Medicinal plants and their use by an ethnic minority Jirel in Dolakha district, Central Nepal

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Research

Abstract

Background: Plants are important source of traditional medicine and are used widely in the primary healthcare of indigenous peoples and local communities. Despite a considerable number of ethnobotanical studies in Nepal, there are still several regions to be explored and scientifically document the traditional uses of medicinal plants. This study was conducted in one of such areas in the Dolakha district of central Nepal with the indigenous Jirel community.

Methods: Ethnobotanical information was collected using guided field walks, semi-structured interviews, and key informant interviews with traditional herbalists and elderly men and women of the Jirel community. The data were analyzed both qualitatively and quantitatively using use value (UV), informant consensus factor (FIC), and preference ranking.

Results: This study recorded 111 medicinal plant species belonging to 103 genera that were used to treat 11 health disorders. Families such as Asteraceae, Lamiaceae, and Rosaceae have contributed a higher number of species of the total species recorded. Gastrointestinal disorders, skeleton-muscular disorders, fever, headache and cut and wounds were the common health problems among the Jirel people. Roots were mostly used for the preparation of remedies, followed by leaves and fruits. The informant consensus factor (FIC) ranges from 0.74 to 0.93 with an average of 0.87. *Paris polyphylla, Cirsium verutum,* and *Astilbe rivularis* have the highest use values of 0.98, 0.96 and 0.92 respectively. This research finds that traditional knowledge about the use of medicinal plants is more centered on Jirel herbal healers (*Lama*/*Jhakris*) and elderly people than youths. Similarly, knowledge transmission routes are mainly from parents to their eldest child. Over-harvesting, premature harvesting, and deforestation were found as major threats to medicinal plants. Furthermore, the abandonment of traditional herbal practices, the loss of traditional healers, and the youth's unwillingness to traditional healing systems were threats to the ethnobotanical knowledge of medicinal plants in the Jirel community.

Conclusions: The diversity of medicinal plants in the area and the associated indigenous knowledge of use among Jirel people have contributed significantly to their healthcare system. The medicinal uses of the documented species provide the primary information for further ethnopharmacological studies and conservation of most useful species in the study area.

Keywords: Ethnobotany, Traditional knowledge, Informant consensus factor, Knowledge transmission, Preference ranking, Use value

Background

Medicinal plants have been considered as vital sources of traditional medicine worldwide (Lama *et al.* 2001; Mbuni *et al.* 2020; Sen and Chakraborty 2015; Zhang *et al.* 2018). Their usages as human medicines have been well documented in different ancient texts of traditional systems of medicines such as Ayurveda, Unani, and Siddha (Srivastava 2018). Indigenous peoples and local communities inhabiting over 25 % of the land surface in the world are rich in traditional knowledge (Garnett *et al.* 2018; Mulalap *et al.* 2020). One such knowledge is ethnomedicinal knowledge that these people often apply to cure various diseases and ailments, since time immemorial (WHO, 1998). This knowledge and associated practices have contributed significantly to the continuation of their culture, species conservation, and maintaining a healthy ecosystem (Beltran and Phillips 2000, Kunwar and Bussmann 2008). The knowledge gained through continuous interaction with their ecosystems has become a useful means to discover a new source of medicines (Cámara-Leret and Dennehy 2019; da Costa Ferreira *et al.* 2021). The specific knowledge about medicinal plant use depends on local communities' perception, belief, and culture, which is transferred from generation to generation (Berkes *et al.* 2000; Cunningham 1996; Qureshi 2004). The use of medicinal plants in the traditional healthcare system is due to their effectiveness, easy availability, less side effects, lack of access to government healthcare facilities, and cheap therapy as compared to modern pharmaceuticals (Manandhar 2002; Murad *et al.* 2013; Kawarty *et al.* 2020). Worldwide, there has been growing public interest towards ethnomedicine, both in developed and developing countries (Ekor 2014; Khan and Ahmad 2018). It is because of the positive intention of the consumers towards plant-based products, believing them as natural rather than synthetic, and assuming that such products are safer than synthetic drugs (Srivastava 2018).

Medicinal plants are also widely used in the primary healthcare of indigenous peoples and local communities in Nepal (Bhattarai *et al.* 2010; Ghimire *et al.* 2016) as in other societies across the globe (Alemneh 2021; Chaachouay *et al.* 2019; Jarić *et al.* 2018; Maroyi 2013; Mbuni *et al.* 2020; Uprety *et al.* 2012). Out of approximately 29 million inhabitants in Nepal, more than 80% living in rural areas have poor access to government health care facilities and rely on traditional medicines as a way to treat themselves from illnesses (Sharma *et al.* 2004). With varied topography and microclimate within the small geographical area, Nepal harbors rich diversity of medicinal and aromatic plants (Baral and Kurmi 2006; Ghimire 2008; Shrestha *et al.* 2022). Out of 5,606 species of flowering plants reported from the country, more than 2,000 plant species have medicinal values (Baral and Kurmi 2006; Kunwar *et al.* 2013; Kunwar and Bussmann 2008; Shrestha *et al.* 2022). However, the number of medicinal plants might increase, as there are numerous regions where the traditional use of medicinal plants has not yet been studied.

There are fairly a good number of ethnobotanical studies in Nepal (Uprety *et al.* 2022). Those studies have elucidated the significance of ethnobotanical knowledge in biodiversity conservation, and sustainable utilization of highly valued plant species (Atreya *et al.* 2018; Bhandari *et al.* 2021; Kunwar and Bussmann 2008; Pradhan *et al.* 2020; Uprety *et al.* 2010). Among those ethnobotanical studies, some of them are focused on major ethnic groups such as Tamang (Luitel *et al.* 2014; Manandhar 1991; Uprety *et al.* 2010; Yadav and Rajbhandary 2016), Tharu (Bhattarai and Acharya 2015; Manandhar 1985), Magar (Acharya 2012; Budha-Magar *et al.* 2020; Pangeni *et al.* 2020; Thapa 2012), Gurung (Gurung and Subedi 2021; Khakurel *et al.* 2021; Shah *et al.* 2019) and Newar (Balami 2004), and majority are conducted with mixed communities (Ambu *et al.* 2020; Bhattarai 2020; Manandhar 1993; Oli *et al.* 2005; Pradhan *et al.* 2020). However, many other indigenous communities with small populations and heavily depending on forest-based ecosystem services to support their livelihoods are still not covered by the ethnobotanical studies. Earlier studies in Dolakha district have covered a few communities (Dhital *et al.* 2021; Ojha Khatri *et al.* 2021; Shrestha and Dhillion 2006), but the traditional knowledge of Jirel community is not systematically studied (but see Lohani 2011). This is important because understanding of how different indigenous people use plant resources remains the central topic in ethnobotany. This may help to identify resources of great economic value with future bioprospecting potential, identification of threatened species (Cox and Balick 1994), and also to the conservation and management of important biological resources. The Jirels are one of the 63 recognized minority socio-linguistic groups in Nepal with a population of approximately 4291 individuals inhabiting mainly in Jiri and Jugu villages of Dolakha district, central Nepal (CBS 2011). Moreover, due to the considerable physiography and elevation gradient, the study area is diverse and home to many plant species including medicinal (Dhital *et al.* 2021; Karki and Ghimire 2020). These medicinal plants have played a great impact on Jirels healthcare system. They have sufficient traditional knowledge to prepare different remedies from locally available medicinal plants. However, rapid road expansion, over-exploitation of forest resources, and encroachment of the forest land have degraded the natural habitats of many plant species pushing them to declining population. This has significantly affected the traditional practices in

the area. Therefore, the present study aimed to document the knowledge about the use of medicinal plants in the Jirel community of Dolakha district.

