



Ethnomedicinal study of medicinal plants used to cure dental diseases by the indigenous population of district Buner, Pakistan

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This is the first study of its kind conducted with the aim to document and conserve the ethnomedicinal knowledge of plants used to cure dental diseases in Buner, Pakistan and to provide starting point for future pharmacological studies about new herbal drugs used for dental disorders. Several field trips were conducted in 2018-19 to collect indigenous knowledge of medicinal plants. A semi-structured questionnaire was used as tool for data collection in individual and group interviews and informants were selected by snowball sampling. In this study 935 men and 323 women were interviewed, yielding information on 55 plant species belonging to 34 families. Lamiaceae and Solanaceae were the dominant plant families used and the main life forms used were herbs (28 species). Leaves were the most used part (19 species). The local population was found to be sensitive and careful about oral hygiene and had rich ethnomedicinal knowledge.

Keywords: Dental diseases, District Buner, Ethnomedicine, Medicinal plants, Pakistan

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There is a well-known connection between oral health and general health¹. The use of plants for the improvement of tooth and gum health has a very long history. In different areas of the world where modern method of tooth-brushing is not performed, the use of chewing sticks (*Miswak*) is common. Babylonians reported this method already in 5000 BC. This practice of tooth-brushing is still widely used especially in African and South Asian communities, as well as remote parts of the Southern United States and Tropical America².

Dental diseases such as periodontitis and caries are very common around the world¹. In school children, the infection prevalence is about 90%^{3,4}. Different drugs are used to cure dental diseases, but they often have side effects like diarrhea, vomiting and staining of teeth. On the other hand, many bacteria have already developed resistance against antibiotics and the search for substitutes is a big challenge. Natural

phytochemicals extracted from medicinal plants used in traditional remedies can be a good alternative to allopathic medicines⁴.

The causes of dental ailments are bacterial infections, foods and lifestyle. Oral hygiene deficiency and the consumption of more meat and pastry can harm the teeth, leading to bleeding gums, dental caries and pyorrhea¹ and might also disturb the digestion process. The treatment of dental diseases with herbal preparation has been studied by a variety of researchers and commonly used species are *Acacia nilotica* L., *Azadirachta indica* A. Juss. and *Vitex negundo* L.¹. Most of the plants used for dental diseases have anti-bacterial activity and alkaline nature and help to maintain the saliva acid-alkaline equilibrium, decreases the plaque formation and predisposition to periodontal infections. Microorganisms isolated from infected gums showed frequent resistance to antibiotics but not to medicinal plants e.g., neem¹.

During the survey of the study area, it was observed that medicinal plants resources were still in

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wide use by the local communities. In Buner, the Public Healthcare System consists of one District Health Quarter Hospital, three THQ-Hospitals, two Rural-Health-Centers, twenty BHUs and eight dispensaries. Only one Maternal and Child Health Center (MCH) is present, but without a single doctor⁵. In this project we collected and documented medicinal plants used to cure dental diseases with the aims (i) to find valuable medicinal plants, (ii) to preserve the indigenous wealth of knowledge and (iii) to make the indigenous population aware about the importance of sustainable use of medicinal plants.

Materials and Methods

Geographical position of the area

The study area lies between 34°09'-34°43'N and 72°10'-72°47'E. The area is bordered by district Swat in the North, the Malakand Agency to the West,

Mardan district to the South bordered, the Hazara Division and Indus River to the East and Swabi district to the North-East is (Fig. 1). The study area has been a sub-division part of district Swat until 1990. In 1991 it received the status of district⁶. The area is spread over 1865 km² with a total population of 897319 as per 2017 census. The entire population of the district is homogenous both culturally and religiously.

In Buner most of the local population has a low economic level, about 95% mainly depends on agriculture and livestock and 5% have earned work income. The houses of local people are like small kingdoms in which the father acts as a king. Every member of the house has their own duty and at night time all family sit together for dinner. After dinner, the men go to Hujra or Dera (the equivalent of a community club) where the older people tell stories to



Fig. 1 — Map of the study area

the youngers and also share cultural norms with them⁷.

Buner is surrounded by mountains on all sides. The elevation of mountains ranges from 366 m in Totalai to 2911 m in Dosara Peak. The district climate varies with altitude and can be categorized as dry subtropical⁷. Phytogeographically the district is the part of Sino-Japanese region with unique vegetation. The area has two distinctive rainy seasons the *Rabi* season from November to May and the *Kharif* monsoon from July to October. About 1650 mm rainfall occurs annually. The district climate is moderate. In summer, it is pleasant in the upper parts (Gadezai and Gokand), while hot in the lower parts (Khadukhel), where the temperature reaches up to 40°C. In winter, snow falls in the upper parts. About 32102 hectares of the area are covered by subtropical forest. In the time of Wali-i-Swat (from 1926 to 1969), this region was famous for its large forests, dominated by *Pinus roxburghii*, *Olea ferruginea*, *Acacia modesta* and *Quercus incana*. The mountains of Buner have a rich variety of medicinal flora. Ananganay (Wild pomegranate), Bakayana (Persian lilac), Inzer (Wild figs) and Toot (Mulberry), *Celtis australis*, *Monothea buxifolia*, *Berberis lyceum*, *Olea ferruginea*, *Acacia modesta*, *Dodonaea viscosa*, *Pinus roxburghii* and *Quercus incana* are the most famous medicinal plant⁷. Due to the remoteness of the area, the people mainly prefer medicinal plants to cure minor diseases.

