Ethnomedicinal plants used for the treatment of gastrointestinal disorders in Tribal District North Waziristan, Khyber Pakhtunkhawa, Pakistan

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Ethnobotany Research and Applications 26:63 (2023) - http://dx.doi.org/10.32859/era.26.63.1-22
Manuscript received: 19/07/2023 – Revised manuscript received: 26/11/2023 - Published: 207/11/2023

Research

Abstract

Background: The local communities of Tribal District North Waziristan rely on therapeutic plant species for their primary health care needs. The present study aimed to record the indigenous knowledge and use of therapeutic plant species to treat different gastrointestinal disorders by the local inhabitants.

Methods: Ethnomedicinal data was collected through semi-structured interviews on the use of therapeutic plant species. A total of 130 informants (106 men and 24 women) were randomly selected. The data was quantitatively analyzed using Relataive Frequency of Citiation (RFC), Use Reports (UR), Fidelity Level (FL), Use Value (UV), and Family Importance Value (FIV).

Results: A total of 69 medicinal plant species belonging to 36 families were recorded. Among them, Lamiaceae was the most prevalent (10 species), followed by Asteraceae (5 species), and Amaranthaceae, and Apiaceae (4 species each). The dominant growth form was the herb (62.32%), followed by tree (20.29%) and shrub (13.04%). The most common plant parts used in herbal remedies preparations were the leaves (31.51 %) and fruits (26.03 %). The leading mode of herbal recipe preparation was decoction; and the herbal medicines were administered orally. The therapeutic plant species with maximum UV values were *Mentha arvensis* L., *Morus alba* L., and *Cydonia oblonga* Mill. (0.83 each), followed by *Withania coagulans* (Stocks) Dunal in DC. (0.82). The highest RFC value was reported for *Cydonia oblonga* Mill. (0.37), followed by *Trachyspermum ammi* L. and *Mentha arvensis* L. (0.36) each. The species with 100% FL values were *Carum carvi* L., *Trachyspermum ammi* L., *Morus alba* L., and *Cyndonia oblonga* Mill.

Conclusion: The study showed that indigenous communities still prefer therapeutic plants over allopathic drug for curing different gastrointestinal disorders. However, this invaluable traditional knowledge is presently limited to older people in the study area. There is the need to encourage younger people to engage into this knowledge and participate in its transmission to help conserve the use of medicinal plants for curing ailments in the study area.

Keywords: Medicinal plants, Fidelity level, Indigenous knowledge, Gastrointestinal disorders, North Waziristan, Pakistan.

Background

Medicinal plants are an important source of traditional medication used to treat various ailments. Ethnobotanical knowledge has traditionally been transmitted orally from one generation to the next (Ahmad *et al.* 2014). Ethnobotany is a scientific field that focuses on the study of plants and their various uses within indigenous cultures. These uses encompass a wide range of applications, including food, medicine, construction, fuel, clothing, and shelter (Sargin et al. 2013). Due to the unavailability of-modern health services, people in rural areas depend mainly on natural assets (Tali *et al.* 2019). More than 80% of the global population depends on indigenous medicine for basic health care needs (Ibrar *et al.* 2017; Msomi & Simelane 2017; Rehman *et al.* 2023a). But currently, indigenous knowledge is facing rigorous threats due to modernization in rural communities and changing lifestyles (Shinwari & Gilani 2003). Medicinal plants are essential sources of indigenous medication and are used to cure different diseases without having any side effects (Singh *et al*. 2014). In Pakistan a total of 6000 plants have been documented, out of which only 600 species have been reported as sources for medications (Shinwari & Gilani 2003). These herbal medications are safe and environmentally friendly (Prasad *et al*. 2013). Ethnobotanical studies have emphasized the relationship between ethnic communities and their use of plants (Verpoorte *et al.* 2005). Hence it is necessary to enhance ethnomedicinal surveys to document and conserve this valuable traditional information to avoid its extinction (Khan *et al.* 2011)

Gastrointestinal disorders are the diseases of the digestive tract i.e., indigestion, diarrhea, dysentery, constipation, stomach pain, parasitic worms, acidity etc. (Neamsuvan *et al.* 2012). These disorders occur as a result of unhygienic conditions, malnutrition, and inadequate availability of pure water (Tariq *et al.* 2015), eating spicy foods and drinking of polluted water (Khan *et al.* 2015). Majority of the disorders are caused by microorganisms i.e. *Vibrio cholera* (Pacini), *Shigella dysenteriae* (Shiga)*, Escherichia coli* (Migula), *Staphylococcus aureus* (F. J. Rosenbach)*, Salmonella enterica* (ex Kauffmann & Edwards)**,** *Pseudomonas Aeruginosa* (Migula)*, Aeromonas hydrophila* (Stanier) *Campylobacter jejuni* (Veron & Chatelain)*,* and *Klebsiella pneumonia* (Schroeter) (Acharyya *et al.* 2009; Zaidi *et al.* 2009; Khan *et al.* 2013). In Pakistan the population is nearly 103 million with estimated annual growth rate of 3%. The main threats to poor health in Pakistan are extensive contagious ailments, poor sewerage systems, and shortage of clean drinking water (Motarjemi *et al.* 1993; Ashraf *et al.* 1993). Some of the common gastrointestinal (GI) disorders in Pakistan are constipation, acidity, diarrhea, cholera, dyspepsia, dysentery, indigestion, gastric ulcer, stomachache, and colic (Tariq *et al.* 2015; Zaidi *et al.* 2009; Khan *et al.* 2013). There are many plant species with potential therapeutic properties that have not been thoroughly studied to determine their effectiveness and the active compounds they contain against microorganisms (Tariq *et al.* 2015).

This survey is the first attempt to target gastrointestinal diseases and associated traditional remedies in an unexplored distant region (North Waziristan) of Khyber Pakhtunkhwa, Pakistan, where these disorders occur most frequently. The study was undertaken to document the medicinal plants and ethnobotanical traditional knowledge used to treat gastrointestinal (GI) diseases in the study area, and in the process help with selection of important therapeutic plants for further pharmacological and phytochemical analysis needed to contain gastrointestinal disorders. Available published literature indicate that such studies (e.g. at the present site) can represent the initial point for the discovery of new drugs (Shinwari & Gilani 2003; Bibi *et al.* 2011). The present attempt investigated and documented the indigenous knowledge of therapeutic plants from North Waziristan, Pakistan that have never been recorded before. Therefore the main objectives of the study were (i) to document the traditional use of medicinal plants for treating gastrointestinal disorders. (ii) to analyze the ethnomedicinal data by using various quantitative indices (FC, RFC, UV, FL and FIV) in order to assess most popular species in this regard.

Materials and Methods

Study area

North Waziristan is a tribal territory banding Pakistan with Afghanistan. It lies between 32°35´and “33°20”N latitudes and “69°25´”and “70°40´”E longitude with altitudinal range between 2143 feet and 7717 feet. It is surrounded on the west by Afghanistan, on the south by district South Waziristan, on the east by Bannu district, on the North by district Kurram, district Hangu, and Afghanistan (Figure 1). North Waziristan falls under Inrano-Turanian Region. The lush valley is irrigated by three rivers i.e., Tochi, Katu and Kurram rivers. According to the censuses report of 2017, the total population of the study area is 543,245. The area covers 4,707 square kilometers. The major tribes in the study area are Dawar and Wazir; and Pashto is the main language.

