Ethnobotanical study of medicinal plants used for Wound healing in North Waziristan, Pakistan

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Research

Abstract

Background: Pakistani communities possess a rich tradition of healthcare knowledge, particularly in the use of medicinal plants. The local community of North Waziristan similarly relies on a wide variety of plant species for treating burns, cuts, and wounds. This region is especially significant due to its rich biodiversity, well-preserved indigenous knowledge systems, limited access to modern medical facilities, and a strong cultural dependence on traditional remedies. Therefore, this survey aims to document and explore the therapeutic use of medicinal plants for Wound healing in this relatively under-researched region of Pakistan.

Methods: Ethnomedicinal knowledge was collected through face-to-face, semi-structured interviews with approximately 130 local informants from the research area, representing diverse educational backgrounds and socioeconomic statuses. In addition, sixty-one questionnaire-based interviews were conducted in selected villages. Various ethnobotanical indices, such as Use value (UV), Relative frequency of citation (RFC), and Fidelity level (FL), were used to analyze the data.

Results: A sum of 69 plants, relating to 45 families, was reported for their use in healing 18 different wound-related ailments. Asteraceae was the leading plant family with 8 plant species, followed by Solanaceae with 4 plant species. The most frequently used growth forms were Herbs (59.42%), followed by shrubs (20.29%). Leaves (40.96%) were the heavily utilized plant part used in herbal medication, and paste (32.43%) was the most frequent herbal preparation method. Among the most frequently cited species were *Bergenia ciliata* (0.87), followed by *Agave cantala* and *Salvia macrosiphon* (0.84 each), *Ephedra procera* (0.82), *Berberis lycium* (0.81).

Conclusions: These medicinal plants, which are used to heal wounds, are facing severe threats and therefore need to be conserved. Documenting traditional knowledge not only aids in preserving cultural heritage but also offers a valuable starting point for bioactive compound discovery, potentially leading to the development of novel wound-healing agents in modern medicine. Advanced research should focus on the implementation of phytochemical and pharmacological activity in these valuable herbal drugs.

Keywords: EthnomedicineWound healing, herbal remedies, traditional knowledge, North Waziristan, Pakistan.

Background

Medicinal plants play a significant role in public health worldwide. For centuries, patients have relied on medicinal plants for various daily needs and to maintain their overall well-being (Ahmad & Pieroni, 2016; Rehman *et al.* 2022). These plants provide not only food and medicine but also animal fodder and materials for constructing homes (Shinwari & Khan, 2000; Guzo *et al.* 2023; Rehman *et al.* 2023). The discovery and use of therapeutic plants are as old as the use of plants for food (Ibrar, 2002). Historical records indicate that ancient civilizations used herbal medication to treat a variety of ailments, including burn injuries, due to its affordability, simplicity, and effectiveness (Sher *et al.* 2011; Yazarlu *et al.* 2021; Rehman *et al.* 2023). In modern times, Wound remain a serious global health concern, often associated with high treatment costs and limited therapeutic success (Agyare *et al.* 2016), and they affect folks both psychologically and physically (Gümüş & Özlü, 2017).

It is estimated that several million patients suffer from wounds, injuries, and cuts each year, which can lead to death if not properly treated (Alam *et al.* 2011; Wang *et al.* 2018). Wound infections and related diseases are common in both developed and developing countries due to unsanitary environments (Menke *et al.* 2007; Finnerty *et al*. 2016). Wound can be referred to as physical impairments (Strodtbeck, 2001). Furthermore, injuries affecting the physical structure, physiological functions, and physical characteristics of the skin, as well as its functional integrity, are also considered Wound (Shenoy *et al.* 2009). According to the World Health Organization (WHO), approximately eighty percent or more of people living in developing countries heavily rely on ethnomedicine to manage health conditions affecting their communities (Parasuraman et al. 2014)." According to data assessed by the World Health Organization (WHO) in 2018, approximately 180000 individuals die each year due to wounds, trauma, ulcers, and burns, etc with most of these deaths occurring in low-income countries. Several therapeutic plants have been shown to enhance the skin's natural healing process (Kumar *et al.* 2007; Das *et al.* 2017; Tahir *et al.* 2023; Rehman *et al.* 2023). Various studies have revealed that around 70% of wound-healing drugs are derived from plants, 20% originate from minerals, and the remaining 10% are obtained from animal products (Budovsky *et al.* 2015; Biswas & Mukherjee, 2003; Mobale *et al.* 2023).

Medicinal plants are recommended due to the various side effects associated with antibiotics. These plants have been used since ancient times (Budovsky *et al.* 2015). Bioactive and natural compounds present in plant species possess antifungal and antibacterial properties, which can significantly impact the Wound healing process. Different studies have demonstrated that herbal extracts contain antioxidants that help promote Wound healing (Yazarlu *et al.* 2021). Plant-derived ingredients are known to have fewer side effects and are considered safer compared to synthetic drugs. In Wound care, the use of medicinal plants involves processes such as sanitization and debridement, which create a favorable environment for Wound healing (Oguntibeju, 2019). Natural compounds extracted from plant species play a significant role in various stages of the Wound healing process. Furthermore, these compounds possess both anti-fungal and anti-inflammatory properties (Criollo-Mendoza *et al.* 2023).

According to the literature, extensive work has been carried out worldwide on the documentation of Wound healing practices, including studies from India (Kumar et al., 2007; Thomas et al., 2014) and Africa (Fisher et al. 2025). However, in Pakistan, comparatively little attention has been given to the documentation of indigenous Wound healing practices, resulting in limited reports and a important knowledge gap in this important area. For example, Abbasi et al. (2010) reported 27 plant species representing 23 families used for Wound healing by tribal communities in the Northern Himalayan region, specifically in the Abbottabad district. Similarly, Siddique *et al*. (2019) documented 40 plant species from 29 families used for Wound treatment in the Haripur District, Khyber Pakhtunkhwa (KPK), while Jawadullah and Akhtar (2023) reported 20 plant species belonging to 19 families from the Dir Upper District.

