Exploration of ethnomedicinal plants and their practices in human and livestock healthcare in Haripur District, Khyber Pakhtunkhwa, Pakistan

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Abstract

Background: The utilization of plants and plant resources for various ethnobotanical purposes is a common practice in local towns and villages of developing countries, especially in regard to human and veterinary healthcare. For this reason, it is important to unveil and document ethnomedicinal plants and their traditional/folk usage for human and livestock healthcare from unexplored areas. Here we advance our findings on ethnomedicinal plants from Haripur District, Pakistan, not only for conservation purposes, but also for further pharmacological screenings and applied research.

Methodology: Information of ethnomedicinal plants was obtained using a carefully planned questionnaire and interviews from 80 local people and traditional healers (Hakims) in Haripur District, Pakistan, from 2015 to 2017. Informed consent was obtained from each participant before conducting the interview process. Quantitative ethnobotanical indices, such as relative frequency of citation (RFC), use value (UV) and Jaccard index (JI), were calculated for each recorded species. Correlation analysis between the RFC and UV was tested by Pearson’s correlation, SPSS (ver. 16).

Results: A total of 80 plant species (33 herbs, 24 trees, 21 shrubs and 2 climbers) belonging to 50 families were being used in the study area to treat livestock and human diseases. Lamiaceae was the most dominant family with 7 species (8.7%), followed by Fabaceae with 6 species (7.5%), and Moraceae with 5 species (6.2%). Local people used different methods of preparation for different plant parts; among them, decoction/tea (22 species) was the popular method, followed by powder/grained (20 species) and paste/poultice (14 species). It was observed that most of the species (~12 to 16 species) were utilized to treat human and livestock digestive system-related problems, respectively. The Jaccard index found that plant usage in two studies (District Abbottabad and Sulaiman Range) was more comparable. Local people mainly relied on folk medicines due to their rich accessibility, low cost and higher efficacy against diseases. Unfortunately, this important traditional knowledge is vanishing fast, and many medicinal plants are under severe threat. The most threats associated to species observed in the study area include Dehri, Garmthun, Baghpur, Najafpur and Pharala.

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Introduction

Humans have a long history of utilizing plants to fulfill various daily requirements. Plants are used as medicines, food, fodder for livestock and materials to construct houses [1]. The application of medicinal plants and herbs for therapeutic purposes is a global practice, and almost every country has benefited from their useful therapeutic and medicinal elements [2]. Herbal medicines play a distinctive role from the primitive period until today in healthcare systems. The first ethnomedicinal plant in sub-continent history was recorded in Rigveda during 4500–1600 BC and Ayurveda 2500–600 BC [3]. The concepts of ethnobotanical medicines are thought to have originated from Greece and adopted by Arabs, thereafter learned and spread by Indians and Europeans [4–6]. Medicinal plants are an important part of the conventional healthcare system, as various allopathic drugs are extracted or derived from medicinal plants [7, 8]. The utilization of alternative medicine may increase due to its low costs, higher efficacy and increased faith in herbal remedies. Although allopathic medicines can treat several diseases, they are often more expensive and may have adverse effects, which forces common people to take advantage of herbal medicines, which may have fewer side effects [9]. Scientific investigations on medicinal plants have been underway in various countries due to their vast therapeutic potential and are also used as an alternative therapy in various healthcare systems [10].

Traditional veterinary medicine was first practiced around 1800 B.C. during the age of King Hammurabi of Babylon, who formulated laws and introduced a veterinary fee structure for treating animals [11]. Ethnoveterinary medicine (EVM) is the major source for the treatment of diseases in livestock throughout the world, even today. Humans have used herbal remedies to treat different diseases in domesticated animals since the advent of civilization. It is estimated that medicinal plants, for several centuries, have been widely used as a primary source of prevention and control of livestock diseases [12, 13]. Many studies have been carried out on treating specific ailments in livestock with herbal medicines and their derivatives [14]. Traditional EVM provides affordable therapy and easy accessibility in comparison to western medicines [15].

Pakistan is an agricultural country, and about 80% of its population depends on farming and livestock. Pakistan is the world’s fifth-largest milk-producing country because of its high reliance on farming and livestock [16]. About 84% of Pakistan’s population depended on traditional medicine in the early 1950s, and a rapid decrease was recorded in recent years from traditional knowledge, now limited only to remote areas of Pakistan [17, 18]. Resource-poor farmers of Pakistan substantially depend upon traditional medicine because of their minimal access to modern-day healthcare systems and lack of well-developed basic healthcare units in their areas [3]. While much work has been done worldwide on documenting ethnoveterinary practices, in Pakistan, very little attention has been given to documentation of plants used as EVM, and there is an immense need to document this knowledge [19].

While literature has revealed that many ethnoveterinary researchers have visited most parts of Pakistan in recent years, but no/less areas has been thoroughly explored regarding the EVM [20]. A similar trend is evident in human medicinal plant inventories, where many researchers and ethnobotanists have visited most parts of Pakistan and contributed to the records [20–26]. Still, much information and traditional knowledge remain to be recorded. The main aim of this study was (1) to document the traditional knowledge of ethnomedicinal plants from Haripur District, Khyber Pakhtunkhwa (Pakistan), an unexplored area which lacks such documentation, (2) to report the traditional folk knowledge, ethnomedicinal plant utilization along with recipes, mode of preparation, parts used, used form in veterinary and human healthcare by local and ethnic communities, (3) to identify potential conservation threats, (4) to compile the data of traditional knowledge of ethnomedicinal plants by using quantitative ethnomedicinal indices like UV, RFC and JI in order to evaluate the most frequently used species and access their matching with other studies published from Pakistan in traditional ethnomedicinal plant utilization. It is hypothesized that studies conducted in surrounding areas may more similar to present study which can be
evaluated by JI value; and (5) to provide further research baseline to pharmacologists, phytochemists and conservationists for further research studies.

**Materials and methods**

This study was authorized by the Department of Biosciences and Office of Research, Innovation and Commercialization University of Wah (ORIC-UW), Wah Cantt, Pakistan. Informed consent was obtained from each informant before conducting the semi-structured interview process.

The research study was completed in four phases as follows, (1) description of the study area, (2) ethnomedicinal field survey (primary data), (3) plant's identification and statistical analysis (secondary data) and (4) data compilation/documentation.

**Study area**

Haripur District is under the Khyber Pakhtunkhwa province of Pakistan, situated between 33° 44’–34° 22’ N latitude and 72°–35’ to 73°–15’ E longitude, at approximately 610 m above the sea level (Fig. 1). The district’s total area is 1725 km², divided into sub-districts (Haripur, Khanpur and Ghazi) and subdivided into 44 Union Councils. Haripur District has distinct geographical significance as its boundaries touch Districts Abbottabad, Mansehra, Attock, Torgarh, Swabi, Buner, Rawalpindi (Punjab province) and the capital of Pakistan (Islamabad) [27]. According to the National Institute of Population Studies (NIPS), the district’s estimated population was 1,003,031 in 2017, having a population density of 580 residents per square kilometer. The dominant caste or tribe of District is Awan followed by Gujjar and Tanoli. The Haripur is largely a rural district, and about only 12% of the population resides in urban areas. The temperature in the area ranges from almost 39 °C in summer to less than 10 °C in winter. Agriculture is the primary source of livelihood of the rural population of the study area. The area’s economic growth depends on pastures, crop diversity, cultivation of fodder species and the development of medicinal plants and livestock diversity.