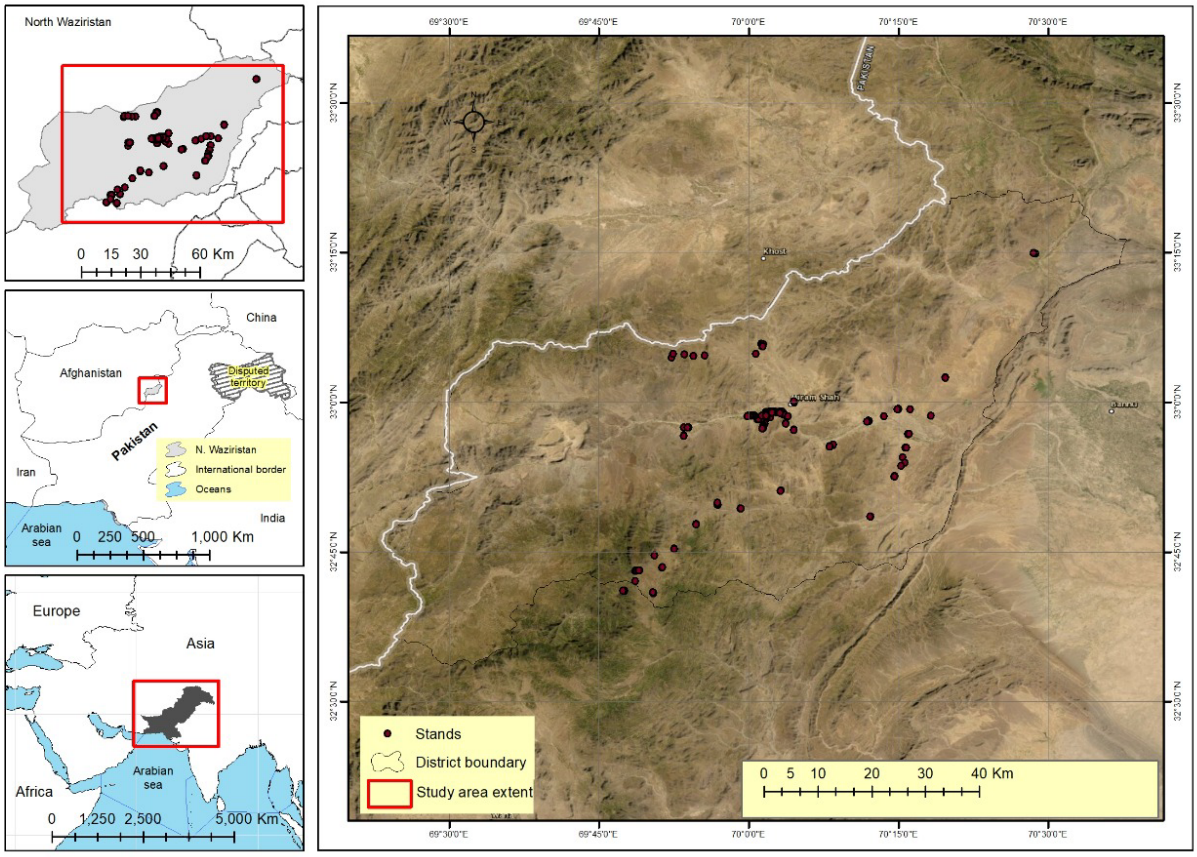

Figure 1.Map of the study area. The black dots show study points.

Medicinal plants collection

The ethnobotanical survey was conducted from April 2018 to October 2020. Semi-structured interviews were conducted to obtain information about medicinal plant knowledge and use (Albuquerque *et al.* 2014). One hundred and thirty (130) informants, consisting of 106 men and 24 women were randomly chosen from various localities such as Miran Shah, Mir Ali, Spin Wam, Shawa, khysore, Spelga, Tapi, Shawal, Dossali, Asad Khel, Boya, Mada Khel, Zova sedgai, Derdoni, Tabi, Dande Darpa Khel, Darpa khel, Hamzoni and Bonda communities and interviewed. Their ages ranged from 35 years to above 65 years. The life forms of the plant species, parts used, and modes of preparation and administration of the herbal treatments were recorded.

Medicinal plant identification and preservation

The medicinal plant's specimens were collected in flowering conditions, pressed, dried and treated with (1% $HgCl_2$ solution), and were pasted on herbarium sheets 11.5 x 17.5 in.^{2}. The specimens were identified by plant taxonomist (Dr. Rahmatullaha Qureshi) and confirmed with the help of the flora of Pakistan (Nasir & Ali 1970). After identification, the plant specimens were assigned voucher numbers and the plant specimens were deposited at the Department of Botany herbarium, Hazara University, Mansehra for future reference.

Quantitative data analysis

The data was analyzed using various quantitative indices such as Relative Citation of Frequency (RFC), Use Value (UV), Fidelity Level (FL %), and Family Importance Value (FIV).

Relative Frequency of Citation (RFC)

Relative citation of frequency (RFC) was calculated to find out the local importance of every therapeutic plant recorded in the study area (Butt *et al.* 2015).

$$\mathrm{RFC} = \frac{\mathrm{FC}}{\mathrm{N}} \ (0< \mathrm{RFC} < 1) \text{ (Butt } et\ al.\text{, 2015)}$$

Where
FC= Number of informants who cited the use of plant species.
N= Total number of respondents in the survey (N= 130).

Use Value(UV)
Use value (UV) of a plant species was determined by using the following formula:

$$\mathrm{UV} = \frac{\mathrm{u}}{\mathrm{n}}$$ (Kayani *et al*. 2014)

Where u= Number of use reports documented by the informants for a given medicinal plant.
n = Total number of respondents.

Fidelity Level (FL %)
Fidelity level is the percentage of respondents who mention the use of a specific therapeutic plant to treat particular disorder in the study area. The FL index was calculated by using the formula by Friedman *et al.* (1986).

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

Where "Np" is the number of citations of a specific plant for a particular disease,
'N'= Total number of informants who cited the species for any disease.

Family Importance Value (FIV)
Family importance value (FIV) was calculated from the percentage of respondents citing the family (Kayani *et al.* 2014).

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

Where FC is the number of respondents who mention the family, while N is the total number of respondents participating in the study N=130).

Results

Socio-demographic characteristics of participants
The number of male informants (106) was higher than that of female informants (24). Most of the informants were in the above 65 age group (50%), followed by 50-65 age group (39.23%) and 35-50 age group (10.77%) (Table 1). In this study, most of the respondents were herbalists (56.15%). The majority of the participants did not have formal education (42.31 %), and only 4.62 % had reached the graduate level. The participants over the age of 65 were found to have more traditional knowledge.

Table 1. Demographic data of informants.

Variable	Categories	No. of Informants (N=130)	Percentage (%)
Gender	Male	106	81.54
	Female	24	18.46
Age groups	35–50	14	10.77
	50–65	51	39.23
	Above t 65	65	50.00
Occupation	Herbalists	73	56.15
	Housewives	24	18.46
	Professional	33	25.38
Education qualification	No formal education	55	42.31
	Primary level	32	24.62
	Middle level	16	12.31
	Secondary level	11	08.46
	Undergraduate	10	07.69
	Graduate level	6	04.62

Diversity and growth forms of medicinal plants

During the current survey, a total of 69 therapeutic plants belonging to 36 families were documented, which were used for the treatment of gastrointestinal diseases (Table 2). Among them Lamiaceae was the dominant family (10 species), followed by Asteraceae (5 species.), Amaranthaceae and Apiaceae (4 species each), Brassiaceae, Fabaceae, Moraceae, Rhamnaceae, and Rosaceae (3 species each) Cactaceae, Liliaceae, Malvaceae, Mimosaceae and Plantaginaceae (2 species each), while the remaining 23 families contributed only(a single species each (Fig. 2). In the present study, the growth forms used for the treatment of different gastrointestinal disorders were herbs (43 species, 62.32%), followed by trees (14 species, 20.29%), shrubs (9 species, 13.04%), and 1 species each of climber, fern and sedge (1.45% each)(Fig. 3).