Materials and Methods

Study area

The study was conducted in the Jugu village of Gaurishankhar Rural Municipality (ward no. 1 and 2), located in the northern part of Dolakha district, Bagmati province. The village covers the areas of about 3385 hectares and is about 182 km north-east from the capital city of Nepal. Geographically, the study area is located between 27° 53′ N to 27.88° N latitudes and 86° 24′ E to 86.40° E longitudes at an altitude ranging from 920m to 3000m (Figure 1). It harbors various vegetation types including tropical hill *Shorea robusta* forest, sub-tropical *Schima* - *Castanopsis* forest and temperate Oak-Laurel-Rhododendron forest. According to the report of the nearest Jiri weather station, the annual rainfall of the area is 2427mm. The annual mean minimum and maximum temperature are 8.17 °C and 20.71 °C respectively (Data from Department of Hydrology and Meteorology, Nepal). During the winter season, the temperature falls below 0°C and some high-altitude hilltops receive snowfall.

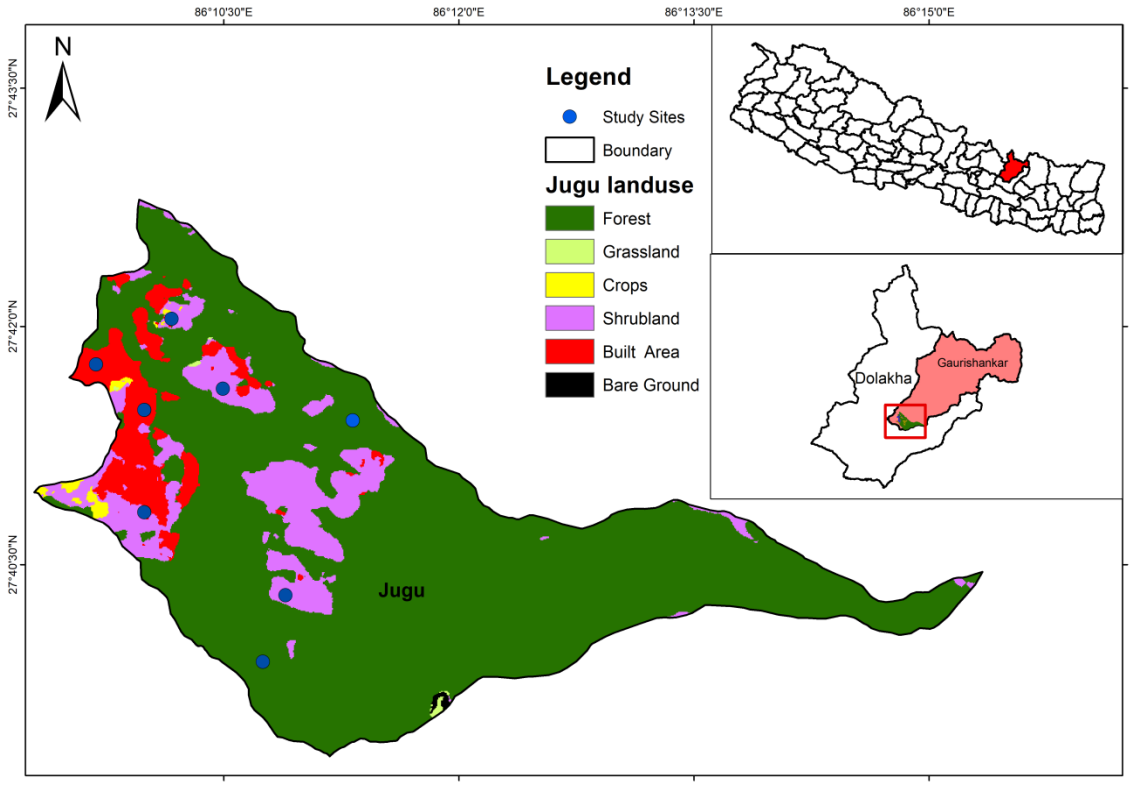

Figure 1. Map of the Dolakha district showing study area. Blue dots are villages where the study was conducted.

Chhetri, Jirels, and Tamangs are dominant inhabitants of Jugu. Jirel community is one of the economically and socially marginalized indigenous nationalities of Nepal, mainly living in Dolakha, Ramechhap, and Sindhupalchok districts with a few thousand people (CBS 2011). In Dolakha district, they are scattered in Jiri, Jugu, Jhyaku, Khimti, and Suri region. Jirel are second most dominant inhabitants (12.75%) after Chhetri (64.58%) in Jugu, Dolakha (CBS 2011). Because of rich biocultural diversity, the study area was selected as one of the pilot sites for the access and benefit sharing (ABS) project of Government of Nepal and IUCN.

Field work and ethnobotanical data collection

Selection of informants

The population of Jirels in Jugu was approximately 495 (CBS 2011). From this population, a total of 45 informants (about 9%) were selected to collect ethnomedicinal information. Verbal consent to document the traditional knowledge was obtained from all the informants. Among the 45 informants, five local herbalist were identified purposively as key informants; the other 40 informants were selected based on snowball sampling method. In snowball sampling, the currently enrolled participant assists the researcher in recruiting another potential

participant (Bhattarai *et al.* 2010). Participants were of different age groups (25 - 75 years - about 55% from the age group 56-75), of which 28 were male and 17 were female. Majority of the informants were unlettered (64%) and about 35% were educated (Table 1). Seven focus group discussions (FGDs) with 8 to 10 participants, including some individuals from the pool of 45 informants were conducted. As the area was one of the pilot sites selected for the access and benefit sharing (ABS) project of Government of Nepal and IUCN, participants were further briefed about the implication of the study in ABS processes (Uprety *et al.* 2020).

Table 1. Demographic features of the informants

Informants	**Number**	**Percentage (%)**
Men	28	62.22
Women	17	37.78
Total	45	100
Age groups		
25-40 years	4	8.89
41-55 years	16	35.56
56-75 years	25	55.56
Education		
Secondary	6	13.34
Primary	10	22.23
Unlettered	29	64.45

Collection of ethnomedicinal data

Four field visits were made in the study area during September 2018 to August 2019. Ethnobotanical information was obtained through free list technique, followed by semi-structured interviews, discussions, formal and informal conversations and field visits. In free list technique, informants were randomly asked about the list of medicinal plants they have been using. A detailed list of medicinal plants was prepared through this method. A semi-structured questionnaire was designed containing predefined questions about medicinal plants. Individual interviews were carried out, where informants were asked about the socio-demographic information, local name(s) of the plant, habitat, parts used, method of preparation, ailment treated and other uses to validate the information gathered from the FGDs. Similarly, they were asked about the source of the knowledge (person) from where they obtain it in order to find the routes of transmission of knowledge to next generation. The vernacular names (in Jirel language) of all plants recorded were asked to the respondents. Plant collection and species display were conducted during group discussion and individual interviews. In addition, guided field walks were also carried out in order to collect and verify the cited species. For the easy understanding of the vernacular names in the field, local person from Jirel community was requested to join the field visits. The photographs of the cited species were taken during the field visits.