**Field survey and data collection**

The entire study area was regularly and seasonally (spring, summer, winter and autumn) visited from January 2015 to January 2017. In the study area, the primary
target sites were Muslimabad, Barkot, Jatti Pind, Tofkian, Khanpur, Kalinjar, Barella, Hattar, Qazipur, Ghazi, Najafpur, Jabri, Nara Amazai, Rehana, Teer, Syria, Sirikot, Bagra, Beer and Dingi. The field survey aimed to gather field data and activities, such as (1) plant’s collection, (2) local knowledge concerning plants, (3) identifying associated consequences to plants through personal observation and interviews, (4) photography and (5) medicinal plant uses along with recipes, through semi-structured questionnaires, interviews, keen observations and group discussions. The questionnaire and interview method helped to document indigenous folk knowledge by involving knowledgeable persons, traditional healers (Hakims) and local people (Table 1). Respondents were chosen by random selection of residents who were considerably connected to plants and were interested in traditional healthcare. Interviews were conducted mostly in fields, and photographs were shown for identification with local plant name. Women were interviewed indirectly through male family members. Participants were briefed about the research objectives and were allowed to discontinue the interview at any time. Each informant was interviewed regularly every season. The national language of Pakistan (Urdu) and the native language of the study area (Hindko) were used as a medium of communication. Thereafter, an English language questionnaire was filled for each informant (Additional file 1).

**Plant identification**

Collected plant species were identified with the help of Flora of Pakistan, Flora of West Pakistan [28] and Flora of Punjab [29], and online Flora (www.efloras.org). Plants names were also identified through literature, plant list (www.theplantlist.org), Medicinal plant names services (https://mpns.science.kew.org/mpns-portal/) [30]. The system proposed by Raunkier [31, 32], and modified by Brown [33], was followed to categorize the collected plant specimens into their habits and life forms. Plants were submitted to the Herbarium, Department of Botany, Hazara University Mansehra (Pakistan), and vouchers were issued. For voucher specimen, standard herbarium techniques [34, 35] were strictly followed.

**Quantitative and correlative analysis of ethnomedicinal data**

The collected ethnomedicinal data were analyzed using different quantitative analyses, including relative frequency citation (RFC), use value (UV) of medicinal plant and Jaccard index (JI) analysis by comparing the present study with published work to access knowledge variation among different communities. The obtained data were presented in percentages and proportions.

Relative frequency citation (RFC)

The RFC was calculated without taking into account the use categories by following the formula [36].

$$RFC = \frac{FC}{N} \text{ (0 > RFC > 1)}$$

RFC shows the importance of each species in the study area given by the FC (FC is the number of local informants reported the uses of plant species) divided by the total number of informants (N).

Use value (UV) of plant species

Use value (UV) determines the relative importance of plant species uses. It was calculated using the following formula [37].

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

where “UV” indicates the use value of individual species, “Ui” is the number of uses recoded for a given species by each informant and “N” represents the number of total informants.

Pearson’s correlation

Pearson’s correlation, SPSS (ver. 16), tested correlation analysis between the RFC and UV.

Jaccard index (JI)

To compare the study with published literature and to access the similarity and dissimilarity of traditional knowledge among different communities and areas, the Jaccard index was calculated using the following formula [38].

| Table 1 Demographic data about informants of the study area |
|-----------------|-----------------|-------|-------|
| Variable        | Demographic categories | Numbers | Percentage |
| Gender          | Male             | 70    | 87.5  |
|                 | Women            | 10    | 12.5  |
| Experience      | Traditional healer | 5     | 6     |
|                 | Herdsmen         | 17    | 21    |
|                 | Farmer           | 52    | 65    |
|                 | Local people     | 6     | 8     |
| Age groups      | 20–40            | 15    | 19    |
|                 | 41–60            | 40    | 50    |
|                 | Above 60         | 25    | 31    |
| Education       | Illiterate       | 21    | 26    |
|                 | Primary          | 21    | 26    |
|                 | Middle           | 16    | 20    |
|                 | Matric and above | 22    | 28    |
where 'a' represents the total number of species in area A (our study area), 'b' represents the number of species from other published area B and 'c' represents the number of common species in both A and B.

Results

Description of medicinal plant families
The high diversity of plant families in the study area can be deduced from the presence of 50 different families. Among them, Lamiaceae was the largest family having 7 species, followed by Fabaceae (6 species), Moraceae (5 species), Apocynaceae (4 species), Asteraceae, Euphorbiaceae, Rhamnaceae and Solanaceae (3 species each), Amaranthaceae, Apiaceae, Brassicaceae, Malvaceae, Meliaceae, Menispermaceae (2 species each) (Fig. 2) and remaining families with one species each.

Medicinal plant enumerations
Eighty plants were recorded covered in this study; herbs (33, 41.2%) were dominant, followed by shrubs (21, 26.2%), trees (24, 30%) and climbers (2, 2.5%). Furthermore, life spans for the majority of plants were recorded as perennial (62, 77.5%), followed by annual (16, 20%) and biennial (2, 2.5%) (Fig. 3). Among these, 40 plant species were used for livestock healthcare, and 49 plant species were used to treat human diseases, including 9 plant species which were commonly used for both (human and livestock). Complete information about each plant species includes botanical name, family, local name, voucher number, habit, life span, locality, part used, either utilized to treat human or animal diseases or both, and their recipes are listed with RFC and UV in Tables 2, 3 and 4.

Plant part(s) used
Locals utilized different plant parts (either in combination or separately) in the study area for the management of livestock and human diseases. Among them, leaves (47.9%) were the most commonly used part in herbal preparations, followed by fruits (16%), whole plant (8.5%), roots (4.3%), bark (3.2%), gum, bulb, twigs, flower, resin (2.1%) each, spines and pods (1.1% each) (Fig. 4A). In combination, leaves were the most common plant parts combined/utilized with fruits (3), flower, roots, seed and gum, twigs and stem (1 each). The
combination of gum with the spine was utilized only one time (Fig. 4B).

Mode of preparation, administration and application

The remedies/recipes preparations of the 80 plant species are categorized according to their type of preparation, which revealed that decoction/tea (22 species) was a widely used preparation method by locals, followed by powdered/grinded (20 species), paste/poulitce (14 species), directly eaten (12 species), juice/extract (09 species), roasted/cooked (07 species), crushed (04 species) and chewed (one species) (Fig. 5). It was also recorded that the local people use preparations/recipes of ethnomedicinal plant, both as externally (25%) and internally (75%) application.

Species richness for the management of human and livestock diseases

Local people of the study area used 49 medicinal plants to treat 42 different ailments related to humans. These 42 ailments were further categorized into 12 major diseases categories. It was found that single medicinal plant species can treat several human ailments, and several medicinal plant species can treat single disease. In the study area, 34 livestock ailments were identified to be treated by 40 medicinal plants. These 34 ailments were further categorized into 07 major disease categories (Table 5). The ethnoveterinary medicinal plants were utilized mostly for cows (35%), followed by buffaloes (34%) and goats (31%).

Quantitative analysis

To analyze ethnomedicinal data, quantitative value indices were determined in this study. The RFC value ranges from 0.07 to 0.81 for the recorded species, and the highest value of RFC was recorded for Melia azedarach, Dodonaea viscosa, Grewia optiva and Mallotus philippensis (0.81, 0.77, 0.71 and 0.7), respectively.