Despite these efforts, no documentation has yet been carried out in the unexplored and remote tribal region of North Waziristan, Pakistan, highlighting a critical need to record this traditional knowledge. Therefore, the current study is the first to investigate Wound healing practices in North Waziristan, where indigenous communities possess extensive traditional knowledge and rely heavily on therapeutic plants for Wound healing. This study aims to help bridge the existing knowledge gap caused by the lack of documentation in this area. This study aimed to: (i) to identify valuable medicinal plants used for Wound healing in North Waziristan (ii) to document indigenous folk knowledge related to Wound healing and (iii) to provide baseline data for phytochemists, pharmacologist, and conservationists to support future research.

Materials and Methods

Study area

North Waziristan is located in Pakistan and shares a border with Afghanistan. It lies between longitude "69°25′" and "70°40′"E and latitudes 32°35′and "33°20"N. The area is bordered by Afghanistan to the west; District Bannu to the east, South Waziristan District to the south, and Kurram District, Hangu District, and Afghanistan to the North. In addition, sixty-one questionnaire-based interviews were conducted in selected villages, which are indicated by black dots on the map (Figure 1). North Waziristan is the part of the Irano-Turanian Region. According to the 2017 census report, the total population i of the research area is 543,245. The study area covers an area of 4,707 sq. km. The main tribes residing in the research area are the Wazir and Dawar; with Pashto being the primary language spoken.

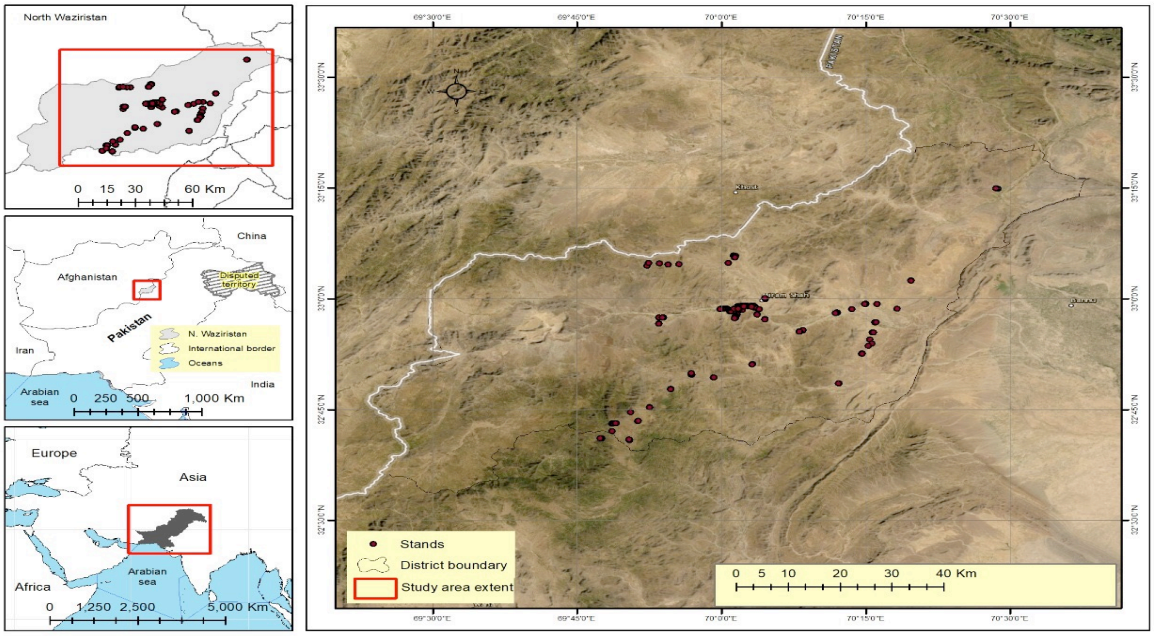

Figure 1. Map of the study area.

Therapeutic plants collection

An ethnobotanical study was conducted in the study area from April 2020 to October 2022 to document therapeutic plants. Prior informed oral consent was obtained from all 130 informants. Field interviews were carried out with various members of the local community, comprising traditional medical practitioners, herbalists, elderly individuals, shepherds, and farmers. A total of 130 local informants from various age groups were interviewed. Many of them were aged 61-75 years (41.54%), 46-60 years (29.23%), and above 75 years (19.23%). Data were collected through face-to-face interviews using semi-structured questionnaires. The information gathered from the informants included age, gender, occupation, local plant names, plant family names, life form, education, plant parts used, folk uses, methods of preparation, modes of utilization, and routes of administration.

Identification and Preservation of Therapeutic Plants

The therapeutic plant species samples were collected when they were in the flowering stage. They were then dried, pressed, and treated with (1% HgCl2 solution). Due to its high toxicity and environmental hazards, the use of $HgCl_2$ should be handled with extreme caution, following proper safety protocols and disposal regulations including the use of personal protective equipment (PPE), proper ventilation, and environmentally safe disposal methods. Safer alternatives to 1% mercuric chloride ($HgCl_2$) solution, such as povidone-iodine, chlorhexidine, or hydrogen peroxide, are recommended for use as antiseptics and disinfectants." Next, the specimens were pasted onto the herbarium sheets (11.5 x 17.5) inches. The plant samples were identified by a taxonomist, Prof. Dr. Rahmatullaha Qureshi and their identification was confirmed using the flora of Pakistan (Ali & Qaiser, 1993-2023). Once identified, the specimens were assigned voucher numbers and submitted to the Department of Botany Hazara University, Mansehra for future reference.

Data analysis

The collected data was analyzed using different quantitative indices including Relative Frequency of Citation (RFC), Use Value (UV), and Fidelity Level (FL %).