Interviews with the local community

To collect data on medicinal plants, the study area was visited several times in the period of 2018-19 in different seasons. During the course of work the use of medicinal plants and their ethnomedicinal uses for dental problems were documented by interviewing 1258 people of different ages (15-110 years) through semi-structured interviews⁷. Both men and women (935 men, 323 women, 43 male herbalists) (Table 1) were selected by using snowball sampling⁸. The questionnaire which was used as a tool for data collection⁹ consisted of the following questions: (i) informant name, residence place, gender, education level, age and job, (ii) plant local name, collection place, medicinal importance, medicinal important part, route of use, indigenous medicinal recipe, dose of drug and side effect/s. The informants were asked to mention all plants they knew to get maximum ethnomedicinal data.

Medicinal plant collection, preservation and identification

During collection, walks in the woods and mountains were conducted, and plant specimens were collected and preserved according to Samant *et al.*¹⁰. The place of collection, local name and important characteristics of plant e.g., habit, flower color, flower shape, leaf form and habitat etc. were also noted. Collected specimens and photos taken in the field were used for identification. The collected specimens were identified with the help of available literature⁷ comparing with herbarium specimens and also by Dr. Samin Jan and Dr. Sher Wali (Department of Botany, Islamia College Peshawar) and Dr. Zahid Ullah Department of Botany, University of Swat. For authentication and correction the names were compared with the online “the Plant List”¹¹. All collected specimens were stored at the Herbarium of the Botany Department, Islamia College Peshawar. All the practical work conducted during the study, is summarized in the Fig. 2.

Study of literature

Previously published data were searched using Google Scholar, HINARI, Medline/PubMed and Science Direct databases. To find topic related papers,

Table 1 — Demographic profile of the study area

S/No.	Informants Interviewed			
	Gender	No. Informants		
1	Male	1952		
2	Female	323		
Traditional Knowledge of Medicinal Plants				
S/No.	Age Group	No. Informants	Medicinal Plants Reported	Complete Recipe/s
1	20-29	212	39	35
2	30-39	257	81	67
3	40-49	471	129	113
4	50-59	673	196	268
5	60-69	396	178	189
6	70-79	187	146	213
7	80-Above	79	167	151
	Total	2275		
Literacy Rate of Informants				
S/No.	Age Group	No. Informants	% age	
1	20-29	158/212	74.53%	
2	30-39	106/257	41.24%	
3	40-49	129/471	27.39%	
4	50-59	86/673	12.78%	
5	60-69	45/396	11.36%	
6	70-79	11/187	05.88%	
7	80-Above	2/79	02.53%	
	Total	537/2275	23.60%	



Fig. 2 — Work phases of the study

10 different keywords were used ethno-pharmacological study/survey, ethno-medicine, ethno-botany, herbal medicines, traditional medicines, medicinal plants, medicinal plants of Pakistan and medicinal plants of Northern Areas of Pakistan.

Application of quantitative indices

The collected indigenous ethnomedicinal data was sorted in MS-Excel 2010 and quantitatively analyzed using the following statistical ethnomedicinal indices.

Jaccard Similarity Index (JI)

In ethnomedicinal studies similarities and differences show the significance of folk knowledge about medicinal plants in various parts of the world, where their selection is affected by historical phytochemical and ecological¹² factors. To find out similarities and differences in the traditional knowledge about the medicinal plants of the study area and neighboring areas we used the Jaccard index, because Jaccard's index is not affected by negative matches. Therefore, the Jaccard index values remain unaffected by the number of operational taxonomic units studied.

The data were compared with 18 previously published ethnobotanical studies from Pakistan and adjoining countries to find the similarities and differences to the present survey¹³. This was calculated by using:

$$JI = C \times 100 / (a + b + c)$$

In the above formula “c” represents the medicinal plants reported from both locations, “a” the number of medicinal plants reported in the present study area and “b” representing the number of medicinal plants only reported from other areas.