Plant parts used in herbal medication

The most commonly plant part used in herbal remedies were leaves (31.51%), followed by fruits (26.03%), seeds (10.96%), aerial parts (9.59%) each, whole plant (8.22%), and Bark (5.48%)(Fig. 4).

Method of Preparation and route of Administration

Decoction (44.93%) was the dominant mode for preparation of remedies, followed by powder (20.29 %), raw (10.14%), and cooked and herbal tea (5.80%) each (Fig. 5). All the herbal remedies were administered orally.

Therapeutic plants used for the treatment of gastrointestinal disorders

The indigenous people have great traditional knowledge for healthcare needs. Twenty-one gastrointestinal ailments were reportedly cured using 69 therapeutic plants. The most prevalent gastrointestinal disorder in the research area was constipation and was treated using 22 species(13.17 %), followed by diarrhea with 21 species (12.57 %), dysentery by 16 species (9.58 %), as appetizer with 14 species (8.38 %), stomachache using 13 species (7.78%), indigestion with 12 species (7.19%), abdominal pain, intestinal worms and flatulence using 11 species each (6.59%)(Fig.6).

Relative frequency of citation (RFC)

In this study, RFC ranged from 0.12 to 0.37. The highest RFC value of 0.37 was calculated for *Cydonia oblonga* Mill*.,* followed by *Trachyspermum ammi* L. and *Mentha arvensis* L. (0.36) *Carum carvi* L*., Mentha longifolia* (L.) Huds*., Mentha spicata* L*.,* and *Withania coagulans* (Stocks) Dunal (0.35), *Mentha viridis* L. (0.34), *Coriandrum sativum* L*., Artemisia maritima* L*.,* and *Vitis vinifera* L. (0.33), *Caralluma tuberculata* N.E. Brown*, Punica granatum* L. and *Acacia modesta* Wall. (0.32), and *Berberis lyceum* Royle. and *Cassia fistula* L. (0.31) (Table 2).

Use Value (UV)

The UV is used to determine the relative significance of therapeutic plant species in the research area. Its value ranges from 0 to 1. The therapeutic plant species having more use reports (UR) have maximum UV, and therapeutic plant species with few use reports (UR) have low UV. In this study, UV values ranged from 0.33 to 0.83 (Table 2). The maximum UV value was recorded for *Mentha arvensis* L., *Morus alba* L., and *Cydonia oblonga* Mill. (0.83), followed by *Withania coagulans* (Stocks) Dunal in DC. (0.82), *Trachyspermum ammi* L. (0.81), and *Carum carvi* L. and *Acacia modesta* Wall. (0.80)..The lowest use value was reported for *Hibiscus trionum* L. (0.33).

Fidelity level (FL %)

The high fidelity level (FL) values of some plant medicinal species indicate that each of these species is frequently used to treat specific gastrointestinal disorder. In the current study FL values ranged from 35.29 to 100% (Table 2). The highest FL value was reported for *Carum carvi*, *Trachyspermum ammi*, *Morus alba,* and *Cyndonia oblonga* (100% each) for the treatment of gastric trouble, indigestion, constipation, and vomiting respectively; followed by *Mentha arvensis* (97.87%) for indigestion, *Mentha spicata* (95.56%) for dyspepsia, *Mentha viridis* (93.18) for gastrointestinal disorders, *Acacia modesta* (92.68) for abdominal pain, *Cassia fistula* (92.50%) for colic pain, and *Withania coagulans* (91.11%) for abdominal pain. The lowest FL value was recorded for *Hibiscus trionum* (38.89%) used to treat stomachache.

Table 2. Medicinal plants and their scientific names, local names, family names, Voucher nos., growth forms, parts used, UV, URs, FC, RFCs, and FL.

Family name /Botanical name/Voucher no.	Local name	Growth form	Part used	Mode of Preparation	Mode of administration	Diseases cured	FC	RFC	UR	UV	FL%
Amaranthaceae											
Achyranthes aspera L. SR-13311	Ghoshkai	Herb	Leaves	Decoction	Oral	Dysentery and diarrhea	37	0.28	0.62	23	59.46
Amaranthus spinosus L. SR-13326	Ghotasurme	Herb	Leaves	Herbal tea	Oral	Constipation	29	0.22	0.59	17	62.07
Celosia argentea L. SR-13286	Plash gull	Herb	Leaves, seed	Decoction	Oral	Diarrhea, dysentery and appetite stimulant	25	0.19	0.52	13	64.00
Digera muricata (L.) Mart. SR-13320	Soba ghonde	Herb	Leaves	Herbal tea	Oral	Constipation and stomach pain	31	0.24	0.55	17	74.19
Anacardaceae											
Pistacia integerrima (J. L. Stewart ex Brandis) Rech.f. SR-13464	Shnia	Tree	Fruit	Raw	Oral	Flatulence, dysentery, dyspepsia, intestinal worms	39	0.30	0.69	27	84.62
Apiaceae											
Bupleurum falcatum L. SR-13443	Pest bote	Herb	Leaves	Decoction	Oral	Diarrhea, indigestion and constipation	21	0.16	0.52	11	57.14
Carum carvi L. SR-13467	Zera	Herb	Seeds	Herbal tea	Oral	Gastric trouble, stomachic, abdominal pain and gastric ulcer	46	0.35	0.80	37	100.00
Coriandrum sativum L. SR-13468	Dhania	Herb	Seeds	Powder	Oral	Indigestion, vomiting, and flatulence	43	0.33	0.79	34	79.07
Trachyspermum ammi L. SR-13206	Sperkiye	Herb	Seeds	Powder	Oral	Indigestion, flatulence and lack of appetite	47	0.36	0.81	38	100.00

Family name /Botanical name/Voucher no.	Local name	Growth form	Part used	Mode of Preparation	Mode of administration	Diseases cured	FC	RFC	UR	UV	FL%
Asclepiadaceae											
Caralluma tuberculata N. E. Brown SR-13195	Pamanai	Herb	Aerial part	Vegetable	Oral	Appetizer and anti-flatulent	41	0.32	0.76	31	90.24
Asteraceae											
Artemisia maritima L. SR-13264	Terkha	Herb	Leaves	Decoction	Oral	Abdominal pain, indigestion, diarrhea, stomach-ache, intestinal worms	43	0.33	0.77	33	90.70
Cichorium intybus L. SR-13334	Ghotkhatakai	Herb	Whole plant	Decoction	Oral	Stomachache, gas trouble and diarrhea	36	0.28	0.50	18	69.44
Conyza bonariensis (L.) Cronquist. SR-13521	Bashke	Herb	Leaves	Decoction	Oral	Intestinal worms	19	0.15	0.42	8	57.89
Conyza canadensis (L.) Cronquist. SR-13522	Bashke	Herb	Root	Decoction	Oral	Dysentery and diarrhea					
Tagetus erecta L. SR-13260	Zendagula	Herb	Shoot	Infusion	Oral	colic pain, stomachache, dyspepsia and intestinal worms	23	0.18	0.48	11	56.52
Berberidaceae											
Berberis lycium Royle. SR-13444	Danedarbote	Shrub	Fruit	Decoction	Oral	Diarrhea, dysentery and anthelmintic	40	0.31	0.78	31	90.00