The UV of plant species determines the relative importance of plants in the study area. The UV values for Curcuma longa, Adhatoda vasica, Viola odorata, Berberis lycium, Achyranthus aspera, Melia azedarach and Chenopodium album were 1.06, 1.01, 1.03, 0.98, 0.93, 0.91, 0.88, 0.87, 0.87 and 0.85, respectively, Phyllanthus emblica and Catharanthus roseus (0.82 each), Amaranthus viridis, Cannabis sativa, and Cynodon dactylon (0.81 each), and Ailanthus altissima and Solanum surattense (0.8 each). The other remaining plant species were recorded with a UV value of <0.81, which indicated that they were less exploited by local people (Table 2). RFC and UV were significantly correlated (Pearson’s test; \(p=0.01\)), and the correlated values explained approximately 31% of the data (Additional file 2: Table S1).

Comparison and Jaccard index

The comparative analysis exhibited a significant difference in the medicinal plant utilization among different communities of Pakistan. Twenty national studies from different areas of Pakistan were compared with the present study. Overall, 49 species were reportedly used to manage human diseases. Similarity percentages ranged
| S. no | Taxonomic name/ family, voucher no | Local name | Locality | Life habit/ life span | Part used | Diseases treated | Ethnomedicinal recipes | Quantitative indices |
|-------|-------------------------------------|------------|----------|-----------------------|-----------|-----------------|------------------------|---------------------|
|       |                                     |            |          |                       |           |                 |                        | FC          RFC  UV |
| 1     | Achyranthus aspera L. (Amaranthaceae), 04-Z | Puth-Kanda, Leehndi Booti | Choi | H P RT | Tonsillitis | External application of fresh root paste for one week twice a day | 12 0.15 70 0.87 |
| 2     | Ailanthus altissima (Mill) Swingle (Simaroubaceae), 06-Z | Darawa | Dartian | T P BA | Dysentery and Diarrhea | Bark Juice (½ cup) mixed with milk and taken | 13 0.16 64 0.8 |
| 3     | Allium sativum L. (Alliaceae), 07-Z | Thoom | Khanpur | H B BB | High blood pressure | Two bulbs are eaten with a meal | 15 0.18 42 0.52 |
| 4     | Althaea officinalis L. (Malvaceae), 10-Z | Khatmi | Jabri | H A LE | Cough and tonsillitis | One cup of seed or leaf tea is used thrice a day | 23 0.28 45 0.56 |
| 5     | Artemisia vulgaris L. (Asteraceae), 12-Z | Afsanteen | Joulian | H P TW | Hepatitis | 10-g twigs powdered with water are taken thrice times a day | 22 0.27 25 0.31 |
| 6     | Azadirachta indica A. Juss. (Meliaceae), 13-Z | Nim | Pakhai | T P FR | Diabetes | Powder (1 spoon) form of fruit with water, orally everyday | 13 0.16 35 0.43 |
| 7     | Bauhinia variegata L. (Fabaceae; subfamily Caesalpinioidea), 14-Z | Kalyarh, Kachnar | Garam thoon | T P FL | Stomach Tonic | Young flowers are cooked as a vegetable and eaten | 14 0.17 62 0.77 |
| 8     | Boerhavia diffusa L. (Nyctaginaceae), 17-Z | It-sit | Barkot | H P LE | Diabetes and jaundice | Decoction of leaves is taken | 16 0.2 17 0.21 |
| 9     | Caralluma edulis (Edgew) Benth. ex Hook.f (Apocynaceae), 23-Z | Chong | Karwali | H P ST | Diabetes | One cup of stem juice is taken thrice times a day | 29 0.36 65 0.81 |
| 10    | Catharanthus roseus (L.) G.Don (Apocynaceae), 29-Z | Sadabahar | Bagra | H P LE | Wasp-sting | Leaf juice is applied | 12 0.15 66 0.82 |
| 11    | Celtis australis auct. non L. (Ulmaceae), 30-Z | Batkhar | Najafpur | T P FR | Stomach problems | 10 g of fruit powdered is taken with water | 13 0.16 24 0.3 |
| 12    | Cichorium intybus L. (Asteraceae), 37-Z | Kasni | Kotla | H P RT | Stomach problem | Grinded root is taken | 12 0.15 15 0.18 |
| 13    | Cissampelos pareira L. (Menispermaceae), 42-Z | Phalaan jarhi, Ghora-sum | Dhuniya | C P LE | Wounds | Leaves are crushed and applied | 14 0.17 36 0.45 |
| 14    | Colebrookia oppositifolia Sm. (Lamiaceae), 44-Z | Shakardana | Dhuniya | S P LE | Cough | Leaves are chewed | 13 0.16 34 0.42 |
| 15    | Datura stramonium L. (Solanaceae), 58-Z | Datura | Dara | H A FL, LE | Bleeding piles | Powdered flowers and leaves are used as an ointment | 12 0.15 35 0.43 |
| 16    | Diospyros lotus L. (Ebenaceae), 60-Z | Amlok | Shah kabul | T P FR | Chest phlegm | Fruit is eaten | 16 0.2 19 0.23 |
| 17    | Eucalyptus globulus Labill (Myrtaceae), 67-Z | Gond | Khanpur | T P RE | Cuts and wounds | Resin is applied externally | 13 0.16 25 0.31 |
| 18    | Ficus carica L. (Moraceae), 78-Z | Anjeer | Ranjha | T P FR | Blood deficiency | Fruit is eaten | 25 0.31 32 0.4 |
| S. no | Taxonomic name/ family, voucher no | Local name | Locality | Life habit/ life span | Part used | Diseases treated | Ethnomedicinal recipes | Quantitative indices |
|-------|----------------------------------|------------|----------|-----------------------|-----------|-----------------|-----------------------|-----------------------|
|       |                                  |            |          |                       |           |                 |                       | FC  RFC ΣUI UV         |
| 19    | *Ficus palmata* Forssk. (Moraceae), 79-Z | Phagwari | Ranjha   | T P FR                | Blood deficiency and abdominal problems | The fruit is left in the water overnight and eaten as a first food in the morning | 13 0.16 45 0.56 |
| 20    | *Malva sylvestris* L. (Malvaceae), 120-Z | Khabazi   | Kohala   | H B LE                | Chest infection and asthma | One cup of leaf tea is taken 2–3 times a day | 13 0.16 32 0.40 |
| 21    | *Mentha longifolia* L. (Lamiaceae), 131-Z | Chita podna | Bhamala  | H P LE                | Fever, dysentery and vomiting | Leaf tea is used | 13 0.16 24 0.30 |
| 22    | *Myrsine africana* L. (Primulaceae), 148-Z | khokonr   | Najafpur | S P FR                | Anthelmintic | Fruit is eaten | 13 0.16 35 0.43 |
| 23    | *Nasturtium officinale* W.T.Aiton (Brassicaceae), 155-Z | Tara meera | Chaskalawaan | H P LE | Constipation, diuretic and obesity | Cooked vegetable of leaves is eaten | 6 0.07 62 0.77 |
| 24    | *Ocimum basilicum* L. (Lamiaceae), 174-Z | Niaz-bo   | Desra    | H A LE                | Skin care | Leaf juice is applied | 16 0.2 32 0.40 |
| 25    | *Olea ferruginea* Royle (Oleaceae), 186-Z | Kaho      | Garam thoon | T P LE | Skin pimples | Leaf tea is used | 23 0.28 45 0.56 |