Results and Discussion

Informants' demographic characteristics

During the fieldwork, a total of 935 men and 323 women of different ages (15-110 years) were asked about ethnomedicinal knowledge (Table 1). Most of the ethnobotanical knowledge was received from informants more than 45 years old. The informants with age above 60 were mostly illiterate. It was observed that the informants of age 45-70 were more

knowledgeable. Similar results were reported by other authors from surrounding areas and from other countries¹⁴. The data showed that women were more knowledgeable as compared to males, similar to other studies¹⁵. This might be explained because women play a basic role in providing everyday meals, herbal homemade medicines, and caring for the health of all family members¹⁶.

It was also observed that elder people had more medicinal knowledge about plants, which may be due to their long experience. It was also observed that most of the people also reported experiences of other people about the use of medicinal plants. However, the dissemination of traditional knowledge is threatened because the younger generation had little interest in learning, and thus was generally less knowledgeable about medicinal plants. Similar results were recorded by other researchers^{6,7}. The modernization of lifestyle leads young generations to use fewer plants as remedies⁷.

The data analysis showed a clear correlation between the education level of informants and their knowledge about the uses of medicinal plants. It was observed that only 26.15% informants were literate. Among them 47.82% were educated up to primary school, 34.59% were educated up to 12th class, 15.21% were graduates and only 6.72% were postgraduates (Fig. 3). The highly educated people of the area preferred the modern healthcare system based on modern scientific knowledge. The same results were documented by other researchers^{17,18}.

During this survey, we only interviewed 323 women because the research area is situated in the Pakhtun belt of Pakistan where women are strictly not allowed to meet with or talk to outsider males^{17,19}. The informants interviewed in this study were mostly from rural areas (92%) because they use more herbal medicine in comparison to urban areas²⁰. For local

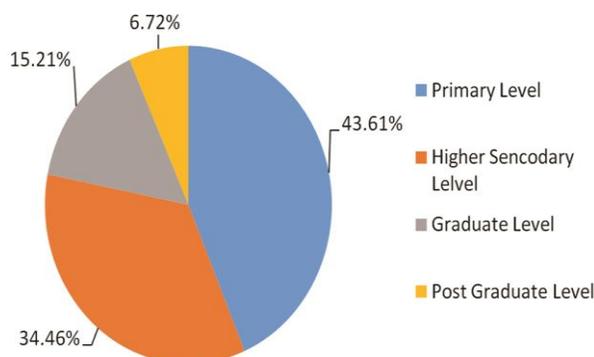


Fig. 3 — Percentage of the informants according to their education

people, the transferring of the traditional knowledge heritage is an important tool²¹.

On the other hand, it was also noted that local herbalists mainly learned traditional herbal knowledge from literature (39%), as compared to experiences of local people (27%), inherited from family (24%) and from personal experiences (8%).

Indigenous medicinal floral diversity

In Table 2 we give details about all medicinal plants, including botanical names, family name, indigenous name/s, part/s used, method of preparation, side effect/s, medicinal use/s and complete local recipe/s, are listed. The 55 plants species found belonged to 34 families. The medicinal plant families that were dominant in this study with regard to species number were Lamiaceae, similar to previous studies¹⁹ and Solanaceae (6 sp. each), followed by Moraceae and Rutaceae (3 sp. each) (Fig. 4). The reason behind the dominance of the family Lamiaceae might be that this is one of the major families reported from Pakistan²¹. Furthermore, species of the Lamiaceae are rich in aromatic compounds, which are very effective to cure various diseases²². The frequent use of Solanaceae has also been previously reported²³ and is often explained by their richness in secondary metabolites such as alkaloids and steroids²⁴. The most dominant life form used in dental medicine was herbs (28 species = 50.9%), followed by trees (16 species = 29.09 %) and shrubs (11 species = 20.01%) (Fig. 5). Herbs often have a high amount of bio-active compounds²⁵ and so their medicinal action is more effective than shrubs and trees²⁶. Herbs also grow more commonly along road-sides and in home gardens and therefore are available in nature²⁷ and easily accessible.

Leaves (19 sp.) were the most commonly used plant part, as also previously reported in other studies⁷ followed by branches (13 sp.), roots (9 sp.) and bark (7 sp.) (Fig. 6). The reason of more frequent use of leaves than other part of plant, maybe because in the leaf the photosynthesis and other metabolic processes occur for the secondary metabolites formation⁷. The medicine preparation from leaves is also easier and their collection too. For these reasons, leaves are frequently used in folk medicines²⁸. From a conservation point of view, the consumption of leaves as compared to other parts for therapeutic purposes is more sustainable²⁹.