Plant specimen collection and identification

The samples of plant species (except common species) cited for medicinal use were collected from the field for the herbarium preparation. Most of the species cited by the informants were identified up to species level in the field. For rest of the species, identification was done with the help of herbarium comparison and study of relevant literature (e.g. Rajbhandari and Rai 2017) at Tribhuvan University Central Herbarium (TUCH), where the herbarium specimens were deposited. Nomenclature follows the Catalogue of Life (www.catalogueoflife.org., accessed on 13 September 2022).

Quantitative data analysis

Informant consensus factor (FIC)

Informant consensus factor (FIC) was computed after the reported traditional remedies and corresponding diseases were grouped into 11 categories following Singh *et al.* (2012), with some modifications. FIC was obtained by computing the number of use citations in each disease category (*Nur*) minus the number of times a species used (*Nt*), divided by the number of use citations in each category minus one (Heinrich *et al.* 1998).

$$Fic = \frac{(Nur - Nt)}{(Nur - 1)}$$

Where, *Nur* = Number of use citations in each ailment category, *Nt* = Number of species used

Use value (UV)

The relative importance of ethnomedicinal plant species was calculated by using the use value (UV) for each species (Phillips and Gentry 1993).

$$UVs = \frac{(\Sigma Us)}{(Ns)}$$

Where *Us* = Total number of use-reports cited by each informant for a given plant species '*s*'and *Ns* = Total number of informants interviewed for plant species '*s*'. In this case, Ns = 45. Use value is high when there are many use reports for a particular species, which also indicates the significance of a species in the community. On the other hand, use value is low if the particular species have a few use reports.

Preference ranking

Preference ranking method was used to understand the effectiveness of medicinal plants used against gastrointestinal disorders, which is most common ailment in the study area. The response of ten selected Jirel informants (5 healers and 5 local representatives) towards the effectiveness of medicinal plants is assigned with some categorical variables. For example, medicinal plants believed to be most effective to treat gastrointestinal disorders were given the highest value (5), while the least effective gets the lowest value (1). The values obtained by each species were summed and their rank was determined based on the total score (Tefera and Kim 2019).

Results

Plant diversity and uses

In total, 111 plant species from 103 genera and 70 families were documented (Table 2). Out of 70 families, 9 were representing the families from monocotyledons (Acoraceae, Araceae, Asparagaceae, Asphodelaceae, Dioscoreaceae, Melanthiaceae, Orchidaceae, Poaceae, Zingiberaceae) whereas 61 families were from dicotyledons (55), gymnosperms (2) and pteridophytes (4). The most represented families were Asteraceae, Rosaceae and Lamiaceae (6 species each), followed by Orchidaceae (4 species) and Menispermaceae (3 species) (Table 2). Life form categories of plants showed the predominance of herbs (53 species), followed by trees (37 species), shrubs (11 species) and climbers (10 species) (Figure 2).

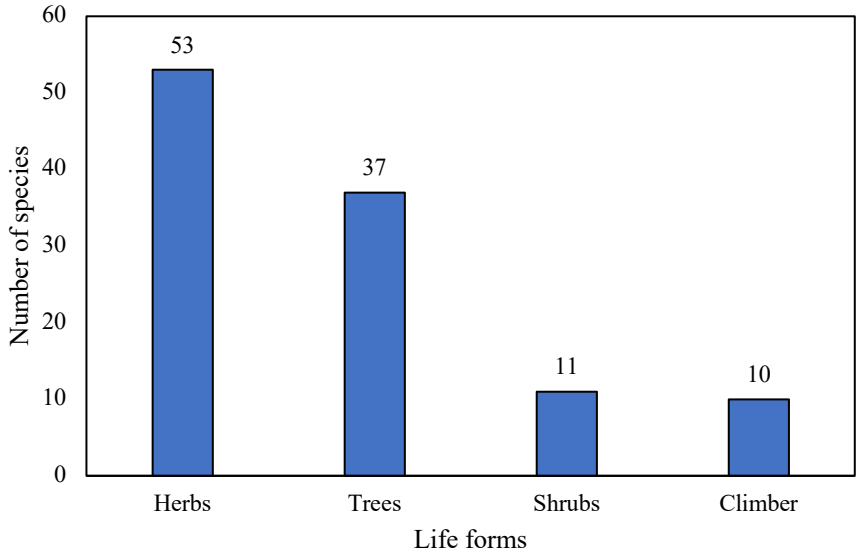

Figure 2. Life form categories of medicinal plants

Table 2. List of plants and their ethnomedicinal uses in Jugu, Dolakha (sorted by family names).

Family	Botanical name and voucher number	Jirel name	Life form	Parts used	Use category	Use value	Form	Mode of use
Acanthaceae	*Strobilanthes lachenensis* C.B. Cl. D0103	**Kheu**	Hb	Lf	1	0.09	Juice	Leaf juice is used to treat typhoid, fever.
Acoraceae	*Acorus calamus* L.	**Chudak**	Hb	Rt	2	0.67	Raw	Small piece of rhizome is chewed during sore throat, cough and cold; rhizome juice is applied for scabies, skin diseases.
Actinidiaceae	*Saurauia napaulensis* DC. D078		Tr	Ba, Fr	2	0.12	Paste	Bark paste is applied in fracture and pneumonia, fruit jel is eaten to treat cough.
Amaranthaceae	*Achyranthes bidentata* Blume D036		Hb	Rt	1	0.07	Juice	Root extract is used during dysentery.
Anacardiaceae	*Choerospondias axillaris* (Roxb.) B.L. Burtt & A.W. Hill D018	**Khulchi**	Tr	Sd	1	0.12	Paste	Semi-burned seed paste is applied to skin allergies and bowls.
Anacardiaceae	*Melanochyla caesia* (Bl.) Ding Hou = *Semecarpus anacardium* Blume	**Se**	Tr	Fr	1	0.18	Juice	Fruit juice is eaten during diarrhea and dysentery.
Apiaceae	*Centella asiatica* (L.) Urb. D016	**Damma firkir**	Hb	WP	3	0.78	Juice	Whole plant is chewed during sore throat; leaf juice is applied to treat fever.
Araliaceae	*Hydrocotyle modesta* Cham. & Schltdl. D030	**Damma firkir**	Hb	WP	1	0.12	Juice	Plant juice is used during urine blockage.
Apocynaceae	*Plumeria rubra* L.		Tr	Lt	1	0.09	Latex	Latex is used in toothache.
Araceae	*Rhaphidophora decursiva* (Roxb.) Schott D051	**She**	Hb	St	1	0.29	Paste	Stem paste is used externally to treat cuts and healing wounds.