Family name /Botanical name/Voucher no.	Local name	Growth form	Part used	Mode of Preparation	Mode of administration	Diseases cured	FC	RFC	UR	UV	FL%
Brassicaceae											
Capsella bursa-pastoris (L.) Medik SR-13422	Avorbote	Herb	Whole plant	Decoction	Oral	Stomach problems and abdominal pain	24	0.18	0.54	13	54.17
Lepidium sativum L. SR-13320	Bashkeghonde	Herb	Seeds	Powder	Oral	Abdominal pain and appetizer	30	0.23	0.57	17	53.33
Nasturtium officinale W.T. Aiton SR-13317	Narmbote	Herb	Leaves	Decoction	Oral	Indigestion, dyspepsia and constipation.	34	0.26	0.53	18	55.88
Cactaceae											
Opuntia dillenii (Ker Gawl.) Haw. SR-13168	Saparegul	Shrub	Fruit	Decoction	Oral	Constipation	36	0.28	0.58	21	63.89
Opuntia ficus-indica (L.) Mill. SR-13481	Saparegul	Shrub	Fruit	Decoction	Oral	Stomachache and flatulence	32	0.25	0.69	22	65.63
Cannabaceae											
Cannabis sativa L. SR-13324	Bhanga	Herb	Leaves	Infusion	Oral	Appetizer and intestinal worms	25	0.19	0.68	17	60.00
Capparidaceae											
Capparis decidua (Forssk.) Edge. SR-13484	Sredanebote	Shrub	Fruit	Raw	Oral	Laxative	28	0.22	0.57	16	64.29
Celastraceae											
Gymnosporia nemorosa (Eckl. & Zeyh.) Szyszyl. SR-13364	Sagherzai	Shrub	Leaves	Powder	Oral	Diarrhea, dysentery, and intestinal worms	35	0.27	0.66	23	54.29
Chenopodiaceae											
Chenopodium album L. SR-13227	Khresapaka	Herb	Leaves	Cooked	Oral	Laxative and intestinal worms	26	0.20	0.46	12	53.85
Convolvulaceae											
Convolvulus arvensis L.	Purvuthia	Herb	Leaves	Decoction	Oral	Laxative	23	0.18	0.48	11	52.17

Family name /Botanical name/Voucher no.	Local name	Growth form	Part used	Mode of Preparation	Mode of administration	Diseases cured	FC	RFC	UR	UV	FL%
SR-13215											
Cucurbitaceae											
Citrullus colocynthis L SR-13486	Maraginye	Herb	Fruit	Jam	Oral	Laxative and carminative	34	0.26	0.62	21	61.76
Cyperaceae											
Cyperus rotundus L. SR-13296	Deela	Sedge	Rhizome	Powder	Oral	Diarrhea and dyspepsia	21	0.16	0.57	12	57.14
Elaeagnaceae											
Elaeagnus hortensis M. Bieb SR-13313	Sanzalla	Tree	Fruit	Powder	Oral	Stomach disorders and dysentery	27	0.21	0.56	15	66.67
Equisetaceae											
Equisetum arvense L. SR-13216	Bandkai	Fern	Aerial part	Decoction	Oral	Stomachache	26	0.20	0.73	19	61.54
Euphorbiaceae											
Euphorbia hirta L. SR-13538	Pratavara	Herb	Whole plant	Decoction	Oral	Gastric ulcer	17	0.13	0.53	9	35.29
Fabaceae											
Acacia modesta Wall. SR-13196	Palosa	Tree	Bark	Decoction	Oral	Abdominal pain and gas trouble	41	0.32	0.80	33	92.68
Acacia nilonitica L. SR-13448	Kikar	Tree	Bark	Decoction	Oral	Dysentery, diarrhea and stomach pain	38	0.29	0.68	26	86.84
Cassia fistula L. SR-13483	Gernalai	Tree	Fruit	Pulp	Oral	Colic pain, flatulence and purgative	40	0.31	0.78	31	92.50
Fagaceae											
Quercus baloot Griff. SR-13258	Tora serai	Tree	Fruit	Decoction	Oral	Gastric ulcer	29	0.22	0.66	19	72.41

Family name /Botanical name/Voucher no.	Local name	Growth form	Part used	Mode of Preparation	Mode of administration	Diseases cured	FC	RFC	UR	UV	FL%
Fumariaceae											
Fumaria indica (Hausskn.) SR-13312	Shatrapapra	Herb	Leaves	Decoction	Oral	Indigestion and constipation	34	0.26	0.62	21	73.53
Geraniaceae											
Erodium cicutarium (L.) L'Hér. Ex Aiton. SR-13209	Dhaniaghonde	Herb	Aerial part	Decoction	Oral	Constipation and intestinal ulcer	30	0.23	0.70	21	63.33
Lamiaceae											
Ajuga bracteosa Wall. Ex Benth. SR-13425	Ghotakai	Herb	Aerial part	Decoction	Oral	Abdominal pain	28	0.22	0.61	17	82.14
Mentha arvensis L. SR-13293	Velanai	Herb	Leaves	Powder	Oral	Stomach pain, flatulence, and indigestion	47	0.36	0.83	39	97.87
Mentha longifolia (L.) Huds. SR-13331	Janglivelanai	Herb	Leaves	Powder	Oral	Appetizer, carminative, flatulence, dysentery, and digestive problem.	46	0.35	0.72	33	89.13
Mentha spicata L. SR-13283	*Velanai*	Herb	Leaves	Powder	Oral	Appetizer, carminative, antiemetic, diarrhea and dyspepsia.	45	0.35	0.78	35	95.56
Mentha viridis L. SR-13284	Sarkorevelanai	Herb	Leaves	Decoction	Oral	Appetizer, carminative, anti-diarrheal, gastrointestinal disorders	44	0.34	0.73	32	93.18
Nepeta cataria L. SR-13420	Khez bee boti	Herb	Whole plant	Decoction	Oral	Diarrhea, intestinal worms	29	0.22	0.66	19	79.31

Family name /Botanical name/Voucher no.	Local name	Growth form	Part used	Mode of Preparation	Mode of administration	Diseases cured	FC	RFC	UR	UV	FL%
Nepeta laevigata (D. Don) Hand SR-13259	Sheen berai	Herb	Seeds	Soaking	Oral	Dysentery and diarrhea	25	0.19	0.68	17	72.00
Teucrium stocksianum B Boiss. SR-13274	Matokaibote	Herb	Aerial part	Decoction	Oral	Intestinal worms	27	0.21	0.70	19	77.78
Thymus linearis L. SR-13451	Prêt bote	Herb	Aerial part	Decoction	Oral	Appetizer, anti-flatulent, carminative, abdominal pain	31	0.24	0.55	17	51.61
Ziziphora tenuior L. SR-13414	Khez bee boti	Herb	Leaves	Powder	Oral	Carminative, appetizer, nausea, diarrhea, gastrointestinal disorders	37	0.28	0.70	26	78.38
Liliaceae											
Gagea elegans Wall. ex G.Don. SR-13128	Zergulai	Herb	Whole plant	Cooked	Oral	Indigestion	15	0.12	0.40	6	60.00
Tulipa clusiana DC. SR-13271	Shande Gul	Herb	Rhizome	Powder	Oral	Intestinal worms	19	0.15	0.58	11	73.68
Malvaceae											
Hibiscus trionum L. SR-13252	Bahindaigul	Herb	Leaves	Decoction	Oral	Stomachache	18	0.14	0.33	6	38.89
Malva neglecta Wall. SR-13368	Speetakalay	Herb	Leaves	Decoction	Oral	Stomach pain, constipation and dysentery	21	0.16	0.38	8	52.38
Moraceae											
Ficus carica L. SR-13124	Inzar	Tree	Fruit	Raw	Oral	Indigestion and constipation	27	0.21	0.59	16	62.96
Ficus palmata Forssk. SR-13139	ZangaliInzar	Tree	Fruit	Juice	Oral	Abdominal pain and constipation	26	0.20	0.50	13	57.69