Quantitative analysis of the prime data

In this study we compared the collected medicinal plants knowledge with 18 previously published

Table 2 — Medicinal plants used for dental diseases by the local community of the study area

S/No.	Botanical Name/Family/ Voucher No.	Local Name/s	Habit	Part/s Used	Informants	Local Recipes	Med. Uses from Previous Literature	
							Similar Use	Different Use
1	<i>Acacia modesta</i> Wall. Mimosaceae BUR-01	Palosa	T (W)	B	137	The young branches of about 20 cm long are taken to be used as toothbrush (<i>Miswak</i>) for cleaning teeth and against the microbes of mouth.	29	7, 20, 34, 35, 38,40, 42, 45
2	<i>Acacia nilotica</i> (L.) Delile Mimosaceae BUR-02	Kiker	T (W)	Fr, Br	109	The fresh fruits and the bark are taken in equal amount and then crushed. The mixture is rubbed on gums gently to cure swelling gums. The mixture is also used for toothache by placing it on the aching tooth 2-3 times a day until the relief. The bark is also used against the microbes of mouth by chewing it.	40	38, 41, 42, 45
3	<i>Achyranthes aspera</i> L. Amaranthaceae BUR-03	Geshkay	H (W)	L, Rt, B	192	Decoction of both leaves and roots are used as toothache/ Small branches are cut in to small pieces and used as tooth brush; mixture of the twig is also used as a wash for tooth pain. The dried root powder is used as tooth paste and it used to treat gum disorders. Further Soak cotton in the extract of 3-4 leaves and apply it on aching tooth. Ash is mixed with common salt and used to massage the gum and tooth area for relief from tooth ache	7	20,30,34, 35, 36, 37, 39, 43, 44, 45
4	<i>Acorus calamus</i> L. Acoraceae BUR-04	Skhawaja	H (W & C)	R	144	Paste of the Rhizome is applied to painful teeth and gums		7, 29, 34, 35, 36, 41, 43, 45
5	<i>Ajuga bracteosa</i> Wall Lamiaceae BUR-05	Butte	H (W)	L	96	The fresh leaves are crushed and rubbed on aching teeth to relief pain.		21, 29, 34, 35, 39, 40, 41, 42, 43, 44, 45
6	<i>Allium cepa</i> (L.) R. Br. Alliaceae BUR-06	Piaz	H (C)	Bb	245	Bulb juice used to cure toothache, bleeding gums		7, 27, 29, 35, 38, 39, 44, 45
7	<i>Allium sativum</i> L. Alliaceae BUR-07	Owga	H (C)	Bb	197	The bulb is crushed and placed on aching tooth to relief pain.		7, 27,38, 43, 44, 45
8	<i>Alternanthera pungens</i> Kunth Amaranthaceae BUR-08	Khaki butai	H (W)	L	82	Dried leaves are pounded with millet flour and the powder is applied to affected gums until recovery		21
9	<i>Aquilegia pubiflora</i> Wall. Ex Royle Ranunculaceae BUR-09	Unknown	H (W)	Rt	76	The roots are dried and crushed to make powder which is used to toothache		41
10	<i>Berberis lyceum</i> Royle Berberidaceae BUR-10	ZyarLargai	Sh (W)	Rt	285	The roots are dried and powdered by crushing it which is used to cure toothache. The young branches are used as toothbrush for cleaning teeth.	7, 41, 44	20, 21, 27,29, 34, 35, 37, 39, 40, 43, 45
11	<i>Bergenia ciliata</i> (Haw.) Sternb. Saxifragaceae BUR-13	Zakham Mora	H (W)	R	158	Powdered rhizomes mixed with honey are given to the children when teething.		21, 34, 39, 41, 43, 44, 45
12	<i>Butea monosperma</i> (Lam.) Taub. Leguminosae BUR-17	Palay	T (W)	Br, Rt	241	Shoot bark is burned to ash used as tooth powder for pyorrhea and gum affection. The tender juice of root introduced in the left or right ear to cure pain in upper or lower molar teeth.		7, 36, 40
13	<i>Calotropis procera</i> (Aiton) Dryand. Apocynaceae BUR-22	Spalmay	H (W)	Lt	202	The latex from stem and leaves is applied upon teeth to get rid of the worms.		7, 29, 34, 36, 39, 40, 42, 45
14	<i>Capsicum annum</i> L. Solanaceae BUR-28	Marchakay	H (C)	Fr	211	Fruit juice is applied to the tooth cavity for toothache		43
15	<i>Citrullus colocynthis</i> (L.) Schard. Cucurbitaceae BUR-30	Tarkha Endwana	H (C)	Rt	167	Roots were used as tooth sticks to relieve toothache.		40

(contd.)