Asparagaceae	*Asparagus racemosus* Willd. D012		Hb	Rt	2	0.16	Juice	Root juice is applied during urine blockage, vaneral diseases (*dhaturog*).
Asparagaceae	*Chlorophytum nepalense* (Lindl.) Baker D017		Hb	Rh	1	0.25	Paste	Root paste is used in body ache.
Asphodelaceae	*Aloe vera* (L.) Burm. f.		Hb	Lf	1	0.32	Raw	The gel of leaves is used to get relief from burning, jaundice, skin allergies, and *kamalpitta*.
Asteraceae	*Ageratina adenophora* (Spreng.) R.M. King & H.Rob. D007	**Nakpo jek**	Hb	Lf	1	0.43	Juice	Leaf juice is directly applied to stanch bleeding wounds, cuts; also used as fodder to animals.
Asteraceae	*Artemisia indica* Willd. D011	**Khempak**	Hb	Sh, Lf	2	0.36	Juice	Root juice is applied on wounds, poisons, used to treat intestinal worms, used to heat body (*sul*).
Asteraceae	*Cirsium verutum* (D. Don) Spreng. D019		Hb	Rt	5	0.96	Paste	Root paste is applied during skin diseases, juice is used during jaundice, fever, neck pain, infertility and urine blockage.
Asteraceae	*Duhaldea cappa* (Buch.Ham. ex D. Don) Pruski & Anderb. D0		Hb	Rt	1	0.2	Paste	Root paste is applied in fracture.
Asteraceae	*Ixeridium sagittarioides* (C. B. Cl.) Pak & Kawano D062		Hb	WP	1	0.16	Juice	Plant juice is applied to treat ear problems.
Asteraceae	*Aster* sp.	**Sewa**	Hb	Lf	1	0.12	Juice	Plant juice is used to treat worms.
Berberidaceae	*Mahonia napaulensis* DC.	**kerwa**	Sh	Fr	1	0.27	Paste	Bark paste applied in fracture, bark juice is applied in eye pain.
Bignoniaceae	*Oroxylum indicum* (L.) Kurz	**Champaka**	Tr	Br, Sd	2	0.43	Paste	Bark paste is applied in fracture; seed juice is taken for jaundice.
Buxaceae	*Sarcococca wallichii* Stapf D0119		Sh	Rt	1	0.12	Juice	Root juice is poisonous used to treat intestinal worms.
Campanulaceae	*Lobelia pyramidalis* Wall.		Hb	Rt	1	0.2	Juice	Root juice is used to treat fever.
Cannabaceae	*Cannabis sativa* L. D015		Hb	Lf	1	0.34	Paste	Leaves paste mixed with maize powder is animal fed to treat diarrhea.

Caryophyllaceae	*Drymaria cordata* (L.) Willd. Ex Roem. & Schult.		Hb	WP	3	0.58	Juice	Plant juice is applied to cut wounds, typhoid.
Cervantesiaceae	*Pyrularia edulis* A. DC.	**Ji Feksing**	Tr	Sd	1	0.12	Oil	Oil extracted from seed of plant is used to prevent skin from extensive dryness, burns, scabies, and skin dryness of animal neck.
Combretaceae	*Terminalia bellirica* (Gaertn.) Roxb.		Tr	Fr	2	0.45	Raw	Fruit is used to treat fever, cough.
Combretaceae	*Terminalia chebula* Retz.		Tr	Lf	2	0.49	Juice	Leaf juice is used to treat fever, cough.
Convolvulaceae	*Cuscuta reflexa* Roxb. D021	**Jhaljhale**	Cl	WP	3	0.43	Juice	Plant juice is taken in jaundice, fever, urine blockage.
Crassulaceae	*Kalanchoe pinnata* (Lam.) Pers.		Hb	Lf	1	0.32	Juice	Plant juice is used in jaundice and kidney stone.
Cucurbitaceae	*Solena amplexicaulis* (Lam.) Gandhi in Saldanha & Nicolson D053	**Fefurik**	Cl	Fr, Rt	2	0.16	Raw	Fruit is eaten in fever, root juice neck pain.
Cucurbitaceae	*Trichosanthes tricuspidata* Lour. D055	**Kwajeng Sintak**	Cl	St	1	0.14	Paste	Root paste is applied in snake bite.
Cyatheaceae	*Alsophila spinulosa* (Wall. ex Hook.) R. M. Tryon = *Cyathea spinulosa* Wall.		Tr	Rh	1	0.05	Paste	Rhizome paste applied to expel spines from the body.
Dioscoreaceae	*Dioscorea hamiltonii* Hook.f. D081	**Rirega**	Cl	Fr, Tu	1	0.18	Raw	Fresh tuber and fruits are chewed during sooth voice, cough and fever.
Dioscoreaceae	*Dioscorea* sp.		Cl	Fr	1	0.05	Powder	Fruit powder eaten to treat intestinal worms.
Elaeagnaceae	*Elaeagnus infundibularis* Momiyama D023	**Dulima**	Tr	Br	1	0.27	Paste	Bark paste is applied in fracture.
Equisetaceae	*Equisetum arvense* L. D0126		Hb	Rt	1	0.23	Juice	Root juice is taken during urine blockage.
Ericaceae	*Gaultheria fragrantissima* Wall. D003	**Phoyanga**	Sh	Lf, Fr	2	0.32	Juice	Leaf juice is applied to bone fracture, fruits are eaten during stomach disorder, diarrhea.

Ericaceae	*Lyonia ovalifolia* (Wall.) Drude D036	**Sakun**	Tr	Lf	1	0.23	Paste	Young leaves are applied in scabies; wounds of animals, young leaves are poisonous to cattle.
Ericaceae	*Rhododendron arboreum* Sm. D044	**Tongmar**	Tr	Fl	1	0.12	Juice	Flower juice or petals are taken to extract fish bones from throat.
Fagaceae	*Quercus lanata* Sm. D042	**Fekar**	Tr	Br	1	0.16	Paste	Bark paste is applied in fracture.
Gentianaceae	*Swertia chirayita* (Roxb.) H. Karst. D005	**Tikta**	Hb	WP	2	0.92	Juice	Plant juice is used to treat fever, cough.
Hydrangiaceae	*Hydrangea febrifuga* (Lour.) Y. De Smet & C. Granados	**Churukuku**	Sh	Rt, Lf	1	0.32	Juice	Root and leaf juice is taken in high fever (*kamjoro*).
Juglandaceae	*Juglans regia* L. D032	**Khotasi**	Tr	Br	1	0.23	Paste	Bark paste is applied in skin allergies (*hilolagne*).
Lamiaceae	*Colebrookea oppositifolia* Sm. D025		Sh	Rt	1	0.18	Juice	Root juice is used in *Harital,* a kind of body weakness, eye problem.
Lamiaceae	*Leucosceptrum canum* Sm. D033		Tr	Rt	3	0.34	Paste	Root paste is applied in fracture, also used in *dokh,* intestinal disorders.
Lamiaceae	*Mentha spicata* L.		Hb	WP	2	0.52	Raw	Plant is chewed during cough, kidney stone (*paththari*).
Lamiaceae	*Ocimum tenuiflorum* L.		Hb	WP	1	0.56	Juice	Plant juice is taken during cold, cough.
Lamiaceae	*Clinopodium umbrosum* (M.Bieb.) K.Koch	**Dotorma**	Hb	WP	1	0.52	Juice	Plant juice is applied to cut, wounds.
Lamiaceae	*Elsholtzia flava* (Benth.) Benth. D028		Hb	Rt	1	0.2	Paste	Root paste is used to treat bone fracture.
Lauraceae	*Cinnamomum glanduliferum* (Wall.) Nees		Tr	Br	1	0.09	Juice	Bark is used in Pneumonia.
Lauraceae	*Cinnamomum tamala* (Buch.-Ham.) T. Nees & Eberm.		Tr	Lf	1	0.29	Juice	Leaf juice is boiled and applied to cough.
Lauraceae	*Lindera neesiana* (Wall. ex Nees) Kurz D034	**Dum**	Tr	Fr	1	0.2	Cooked	Fruits are eaten during gastric, fever and stomach disorder.
Lycopodiaceae	*Lycopodium japonicum* Thunb. D035		Hb	St	1	0.27	Juice	Young shoot juice is used in jaundice.