Family name /Botanical name/Voucher no.	Local name	Growth form	Part used	Mode of Preparation	Mode of administration	Diseases cured	FC	RFC	UR	UV	FL%
Morus alba L SR-13435	Spin toot	Tree	Fruit	Raw	Oral	Constipation	42	0.32	0.83	35	100.00
Oxalidaceae											
Oxalis corniculata L. SR-13254	Terwekai	Herb	Whole plant	Decoction	Oral	Diarrhea and intestinal worms					
Plantaginaceae											
Plantago lanceolata L. SR-13210	Khatakai	Herb	Seed husk	Herbal tea	Oral	Constipation, diarrhea, dysentery, and digestive problems.	23	0.18	0.57	13	47.83
Plantago ovata Forssk. SR-13391	Isobaghel	Herb	Seed husk	Soaking	Oral	Constipation and gastrointestinal disorders	37	0.28	0.73	27	89.19
Portulacaceae											
Portulaca oleracea L. SR-13169	Parkhurai	Herb	Aerial part, seed	Cooked	Oral	Laxative, anti-flatulent.	31	0.24	0.55	17	54.84
Punicaceae											
Punica granatum L. SR-13333	Valengai	Shrub	Fruit	Juice	Oral	Dysentery, indigestion and stomachache					
Rhamnaceae											
Ziziphus jujuba Mill. SR-13440	Ghotabera	Tree	Bark	Powder	Oral	Abdominal pain and diarrhea	27	0.21	0.67	18	77.78
Ziziphus mauritana Lam. SR-13198	Vrabera	Tree	Fruit, leaves	Decoction	Oral	Laxative, appetizer,	32	0.25	0.50	16	53.13

Family name /Botanical name/Voucher no.	Local name	Growth form	Part used	Mode of Preparation	Mode of administration	Diseases cured	FC	RFC	UR	UV	FL%
						diarrhea and dysentery					
Ziziphus nummularia (Burm. f.) ight & Arn. SR-13179	Kakena	Shrub	Bark, leaves	Decoction	Oral	Diarrhea and dysentery	23	0.18	0.74	17	52.17
Rosaceae											
Cyndonia oblonga Mill. SR-13520	Bahi	Shrub	Fruit	Jam	Oral	Nausea, vomiting and constipation	48	0.37	0.83	40	100.00
Prunus armeniaca L. SR-13125	Mondeta	Tree	Fruit	Raw	Oral	Constipation	23	0.18	0.70	16	82.61
Prunus microcarpa C. A. Mey SR-13522	Alocha	Tree	Fruit	Raw	Oral	Appetizer, nausea and vomiting	28	0.22	0.61	17	71.43
Solanaceae											
Withania coagulans (Stocks) Dunal in DC. SR-13188	Shafyanga	Shrub	Fruit, leaves	Powder	Oral	Abdominal pain and gastric problem	45	0.35	0.82	37	91.11
Salvadoraceae											
Salvadora oleoides Decne. SR-13148	Plawon	Tree	Leaves	Powder	Oral	Abdominal pain and flatulence	42	0.32	0.71	30	85.71
Vitaceae											
Vitis vinifera L. SR-13538	Melava	Climber	Fruit	Raw	Oral	Laxative and gastric problem	43	0.33	0.56	24	48.84
Zygophyllaceae											
Tribulus terrestris L. SR-13236	Kandalai	Herb	Seed	Powder	Oral	Dysentery, diarrhea, and dyspepsia	36	0.28	0.64	23	63.89

Key words: FC= Frequency of citation, RFC= Relative frequency of citation, UV= Use value, URs= Use Reports, FL= Fidelity level

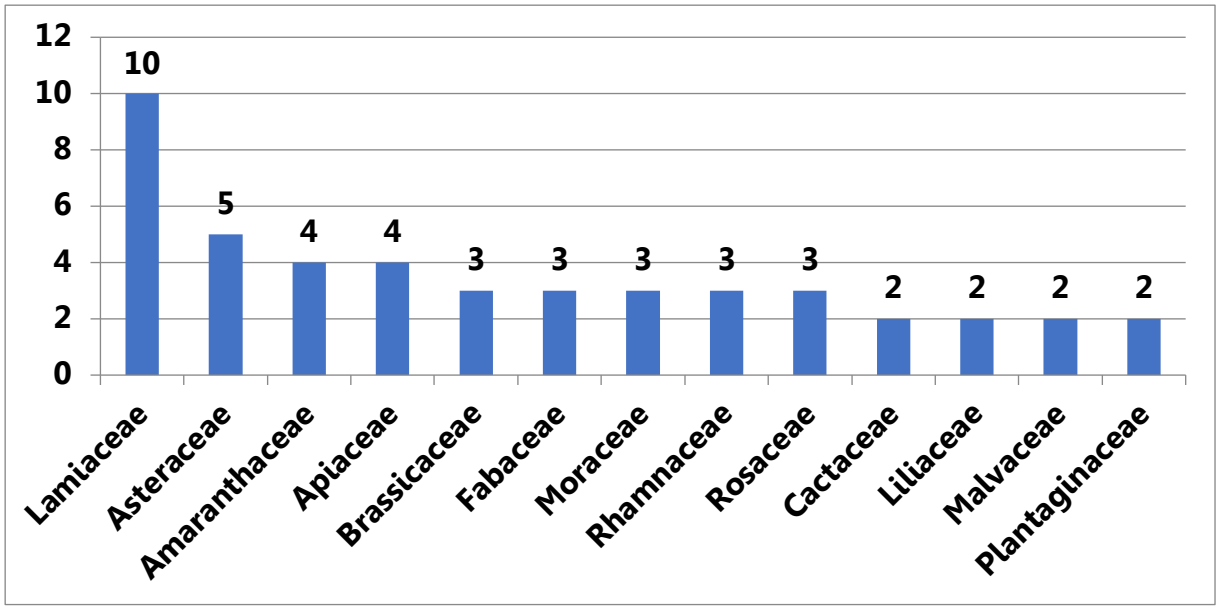

Figure 2. The number of species in the top 13 families.