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					Used	Similar Use	Different Use
16 <i>Citrus limon</i> (L.) Osbeck Rutaceae BUR-31	Lembo	T (C)	L, Fr	246	Leaves and rind of fruits recommended for scouring teeth along with a pinch of rock salt. Fruit juice used for teeth whitening, to treat bleeding gums in scurvy, due to high content of Vitamin-C.		36, 39
17 <i>Cynodon dactylon</i> (L.) Pers. Poaceae BUR-32	Kabal	H (W)	L	301	The fresh leaves are crushed and then added to it water and squeezed it the extract obtained is rubbed on teeth for cleaning and against worm of teeth.		27, 34, 36, 38, 39, 40, 44
18 <i>Dalbergia sissoo</i> DC. Papilionaceae BUR-33	Shawa	H (W & C)	B	107	Branches are used as Miswak (tooth brush) and kill worms in the teeth.		20, 34, 35, 42
19 <i>Datura innoxia</i> Mill. Solanaceae BUR-37	Daltora	Sh (W)	S	183	The dried seeds are crushed and rubbed on teeth to cure toothache.	41, 42	7, 34, 40
20 <i>Dodonaea viscosa</i> (L.) Jacq. Sapindaceae BUR-39	ghuraskay	Sh (W)	L	214	The fresh leaves are crushed and applied on the worm affected teeth.		7, 21, 34, 29, 38, 39, 40, 42, 44, 45
21 <i>Ficus benghalensis</i> L. Moraceae BUR-42	Barr	T (W & C)	B	163	The dried branches are used for cleaning of teeth as toothbrush.		
22 <i>Ficus racemosa</i> L. Moraceae BUR-43	Inzar	T (W & C)	Br	117	Stem bark juice is applied to the affected teeth		21, 34, 36, 45
23 <i>Ficus religiosa</i> L. Moraceae BUR-44	Barr	T (W & C)	Br	176	Decoction of stem bark is used as mouth wash to remove the foul smell of breathing.		35, 38, 45
24 <i>Foeniculum vulgare</i> Mill. Apiaceae/Umbelliferaceae BUR-45	Kagu	H (C)	L	278	Leaves help against painful teething in babies		7, 27, 34, 38, 43, 45
25 <i>Grewia optiva</i> Drum. Ex. Burret. Malvaceae BUR-50	Pastonay	T (W)	B	126	Branches are used as toothbrush (<i>Miswak</i>).		20, 34, 35
26 <i>Hibiscus rosa-sinensis</i> L. Malvaceae BUR-56	Unknown	Sh (C)	S	103	Stem used as tooth stick in some parts of the district.		36
27 <i>Isodon rugosus</i> (Wall. ex Benth.) Codd Lamiaceae BUR-57	Unknown	H (W)	L	79	The fresh leaves are taken and boiled in water until half of the water is evaporated, the half warm decoction is used as mouth wash for toothache.	34, 27	35
28 <i>Juglans regia</i> L. Juglandaceae BUR-58	Chazghay	T (W & C)	Br	437	The bark both fresh and dry is used for cleaning teeth.	29, 34, 35, 27, 39, 40, 41, 43	45
29 <i>Justicia adhatoda</i> L. Acanthaceae BUR-60	Bekar	Sh (W)	S	239	The stem is used as tooth stick for cleaning teeth.	39	7, 20, 29, 30, 34, 36, 38, 40, 41, 44, 45
30 <i>Lespedeza sericea</i> (Thunb.) Miq. Fabaceae BUR-61	Unknown	H (W)	S, B	93	The young aerial parts from the plant are boiled in water to made decoction which is orally applied on teeth to cure toothache		
31 <i>Melia azedarach</i> L. Meliaceae BUR-62	Bakyana	T (W & C)	L	195	The decoction of leaves or bark is used for toothache.		7, 20, 27, 34, 29, 35, 36, 38, 39, 40, 44, 45
32 <i>Mentha royleana</i> Wall. Ex Benth. Lamiaceae BUR-63	ZangaliPodina	H (W)	B	238	The twigs are used to clean teeth.		27

(Contd.)