Lythraceae	*Woodfordia fruticosa* (L.) Kurz D070		Sh	Fl	1	0.38	Powder	Flower powder is taken during diarrhea.
Melanthiaceae	*Paris polyphylla* Sm. D004	**Tintale banko**	Hb	Tu	5	0.98	Paste	Tuber paste is applied in bone fracture and wounds, cuts, stomach disorders, cold.
Melastomataceae	*Osbeckia nepalensis* Hook. D022		Hb	Lf	1	0.36	Paste	Leaf paste is applied during cut, wounds.
Meliaceae	*Heynea trijuga* Roxb.		Tr	Fr	1	0.05	Paste	Fruits are made paste and applied to dermatological allergies on head.
Menispermaceae	*Cissampelos pareira* L. D0133	**Batule sintak**	Cl	Lf	1	0.16	Juice	Leaf juice is applied to check bleeding of pregnant woman.
Menispermaceae	*Tinospora cordifolia* (Willd.) Miers D0107		Cl	Br	1	0.05	Juice	Bark juice is applied to scabies.
Menispermaceae	*Stephania glandulifera* Miers		Cl	Lf	1	0.18	Juice	Leaf juice is used during menstrual disorders.
Moraceae	*Ficus benghalensis* L.		Tr	Lt	1	0.09	Latex	Latex is used to remove corneal opacities.
Moraceae	*Morus serrata* Roxb. D079		Tr	Br, Fr	1	0.2	Paste	Bark paste is applied in fracture.
Myricaceae	*Morella esculenta* (Buch.-Ham. ex D. Don) I. M. Turner = *Myrica esculenta* Buch.-Ham. ex D. Don D037	**Singalamu**	Tr	Br	2	0.27	Paste	Bark paste is applied in fracture, fruits are eaten in diarrhea, and teeth ache.
Nephrolepidaceae	*Nephrolepis cordifolia* (L.) C. Presl D073		Hb	Tu	1	0.27	Raw	Fresh tubers are chewed during jaundice.
Oleaceae	*Fraxinus floribunda* Wall.		Tr	Br	1	0.25	Paste	Bark paste applied in fracture.
Oleaceae	*Nyctanthes arbor-tristis* L.		Tr	Lf, Br	3	0.47	Juice	Leaf juice is taken during fever; bark paste is applied in fracture.
Orchidaceae	*Anthogonium gracile* Wall. Ex Lindl.	**Maan**	Hb	Tu	1	0.05	Raw	Pseudobulb chewed to smoothen the neck, neck pain relief.
Orchidaceae	*Coelogyne cristata* Lindl.	**Aajengsing**	Hb	Ps	1	0.09	Paste	Pseudobulb paste is applied to cure cuts and wounds.
Orchidaceae	*Coelogyne corymbosa* Lindl.	**Aajengsing**	Hb	Ps	1	0.09	Paste	Pseudobulb paste is applied in cuts.

Orchidaceae	*Rhynchostylis retusa* (L.) Blume	**Aajengsing**	Hb	Lf	1	0.07	Paste	Leaf paste is applied during cuts.
Oxalidaceae	*Oxalis corniculata* L. D038	**Sakirbu**	Hb	WP	1	0.25	Paste	Plant paste along with the paste of *Centella asiatica* (*ghodtapre*) applied in snake bite.
Phyllanthaceae	*Phyllanthus emblica* L.		Hb	Br	2	0.43	Paste	Bark paste is applied in fracture.
Phyllanthaceae	*Phyllanthus parvifolius* Buch.-Ham. ex D.Don		Hb	Lf	1	0.2	Paste	Leaf paste applied in fracture, bone dislocation.
Pinaceae	*Pinus roxburghii* Sarg.	**Metang**	Tr	Lf	1	0.23	Resin	Resin used as insecticidal.
Plantaginaceae	*Plantago centralis* Pilg. D052		Hb	Rt	1	0.05	Juice	Root juice is applied in snake bite.
Plantaginaceae	*Hemiphragma heterophyllum* Wall. D0121		Hb	Fr	1	0.14	Juice	Fruit and stem juice is used during stomach disorder, constipation and *gano-gola.*
Poaceae	*Imperata cylindrica* (L.) P. Beauv.		Hb	Rt	1	0.12	Juice	Root juice is applied in intestinal disorders (*gano-gola*).
Poaceae	*Cynodon dactylon* (L.) Pers.		Hb	WP	1	0.36	Paste	Plant paste is applied in cuts.
Polygonaceae	*Rumex nepalensis* Spreng. D048	**Dammasemyo**	Hb	Rt	2	0.29	Paste	Root paste is applied in skin diseases like '*dubi',* also used to treat jaundice.
Ranunculaceae	*Thalictrum foliolosum* DC. D063		Hb	Rt	1	0.23	Paste	Root paste is used in gastric, root juice in jaundice.
Ranunculaceae	*Clematis buchananiana* DC. D020		Cl	Rt	2	0.14	Juice	Root juice is applied during headache, nasal blockage (*pinas*).
Rosaceae	*Prunus cerasoides* D. Don D040	**Galamu**	Tr	Br, Fr	2	0.36	Paste	Bark paste is applied in fracture, fruits are eaten to treat intestinal worms.
Rosaceae	*Prunus domestica* L.	**Khampu**	Tr	Br	1	0.16	Paste	Bark paste is applied in fracture.
Rosaceae	*Pyracantha crenulata* (D. Don) M. Roem D041		Sh	St	1	0.25	Raw	Three small branches are given to cattle during delivery to remove placenta.
Rosaceae	*Pyrus pashia* Buch.-Ham. ex D. Don	**Nadak**	Tr	Fr	1	0.14	Juice	Fruit juice applied in eyes problems in animals (*phulo*)
Rosaceae	*Rubus ellipticus* Sm. D046		Sh	Sh, Rt	3	0.56	Paste	Stem and root paste is applied in bone fracture, young shoot juice is