Relative Citation of Frequency (RFC)

Relative frequency of citation (RFC) was calculated to find out the traditional value of every medicinal plant reported in the research area. It was obtained by dividing the number of informants who cited the species (FC) by the number of informants (N) according to the formula (Vitalini *et al.* 2013).

$$\mathrm{RFC} = \frac{\mathrm{FC}}{\mathrm{N}} \ (0 < \ RFC \ < \ 1)$$

Where

FC= Number of respondents who mentioned the use of medicinal plants.

N= Total number of informants in the survey (N= 130).

Use Value (UV)

Use value (UV) of a species gives the relative importance of the local plants in the study area.

The use value (UV) of medicinal plants was calculated by the following formula:

$$\mathrm{UV} = \frac{\mathrm{u}}{\mathrm{N}}$$ (Savikin *et al.* 2013)

Where

u= Number of use reports recorded by the respondents for a given therapeutic plant.

N = Total number of informants.

Fidelity Level (FL %)

Fidelity level is used to estimate the percentage of the most preferred and used plant for a particular ailment category by the informants in the research area. The FL value was determined by using (Friedman *et al.* 1986) formula.

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

Where “Np” = Number of records of a particular plant for a specific disorder,

'A whole number of respondents mentioned the plant species for any disorder.

Results

Demographic Data

A total of 130 informants were interviewed. Most of the informants were men (82.31%), while the remaining 17.69% were women. This shows the cultural barriers of the study area, as the women of the study area cannot talk with a male outside of their families. The majority were between 61-75 years old (41.54%), followed by those aged 46-60 years (29.23%), and those above 75 years old (19.23%). It is worth noting that due to the lack of educational facilities in the study area, a significant number of the participants were illiterate (42.31%)(Table 1). However, some participants had received formal education, reflecting their awareness of its importance (4.62%). Among the educated participants, many had completed primary education (24.62%), followed by middle-level education (12.31%). All participants spoke Pushto.

Table 1. Socio-demography of informants in the research area.

Variable	Categories	No. of Informants N=130	Percentage (%)
Gender	Men	107	82.31
	Women	23	17.69
Age	30-45	13	10.00
	46-60	38	29.23
	61-75	54	41.54
	Above than 75	25	19.23

Major Tribes	Dawar	46	35.38
	Wazir	84	64.62
Occupation	Herbalists	74	56.92
	Traditional medical practitioners	35	26.92
	Shepherd	21	16.15
Education background	Illiterate	55	42.31
	Middle level	16	12.31
	Primary level	32	24.62
	Secondary level	11	8.46
	Undergraduate level	10	7.69
	University level	6	4.62

Wound healing Plants

In this study, we documented a total of 69 plants from 45 plant families that are utilized by the indigenous people to treat 18 various ailments. We have summarized the results of the research area, which include information on each plant species such as its botanical name, local name, plant family, growth form, plant part, preparation mode, and the disease its treats (Table 2).

Growth Forms and Therapeutic Plants Families

The result of our study showed that the indigenous people predominantly used herbs (59.42%) as their primary form of plant life, followed by shrubs (20.29%), trees (14.49%), ferns (2.90%), climbers and sedges (1.45% each) (Figure 2).

The families with the maximum number of plants used for indigenous Wound healing medication were Asteraceae (8 spp.), followed by Solanaceae (4 spp.), Amaranthaceae, Brassicaceae and Lamiaceae (3 spp. each). Alliaceae, Apiaceae, Asclepiadaceae, Euphorbiaceae, Fabaceae, Moraceae, Polygonaceae and Rhamnaceae (2 spp. each). The remaining families had 1 species each, as shown in Table 2.

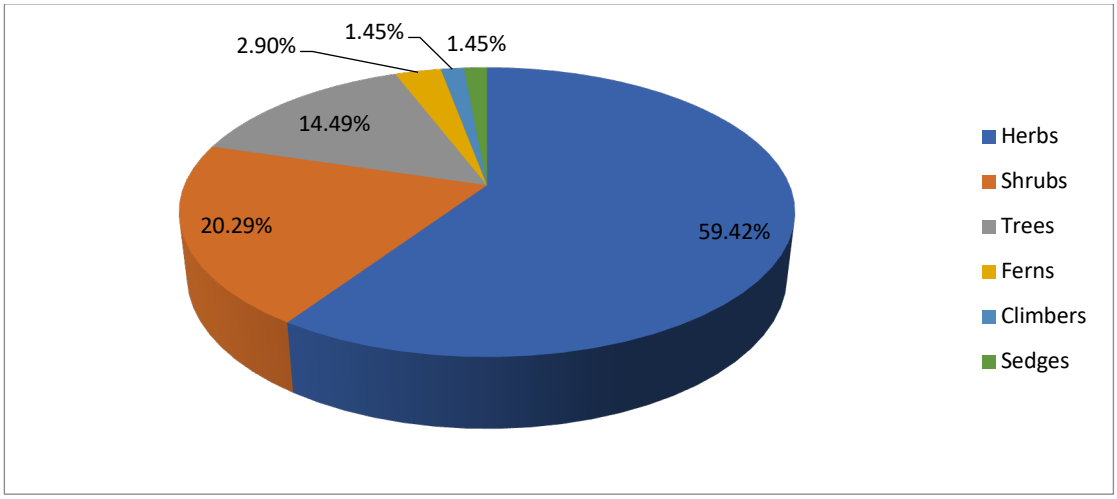

Figure 2. Habits of therapeutic plant species used for Wound healing.

Plant parts used

Different plant parts were utilized in the preparation of medicinal recipes for Wound healing and treating different ailments. Out of the 13 plant parts, the leaves were the most heavily utilized for preparing medication (40.96%), followed by aerial parts (13.25%), bark (7.23%), flowers, roots and whole plants (6.02% each), bulbs and seeds (4.82% each), and fruits (3.61%). (Figure 3). The leaves collection and preparation of recipes from them is much easier. Therefore, leaves were the most utilized plant part in remedy preparations for the cure of Wound healing.