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S/No. Botanical Name/Family/ Voucher No.	Local Name/s	Habit	Part/s Used	Informants	Local Recipes	Med. Uses from Previous Literature	
						Similar Use	Different Use
33 <i>Micromeria biflora</i> (Buch.-Ham. ex D. Don) Benth. Lamiaceae BUR-64	Unknown	H (W)	Rt	93	Root paste is used to treat toothache		20, 34
34 <i>Mukia maderaspatana</i> (L.) M. Roem Cucurbitaceae BUR-65	Gandabutay	H (W)	Rt	85	Root is chewed for about 15 min to relieve toothache.		
35 <i>Nicotiana tabacum</i> L. Solanaceae BUR-66	Tamaku	H (C)	L	216	The dry of fresh leaves are crushed and applied in small amount on the affected teeth to cure the pain. It is also used as antimicrobial agent against the microbes of teeth.		29, 30
36 <i>Olea ferruginea</i> Wall. ex Aitch. Oleaceae BUR-67	Khuna	T (W)	L	314	Leaf decoction is used for toothache. Young leaves are chewed to avoid toothache	44	7, 29, 38, 39, 45
37 <i>Origanum vulgare</i> L. Lamiaceae BUR-68	Shamakay	H (W)	L	112	Fresh leaf juice is used to treat toothache	27, 34	20, 21, 29, 40, 45
38 <i>Ostegia limbata</i> (Benth.) Boiss. Lamiaceae BUR-69	Pishkand	Sh (W)	L	268	The leaves decoction is used for toothache.	44	7, 27, 34, 38, 39, 40
39 <i>Pistacia integerrima</i> J. L. Stewart ex Brandis Anacardiaceae BUR-69	Shnay	T (W & C)	B, Br	247	The young shoots are used as <i>Miswak</i> to clean the teeth. The decoction of bark is used to cure toothache.		7, 34, 39, 43, 44, 45
40 <i>Psidium guajava</i> L. Myrtaceae BUR-70	Amrud	T (C)	L, B	147	Leaf decoction: A young leaf is used daily for mouth-wash till cure./ Tender shoots widely used as tooth brush to cure pyorrhea and toothache, equal amount of leaf of <i>Mimusops elengi</i> and <i>Psidium guajava</i> are boiled in 500 mL of water and used as mouth wash to relieve toothache		35, 36
41 <i>Quercus incana</i> Bartram Fagaceae BUR-71	Banj	T (W)	Rt	234	The roots are used as <i>Miswak</i> for cleaning teeth.	7, 34, 45	
42 <i>Robinia pseudoacacia</i> L. Fabaceae BUR-72	Kiker	T (W & C)	Br	127	The Bark is used to clean the teeth.		29, 37, 40
43 <i>Rumex dentatus</i> L. Polygonaceae BUR-73	Shalkhay	H (W)	L	94	The leaves decoction is used for toothache.		7, 21, 27, 34, 38, 45
44 <i>Rumex hastatus</i> D. Don Polygonaceae BUR-74	Trookay	H (W)	L	58	The leaves are rubbed on teeth for cleaning them.		7, 34, 40, 44, 45
45 <i>Sageretia theezans</i> Brongn. Rhamnaceae BUR-75	Mamanra	Sh (W)	B	141	The young shoots are used as <i>Miswak</i> for cleaning teeth.		7, 38
46 <i>Skimmia laureola</i> French. Rutaceae BUR-76	Nazarpanra	Sh (C)	R	120	The rhizome is rubbed down and given with honey to children when teething.		21, 27, 34, 39, 45
47 <i>Solanum virginianum</i> L. Solanaceae BUR-77	Karezabutay	H (W)	Fr	105	Powder of dried fruit is used in cigarette and the smoke is kept inside the mouth for about 10 min to relieve dental caries.		27
48 <i>Solanum surattense</i> Burm. f. Solanaceae BUR-78	Kareza	H (W)	L	133	The extract of leaves is applied on body swellings to get relief. Its seeds are burnt in "Chehlum" and the smoke is inhaled to get relief from toothache	7	29, 34, 40, 42, 43, 44, 45
49 <i>Tamarix aphylla</i> (L.) H. Karst. Tamaricaceae BUR-79	Ghaz	T (W)	L	59	Extract from powdered leaves is used to treat toothache	42	40
50 <i>Verbascum thapsus</i> L. Scrophulariaceae BUR-80	Gedartambaku	H (W)	Rt	218	The decoction of the roots is used to cure toothache.		7, 21, 34, 35, 39, 40, 44, 45 (contd.)

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S/No.	Botanical Name/Family/ Voucher No.	Local Name/s	Habit	Part/s Used	Informants	Local Recipes	Med. Uses from Previous Literature	
							Similar Use	Different Use
51	<i>Vitex negundo</i> L. Verbenaceae BUR-81	Marvaday	Sh (W)	B	149	Branches are cut in to small pieces and used as tooth brush to cure pyorrhea and toothache	43	7, 20, 29, 34, 35, 36, 39, 40, 44, 45
52	<i>Withania somnifera</i> (L.) Dunal. Solanaceae BUR-82	Unknown	H (W)	Fr	235	The fruit is used as remedy for toothache		7, 29, 27, 34, 38, 40, 42, 43, 45
53	<i>Woodfordia fruticosa</i> (L.) Kurz Lythraceae BUR-83	Kinthay	Sh (W)	B, L	186	The young shoots are used as <i>Miswak</i> for cleaning teeth. The decoction of leaves is used to cure toothache.		44
54	<i>Zanthoxylum armatum</i> DC. Rutaceae BUR-84	Dambara	Sh (W)	B	313	The young shoots are used as <i>Miswak</i> for cleaning teeth and to cure toothache.	7, 34, 39, 44	29, 37, 45
55	<i>Zingiber officinale</i> Roscoe Zingiberaceae BUR-85	Adrak	H (C)	R	262	Paste of rhizomes is used to treat toothache and tooth decay		35