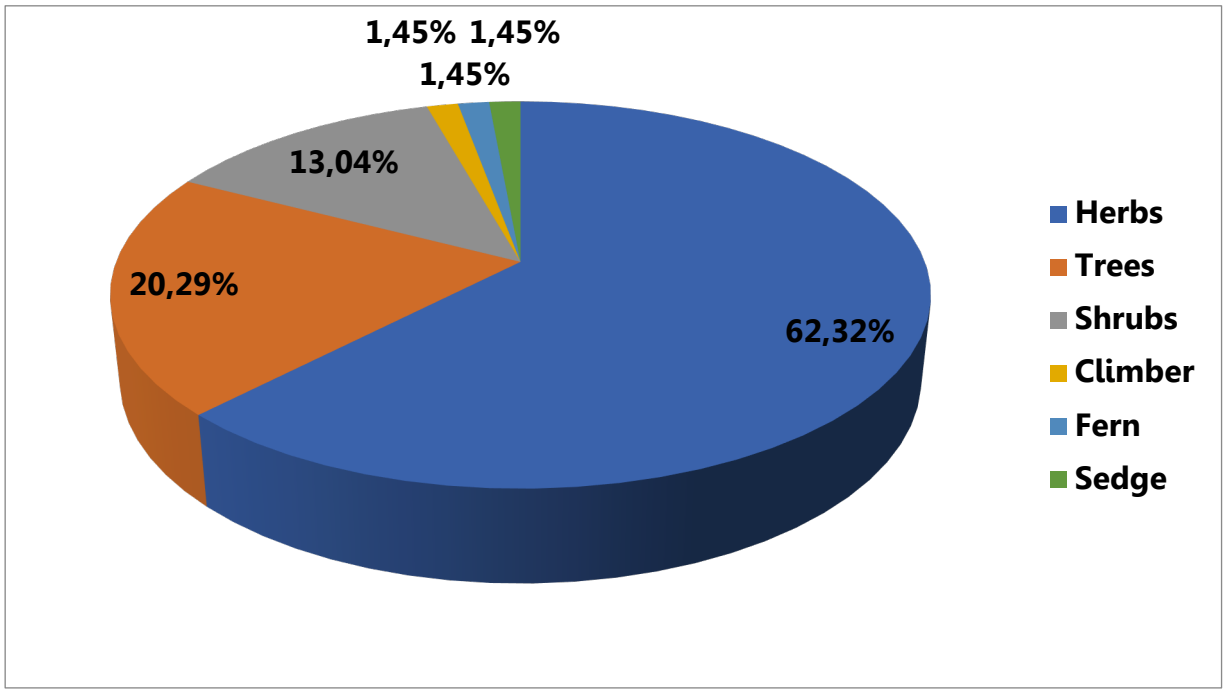

Figure 3. Life forms of medicinal plants (%).

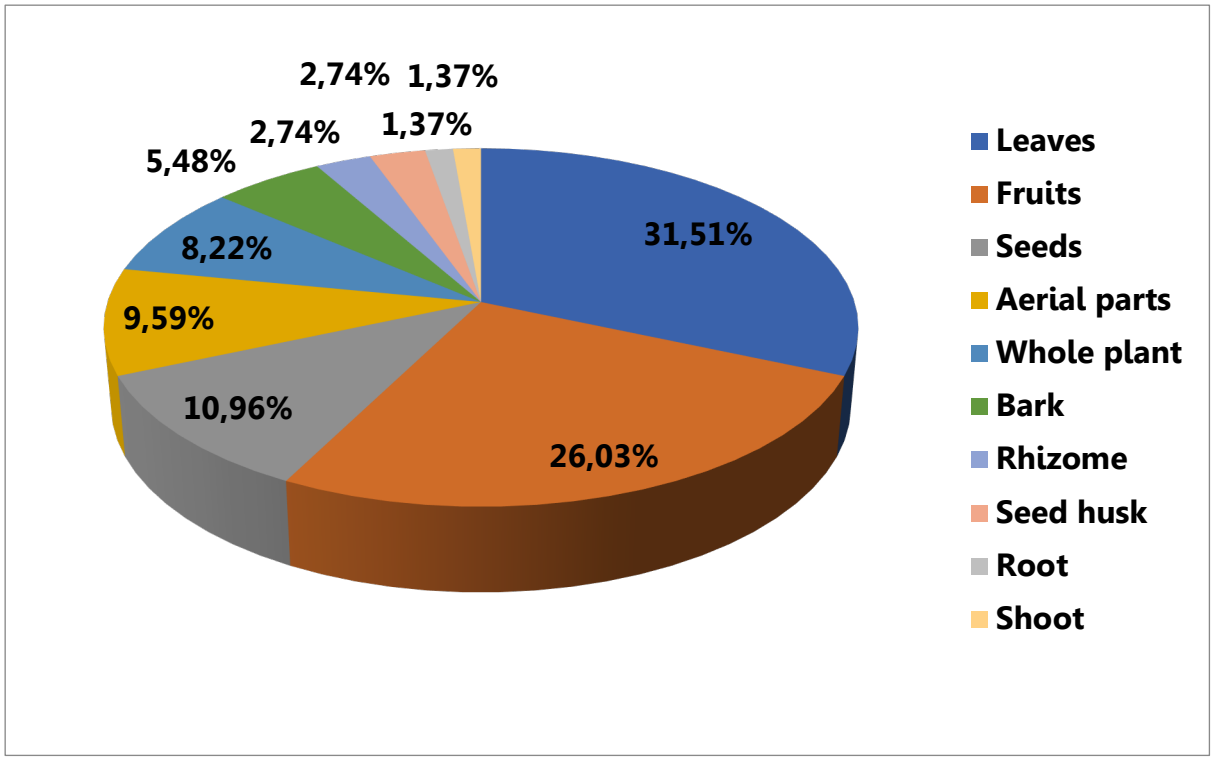

Figure 4. Plant parts used in herbal medication.

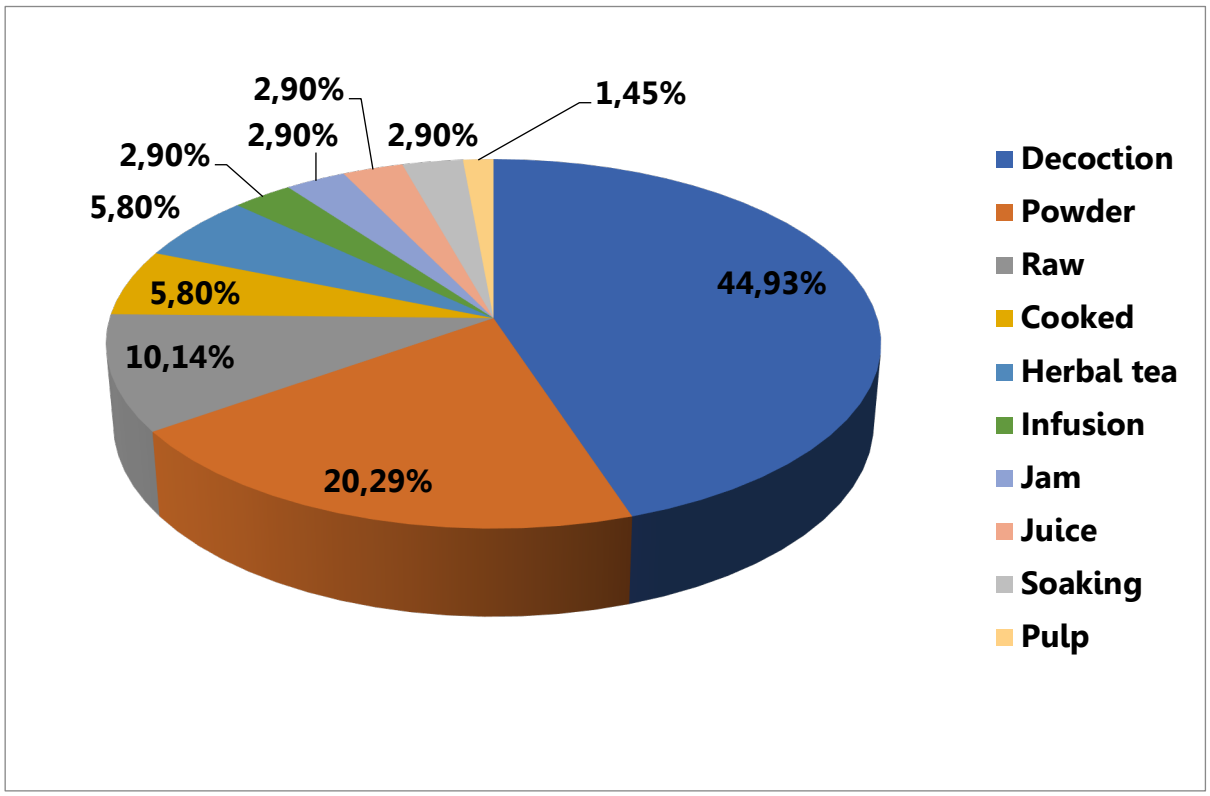

Figure 5. Methods of preparation of herbal recipes.

