
Analgesic	10	9	1	8	0.1
Reproductive disorder	10	9	1	8	0.1
Snake venomous	4	3	1	2	0.5
Dental disorder	6	5	1	4	0.2
Antiseptic	5	4	1	3	0.3
Respiratory disorder	20	7	13	6	2.1
Cancer	10	8	2	7	0.2
Bone disorder	8	7	1	5	0.2
Ulcer	4	3	1	2	0.5
Spleen enlargement	4	3	1	2	0.5
Brain disorder	5	4	1	3	0.3

Nur = use report in selected groups of diseases, Nt = species used for treating various diseases of that group.

Jaccard's Similarity Index

Jaccard's Similarity Index (JSI) is a statistical measure used to compare the similarity and commonly used to assess the overlap or similarity among two or more two ethnic or religious communities or groups, this study was conducted in the three adjacent villages which have the same ethnic and same religious group where traditional knowledge easily shared among this community. The number of medicinal plants reported from each study region was used to analyze Jaccard's similarity index, demonstrating the similarity in traditional medicinal plant knowledge between Jandrai, Turkhakoi, and Toormirch. The highest similarity index, according to Jaccard's similarity index (JSI), is shared by Jandrai and Toormirch, followed by Toormirch and Turkha koi, with JSI values of (61%), (34%), and respectively. Jandrai and Turkha koi, with a Jaccard's similarity

value of 0.28%), showed the least similarity in the research area (Fig 13). Because all three sites were related to one another agroecological and as the same ethnic group with the same cultural background lived in each of the three areas that were selected, the results indicated that nearly all sites had similar knowledge of traditional medicinal plants. The highest degree of similarity index was found with studies conducted by, (Rahman *et al.* 2022) with JI (15.69%, 15.22%, 13.89%, 10.78% and 10.10%) respectively. However, it is noteworthy that all these studies focused on different medicinal uses, suggesting that Jaccard's similarity indices only reflect the common medicinal plant species in both regions, rather than their shared medicinal applications, (Yaseen *et al.* 2015).

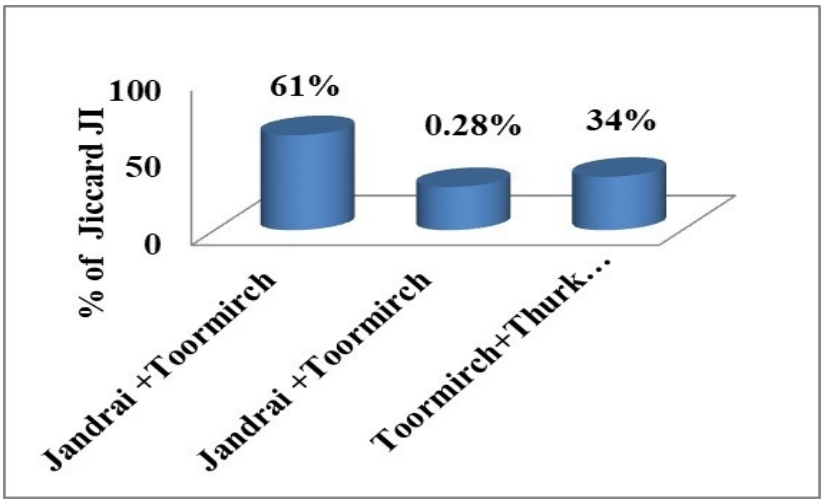

Figure 13. Jaccard Coefficient Index or Similarity Index for ethnomedicinal plants