| 26    | *Oxalis corniculata* L. (Oxalidaceae), 197-Z | Khat-matra | Halli    | H A LE                | Skin inflammations | Powdered leaves are applied as a poultice | 12 0.15 34 0.42 |
| 27    | *Papaver somniferum* L. (Papaveraceae), 202-Z | Khashkhash | Halli    | H A FR                | Chest infection and cough | Tea of dried fruit is taken | 11 0.13 45 0.56 |
| 28    | *Pinus roxburghii* Sarg. (Pinaceae), 212-Z | Chir       | Bagla    | T P RE                | Skin problems | Resin is applied externally | 13 0.16 25 0.31 |
| 29    | *Pistacia chinensis* subsp. integerrima (J.L. Stewart) Rech.f. (Anacardiaceae), 218-Z | Kangur     | Chaskalawaan | T P BA | Jaundice | ½ cup of bark decoction is taken daily | 13 0.16 39 0.48 |
| 30    | *Rubus fruticosus* L. (Rosaceae), 235-Z | Garacha   | Ranjha   | S P FR                | Carminative | Fruit is eaten | 15 0.18 42 0.52 |
| 31    | *Rydiniga limbata* (Benth.) Scheen & V.A. Albert (Lamiaceae), 192-Z | Chita Kanda, Bamboli | Old Khanpur | S P WP | Wounds | The powder of whole plant mixed with butter before being applied | 24 0.3 36 0.45 |
| 32    | *Sageretia thea* Osbeck M.C. Johnst. (Rhamnaceae), 252-Z | Gangeeri   | Rajdhani | S P FR                | Diabetes and kidney stones | Dried powdered (½ spoon) of fruit, taken in the morning and evening with water | 10 0.12 42 0.52 |
| 33    | *Sisymbrium irio* L. (Brassicaceae), 267-Z | Khub kalan | Kot-jandaan | H A LE | Chest infection | Leaves infusion is given | 8 0.1 26 0.32 |
| 34    | *Solanum nigrum* L. (Solanaceae), 260-Z | Kach mach | Najafpur | H A LE | Asthma | Tea of shade dried leaves is taken | 16 0.2 43 0.53 |
| S. no | Taxonomic name/ family, voucher no | Local name | Locality | Life habit/ life span | Part used | Diseases treated | Ethnomedicinal recipes | Quantitative indices |
|-------|----------------------------------|------------|----------|-----------------------|-----------|------------------|------------------------|---------------------|
|       | **Tamarindus indica L. (Fabaceae), 268-Z** | Imli       | Bees ban | T P PP                | Fever and liver tonic | Juice of pulp is drunk daily | 23 0.28 50 0.62 |
| 36    | **Tribulus terrestris L. (Zygophyllaceae), 274-Z** | Gokhru     | Neelan bhoto | H A LE | Male sexual weakness | A few leaves are soaked for a while in a glass of water and taken three times daily | 13 0.16 33 0.41 |
| 37    | **Viola odorata L. (Violaceae), 277-Z** | Ba-nafsha  | Kharian  | H A LE | Cough, cold and flu | Leaf tea is taken | 27 0.33 73 0.91 |
| 38    | **Woodfordia fruticosa (L.) Kurz (Lythraceae), 279-Z** | Taawi, Dhawli | Shah Kabul | S LE | Skin diseases | A poultice of leaves is applied externally | 9 0.11 45 0.56 |
| 39    | **Zanthoxylum armatum DC. (Rutaceae), 280-Z** | Timber     | Halli    | S/T P SD | Jaundice | One spoon of dried or fresh seeds powdered is taken daily | 32 0.4 60 0.75 |
| 40    | **Ziziphus nummularia (Burm.f.) Wight & Arn. (Rhamnaceae), 281-Z** | Beri       | Sarhadna | S P LE | Wounds | Paste of grinded leaves are applied | 13 0.16 38 0.47 |
| S. no | Taxonomic name/ family, voucher no | Local name | Locality | Life habit/ life span | Part used | Animal treated | Animal disease treated | Ethnoveterinary recipes | Quantitative indices |
|-------|-----------------------------------|------------|----------|-----------------------|-----------|----------------|-----------------------|------------------------|---------------------|
| 1     | *Allium cepa* L. (Amaryllidaceae), 08-Z | Payaz      | Khanpur  | H P BB                | Goat, buffalo and cow | Mouth infections | Grinded bulb mixed with black salt is given with water | FC 13 RFC 0.16 ΣUi35 UV 0.43 |
| 2     | *Amaranthus vindis* L. (Amaranthaceae), 11-Z | Chaleray   | Jabri    | H A LE                | Buffalo and cow         | Milk Production  | A decoction of leaves is given with a small amount of salt | FC 13 RFC 0.16 ΣUi65 UV 0.81 |
| 3     | *Berberis lyction Royle* (Berberidaceae), 16-Z | Simbulu    | Dartian  | S P RT                | Goat, buffalo and cow | Wounds and internal injury | The powdered root bark is applied to wounds. It is also given for internal injury | FC 35 RFC 0.43 ΣUi71 UV 0.88 |
| 4     | *Bombax ceiba* L. (Bombiacaceae), 19-Z | Sambal     | Darbula  | T P ST, BA            | Goat, buffalo and cow | Dislocated bones     | Paste of stem bark mixed with turmeric (haldi) and applied | FC 11 RFC 0.13 ΣUi39 UV 0.48 |
| 5     | *Calotropis procera* W. T. Aiton (Asclepiadaceae), 20-Z | Akk        | Ghazi    | S P LA                | Cow, buffalo and goat | Wounds             | Latex is applied externally | FC 13 RFC 0.16 ΣUi81 UV 1.01 |
| 6     | *Cannabis sativa* L. (Cannabaceae), 22-Z | Pang, bhang | Hattar   | S A LE                | Cow, buffalo and goat | Loss of appetite | Fresh leaves are fed | FC 12 RFC 0.15 ΣUi45 UV 0.56 |
| 7     | *Carissa opaca* Stapf ex Haines (Apocynaceae), 26-Z | Garinda    | Choi     | S P LE                | Cow, buffalo and goat | Foot and mouth disease | Leaves are crushed and fed | FC 31 RFC 0.38 ΣUi25 UV 0.31 |
| 8     | *Cassia fistula* L. (Fabaceae; subfamily Caesalpinioidea), 28-Z | Kinjal, Amaltas | Ranja    | T P PD                | Cow, buffalo and goat | Asthma and pneumonia | Dried pod powder is given orally | FC 30 RFC 0.37 ΣUi45 UV 0.56 |
| 9     | *Chenopodium album* L. (Chenopodiaceae), 34-Z | Bthawa     | Kohala   | H A WP                | Goat and cow             | Wound healing       | The paste is applied to wounds | FC 13 RFC 0.16 ΣUi68 UV 0.85 |
| 10    | *Coriandrum sativum* L. (Apiaceae), 46-Z | Dhania     | Beer     | H A LE, RT            | Buffaloes                | Antidiuretic       | Root and leaves decocion is given for 5 days | FC 13 RFC 0.16 ΣUi19 UV 0.23 |
| 11    | *Curcuma longa* L. (Wild) (Zingiberaceae), 49-Z | Haldi      | Khanpur  | H P LE                | Cow and goat             | Wound healing       | A decoction of leaves is given for 3 days | FC 37 RFC 0.46 ΣUi79 UV 0.98 |
| 12    | *Cynodon dactylon* (L.) Pers. (Poaceae), 54-Z | Khabal     | Nara Amzai | H P WP               | Buffaloes, cow and goat | Hematuria           | Plant juice is given twice a day for a week | FC 41 RFC 0.51 ΣUi65 UV 0.81 |
| 13    | *Dalbergia sissoo* Roxb. ex DC. (Fabaceae), 55-Z | Taali, Sheesham | Bareela  | T P LE                | Cow, buffalo and goat | Diarrhea            | Leaf paste with a little amount of salt is given | FC 12 RFC 0.15 ΣUi25 UV 0.31 |