H=Herb, Sh=Shrub, T=Tree, C= Cultivated, W=Wild, B=Branch, Bb=Bulb, Br=Bark, F=Flower, Fr=Fruit, L=Leaves, Lt=Latex, R=Rhizome, Rt=Root, S=Stem

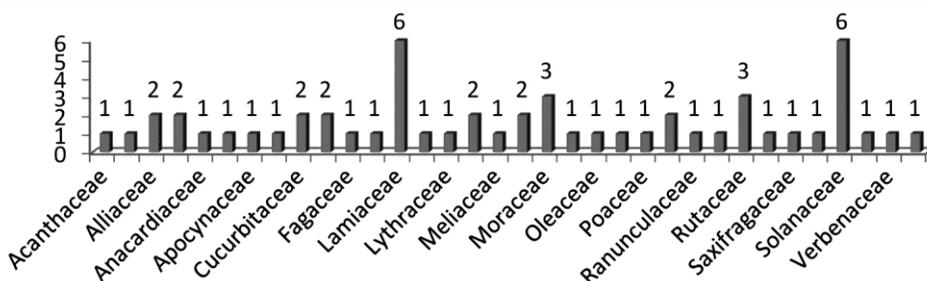


Fig. 4 — Medicinal important families of the study area

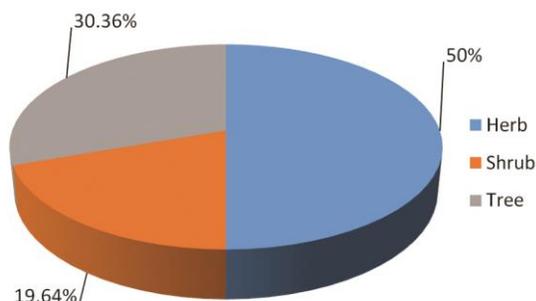


Fig. 5 — Life forms of medicinal plants

ethnomedicinal/ethnobotanical studies of the surrounding area (Table 3) using the Jaccard Index (JI). The results obtained showed similarities with other studies in the range of 3.09%-15.62%. The highest Jaccard index value was noted for the study conducted by Alamgeer *et al.*²⁹ and the lowest one was obtained for the study conducted by Sajem and Gosai³⁰.

From the results it could be concluded that any similarities or differences in the JI value were due to distance between study area and neighboring regions.

According to Molares and Ladio³¹ the similarities with neighboring areas may be due to environmental factors, or the study methodologies used to gather the ethnomedicinal knowledge in different study areas. The highest JI value was obtained for the study conducted in the areas nearest to the study area. It may be possibly due to the same medicinal flora and/or to the cross cultural exchange of ethnomedicinal information³² over time. On the other hand, the least similarity with the cited areas may be due to a restrictive culture, leading to low ethnomedicinal knowledge exchange³³ and to environmental factors between the countries because of disconnection by mountains and other barriers³⁴. The overall results indicated that the population of our study region harbors very distinct ethnomedicinal knowledge.

Herbal remedies comparative analysis

Some plant species have medicinal importance and were previously reported while others were reported for the first time. The following species were

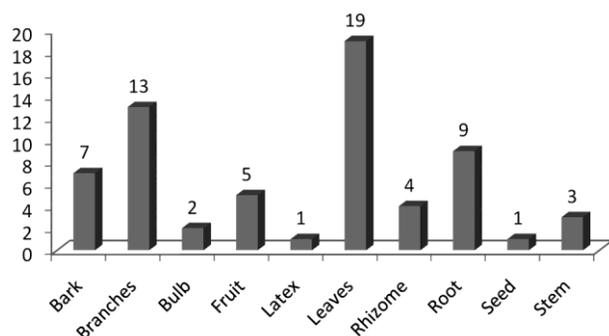


Fig. 6 — Plants parts used by local people for medicinal purpose

Table 3 — Comparison of the present study with previously published work

S/No.	Previously published work	Common Medicinal Plants	Jaccard Index
1	Abbasi <i>et al.</i> ^{a39}	11	7.85
2	Abbasi <i>et al.</i> ^{b44}	9	5.81
3	Akhtar <i>et al.</i> ²⁷	18	10.91
4	Alamgeer <i>et al.</i> ²⁹	15	10.94
5	Ali <i>et al.</i> ²¹	12	4.95
6	Barkatullah <i>et al.</i> ⁴⁰	16	11.59
7	Buragohain ³⁶	19	13.57
8	Hamayun ⁴³	15	8.52
9	Haq <i>et al.</i> ³⁴	21	12.50
10	Hassan <i>et al.</i> ⁴²	9	8.65
11	Hazrat <i>et al.</i> ⁴¹	10	7.93
12	Ijaz <i>et al.</i> ²⁰	13	10.92
13	Jan <i>et al.</i> ⁷	19	14.84
14	Khan <i>et al.</i> ³⁸	11	8.66
15	Sajem and Gosai ³⁰	9	7.31
16	Shah <i>et al.</i> ³⁵	10	6.13
17	Sharma and Devi ³⁷	6	4.19
18	Sher <i>et al.</i> ⁴⁵	5	4.71