Comparison with Previously Reported literature at the Regional and Global level

The present study has been evaluated with the already published ethnomedicinal literature from 2006 to 2025. A recognized list of 52 ethnomedicinal plants from this study has been cross-checked with 41 published articles spanning the years 19 years (2006–2025). (Table 6). This evaluation supported the identification of exploitation variations in native plants across different areas and communities. This evaluation supported to finding that the exploitation variations of native plants existed across a diversity of areas and communities. This kind of difference and similarity is usually numerically calculated in terms of the Jaccard Index (JI) by the ethnobotanists (Yaseen *et al.* 2015). The JI values ranged from 1% to 31%, indicating varying levels of similarity in plant use (Table 6). The highest values have been reported for the Bahadur Khel tract (Tehsil Banda Daud Shah) in Karak district 31%, (Rashid *et al.* 2006) High-Temperature Areas of Southern Punjab, Pakistan, 29.4% (Usman *et al.* 2021), District Karak, KPK, Pakistan 29.3% (Zulqarnain 2017), Peshawar Valley, Pakistan 28.1% (Bahadur *et al.* 2020), Tehsil Mandan, District Buner, KPK, Pakistan 19.5% (Rahman *et al.* 2024). While the other regions show JI values of less than 19% which are shown in (Table 6). The total number of reported plant species varied significantly across studies, ranging from 21 to 381 species. The number of common plant species between studies ranged from 3 to 27, with an average of 10.5 species per study. Jaccard Index (JI) was employed to quantify the similarity in plant use between different regions. The number of common plant species between different regions ranged from 3 to 27, with a mean of 10.5 species per study. A regional comparison of the results revealed that studies conducted in Pakistan reported a higher number of plant species with similar uses (mean = 7.3 species per study) compared to studies conducted in India (mean = 3.5 species per study) and other regions. The results showed a significant positive correlation between the number of reported plant species and the JI values ($r = 0.65$, $p < 0.01$). This indicates that regions with higher plant species diversity tend to have higher similarity in plant use. High JI regions indicate a strong cross-cultural exchange of ethnobotanical knowledge. Low JI regions indicate more localized and independent plant use traditions. Plants like *Caralluma edulis, Astragalus adscendens, Emex australis, and Gymnosporia royleana* are rarely mentioned in global/regional studies. The uncommon use plants like *Melia azedarach* and *Peganum harmala* have unique local uses in Jandrai. The rare families in ethnobotanical studies were Juncaceae (*Juncus maritimus*) and Typhaceae (*Typha angustifolia*) are not widely reported in ethnomedicine. The findings of this study provide valuable insights into the diversity of plant use in different regions and highlight the importance of ethnobotanical research in promoting sustainable use and conservation of plant resources.

A comparative ethnobotanical study conducted by Amjad *et al.* (2020) in Harighal, Azad Jammu & Kashmir, Pakistan, assessed the similarity of their findings with 22 published studies from geographically proximal regions with analogous vegetation in

Pakistan and globally. 1 The highest Jaccard Index (JI) values were observed when comparing the results of *Amjad et al.* (2020) with those of Shaheen *et al.* (2017) in the Toil peer (AJK) and Perl valley, respectively. Conversely, the lowest JI values were reported in studies by Jadhava et al. (2015) in Sangli, Maharashtra, India, and Gidey *et al.* (2015) focusing on the traditional knowledge of the Kunama ethnic group in Northern Ethiopia. A high degree of similarity, as indicated by a high JI, suggests shared cultural practices, traditional ecological knowledge, vegetation types, and geographical proximity, potentially facilitated by cross-cultural exchange. Conversely, low JI values indicate significant divergence in these aspects between the compared regions. Therefore, the Jaccard Index serves as a valuable quantitative tool for comparing ethnobotanical knowledge across different regions, providing insights into the interplay of cultural, environmental, and historical factors that shape local plant use practices.

Table 6. Comparison with Previous Reported literature at Regional and Global Level

Study years	*Study Area*	*Total Reported species in area(a)*	*Total Reported species in area(b)*	*Total with similar uses*	*Total with dissimilar uses*	*Common in both areas*	*C×100*	*a+b*	*JI*	*Reference*
2020	Jasrota Hill in Western Himalaya	52	121	2	13	15	1500	173	9.49%	(Singh *et al.* 2020)
2006	Bahadur khel tract (Tehsil Banda Daud Shah) in karak district	52	37	3	23	26	2600	89	31%	(Rashid *et al.* 2006)
2014	Karakoram-Himalayan range, Pakistan	52	50	0	3	3	300	102	3.03%	(Bano *et al.* 2014b)
2014	Skardu valley at high altitude of Karakoram-Himalayan range, Pakistan	52	50	1	2	3	300	102	3.03%	(Bano *et al.* 2014a)
2015	District Karak, kpk, Pakistan	52	45	6	4	22	2200	97	29.3%	(Zulqarnain *et al.* 2017)
2015	Tehsil Banda Daud Shah District Karak KPK Pakistan	52	21	7	10	17	1700	73	6.49%	(Shabir *et al*. 2015)
2015	Tehsil Charbagh, District Swat, Khyber Pakhtunkhwa, Pakistan	52	122	12	13	15	1500	174	9.43%	(Khan *et al.* 2015)
2015	Tehsil Kabal, District Swat, KP, Pakistan	52	45	2	5	7	700	97	8.75%	(Khan *et al.* 2015)
2016	District Karak, kpk, Pakistan	52	52	9	10	19	1900	104	22.3%	(Siddique *et al.* 2016)
2017	Kel village, Neelum Valley, Azad Kashmir, Pakistan	52	50	0	4	4	400	102	4.08%	(Ahmad *et al.* 2017)
2017	The Inhabitant OfLaspur Valley, Hindukush Range, Chitral Northern Pakistan	52	50	0	3	3	300	102	3.03%	(Qadir *et al.* 2017)
2018	Bahadur Khel, district Karak, Khyber	52	68	11	8	19	1900	120	18.8%	(Khan *et al.* 2018)