								taken during neck ache and jaundice.
Rosaceae	*Argentina lineata* (Trevir.) Soják D010		Hb	Rt	1	0.12	Paste	Root paste is used during stomach disorder, (*ganogola*).
Rubiaceae	*Dimetia scandens* (Roxb.) R. J.Wang D0124		Sh	Rt	1	0.07	Juice	Juice obtained from the mixture of root of *Dimetia scandens*, *Curcuma caesia* and *Colebrokia oppositifolia* is used during '*Harital*'.
Rubiaceae	*Rubia manjith* Roxb. D045	**Chotki sintak**	Hb	St	1	0.12	Paste	Stem paste is applied in cuts, wounds.
Rutaceae	*Citrus medica* L.	**Kirbu**	Tr	Rt	1	0.09	Juice	Root juice is used to treat fever, gastritis, intestinal worms.
Rutaceae	*Zanthoxylum armatum* DC. D061	**Yerma**	Tr	Fr	2	0.38	Raw	Fruit is eaten in gastric, fever, stomach disorder.
Santalaceae	*Osyris wightiana* Wall. ex Wight D066		Sh	Ba	1	0.47	Paste	Bark paste is applied in fracture.
Santalaceae	*Viscum album* L. D060	**Sirlinge**	Hb	WP	1	0.36	Paste	Plant paste is applied in bone fracture
Saururaceae	*Houttuynia cordata* Thunb. D069	**Susuli**	Hb	Rt	1	0.27	Juice	Root juice is treated in fever, gastrointestinal disorders (*Aruchi*).
Saxifragaceae	*Astilbe rivularis* Buch.-Ham. ex D. Don D001		Hb	Rh	3	0.92	Powder	Rhizomes are used as tonic; rhizome powder is given to pregnant women in pre and post pregnancy as a tonic, fracture.
Saxifragaceae	*Bergenia ciliata* (Haw.) Sternb. D002	**Pakhombed**	Hb	Rh	2	0.74	Powder	Rhizome powder is used to treat cough, diarrhea, rhizome powder is mixed with local rice powder and cooked to make '*puwa*' and given to pregnant women as a tonic and to reduce weakness.
Simaroubaceae	*Brucea javanica* (L.) Merr. D013	**Richi**	Tr	Fr	1	0.29	Raw	Fruits are eaten during diarrhea and dysentery.
Smilaxaceae	*Smilax aspera* L.		Sh	Fr, Rt	1	0.36	Raw	Fruit is used to treat skin allergies like bowls, root is used during delivery disorder, young shoot are used in cancer.

Solanaceae	*Datura stramonium* L.		Hb	Fr	1	0.14	Powder	Seed are used during teeth ache.
Symplocaceae	*Symplocos pyrifolia* Wall.	**Khangkate**	Tr	Sd	1	0.09	Oil	Seed are used to extract oil which is used to treat skin diseases, dryness.
Taxaceae	*Taxus wallichiana* Zucc. D006		Tr	Br	1	0.12	Juice	Bark juice is taken in jaundice.
Theaceae	*Schima wallichii* (DC.) Korth. D049	**Chwasing**	Tr	Br	1	0.25	Paste	Bark paste is applied in bone fracture.
Urticaceae	*Urtica dioica* L. D068	**Sadukpa**	Hb	Rt	1	0.4	Paste	Root paste is applied to treat bone fracture.
Viburnaceae	*Viburnum cylindricum* Buch.-Ham. ex D. Don D058	**Phersokpa**	Tr	Sd	1	0.12	Oil	Seed oil is used in skin abrasions.
Viburnaceae	*Viburnum erubescens* Wall.		Tr	Rt	1	0.05	Paste	Root paste is used during goitree.
Viburnaceae	*Viburnum mullaha* Buch.-Ham. ex D. Don D047		Tr	Fr	1	0.07	Raw	Fruits are taken during diarrhea.
Violaceae	*Viola pilosa* Blume D059		Hb	WP	1	0.58	Juice	Plant juice is applied in cut wounds to stop bleeding.
Vitaceae	*Cissus adnata* Roxb.	**Phakchembo sintak**	Cl	St	1	0.29	Latex	Stem fluid is used to treat cataract, corneal opacities.
Zingiberaceae	*Curcuma caesia* Roxb.	**Menakyo**	Hb	Rh	1	0.18	Juice	Tuber juice is used to treat gastric and acidity, skin diseases, taken as antidote.
Zingiberaceae	*Kaempferia rotunda* L.		Hb	Rh	1	0.34	Paste	Root paste is applied in fracture, juice is used in pneumonia.

(Life form: Hb = Herb, Sh = Shrub, Tr = Tree, Cl = Climber. Parts use: Br = Bark, Fl = Flower, Fr = Fruits, Lf = Leaf, Ps = Pseudobulb, Rh = Rhizome, Rt = Root, Sd = Seed, St = Stem, Tu = Tuber, WP = Whole plant).

Jirel people used medicinal plants to treat 11 health ailments categories. They were gastrointestinal disorders, skeleton-muscular problems, fever and headache, genitor-urological problems, cut and wounds, ENT problems, dermatological disorders, cough-cold, oral and dental problems, eye problems and snakebite. Of the total 11 different ailments categories, gastrointestinal disorders was the most frequently mentioned ailments and treated with the use of wide range of plants (34 species) followed by skeleton-muscular disorders (29 species), fever and headache (19 species), and cut and wounds (18 species) (Table 3, Figure 3). These four categories had more than 50% of the total plant species recorded. Based on the complexity of the ailments, multiple ailments can be treated by applying single plant species, and single ailment can be treated by application of multiple plant species.

Table 3. Medicinal plants used to cure different disease categories and Informant Consensus Factors