| 14    | *Dodonea viscosa* (L.) Jacq. (Sapindaceae), 65-Z | Sanatha    | Garam Thoon | S P LE               | Cow, buffalo and goat | Bone fracture       | Leaves are heated and mixed with soil, then tied over the fracture | FC 62 RFC 0.77 ΣUi34 UV 0.42 |
| 15    | *Euphorbia helioscopia* L. (Euphorbiaceae), 70-Z | Chhatri Dodak | Kotorajullah | H A LE and SD      | Goat, buffalo and cow | Food poisoning      | Powdered leaves and seeds are given with water | FC 12 RFC 0.15 ΣUi19 UV 0.23 |
| 16    | *Ficus benghelensis* L. (Moraceae), 76-Z | Bohr       | Bandi    | T P RT                | Goat, buffalo and cow | Diarrhea and dysentry | A paste of prop root along with honey is given | FC 18 RFC 0.22 ΣUi55 UV 0.68 |
| S. no | Taxonomic name/ family, voucher no  | Local name | Locality | Life habit/ life span | Part used | Animal treated | Animal disease treated | Ethnoveterinary recipes | Quantitative indices |
|-------|-----------------------------------|------------|----------|-----------------------|-----------|----------------|------------------------|------------------------|---------------------|
| 17    | Grewia optiva J.R. Drumm. ex Burret (Tiliaceae), 90-Z | Dhaman Babootri | T P LE | Buffalo | Easy delivery | Leaves are fed | 57 0.71 85 1.06 |
| 18    | Lantana camara L. (Verbenaceae), 102-Z | Chandni Hattar | S P LE and TW | Goat, buffalo and cow | Joint pains | Decoction is given | 10 0.12 29 0.36 |
| 19    | Mallotus philippensis (Lam.) Müll. Arg. (Euphorbiaceae), 114-Z | Kamila Noopur | S P FR | Goat, buffalo and cow | Intestinal worms | Dried powdered fruit is given for 3 days | 56 0.7 52 0.65 |
| 20    | Mentha arvensis L. (Lamiaceae), 130-Z | Podina Bhamala | H P LE | Cow, buffalo and goat | Dysentery | Fresh leaves along with black salt are given | 52 0.65 36 0.45 |
| 21    | Morus alba (L.) Roxb. (Moraceae), 144-Z | Chita toot Dara | T P FR and LE | Goat, cow and buffalo | Mastitis | Decoction is given | 23 0.28 35 0.43 |
| 22    | Nerium oleander L. (Apocynaceae), 162-Z | Kundair Najafpur | S P WP | Goat | Stomachache | The dried powdered plant is given with water in a small quantity | 8 0.1 55 0.68 |
| 23    | Punica granatum L. (Punicaceae), 221-Z | Daruna Barkot | S P LE and FR | Goat, cow and buffalos | Anthelmintic | Decoction is given | 45 0.56 83 1.03 |
| 24    | Ricinus communis L. (Euphorbiaceae), 230-Z | Arand Mang | Sb P SD | Cow, buffalo and goat | Constipation | Seed oil is given along with fodder | 16 0.2 40 0.5 |
| 25    | Salvia moccroftiana Wall. ex Benth (Lamiaceae), 254-Z | Kalli Jari Kohala | H P RT | Goat, buffalo and cow | Internal injuries | Decoction is given | 11 0.13 46 0.57 |
| 26    | Solanum surattense Burm. f. (Solanaceae), 264-Z | Mohree Khoi Kaman | H A WP | Goat, buffalo and cow | Fever | Crushed plant mixed with flour is given | 17 0.21 64 0.8 |
| 27    | Taraxacum officinale F.H. Wigg. (Asteraceae), 270-Z | Hand Dara | H P WP | Goat, buffalo and cow | Milk deficiency | The whole plant is fed | 6 0.07 9 0.11 |
| 28    | Tinospora cordifolia (Willd.) Miers. (Menispermaceae), 271-Z | Gulo Kotla | C P ST and LE | Goat, buffalo and cow | Fever | decoction form is used continuously for 4 days | 9 0.11 13 0.16 |
| 29    | Trichodesma indicum (L.) R. Br (Boraginaceae), 275-Z | Kali booti Halli | H A LE | Cow, buffalo and goat | Inflammation and swellings | Leaves poultice is applied externally | 11 0.13 28 0.35 |
| 30    | Vitex negundo L. (Lamiaceae), 278-Z | Somali, Marvanl | Choi S P LE | Cow, buffalo and goat | Fractured bones | Warmed leaves are tied over the fractured bones | 13 0.16 38 0.47 |
| 31    | Ziziphus jujuba Mill. (Rhamnaceae), 283-Z | Bari Kanwali | T P LE | Cow, buffalo and goat | Dysentery | Decoction is given | 19 0.23 41 0.51 |
| S. no | Taxonomic name/family, voucher no | Local name  | Locality  | Life habit/ life span* | Part usedb | Organism treated | Disease treated          | Ethnomedicinal recipes                                                                 |
|-------|----------------------------------|-------------|-----------|------------------------|-----------|------------------|--------------------------|----------------------------------------------------------------------------------------|
| 1     | Acacia modesta Wall (Fabaceae; subfamily Mimosoideae), 03-Z | Phulai      | Dartian   | T P LE, SD             | LE, SD    | Cow and buffalo  | Delivery                 | A decoction of leaves and seeds is given for 3 days. Gum is fried with wheat flour in "desi ghee." This is known as "Halwa" in the local community and given especially to women after delivery |
| 2     | Acacia nilotica (L.) Delile M. (Fabaceae; subfamily Mimosoideae), 02-Z | Kikar       | Najafpur  | T P SP,                 | Cow and buffalo | Colic pain      | A decoction of spines is given for 3 days. Powdered gum at 10-g with milk/water is taken externally application of leaves poultice |
| 3     | Adhatoda vasica Nees. (Acanthaceae), 05-Z | Bhaikur, Aroosa | Halli    | S P LE                  | Cow, buffalo and goat | Wounds and inflammations | One cup of leaves juice is taken in a day. |
| 4     | Aloe barbadensis Mill. (Liliaceae), 09-Z | Kanwar-ghandal | Dara     | H P RT                  | Cow, buffalo and goat | Gastro-intestinal       | Powdered roots are given with water for 4 days. Leaf gel is burnt over the frypan and applied externally |
| 5     | Centella asiatica (L.) Urb. (Apiaceae), 33-Z | Barhami     | Neelan bho | H P LE                  | Goat, buffalo and cow | Diarrhea         | Leaves are roasted and cooled, fed twice a day for 3 days. |
| 6     | Melia azedarach (L.) Pers (Meliaceae), 124-Z | Daraik, Bakain | Sarhadna  | T P LE                  | LE        | Human           | Throat problems           | Crushed leaves are fed along with bamboo leaves 1 spoon of powdered fruit is taken at night with water |
| 7     | Morus nigra L. (Moraceae), 145-Z | Kala toot, She-toot | Dara     | T P LE                  | LE        | Human           | Intestinal worm and stomach flatulence | Dried powdered fruit is given |
| 8     | Phyllanthus emblica L. (Phyl- lanthaceae), 208-Z | Amla        | Daboola   | T P FR                  | FR        | Human           | Cough and throat infection | Powdered fruit with Ocimum basilicum leaves is given orally |