Table 2. List of therapeutic plant species for Wound healing with botanical name, common name, plant family, accession no., growth form, preparation mode, used parts, UV, URs, FC, RFCs, and FL.

Botanical Name/Accession No.	Family	Growth form	used parts	Mode of preparation	Therapeutic uses	FC	RFC	UV	URs	FL%
Justicia adhatoda L. HU-13233	Acanthaceae	Shrub	Leaf	Powder	Skin wounds	37	0.28	0.70	26	72.97
Agave cantala (Haw.) Roxb. Ex Salm-Dyck. HU-13460	Agavaceae	Herb	Leaf	Juice	Cuts, wounds, burns	45	0.35	0.84	38	100.00
Allium cepa L. HU-12350	Alliaceae	Herb	bulb	Heated in mustard oil	Wound healing	21	0.16	0.52	11	66.67
Allium sativum Allium L. HU-12351	Alliaceae	Herb	bulb	Warmed in mustard oil	Wound healing	27	0.21	0.56	15	70.37
Achyranthus aspera L. HU-13311	Amaranthaceae	Herb	Leaf	Poultice, decoction	Wound healing, Wound washing	37	0.28	0.73	27	86.49
Amaranthus viridis L. HU-12432	Amaranthaceae	Herb	Leaf	warmed in mustard oil	Boils, abscesses	24	0.18	0.63	15	58.33
Dysphania botrys (L.) Mosyakin & Clemants HU-13556	Amaranthaceae	Herb	Roots	Infusion	Wound healing	13	0.10	0.31	4	30.77
Pistacia khinjuk Stocks HU-12576	Anacardiaceae	Tree	Bark	Decoction	Wound healing	32	0.25	0.69	22	65.63
Bunium persicum (Boss.) Fedtsch. HU-13466	Apiaceae	Herb	Whole plant	Poultice	Wound healing,	35	0.27	0.60	21	65.71
Bupleurum falcatum L. Hu-13443	Apiaceae	Herb	Leaf, shoots	Decoction	Wound healing, boils	23	0.18	0.61	14	65.22
Periphloca aphylla Dcne. HU-13379	Asclepiadaceae	Shrub	Aerial parts	Latex, powder	Wound healing	23	0.18	0.48	11	56.52
Calotropis procera sub sp. *Hamiltonii* (Wight) Ali HU-13185	Asclepidiaceae	Shrub	Leaf	Paste	Wound healing	26	0.20	0.54	14	65.38
Aloe vera (L.) Burm.f. HU-12362	Asphodelaceae	Shrub	Leaf	Leaf gel	Wound healing, burns	33	0.25	0.58	19	63.64

Botanical Name/Accession No.	Family	Growth form	used parts	Mode of preparation	Therapeutic uses	FC	RFC	UV	URs	FL%
Artemisia martima L. HU-12353	Asteraceae	Shrub	Whole plant	Juice	Wound healing	34	0.26	0.62	21	73.53
Carthamus oxyacantha Bieb. HU-13138	Asteraceae	Herb	Aerial parts	Decoction	Burns, wounds healing	33	0.25	0.64	21	78.79
Carthamus tinctorius L. HU-13559	Asteraceae	Herb	Flower	Decoction	Wound healing	25	0.19	0.52	13	56.00
Eclipta prostrata (L.) L. HU-13304	Asteraceae	Herb	Leaf	Paste	Wound healing	29	0.22	0.66	19	65.52
Galinsoga parviflora Cav. HU-13449	Asteraceae	Herb	Leaf	Poultice	Wound healing	34	0.26	0.62	21	70.59
Sonchus arvensis L. HU-13335	Asteraceae	Herb	Leaf	Paste	Wound healing	17	0.13	0.29	5	29.41
Tagetes erecta L. HU-12437	Asteraceae	Herb	Leaf	Paste	Wound healing	25	0.19	0.52	13	56.00
Taraxacum officinale F.H.Wigg. HU-14346	Asteraceae	Herb	Flower, leaves	Powder	Internal wounds	33	0.25	0.52	17	69.70
Berberis lycium Royle HU-12354	Berberidaceae	Shrub	Root	Powder	Mouth boils, internal wounds, injured parts	43	0.33	0.81	35	97.67
Tecomella undulata (Roxb.) Seeman. HU-14267	Bignoniaceae	Shrub	Bark	Powder	Wound healing	26	0.20	0.69	18	65.38
Capsella bursa-pastoris (L.) Medik. HU-13422	Brassicaceae	Herb	Leaf, stem	Decoction	Wound healing	25	0.19	0.68	17	68.00
Lepidium verginicum L. HU-13442	Brassicaceae	Herb	Leaf, fruit	Decoction	Wound healing	26	0.20	0.62	16	57.69
Nasturtium officinale R.Br. HU-13317	Brassicaceae	Herb	Aerial parts	Powder	Skin boils, pimples	38	0.29	0.55	21	73.68
Cannabis sativa L. HU-13324	Cannabaceae	Herb	Leaf	Bound	Wound healing	35	0.27	0.57	20	82.86
Capparis decidua (Forssk.) Edgew.. HU-13484	Capparidaceae	Shrub	Bark	Powder	Wound healing	24	0.18	0.63	15	58.33