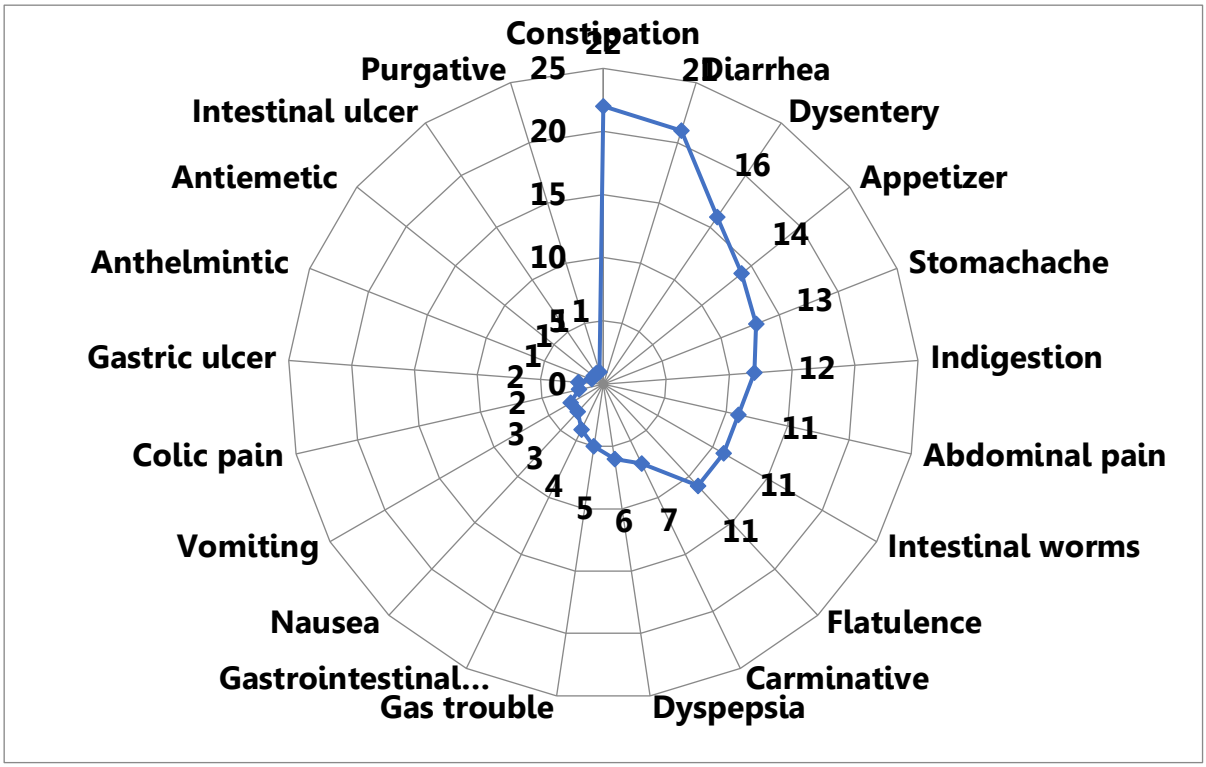

Figure 6. The number of plants used for healing various gastrointestinal disorders.

Family Importance Value (FIV)

The family importance value (FIV) increases with the increase in frequency of citations of plants belonging to a particular family. The family Lamiaceae had the maximum FIV value (97.69%), followed by Apiaceae (88.46%), Asteraceae (84.62%), Rosaceae (76.15%), Amaranthaceae (75.38%), and Moraceae (73.08%); while the lowest FIV value was reported for Oxalidaceae (12.31%)(Table 3).

Table3. Family importance value (FIV)

Sr #	Family Name	No. of species	FC (family)	FIV
1	Lamiaceae	10	127	97.69
2	Asteraceae	5	110	84.62
3	Amaranthaceae	4	98	75.38
4	Apiaceae	4	115	88.46
5	Brassicaceae	3	88	67.69
6	Fabaceae	3	79	60.77
7	Moraceae	3	95	73.08
8	Rhamnaceae	3	82	63.08
9	Rosaceae	3	99	76.15
10	Cactaceae	2	68	52.31
11	Liliaceae	2	34	26.15
12	Malvaceae	2	39	30.00
13	Plantaginaceae	2	60	46.15
14	Portulacaceae	1	31	23.85
15	Anacardaceae	1	39	30.00
16	Asclepiadaceae	1	41	31.54

Sr #	Family Name	No. of species	FC (family)	FIV
17	Berberidaceae	1	40	30.77
18	Cannabaceae	1	25	19.23
19	Capparidaceae	1	28	21.54
20	Celastraceae	1	35	26.92
21	Chenopodiaceae	1	26	20.00
22	Convolvulaceae	1	23	17.69
23	Cucurbitaceae	1	34	26.15
24	Cyperaceae	1	21	16.15
25	Elaeagnaceae	1	27	20.77
26	Equisetaceae	1	26	20.00
27	Euphorbiaceae	1	17	13.08
28	Fagaceae	1	29	22.31
29	Fumariaceae	1	34	26.15
30	Geraniaceae	1	30	23.08
31	Oxalidaceae	1	16	12.31
32	Punicaceae	1	41	31.54
33	Salvadoraceae	1	42	32.31
34	Solanaceae	1	45	34.62
35	Vitaceae	1	43	33.08
36	Zygophyllaceae	1	36	27.69

Novelty and future impact

The results from this study were compared with the earlier published literature related to the indigenous plant uses for the treatment of gastrointestinal disorders. New therapeutic uses of *Berberis lycium*, *Cyndonia oblonga*, *Capparis deciduas*, *Morus alba, Plantago ovata, Pistacia integerrima*, *Prunus armeniaca,* and *Prunus microcarpa* were documented for the first time in Pakistan. All the cited plants were documented for the first time for treatment of gastrointestinal disorders from the North Waziristan Tribal District. This is first ever ethnomedical investigation in the North Waziristan that could serve as a useful baseline for future conservation and will encourage conservation planner to endorse the importance of medicinal flora in traditional health care system and will plan for its conservation and utilization on sustainable basis.