Disease category	**No. of species (*Nt*)**	**Use reports (*Nur*)**	**Informant consensus factors (*Fic*)**	**Species**
Gastrointestinal disorder	33	275	0.89	*Achyranthes bidentata, Cirsium verutum, Argentina lineata, Aster* sp., *Brucea javanica, Cannabis sativa, Citrus medica, Cuscuta reflexa, Dioscorea* sp., *Drymaria cordata, Eulaliopsis bipinnata, Gaultheria fragrantissima, Houttuynia cordata, Hamiphragma heterophyllum, Imperata cylindrica, Kaempferia rotunda, Leucosceptrum cannum, Lindera nessiana, Lycopodium japonicum, Melanochyla caesia, Nephrolepis cordifolia, Oroxylum indicum, Paris polyphylla, Prunus cerasoides, Rubus ellipticus, Rumux nepalensis, Sarcococca wallichii, Strobilanthes lachensis, Taxus wallichiana, Thalictrum foliolosum, Viburnum mullah, Woodfordia fructicosa, Zanthoxylum armatum.*
ENT problems	13	46	0.74	*Anthogonium gracile, Cirsium verutum, Artemissia indica, Centella asiatica, Clematis buchaniana, Drymaria cordata, Eulaliopsis bipinnata, Ixeridium sagittarioides, Rhododendron arboreum, Rubus ellipticus, Solena amplexicaulis, Aster* sp., *Viburnum erubescences*
Fever, headache	19	184	0.9	*Cirsium verutum, Astilbe rivularis, Centella asiatica, Cinnamomum glanduliferum, Clematis buchaniana, Cuscuta reflexa, Hydrangea febrifuga, Dioscorea hamiltonii, Houtunia cordata, Leucosceptrum cannum, Lobelia pyramidalis, Nyctanthes arbor-tristis, Paris polyphylla, Solena amplexicaulis, Strobilanthes lanchensis, Swertia chirayita, Terminalia bellerica, Terminalia chebula, Zanthoxylum armatum*
Skeleto-muscular problems	29	279	0.9	*Asparagus racemosus, Astilbe rivularis, Mahonia napaulensis, Bergenia ciliata, Chlorophytum nepalense, Duhaldea cappa, Elaeagnus infundibularis, Elsholtzia flava, Fraxinus floribunda, Gaultheria fragrantissima, Dimetia scandens, Kaempferia rotunda, Leucosceptrum cannum, Morus serrata, Morella esculenta, Nyctanthes arbor-tristis, Oroxylum*

				indicum, Osyris wighttina, Paris polyphylla, Phyllanthus emblica, Phyllanthus parvifolius, Prunus cerasoides, Prunus domestica, Quercus lanata, Rubus ellipticus, Saurauia napaulensis, Schima wallichii, Urtica dioica, Viscum album
Cough-cold	12	141	0.93	*Acorus calamus, Centella asiatica, Cinnamomum tamala, Dioscorea hamiltonii, Mentha spicata, Nyctanthes arbor-tristis, Ocimum tenuiflorum, Paris polyphylla, Saurauia napaulensis, Swertia chirayita, Terminalia bellerica, Terminalia chebula*
Oral and dental problems	5	33	0.88	*Datura stramomium, Equisetum arvense, Morella esculenta, Phyllanthus emblica, Plumeria rubra*
Cut and wounds	18	172	0.91	*Ageratina adhenophora, Aloe vera, Artemisia indica, Clinopodium umbrosum, Coelogyne corymbosa, Coelogyne cristata, Curcuma caesia, Cynodon dactylon, Alsophila spinulosa, Drymaria cordata, Lyonia ovalifolia, Osbeckia nepalensis, Paris polyphylla, Pinus roxburghii, Rhaphidophora decursiva, Rhynchostylis retusa, Rubia manjith, Viola pilosa*
Genito-urological problems	12	112	0.91	*Cirsium verutum, Asparagus racemosus, Astilbe rivularis, Bergenia ciliata, Cissampaelos pariera, Cuscuta reflexa, Hydrocotyle modesta, Kalanchoe pinnata, Mentha spicata, Pyracantha crenulata, Smilax aspera, Stephania glandulifera*
Dermatological disorders	12	58	0.81	*Acorus calamus, Cirsium verutum, Choerospondias axillaris, Juglans regia, Lyonia ovalifolia, Pyrularia edulis, Pyrus domestica, Rumex nepalensis, Symplocos pyrifolia, Tinospora cordifolia, Trichilia cannaroides, Viburnum cylindricum*
Snakebite	3	19	0.89	*Oxalis corniculata, Plantago centralis, Trichosanthes tricuspidata*
Eye problems	4	31	0.9	*Cissus adnata, Colebrokia oppositifolia, Ficus benghalensis, Pyrus pashila*

Parts used and mode of preparation

Plant parts like root, tuber, rhizome, stem, fruits, seeds, bark, and latex were used for various ailments (Figure 4). The frequently used plant part was root (27 species), followed by leaves and fruits (19 species each), bark (14 species), whole plant (13 species) and tuber (4 species) (Figure 4). Local people believe that mixing two or more plant parts increases the effectiveness of the remedy. The remedies were prepared in different forms, such as paste, juice, powder, latex and raw. Among them, paste was a frequently prepared form, which was used externally most of the time (Figure 5). Juice and raw forms were used orally. The latex of *Plumeria rubra* was used to treat toothache. Similarly, sap of *Cissus adnata* was used against the eye infections (*Phulo*). For external use, other materials like shining stone (*Dalche dhunga*) and insects (*Kholme kira*) were mixed along with the plant parts to make paste (e.g. for fracture). Most of the local people (80%) mentioned that they would prepare remedies themselves from locally available plants to treat common disorders (for example, cough and cold, fever, cuts, and gastrointestinal problems) at household level. Twenty percent of the informants said that they would follow traditional healers (*Lama/ Jhakri/ Phombos*) when the complications are serious (for example, snakebite, genito-urological problems, and fracture). Local Jirel peoples have a strong belief on local medicinal plants over synthetic medicines as these are easily available natural lifesaving material. Therefore, they have been still practicing it applying traditional knowledge.

They perceive that herbal medicines are easy to use, no or less side effects, and are more effective if they are applied at proper dose than costly synthetic medicines.