Quantitative indices:

- FC: Frequency of citation
- RFC: Relative frequency of citation
- ∑Ui: Sum of frequency
- UV: Uniformity value
Table 4 (continued)

| S. no | Taxonomic name/family, voucher no | Local name | Locality | Life habit/ life span<sup>a</sup> | Part used<sup>b</sup> | Organism treated | Disease treated | Ethnomedicinal recipes | Quantitative indices<sup>c</sup> |
|-------|----------------------------------|------------|----------|----------------------------------|----------------------|------------------|-------------------|------------------------|--------------------------|
| 9     | *Rumex hastatus* D.Don (Polygonaceae), 238-Z | Katmal, Tehtur | Najafpur | S P WP                           | WP WP                | Cow, buffalo and goat | Appetite          | The whole plant is fed | Powdered roots are given with water | 9 0.11 31 0.38 |

<sup>a</sup> Life Habit/Life span; S, Shrubs; H, Herbs; C, Climbers; T, Trees; A, Annual; B, Biennial; P, Perennial

<sup>b</sup> Plant Part(s); RT, Root; LE, Leaf; ST, Stem; FR, Fruit; SH, Shoot; WP, Whole Plant; BA, Bark; SD, Seed; RH, Rhizome; FL, Flower; GM, Gum; RE, Resin; BB, Bulb; TW, Twigs; PP, Pulp; SP, Spine

<sup>c</sup> Quantitative Indices; RFC = Relative frequency of citation, FC = Frequency citation, $\sum U_i = \text{sum of uses, \ UV = Use values}$
from 0 to 57.1%. The similarity index (JI) value ranges from 1.76 to 16.85 (Table 6).

Furthermore, 25 national studies from the different areas of Pakistan were compared with the present 40 reported species for management of veterinary diseases. The similarity percentage ranges from 0 to 60%. The degree of similarity index (JI) value ranges from 1.17 to 32.78 (Table 7).

Major threats to plant diversity
Plant resources are under severe threats; the major threats (fires, overgrazing, overexploitation and mining activities) were observed in the visited localities of the study area. Among them, the plant diversity of Garmtun, Najafour, Dartian, Baghpur dehri and Jabri was exposed to all these major threats. Moreover, Sarae Nehmat Khan and Ghazi were less/non exposed to the threat activities except only overgrazing (Table 8).

Discussion
The utilization of medicinal plant species belonging to the dominant plant families (Lamiaceae, Moraceae, Apocynaceae, Asteraceae, etc.) in the study area suggests that the families may have wide distribution, or the plant species are well known to communities for their medicinal purpose. The traditional knowledge of various plant families had been published around the world; among them, Asteraceae, Lamiaceae and Moraceae are well known for their medicinal purpose among the people of Pakistan [20], and other parts of the world [3, 80–82]; this knowledge may be transferred over many different communities. In the traditional medicine system, herbaceous medicinal plant have been commonly used on a large scale compared to other types of plants [83–86]. The medicinal plant or their parts are collected in different seasons depending upon their availability or frequency of active constituent deposition. The accessibility and availability of plant species may also involve their utilization rate, such as perennial plants having longer life cycles than other plant life cycles [1, 87–89]. Thus, indigenous communities in the present study area were more likely to prefer perennial plants due to their long life-cycle and availability.

Plant parts, modes of preparation and application play a significant role in herbal medicine [90]. Most herbalists believe that plant leaves have various bioactive chemical compounds which can be easily extracted [5, 91]. Leaves were the most exploited part for medicinal purposes in the present study and several other studies [92, 93]. Furthermore, the collection of leaves may not threaten the plant survival compared to the collection of the whole plant, stem, or roots, which can drive the plant species to extinction if over-collected [94]. While extraction from fresh material would be considered more useful to avoid microbial fermentation [95], previous studies demonstrated that decoction is the most commonly used preparation method for ethnomedical medicines by traditional healers in herbal recipes [96, 97]. This method may be commonly used due to its simplicity [98], or due to the heating process which speeds up biological reaction and results in higher availability of bioactive compounds [99–101]. In our study area, other areas of Pakistan [5, 82, 102, 103] and a few other countries [104–108], the most frequently used method of preparation is decoction. In regard to the various preparation methods documented in our study, other studies have also revealed similar findings; the most frequently used method of preparation in Azad Jammu and
Kashmir, Pakistan was decoction (18%), followed by powder and juice (17%), paste (15.5%), chewing (11%), extract (8%), infusion (7%) and poultice (5.5%) [97].

The traditional knowledge of herbal remedies for the management of various diseases may vary due to cultural differences, areas and communities. However, it is also believed that one plant species/part can treat various types of disease due to its diverse chemical constituents. Likewise, the present study demonstrated the traditional uses of *Achyranthus aspera* roots for tonsillitis, while its leaves were previously practiced for wound healing [109], *Datura stramonium* for bleeding piles, while in Haramosh and Bugrote Valleys, Pakistan, its leaves are practiced for injuries, wounds, bleedings and pains [52], *Zanthoxylum armatum* for jaundice, while in southern Himalayan regions of Pakistan, its branches are employed for toothache and edible fruits in cardiac disorders [110]. Moreover, in comparison with other studies revealed that some species have similar uses, and some plant species are exploited for different diseases [111–113], in addition to the folk herbal medicinal literature.

Likewise, some plant species we recorded in our study area reflect similar traditional veterinary uses compared to other traditional knowledge of ethnomedicinal plant studies. For example, *Mallotus philippensis* seed powder is used in abdominal worms to remove the threadworms [73], and *Melia azedarach* is used to reduce intestinal worm load in cattle, recoded with high a (100%) fidelity level [114]. In contrast, some studies reflect dissimilar traditional uses of plants, such as *Grewia optiva* for wound healing [58], leaves paste of *Dodonaea viscosa* is used as tonic and for wound healing [62, 115], fruits of *Solanum surattense* are used for pregnancy improvement [115], and in curing myiasis [31], the leaves and shoot of *Carissa opaca* are fed to increase the milk yield in goats [116], *Berberis lycium* root and stem powder for treat trauma in livestock in Afghanistan [117], *Punica granatum* is used in foot infection [118], fever, dehydration,
### Table 6: Comparative analysis between this study and other studies from Pakistan of medicinal plant used for human diseases management