Botanical Name/Accession No.	Family	Growth form	used parts	Mode of preparation	Therapeutic uses	FC	RFC	UV	URs	FL%
Chenopodium ambrosioides L. HU-13531	Chenopodiaceae	Herb	Leaf	Infusion, juice	Wound healing	36	0.28	0.67	24	72.22
Citrullus colocynthis (L.) Schard. HU-13486	Cucurbitaceae	Herb	Fruit, roots	Juice, paste	Wound healing	29	0.22	0.52	15	65.52
Cuscuta reflexa Roxb. HU-13488	Cuscutaceae	Climber	Whole plant	Ash	Wound healing, pimples	29	0.22	0.55	16	58.62
Cyprus rotundus L. HU-12386	Cypraceae	Sedge	bulb	Paste	Wound healing	28	0.22	0.50	14	57.13
Ephedra procera Fish. & Mey. HU-12345	Ephedraceae	Shrub	Aerial shoots	Decoction, powder	Bleeding gums, Wounds	44	0.34	0.82	36	100.00
Equisetum arvense L. HU-13127	Equisetaceae	Ferns	Aerial parts	Infusion	Bleeding gums	26	0.20	0.50	13	65.38
Euphorbia hirta L. HU-13225	Euphorbiaceae	Herb	Leaf	Paste	Wound healing, injuries, abscesses	29	0.22	0.52	15	68.97
Ricinus communis L. HU-14243	Euphorbiaceae	Shrub	Seeds	Paste	Wound healing	24	0.18	0.46	11	50.00
Acacia modesta Wall. HU-12186	Fabaceae	Tree	Leaves, bark	Decoction, powder	Mouth boils, gums bleeding, abscesses	39	0.30	0.67	26	79.49
Acacia nilotica (L.) Delile. HU-12237	Fabaceae	Tree	Flowers, leaves, gum	Powder	Mouth ulcer, stomach ulcer	36	0.28	0.64	23	69.44
Quercus dilatata Royle. HU-14372	Fagaceae	Tree	Bark	Powder	Wound healing, lesion	34	0.26	0.65	22	79.41
Erodium cicutarium L. HU-13209	Geraniaceae	Herb	Aerial parts, seed	Decoction	Wound healing	32	0.25	0.53	17	68.75
Marrubium vulgare L. HU-13239	Lamiaceae	Herb	Whole plant	Paste	Wound healing	25	0.19	0.52	13	64.00
Salvia macrosiphon Boiss. hu-13374	Lamiaceae	Herb	Seed, root	Decoction	Wound healing	45	0.35	0.84	38	100.00
Salvia moocroftiana Wall. HU-13431	Lamiaceae	Herb	Leaf	Paste	Wound healing, abrasion	26	0.20	0.23	6	53.85

Botanical Name/Accession No.	Family	Growth form	used parts	Mode of preparation	Therapeutic uses	FC	RFC	UV	URs	FL%
Fritillaria imperialis L. HU-13383	Liliaceae	Herb	Bulb	Powder	Wound healing	41	0.32	0.80	33	100.00
Malva neglecta Wallr. HU-13368	Malvaceae	Herb	Leaf	Paste	Wound healing	38	0.29	0.61	23	76.32
Melia azedarach L. HU-13266	Meliaceae	Tree	Leaf	Paste	Skin pimples, burns	29	0.22	0.66	19	89.66
Ficus carica L. HU-13124	Moraceae	Tree	Leaf, aerial parts	Milky latex	Wound healing	31	0.24	0.58	18	64.52
Ficus palmata Forssk. HU-13139	Moraceae	Tree	Aerial parts, leaf	Milky latex	Wound healing	25	0.19	0.56	14	56.00
Olea ferruginea Wall. ex Aitch. HU-12513	Oleaceae	Tree	leaves	Herbal tea	Skin boils, pimples:	40	0.31	0.80	32	100.00
Plantago lanceolata L. HU-13308	Plantaginaceae	Herb	Leaf	Paste	Inflamed Wound sores	27	0.21	0.56	15	66.67
Eleusine indica (L.) Gaertn. HU-13248	Poaceae	Herb	Leaf	Decoction	Wound healing, cuts	19	0.15	0.58	11	68.42
Polygonum aviculare L. HU-12361	Polygonaceae	Herb	Aerial parts	Paste	Gums swelling	32	0.25	0.44	14	53.13
Rumex crispus L. HU-13151	Polygonaceae	Herb	Aerial parts	Poultice	Wound healing	24	0.18	0.54	13	66.67
Portulaca oleracea L. HU-13169	Potulacaceae	Herb	Leaf	Decoction	Wound healing	28	0.22	0.50	14	57.14
Adiantum capillus-veneris L. HU-13459	Pteridaceae	Fern	Leaf	Paste	Wound healing	31	0.24	0.68	21	67.74
Punica granatum L. HU-12434	Puniaceae	Shrub	Root	Decoction	Bleeding gums	28	0.22	0.57	16	75.00
Ziziphus mauritiana Lam. HU-13198	Rhamnaceae	Tree	Leaves	Paste	Wound healing	36	0.28	0.69	25	69.44
Ziziphus nummularia (Burm.f.) Wight & Am. Hu-14147	Rhamnaceae	Shrub	Leaves	Paste	Wound healing	35	0.27	0.69	24	74.29
Galium aparine L. HU-14172	Rubiaceae	Herb	Whole plant	Paste	Wound healing	30	0.23	0.50	15	53.33

Botanical Name/Accession No.	Family	Growth form	used parts	Mode of preparation	Therapeutic uses	FC	RFC	UV	URs	FL%
Dodonaea viscose (L.) Jacq. HU-12358	Sapindaceae	Shrub	Leaf	Powder	Wound healing, skin boils	26	0.20	0.46	12	69.23
Bergennia ciliata (Haw.) Stemb. HU-14475	Saxifragceae	Herb	Rhizome	Poultice	Wound healing	47	0.36	0.87	41	100.00
Verbascum thapsus L. HU-13158	Scrophulariaceae	Herb	Leaves, flowers,	Juice	Wound healing	34	0.26	0.68	23	76.47
Datura stramonium L. HU-12473	Solanaceae	Shrub	Leaf, flower	Paste	Painful wounds	32	0.25	0.59	19	65.63
Physalis angulata L. HU-13585	Solanaceae	Herb	Stem	Powder	Chronic wound	31	0.24	0.55	17	61.29
Solanum nigrum L. HU-14232	Solanaceae	Herb	Aerial parts	Poultice	Cleaning wounds	23	0.18	0.39	9	52.17
Solanum surratense Brum. f. HU-14371	Solanaceae	Herb	Fruit	Powder	Wound healing	32	0.25	0.66	21	71.88
*Tamarix aphylla (*L.) H. Karst. HU-14127	Tamaricaceae	Tree	Bark	Powder	Burn wounds	39	0.30	0.77	30	94.87
Curcuma longa L. HU-13235	Zingiberaceae	Herb	Rhizome	Powder	Internal wounds	27	0.21	0.48	13	59.26
Peganum harmala L. HU-13163	Zygophyllaceae	Herb	Seed	Decoction	Oral ulcer, gums diseases	27	0.21	0.48	13	66.67