	Pakhtunkhwa, Pakistan									
2018	Talash Valley of Dir Lower, northern Pakistan	52	50	3	6	9	900	102	9.67%	(Khan *et al.* 2018)
2019	Laspur Valley, Chitral, Northern Pakistan	52	44	1	5	6	600	96	7.5%	(Wali *et al.* 2019)
2019	Pangkhua community in BilaichariUpazilla, Rangamati District, Banglades	52	117	1	5	6	600	169	3.68	(Faruque *et al.* 2019)
2020	Peshawar valley, Pakistan	52	71	12	15	27	2700	123	28.1%	(Bahadur *et al.* 2020)
2020	Toormang Valley, Northern Pakistan	52	91	8	4	12	1200	143	9.16%	(Tahir *et al.* 2020)
2020	Algerian Semi-arid Region	52	44	0	1	1	100	96	1%	(Kefifa *et al.* 2020)
2021	Highest mountainous region of Bahrain Valley, Northern Pakistan	52	72	10	10	20	200	124	19.2%	(Hussan *et al.* 2021)
2021	High-Temperature Areas of Southern Punjab, Pakistan	52	58	5	20	25	2500	110	29.4%	(Usman *et al.* 2021)
2021	Kumrat Valley in District Upper Dir, Pakistan	52	50	0	2	2	200	102	2%	(Ahmad *et al.* 2021)
2021	Mersin (Turkey)	52	93	0	8	8	800	145	5.83%	(Emre *et al.* 2021)
2021	Shishi Koh valley, Chitral, Pakistan	52	48	0	4	4	400	100	1.01%	(Wali et al. 2021)
2022	Central Balkans	52	114	0	3	3	300	166	1.84%	(Janaćković *et al.* 2022)
2022	District Karak Khyber Pakhtunkhwa Pakistan	52	47	7	4	11	1100	99	12.5%	(Amin *et al.* 2022)
2022	Mandi Ahmad Abad, District Okara, Pakistan.	52	126	16	9	25	2500	178	16.3%	(Munir *et al.* 2022)
2022	Tribal communities of Central Kurram, Khyber Pakhtunkhwa, Pakistan	52	100	2	6	8	800	152	5.5%	(Hussain *et al.* 2022)
2023	Dera Ghazi Khan, Punjab, Pakistan	52	130	2	11	13	1300	182	7.69%	(Mustafa *et al.* 2025)
2023	District North Waziristan, KPK, Pakistan.	52	206	14	8	22	2200	258	9.32%	(Rahman *et al.* 2023)