documented for the first time to treat dental disorders: *Acorus calamus* L., *Ajuga bracteosa* Wall, *Allium cepa* (L.) R. Br., *Allium sativum* L., *Alternanthera pungens* Kunth, *Aquilegia pubiflora* Wall. ex Royle, *Bergenia ciliata* (Haw.) Sternb., *Butea monosperma* (Lam.) Taub., *Calotropis procera* (Aiton) Dryand., *Capsicum annum* L., *Citrullus colocynthis* (L.) Schard., *Citrus limon* (L.) Osbeck, *Cynodon dactylon* (L.) Pers., *Dalbergia sissoo* DC., *Dodonaea viscosa* (L.) Jacq., *Ficus racemosa* L., *Ficus religiosa* L., *Foeniculum vulgare* Mill., *Grewia optiva* Drum. Ex. Burret., *Hibiscus rosa-sinensis* L., *Lespedeza sericea* (Thunb.) Miq., *Mentha royleana* Wall. Ex Benth., *Micromeria biflora* (Buch.-Ham. ex D. Don) Benth., *Mukia maderaspatana* (L.) M. Roem, *Nicotiana tabacum* L., *Pistacia integerrima* J.L. Stewart ex

Brandis, *Psidium guajava* L., *Quercus incana* Bartram, *Robinia pseudoacacia* L., *Rumex dentatus* L., *Rumex hastatus* D. Don, *Sageretia theezans* Brongn., *Skimmia laureola* French., *Solanum virginianum* L., *Verbascum thapsus* L., *Withania somnifera* (L.) Dunal., *Woodfordia fruticosa* (L.) Kurz and *Zingiber officinale* Roscoe.

There are numerous ethnomedicinal works which have shared similarities about the traditional practices of medicinal plants for the cure of different diseases from all over the world³⁵. Our study adds to the directory of ethnomedicines, some new medicinal plants and their uses which are recommended for pharmacological and phytochemical analysis for the discovery of new drugs.

Relevance for public health or environmental issues

The results of this study clearly show that the local community is still giving serious consideration to oral hygiene. The interaction of rural and remote areas with urban society due to rapid economic and technological development all over the world has however brought socio-cultural and ecological changes. This change also leads to the reduction of local traditional knowledge about uses of plants for various diseases, which is also shown by the result of this study. The local community has no proper knowledge/skills about the sustainable use, collection and proper processing of the plants, wasting a large amount of medicinal plants, which results in the decrease of valuable medicinal flora. Therefore, we suggested training the indigenous population to use indigenous medicinal plants sustainably.

Present study novelty and future impact

This survey is the first ever to document the ethnomedicinal knowledge about dental disorders in the study area. It was observed that the indigenous community of this area mainly depends on medicinal plants because of limited medical facilities availability. The result of this study clearly indicated that 67.27% of the uses of medicinal plants were newly reported and one species was reported for the first time. This indicated that the local people have a very distinct knowledge of ethnomedicinal plants.

Conclusions

The ethnobotanical results of this study clearly demonstrate that the traditional knowledge of medicinal plants is mainly the asset of elders. Fifty-five (55) plant species used to cure dental diseases were documented. The result clearly indicated that the

most prominent families were *Lamiaceae* and *Solanaceae*. The leaf was the plant part commonly used to cure dental disorders. The comparative analysis with the previously published works showed similarities with our data. The results clearly indicate a real risk of progressive loss of traditional knowledge. In this study some plants are reported for the first time for their ethnomedicinal use; they should be assessed for the phytochemical and pharmacological activities. Further research on conservation strategies needs to be conducted to contribute to the sustainable development of herbal medicines in the study area.

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Availability of data and materials

The raw data without names of participants are available from the authors.

Conflict of interests

The authors declare that they have no competing interests.

Ethics approval

This ethnomedicinal study was approved by the ethical committees of the Department of Botany, of the University and Herbarium, Department of Botany Islamia College Peshawar, Pakistan and Biodiversity Action Plan (BAP-2010-2020) for Pakistan. Before conducting interviews, individual prior informed consent was obtained from all participants. No further ethics approval was required. All work conducted was carried out under the stipulations of the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity. The right to use and authorship of any traditional knowledge of all participants is maintained and any use of this information, other than for scientific publication,

does require additional prior consent of the traditional owners, as well as a consensus on access to benefits resulting from subsequent use.

Author's contributions

SJ and HAJ designed and supervised the study; HAJ, SW and LA conducted the fieldwork, HAJ, FS and NA conducted the main statistical analysis and wrote the manuscript, SJ, RB and FS revised the data analysis and the manuscript; all authors read, corrected and approved the manuscript.

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