Abbreviations: RFC= Relative Citation of Frequency, UR=Use Reports, FC= Frequency of Citation s, FL=Fidelity Level, UV=Use Values

Method of preparation

Ten various formulations were organized from various plant parts to treat 18 various ailments. Most remedies for Wound healing were in the form of paste (32.43%), followed by powder and decoction (21.62% each), poultice and juice (6.76% each), milky latex (4.05%), infusion (2.70%), and gel, ash and herbal tea (1.35% each) (Figure 4).

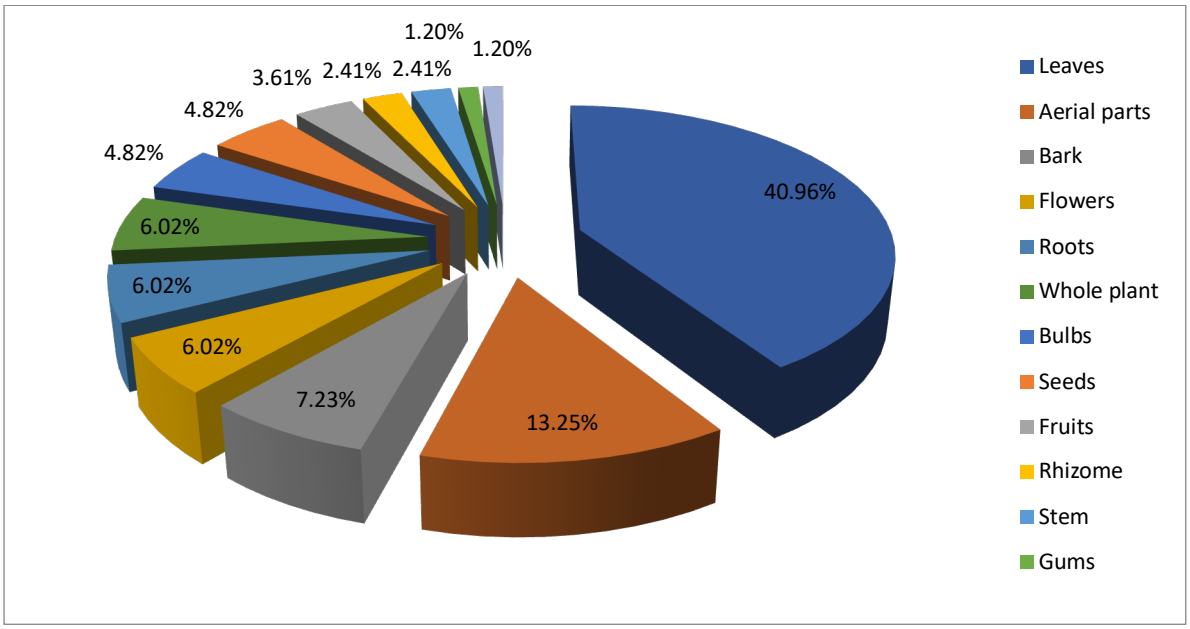

Figure 3. Classification of plants based on their parts used for medicinal purposes.

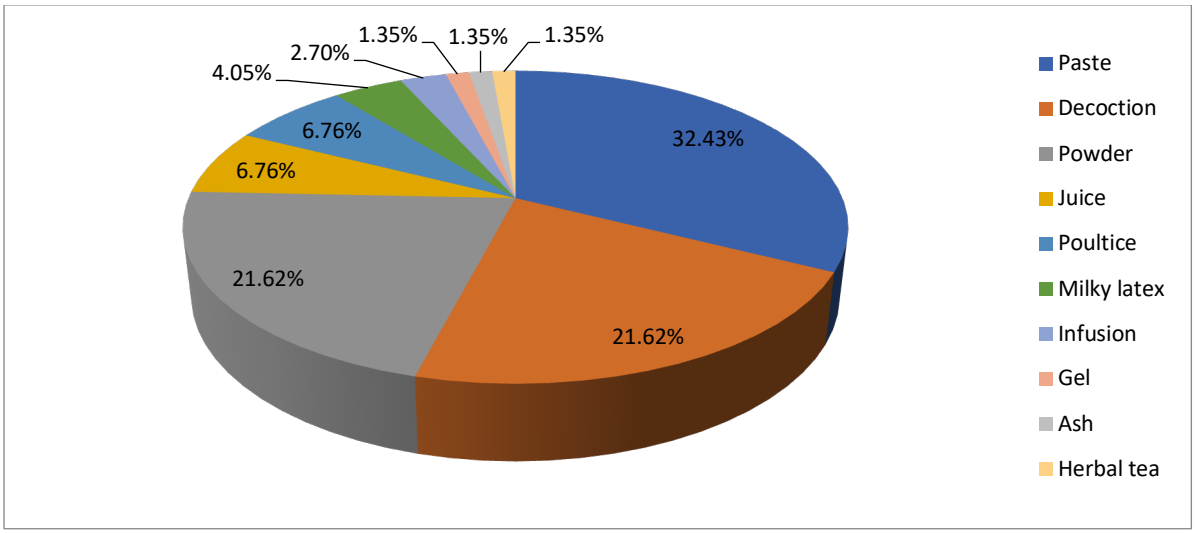

Figure 4. Mode of preparation of herbal remedy

Diseases Treated

The traditional healers and local inhabitants were using these 69 medicinal plant species for treating 18 different disorders. Among the 18 disorders identified in the research area, Wound healing was documented as the most commonly treated condition by traditional healers and other local informants. They identified 50 plants utilized for this purpose. This was followed by burn Wound and pimples, each treated with 5 species; skin boils with 4 species; abscesses, bleeding gums , gums swelling and internal Wound with 3 species each (Figure 5).