| Area                        | Study year | Number of recorded plant species | Plants with similar use | Plants with dis-similar use | Total species common in both areas | Species enlisted only in aligned areas | Species enlisted only in study area | % of plants with a similar use | % of plants with dis-similar use | JI Citation |
|-----------------------------|------------|----------------------------------|-------------------------|-----------------------------|-----------------------------------|---------------------------------------|-----------------------------------|-------------------------------|----------------------------------|--------------|
| Chitral                     | 2017       | 36                               | 01                      | 05                          | 06                                | 30                                    | 74                                | 16.6                          | 83.3                             | 6.12         |
| District Charsadda          | 2016       | 60                               | 04                      | 03                          | 07                                | 53                                    | 73                                | 57.1                          | 42.8                             | 5.88         |
| Indus river                 | 2014       | 70                               | 04                      | 07                          | 11                                | 59                                    | 69                                | 36.3                          | 63.6                             | 9.40         |
| District Abbottabad        | 2013       | 67                               | 03                      | 08                          | 11                                | 56                                    | 69                                | 27.2                          | 72.7                             | 9.64         |
| Hingol national park       | 2012       | 39                               | 0                       | 03                          | 03                                | 36                                    | 77                                | 0                             | 100                              | 2.72         |
| Neelum valley (AJK)        | 2012       | 39                               | 0                       | 02                          | 02                                | 37                                    | 78                                | 0                             | 100                              | 1.76         |
| Khushab                     | 2012       | 14                               | 0                       | 04                          | 04                                | 10                                    | 76                                | 0                             | 100                              | 4.87         |
| District Attock            | 2011       | 43                               | 01                      | 03                          | 04                                | 39                                    | 76                                | 25                            | 75                               | 3.60         |
| District Sallot            | 2011       | 48                               | 02                      | 04                          | 06                                | 42                                    | 74                                | 33.3                          | 66.6                             | 5.45         |
| Kalat and Khuzdar          | 2010       | 61                               | 01                      | 02                          | 03                                | 58                                    | 77                                | 33.3                          | 66.6                             | 2.27         |
| District Bannu             | 2010       | 27                               | 01                      | 04                          | 05                                | 22                                    | 75                                | 20                            | 80                               | 5.43         |
| District Abbottabad        | 2010       | 54                               | 05                      | 10                          | 15                                | 39                                    | 65                                | 33.3                          | 66.6                             | 16.85        |
| Northern Pakistan          | 2009       | 27                               | 0                       | 02                          | 02                                | 25                                    | 78                                | 0                             | 100                              | 1.98         |
| Tehsil Chakwal             | 2009       | 29                               | 01                      | 03                          | 04                                | 25                                    | 76                                | 25                            | 75                               | 4.12         |
| Gilgit                      | 2008       | 98                               | 02                      | 06                          | 08                                | 90                                    | 72                                | 25                            | 75                               | 5.19         |
| District Mianwali          | 2007       | 21                               | 01                      | 01                          | 02                                | 19                                    | 78                                | 50                            | 50                               | 2.10         |
| Bagh (AK)                  | 2007       | 33                               | 0                       | 3                            | 3                                 | 30                                    | 77                                | 0                             | 100                              | 2.88         |
| Mahal (Kohistan)           | 2007       | 50                               | 02                      | 02                          | 04                                | 46                                    | 76                                | 50                            | 50                               | 3.38         |
| M2 motorway                | 2007       | 81                               | 04                      | 09                          | 13                                | 68                                    | 67                                | 30.7                          | 69.2                             | 10.65        |
| Siran valley               | 2006       | 80                               | 01                      | 13                          | 14                                | 66                                    | 66                                | 7.1                           | 92.8                             | 11.86        |
| Area                        | Study year | Total species recorded | Plants with similar uses | Plants with dis-similar uses | Total species common in both area | Species enlisted only in aligned areas | Species enlisted only in study area | % of plants with a similar use | % of plants with dis-similar use | JI Citation |
|-----------------------------|------------|------------------------|--------------------------|-------------------------------|-----------------------------------|----------------------------------------|----------------------------------|-------------------------------|---------------------------------|-------------|
| FATA, Pakistan              | 2018       | 94                     | 02                       | 14                            | 16                                | 78                                     | 64                               | 12.5                          | 87.5                            | 12.69        |
| Bajaur Agency, Pakistan     | 2018       | 73                     | 02                       | 13                            | 15                                | 58                                     | 65                               | 13.3                          | 86.6                            | 13.88        |
| District Jhang, Pakistan    | 2017       | 46                     | 01                       | 11                            | 12                                | 34                                     | 68                               | 8.3                           | 91.6                            | 13.33        |
| Neelum Valley, Pakistan     | 2017       | 50                     | 00                       | 04                            | 04                                | 46                                     | 76                               | 00                            | 100                             | 3.38         |
| Chail valley, Pakistan      | 2017       | 55                     | 02                       | 05                            | 07                                | 48                                     | 73                               | 28.5                          | 71.4                            | 6.14         |
| Hangu, Pakistan             | 2016       | 24                     | 01                       | 07                            | 08                                | 16                                     | 72                               | 12.5                          | 87.5                            | 10           |
| Karak, Pakistan             | 2015       | 46                     | 02                       | 09                            | 11                                | 35                                     | 69                               | 18.1                          | 81.8                            | 11.82        |
| Peshawar, KPK, Pakistan     | 2015       | 83                     | 02                       | 09                            | 11                                | 72                                     | 69                               | 18.1                          | 81.8                            | 8.46         |
| Sulaiman Range, Pakistan    | 2014       | 41                     | 12                       | 08                            | 20                                | 21                                     | 60                               | 60                            | 40                             | 32.78        |
| DI Khan, Pakistan           | 2014       | 43                     | 01                       | 07                            | 08                                | 35                                     | 72                               | 12.5                          | 87.5                            | 8.08         |
| Tharparkar, Pakistan        | 2014       | 22                     | 00                       | 02                            | 02                                | 20                                     | 78                               | 00                            | 100                             | 2.08         |
| Malakand valley, Pakistan   | 2014       | 28                     | 04                       | 05                            | 09                                | 19                                     | 71                               | 44.4                          | 55.5                            | 11.11        |
| Lesser Himalaya, Pakistan   | 2013       | 89                     | 06                       | 13                            | 19                                | 70                                     | 61                               | 31.5                          | 68.4                            | 16.9         |
| Baffa, Pakistan             | 2012       | 30                     | 08                       | 06                            | 14                                | 16                                     | 66                               | 57.1                          | 42.8                            | 20.5         |
| Allai, Pakistan             | 2012       | 24                     | 00                       | 03                            | 03                                | 21                                     | 77                               | 00                            | 100                             | 3.15         |
| Jhang, Pakistan             | 2012       | 35                     | 05                       | 05                            | 05                                | 30                                     | 75                               | 00                            | 100                             | 5            |
| Northern Pakistan           | 2012       | 54                     | 03                       | 08                            | 11                                | 43                                     | 69                               | 27.2                          | 72.7                            | 10.8         |
| Poonch valley, Azad Kashmir | 2012       | 19                     | 04                       | 03                            | 07                                | 12                                     | 73                               | 57.1                          | 42.8                            | 8.97         |
| Hilly area, Pakistan        | 2010       | 35                     | 01                       | 04                            | 05                                | 30                                     | 75                               | 20                            | 80                             | 5            |
| Suleiman region, Pakistan   | 2010       | 08                     | 01                       | 01                            | 01                                | 7                                      | 79                               | 00                            | 100                             | 1.17         |
| Sargodha Pakistan           | 2009       | 25                     | 00                       | 01                            | 01                                | 01                                     | 24                               | 79                            | 00                             | 100         |
| Cholistan desert, Pakistan  | 2009       | 35                     | 01                       | 02                            | 03                                | 32                                     | 77                               | 33.3                          | 66.6                            | 2.83         |
| Faisalabad, Pakistan        | 2009       | 39                     | 01                       | 05                            | 06                                | 33                                     | 74                               | 16.6                          | 83.3                            | 5.94         |
| Kashmir Himalaya, Pakistan  | 2007       | 24                     | 00                       | 02                            | 02                                | 22                                     | 78                               | 00                            | 100                             | 2.04         |
| Samahni valley, Pakistan    | 2006       | 54                     | 03                       | 12                            | 15                                | 39                                     | 65                               | 20                            | 80                             | 16.85        |
Indigenous knowledge of the people may vary greatly due to discrepancies in their origins and cultures. Documenting and comparing this knowledge may reveal a considerable depth of knowledge among communities, resulting in novel sources for drug development [124]. Such studies also illustrate the value of indigenous medicinal plant information, with disparities between areas arising as a result of ecological [125], historical [126], phytochemical and even organoleptic differences [127]. Similar in terms of their cultural values and climatic conditions to the study area, the Jaccard index showed significant results; the highest degree of similarity index was with studies by Abbasi et al. [49], Shah and Khan [57], Ahmad [56], Mussarat et al. [13], with JI values 16.85, 11.86, 10.65 and 9.40, respectively, for the management of human diseases. Likewise, Tariq et al. [66], Abbasi et al. [69], Ch et al. [79], Badar et al. [60] had JI values of 32.78, 16.9, 16.85, 13.88 and 13.33, respectively, for ethnoveterinary medicinal plant. The studies might have a cross-cultural exchange of knowledge between the communities through any means, historical and ecological factors, common ethnic values and similar vegetation types. The lowest JI values were for the studies conducted by Ahmad et al. [43], Afzal et al. [50], with JI values 1.76 and 1.98, respectively, for human disease management. Likewise, Dilshad et al. [27], Raziq et al. [75], Khuroo et al. [69], Ch et al. [79], Badar et al. [60] had JI values of 0.98, 1.17, 2.04 and 2.08, respectively, for ethnoveterinary medicinal plant. These findings are in agreement with studies carried out by Kayani et al. [128]. This might be due to a greater difference in ethnobotanical knowledge due to differences in population size, species diversity, habitat structure, or less chance of exchanging cultural knowledge between the areas. The Jaccard index analysis may strengthen the value of reported medicinal plant species with their matching uses to other studies, which may provide a baseline for phytochemical, and pharmacognostic studies.