2023	District Swabi, KPK Pakistan.	52	154	3	21	24	2400	206	13.1%	(Ullah *et al.* 2021)
2023	Okhaldhunga district, Nepal	52	149	7	3	10	100	201	5.23%	(Karki *et al.* 2023)
2023	Southern communities of khyber Pakhtunkhwa, Pakistan	52	58	7	5	12	1200	110	12.2%	(Khan *et al.* 2023)
2023	Tehsil KallarSywdan District Rawalpindi, Punjab, Pakistan	52	169	4	18	22	2200	221	11%	(Zareef *et al.* 2023)
2023	Teesta Valley, Darjeeling district, West Bengal, India	52	74	0	3	3	300	126	2.43%	(Subba *et al.* 2023)
2024	District Dindori, Madhya Pradesh, India	52	88	4	15	19	1900	140	15.7%	(Ahirwar *et al.* 2024)
2024	District Karak, kpk, Pakistan	52	38	2	5	7	700	90	8.43%	(Nazar *et al.* 2024)
2024	Taounateregion(Northern Morocco)	52	112	3	7	10	100	164	6.49	(Jeddi *et al.* 2024)
2024	Tehsil Mandan, District Buner, KPK, Pakistan	52	140	6	21	27	2600	165	19.5%	(Rahman *et al.* 2024)
2024	Takht Bhai, Mardan, Khyber Pakhtunkhwa, Pakistan	52	79	0	13	13	1300	131	11%	(Shah *et al.* 2024)
2024	Tehsil Sarai Naurang, District Lakki Marwat, KP-Pakistan	52	42	3	4	7	700	94	8%	(Zaman *et al.* 2024)
2025	Daral Valley, Swat Kpk Pakistan	52	381	3	7	10	100	433	2.36%	(Shah *et al.* 2025)

Conclusion

This study examines the relationship between the local community and medicinal plant species in Union Council Jandrai, District Karak, through a quantitative ethnomedicinal survey conducted in three villages (Jandrai, Thurkha Koi, and Toor Mirch). A total of 100 informants (64% male, 36% female) participated in interviews, providing insights into traditional plant usage. The study identified 52 medicinal plant species belonging to 31 families, with Zygophyllaceae and Rhamnaceae being the most dominant. Leaves were the most utilized plant parts, and herbs were the most frequent growth form, followed by shrubs and trees. The research found that 17 medical conditions are treated using these medicinal plants, with tonics (FCI = 2.5) being the most cited category. The most frequently used species were *Z. jujuba, Z. nummularia, B. campestris*, and *A. vera*, based on their Relative Frequency of Citation (RFC = 0.18). The Jaccard Similarity Index (JSI) indicated the highest similarity between Toor Mirch (61.90%) and Thurkha Koi (34.78%), reflecting regional variations in plant use. Additionally, *Z. jujuba* had the highest Relative Importance (RI = 0.15). The study highlights the significance of traditional knowledge in medicinal plant use and emphasizes the need for further pharmacological validation, conservation strategies, community awareness programs, and sustainable utilization of these valuable plant resources. Also, the present study highlights the rich ethnomedicinal knowledge of Union Council Jandrai and its comparison with previously published literature. The variations in plant use across regions emphasize the need for preserving traditional knowledge and promoting sustainable plant conservation. Rare and novel plants such as *C. edulis*, *A. adscendens*, *E. australis*, and *G. royleana* were identified, which are rarely mentioned in global studies. The findings provide a foundation for future ethnobotanical research and cross-cultural knowledge exchange. When people living in rural areas require medical care, they use herbal medicine to treat various disorders. Governments must act immediately to legalize the usage of traditional medicine. The researchers have collected a diverse amount of basic data on indigenous knowledge of the native medicinal plants used to cure common ailments. This information is being stored for future phytochemical and pharmacological investigation, which will help in the development of natural drugs. The government should communicate with the local people to encourage communities to work together and arrange seminars to promote the sustainable use and preservation of therapeutic plants. Further research needs to be conducted on antioxidant, anti-cancer, gynecological problems and respiratory disorders profiling potentially effective medicinal plants used in the study area, with priority being given to *G. royleana, N. oleander, F. cretica.*

Declarations

Conflict of Interest: The authors have no conflict of interest to declare

Ethics Approval and Consent to Participate: Informed consent was obtained verbally prior to the survey.

Consent for publication: Verbal consent was obtained from all participants involved in this study.

Availability of Data and Materials: Data used for this publication is available with the Authors.

Author's Contribution: A.S. designed the questionnaire, carried out the survey, collected the data analyzed the data, and wrote the original draft of the manuscript. Z.R. critically revised edited the manuscript and supervised the study. M.Q. critically revised and edited the manuscript. M.S.K. critically revised and edited the manuscript. M.A. critically revised the manuscript. M.A.R. critically revised the manuscript. S.D. critically revised the manuscript. All authors approved the final draft of the manuscript.

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