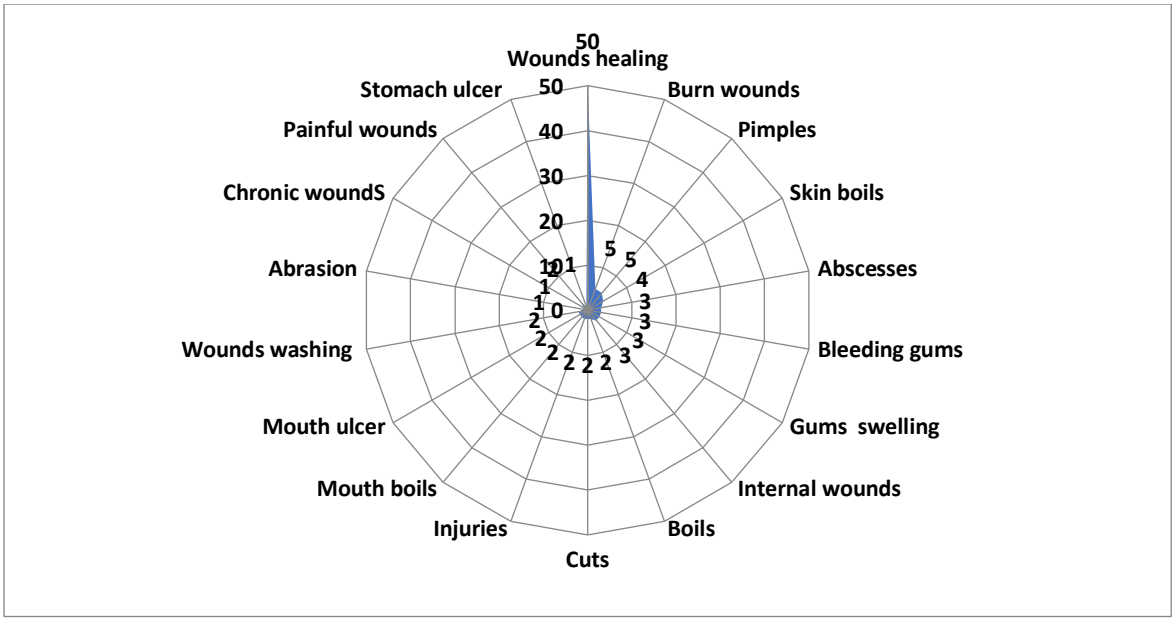

Figure 5. Number of plant species used for Wound healing diseases.

Relative Citation of Frequency

A relative frequency citation is calculated to evaluate the most frequently used medicinal plants for Wound healing disorders. In our data, the RFC value ranged from 0.10 to 0.36 (Table 2). The plant species with a highest RFC value were *Bergenia ciliata* (0.36), followed by *Agave cantala* and *Salvia macrosiphon* (0.35 each), *Ephedra procera* (0.34), and *Berberis lycium* (0.33). The minimum RFC value was recorded for *Dysphania botrys* (0.10).

Use Value

Use values indicated the relative significance and use diversity of plants in the research area. Higher UVs reflected greater URs and FC. The use values of medicinal plant species were ranging from 0.23 to 0.87, and their use reports (URs) from 4 to 41 (Table 2). Dominated medicinal plants with mostly used values were *Bergenia ciliata* (0.87), followed by *Agave cantala* and *Salvia macrosiphon* (0.84 each), *Ephedra procera* (0.82), and *Berberis lycium* (0.81), *Fritillaria imperialis* and *Olea ferruginea* (0.80 each). The minimum use value (UV) was recorded for *Salvia moocroftiana* (0.23).

Fidelity Level

Fidelity level identified the most desired plant species for treating diseases categories, calculated as percentage. The higher values of fidelity level (FL) recorded for some species of medicinal plants indicate that these species are frequently used for the treatment ofWound healing. The medicinal plant species with the maximum medicinal value have the highest fidelity level value (100%). The therapeutic plants that were recorded by one respondent were not mentioned in the fidelity level study. In our study, fidelity levels ranged from 29.41% to 100% (Table 2). Six species viz., *Agave cantala, Bergenia ciliata, Ephedra procera, Fritillaria imperialis*, *Olea ferruginea*, and *Salvia macrosiphon* were used with 100% FL, followed by *Berberis lycium* (97.67%), while the minimum FL value was calculated in the case of *Sonchus arvensis* (29.41%).

Novelty and future impact

All the mentioned plant species were reported for the first time for the curing of Wound healing in North Waziristan. This marks the first-ever ethnomedicinal survey carried out in North Waziristan, and it holds important value as a suggestion for conservation hard work. All the mentioned plants were documented for the first time for Wound healing in North Waziristan, and no prior studies have addressed Wound healing management through ethnomedicine in this region. Therefore, such research contributes not only to the documentation of traditional medicinal knowledge but also to the identification of bioactive constituents in medicinal plants for the development of commercial medications. The result of this research can inform conservation planners about the importance of therapeutic plants in the traditional healthcare system. It provides a basis for planning the consumption and sustainable maintenance of these medicinal plant species in the research area.

Discussion

The traditional medicinal usage of plant species for treating human ailments is vital to the communities of North Waziristan, Pakistan, and is considered an important part of their local sociocultural heritage (Sher et al. 2016). The current survey recorded 69 therapeutic plants related to 45 plant families, which are being utilized to cure wound-healing ailments in Pakistan (Table 2). Most of the indigenous healers in the research region were male. Our findings agreed with (Malik *et al.* 2019; Rehman *et al.* 2023). There was a distinct cultural barrier that prevented women informants from speaking with male informants outside their families. The participants (61-75 years) were found to possess more indigenous information. This indicates that the younger generations have less interest in traditional knowledge about medicinal plants. This reveals the alarming situation that traditional knowledge is neither documented nor preserved, and it may disappear shortly. Our result was consistent with the result obtained by (Ahmad *et al.* 2016).