Discussion

In this study, 69 medicinal plants were used for the treatment of gastrointestinal disorders belonged to 36 families. The number of male informants was higher than that of female informants. This indicates the cultural barrier of the research area, as the women are not allowed to talk with men out of their family. The informants over the age of 65 were found to have more traditional knowledge. This indicated that the young generations had less interest about the traditional knowledge of medicinal plants. This revealed the warming condition that this indigenous information is not recorded and preserved, and it can be vanished in near future. Our findings are similar with (Ahmad & Pieroni 2016; Jan *et al.* 2017). The dominant families were the Lamiaceae, Asteraceae, Amaranthaceae and Apiaceae. This finding corroborates the work done by other researchers (Benarba *et al.* 2015; Miara *et al.* 2018; Taïbi *et al*. 2020; Barkaoui *et al.* 2017; Skalli *et al.* 2019; Rehman *et al.* 2022a). Most of the plant species belonging to the family Apiaceae are used to treat different gastrointestinal disorders not only in the study area (Pakistan), but all over the globe (Saini *et al.* 2014). This probably may be due to the presence of certain phytochemicals that are essential for the treatment of gastrointestinal disorders. In other studies, Asteraceae was the most commonly used plant family against gastrointestinal ailments (Calvo *et al.* 2013). The dominant growth form used for herbal remedies preparation was the Herb. This finding is in line with studies done by Abbasi *et al.* (2013) and Saxena *et al.* (2014). Herbs usually contain a high amount of bioactive compounds (Mesfin *et al.* 2009; Adnan *et al.* 2014; Adnan *et al.* 2014; Lulekal *et al.* 2013), are easily accessible and have abundant growth in wild environment. The dominant plant part used for herbal preparation was the leaf. The collection of leaves and preparations of medication from leaves are so easy as

compared to the other plant parts. For this reason, leaves are frequently used in herbal remedies preparation (Telefo *et al.* 2011). The removal of leaves from the medicinal plants can cause less harm as compared to the removal of other parts of the plant (Kadir *et al*. 2013). Similar findings have been reported in other studies where leaves were mostly used to treat gastrointestinal problems (Saxena *et al.* 2014; Muralidharan & Narasimhan 2012; Benarba 2016; Leto *et al.* 2013; Yebouk *et al.* 2020; Rehman *et al.* 2022b). Of ten various parts of a single plant may be used for a specific type of disorder. For example, the fruit, and leaves of *Withania coagulans* are used to cure abdominal pain and gastric problems (Yebouk *et al.* 2020). In our study fruit was the most frequently used plant part. The reason behind this is that fruit contains a high concentration of secondary metabolites (Shah *et al.* 2016). This finding corroborates that of a study in which fruit was the most frequently used part against gastrointestinal troubles (Dogan & Ugulu 2013). Traditional healers use various modes of preparations, but decoction was the dominant mode used in the study area. A possible argument may be the simplicity of the preparation procedure (Malik *et al.* 2019). Another cause is that boiling of the plant parts in water leads to the extraction and availability of various compounds for the treatment of diseases (Bibi *et al.* 2015). Decoction was found to be the dominant method of preparation of folk medication in other studies (Adnan *et al.* 2014; Merrouni & Elachouri 2021; Mechaala *et al.* 2021; Savic *et al.* 2019; Zatout *et al.* 2021; Rehman *et al.* 2022c). In this study, all the herbal remedies were used by oral means. A similar result was also reported in other studies (Zatout *et al.* 2021; Mahmood *et al.* 2012; Sarri *et al.* 2014; Mrabti *et al.* 2019; Mir *et al.* 2021; Rehman *et al.* 2023b). Based on the choice of route of administration, the therapeutic effect of each plant varies in terms of duration, target remedy, and the control of treatment to a particular region (Sargin *et al.* 2015; Benarba 2016). The prevalent gastrointestinal disease in the research area was constipation, followed by diarrhea, dysentery, appetizer, stomachache, indigestion, abdominal pain, and flatulence. This could probably be due to the poor access to clean drinking by most of the inhabitants in the research area (Azizullah *et al.* 2011).The medicinal plant species with relatively higher RFC values (Table 2) indicate that these therapeutic plants are very familiar among the majority of indigenous healers (Butt *et al.* 2015). Those therapeutic plant species having high RFC value must be further evaluated for pharmaceutical and phytochemical analysis to identify their active component for any medication preparation (Vitalini *et al.* 2013; Yaseen 2019). The therapeutic plants with higher used values (UV) (Table 2) may be due to their good distribution and frequent use in the research area (Srithi *et al.* 2009; Ullah *et al.* 2014). However, it is not true that therapeutic plant species with low use value (UV) are least significant, but it shows that the information on these plant species are less available (Mahmood *et al.* 2012; Chaudhary *et al.* 2006). Fidelity level is used to determine the therapeutic plants that are mainly preferred by the local inhabitants for the treatment of particular ailments (Table 2). Several researchers have calculated the highest fidelity level (FL) values for gastrointestinal disorders (Lulekal *et al.* 2013; Srithi *et al.* 2009). The maximum family importance value (FIV) was reported for the Lamiaceae. Therapeutic plant species in the Lamiaceae, Apiaceae and Asteraceae families have been cited significantly in different pharmacological works (Kayani *et al.* 2014; Shad *et al.* 2013; Tareen *et al.* 2016). The higher FIV values (Table 2) show that plant species of a particular family are frequently used in curing different gastrointestinal disorders in the study area.. The discovery of drugs from therapeutic plant species involves a multidisciplinary approach that combines ethnomedicinal and pharmacological methods. However, any therapeutic plant of the current study was not exposed to the comprehensive pharmacological screenings.

Conclusions

Gastrointestinal disorders are causing health problems for inhabitants in certain communities in Pakistan. Due to poor economic condition and lack of basic medical facilities, inhabitants of these areas use medicinal plant species for the treatment of these ailments . Traditional knowledge about therapeutic plants and herbal remedies preparation for the treatment of gastrointestinal disorders is still common in the tribal district of North Waziristan. During the survey, 69 medicinal plant species belonging to 36 families were documented from the study area. The dominant therapeutic plant species with the highest use values (UV) were *Mentha arvensis*, *Morus alba*, and *Cydonia oblonga*, *Withania coagulans*, and *Trachyspermum ammi*. The highest RFC values were reported for *Cydonia oblonga*, and *Trachyspermum ammi*, and *Mentha arvensis*. The medicinal plants with 100% Fidelity level were *Carum carvi*, *Trachyspermum ammi*, *Morus alba,* and *Cyndonia oblonga* for the treatment of gastric trouble, indigestion, constipation, and vomiting respectively. Five species viz. *Caralluma tuberculata*, *Gagea elegans*, *Elaeagnus hortensis*, *Teucrium stocksianum* and *Pistacia integerrima* are medicinal plants which are being used in various gastric problems by the local communities; however, their populations are drastically reduced in the area due to heavy use. Serious conservation measures required by the forest managers for the long-term availability and their sustainable utilization. It was found that the older generation possessed an immense traditional knowledge on medicinal plants as compared to the younger generation. Traditional healing practice and the transfer of this knowledge in the study area are at risk and requires immediate preservation of this knowledge before its extinction. This ethnobotanical study would probably provide baseline information to phytochemists and pharmacologists for new drug discovery.

Declarations

List of abbreviations: Relative Frequency of Citation (RFC), UR, Use Report; Use Vaue (UV), Fidelity Level (FL) and Family Importance Value (FIV).
Ethics statement: Prior to the survey, we obtained oral informed consent from each participant.
Consent for publications: Not applicable.
Funding: Authors have not received any funding for this research.
Conflicts of Interest: The authors declare that there are no conflicts of interest for this article.
Availability of data and materials: The figures and tables supporting the results of this study are included in the article, and the original data sets are available from the first author upon request.
Authors' contributions: The manuscript was written by Sabith Rehman. Zafar Iqbal and Rahmatullah Qureshi supervised this work. All the authors approved the final manuscript after revision.

Acknowledgements

We are thankful to the local community members of the study area for sharing their valuable information. The manuscript was extracted from the Ph.D. Dissertation of the first author.

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