On the other hand, the JI analysis may reflect the novel uses of medicinal plant from the present study area, which may be due to the areas: (1) unique phytogeography, (2) distinguished indigenous culture and history, (3) remarkable phytodiversity, (4) existence of different tribes and castes, (5) differences in methods of medicinal plant collection, their processing, preparations, usage and storage, (6) ethnobotanical knowledge variations, (7) less chance of the exchange of cultural knowledge between the study area to other areas may be due to restricted movement of people because of their residences in remote and hilly areas, (8) absence of a proper system of documentation, sharing and conservation of

| Locality/threat | Mining activities | Over exploitation | Over grazing | Fire |
|-----------------|------------------|------------------|-------------|-----|
| Khanpur         | +                | −                | +           | +   |
| Beer            | −                | +                | +           | +   |
| Garmthun        | +                | +                | +           | +   |
| Najafpur        | +                |     +            | +           | +   |
| Hattar          | −                | −                | +           | +   |
| Jabri           | +                | −                | +           | +   |
| Baghpur dehri   | +                | +                | +           | +   |
| Dartian         | +                | +                | +           | +   |
| Nilan Bhoto     | −                | +                | +           | +   |
| Babotri         | −                | −                | −           | +   |
| Pharala         | +                | +                | −           | +   |
| Ghazi           | −                | −                | +           | +   |
| Kohala          | +                | −                | +           | +   |
| Sarae Nehmat Khan | −            | −                | +           | +   |
| Nara Amazai     | −                | +                | +           | +   |

Data: + presence, − absence
folk knowledge, (9) least interest of the younger generation in folk knowledge and practices, (10) differences in plant parts used, diseases treated and recipes, such as our study area's preparation methods, are different from other areas of Pakistan for the same plant part and treated disease, and (11) ethnomedicinal use of plant in our study area may not be documented or published from other study areas.

During surveys, it was observed that local plant resources are severely threatened by forest fires in summer, overgrazing (nomadic and normal), overexploitation and mining activities. People living in the far-flung mountains of the area have no or less modern healthcare system, so most people rely on medicinal plant, and unsustainable collection may drive the flora to extinction [129–131]. During our study, it was also unveiled that over time, important folk indigenous knowledge about plants was limited to older people only, as the younger people have less interest in folk knowledge and traditional practices due to transforming lifestyle and culture; this can be inferred from the informant’s knowledge by age, which showed informants 6.2%, ≤ 30 years of age.

**Conclusion**

In summary, the current study reported the important ethnomedicinal plant practiced in veterinary and human healthcare by the local people of District Haripur, Pakistan. Like the rural population of other countries, the local people also rely on medicinal plant to treat livestock and human diseases may due to traditional culture, easy availability and cheaper sources. Comparative analysis of the present study and their matching with other studies from Pakistan may reflect the novel use of these plants, which can provide a base line for pharmacognostic studies. Scientific and experimental validation of traditional knowledge is necessary to ensure safety and efficacy; therefore, the phytochemical, toxicological and clinical studies on the documented flora are recommended for a better understanding. In the study area, ethnomedicinal plant are also under severe threats, and combined efforts should be made to secure both the plant resources and folk knowledge. In this regard, awareness campaigns, conservation efforts and pharmacological and applied research studies are required.

**Abbreviations**

EVM: ethnoveterinary medicine; RFC: relative frequency of citation; FC: frequency citation, ∑U: sum of uses; UV: use values; S: shrubs; H: herbs; C: climbers; T: trees; A: annual; B: biennial; P: perennial; RT: root; LE: leaf; ST: stem; FR: fruit; SH: shoot; WP: whole plant; BA: bark; SD: seed; RH: rhizome; FL: flower; GM: gum; RE: resin; BB: bulb; TW: twigs; PP: pulp; SP: spine.

**Supplementary Information**

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**Additional file 1:** File S1. Sample of questionnaire used during field survey for obtaining ethnobotanical information.

**Additional file 2:** Fig. S1. Description of the study area, Haripur District, Khyber Pakhtunkhwa, Pakistan. Fig. S2. Images of some ethnoveterinary medicinal plant of District Haripur. Table S1. Relationship between Relative frequency of citation (RFC) and Use Value (UV)

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**Authors’ contributions**

N.S. and A.N. contributed to conceptualization; G.M.S., Z.S. and N.S. provided methodology; N.S. provided software; Z.S., M.H. and A.M. performed validation; N.S. and Z.S. carried out formal analysis and investigation; A.N., M.S. and L.Y. performed data curation; Z.S. and N.S. performed writing—original draft preparation; N.S., G.M.S. and A.N. performed writing—review and editing; G.M.S. and M.I. done supervision; I.K. contributed to funding acquisition. All authors read and approved the final manuscript.

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**Availability of data and materials**

All the data are in manuscript and supporting documents.

**Declarations**

**Ethics approval and consent to participate**

This study was authorized by the Department of Bioscience and Office of Research, Innovation and Commercialization University of Wah (ORIC-UW), Wah Cantt, Pakistan.

**Consent for publication**

All authors read and approved the final manuscript for publication.

**Competing interests**

The authors declare that they have no competing interests.

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