As we can see, herbs were the most used type of plant to treat diseases in local medicine. Many researchers mentioned herbaceous growth form as the dominant plant habit (Rehman *et al.* 2022; Birjees *et al*. 2022; Rehman *et al.* 2023), which may influence the potential use of these plant species to treat diseases. Herbs often contain the highest quantity of bioactive compounds (Adnan *et al.* 2012), making their curative effects more potent compared to those of trees and shrubs (Adnan *et al.* 2014). The family that represented the maximum number of plants for indigenous Wound healing medicines was Asteraceae. Our results are consistent with those of studies conducted by (Birjees *et al*. 2022; Calvo *et al.* 2013; Rehman *et al.* 2022). The maximum distribution and wealth of therapeutic plants from the above family may be related to their dominance in the study area (Birjees *et al*. 2022; Rehman *et al.* 2024). Moreover, the extensive utilization of plants from these families may be associated with the presence of valuable bioactive compounds (El-Saadony *et al.* 2023; Rahman *et al.* 2021), that protect humans against ailments (Gazzaneo *et al.* 2005).

The local inhabitants most widely used leaves to cure diseases. Similar results have been reported by another researcher (Rehman *et al.* 2022; Rehman *et al.* 2023). For instance, Rehman et al. (2024) cited leaves as the most used plant part for medicinal purposes. The leaves collection and drug preparation from leaves are greatly easier than those from other plant parts (Samoisy & Mahomoodally, 2015). Traditional healers used different methods of formulations, though, in our study, the leading method of preparation was paste. Our finding agreed with the previous study (Rehman *et al.* 2022). The maximum UV was recorded for *Bergenia ciliata* and *Agave cantala*. A therapeutic plant species with maximum UV is likely due to its common supply in the study area, where local people possess sufficient indigenous knowledge of its healing properties (Rehman *et al.* 2023; Rahman *et al.* 2024). Minimum UV values for therapeutic plant species should not be taken as an indication that they are not therapeutically important; however, it does suggest that there is little indigenous knowledge about these plants (Mahmood *et al.* 2013). In addition, the most valuable and cited medicinal plant species were *Bergenia ciliata* and *Salvia macrosiphon.* Therapeutic plants with maximum RFC values are considered familiar among local people and herbal practitioners (Faruque *et al.* 2018). Medicinal plants with high Use Value (UV) and Relative Frequency of Citation (RFC) may indicate their high abundance in the region, the presence of important bioactive compounds for disease treatment, or even high concentrations of specific active constituents. In this context, these plants should be further evaluated through phytochemical analysis to identify and characterize the active compounds for potential drug discovery (Rehman *et al.* 2023). RFC value is used to identify therapeutic plants with high potential for future drug discovery in the curing ofWound healing disorders (Vitalini *et al.* 2013). Medicinal plants had a high-fidelity level and were documented for single or few medications. These plants have revealed remarkable curative significance, and further assessment through pharmaceutical, biological, and phytochemical activities is important. However, plant species with low Fidelity Level (FL) may not be abundant, highlighting the importance of conserving them for future generations, especially as the threat of gradual depletion and loss of cultural knowledge continues to rise (Birjees *et al.* 2022). The highest FL value indicates the preference of informants to cure a particular ailment (Islam *et al.* 2014). These medicinal plants can be identified as important therapeutic plants through further evaluation using pharmacological and phytochemical screening. *Bergenia ciliata*, traditionally used for Wound healing, contains tannins, Bergenin, Gallic acid —bioactive compounds with anti-inflammatory and antimicrobial properties. Thèse bioactive compounds (tannins, Bergenin, and Gallic acid) promoteWound contraction, reduce infection, and support tissue repair. Scientific validation of such compounds bridges traditional knowledge with modern medicine, highlighting the curative potential of ethnobotanical practices.

Conclusion

The study area is a remote region with no modern medical facilities available to the indigenous people; therefore, they depend entirely on traditional medicinal practices. This reliance has been a key factor in preserving their cultural knowledge and integrity within these geographic boundaries. North Waziristan area is rich in plant diversity, and its local inhabitants

primarily depend mostly on local remedies for Wound healing. This is due to the easy accessibility and affordability of folk medication. In our study, sums of 69 plant species from 45 families were identified as having the ability to cure 18 different types of wounds. This study revealed a diverse range of plant species used by local people for the purpose ofWound healing. Traditional knowledge that is orally transmitted is mostly held by the older generation. Much of it risks disappearing with their passing, leading to the loss of this important knowledge from the human community. Thus, the ethnobotanical knowledge associated with the natural ecosystem of North Waziristan has been relatively well preserved through this documentation. It is recommended that the reported plant species from this remote region be further evaluated through proper experimentation and pharmacological studies to validate their traditional uses. The documentation of commonly used therapeutic plant species raises concerns about potential overharvesting, which could threaten local Phytodiversity and the sustainability of these traditional practices. However, the local flora is under threat due to overexploitation, overgrazing, and improper harvesting practices. For the sustainable management of plant resources, it is imperative to adopt effective conservation measures such as controlled grazing, reforestation, and the management of rangelands. Future research should include broader community involvement and promote conservation strategies alongside ethnobotanical documentation.

Declarations

Ethics statement: Before the survey, we obtained oral informed consent from each participant.
Consent for publication: Not applicable
Availability of data and materials: Not applicable
Competing interests: Not applicable
Funding: Not applicable
Author contributions: S.R. conducted the fieldwork and collected the data. The manuscript was written by S.R., Z.I. and R. Q. Supervised this work. R.Q., W.H., K.R., and M.Y. helped in data analysis. R.Q. and R.B. and advised, reviewed, and approved the final manuscript.

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