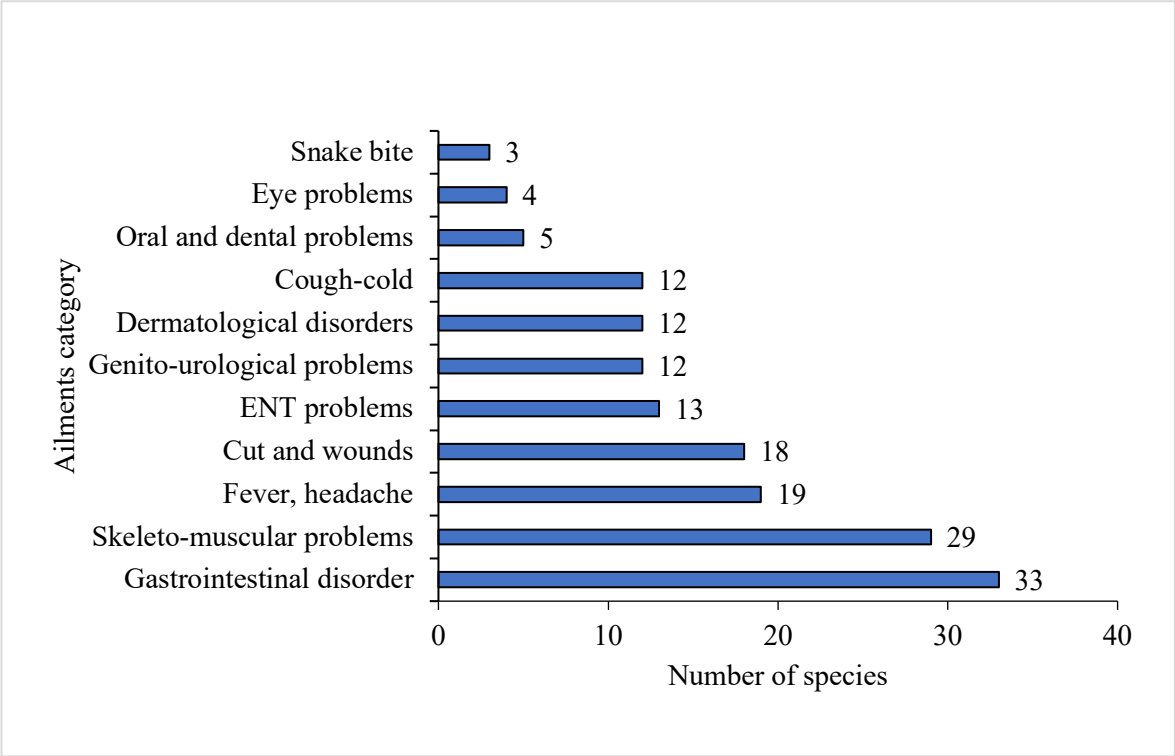

Figure 3. Number of plant species used to treat different ailments

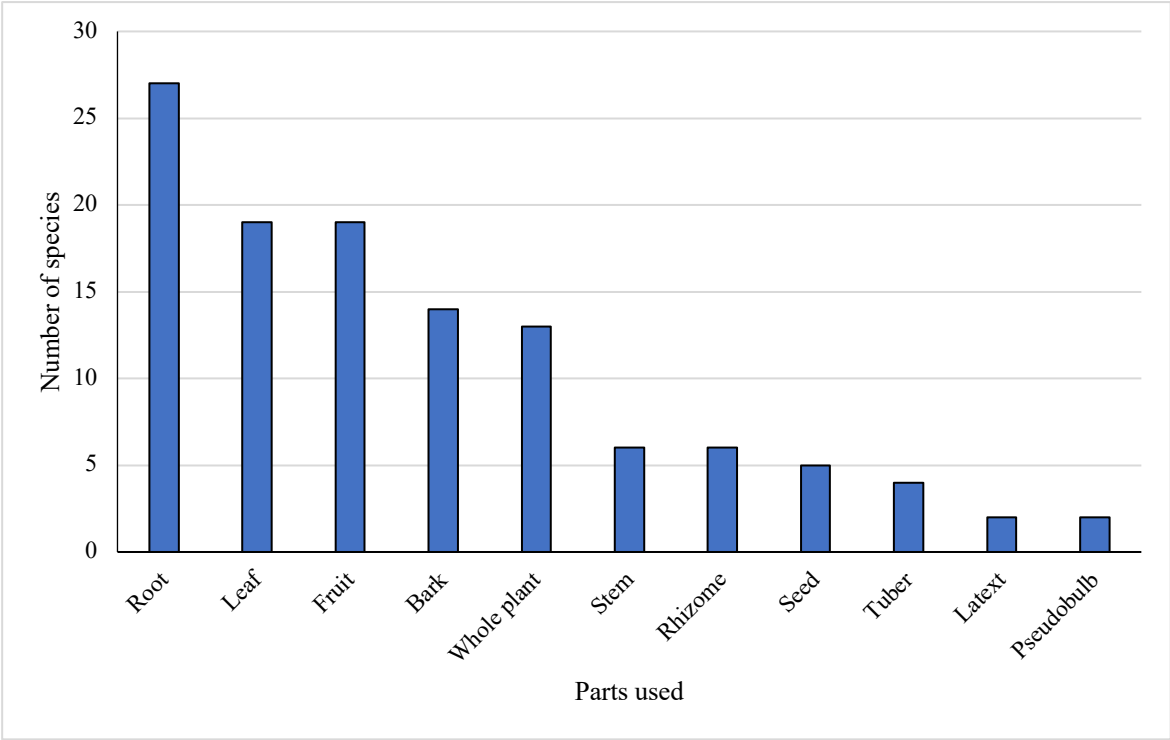

Figure 4. Use frequency of different plant parts

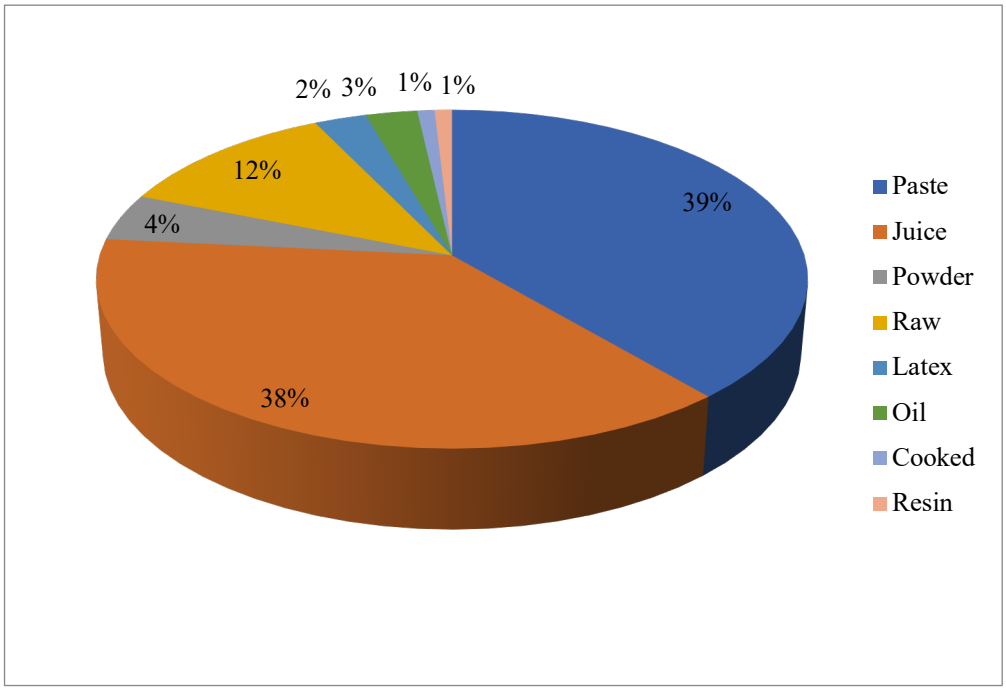

Figure 5. Mode of preparation

Harvesting procedures and conservation status

The harvesting procedure mostly involves uprooting plant parts. People harvest plants from nearby forest, usually when the plant is at fruiting stage, but root are harvested at any stage. Harvesting is done in a small groups with 4 to 5 persons, usually during harvesting seasons for major species (e.g. *Astilbe rivularis*, *Paris polyphylla* and *Swertia chirayita*). However, individual harvest other frequently occuring medicinal plants throughout the year when necessary. Majority of the Jirel peoples (60%) harvest plant for instant uses, however some of them (40%) harvest plant parts for future uses. For that, they would clean and break down harvested plant materials into small pieces, air dry and store. There are 11 community forests in Jugu. Though most of the collecting sites were under the community forestry system, the harvesting of medicinal plants was largely open access to the locals.

Eleven medicinal plant species belonging to nine families, recorded from the study area fall under different conservation categories (Table 4). Of which, five species were listed in Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), including four species in appendix II and one in appendix III. Similarly, four species fall under CAMP category as vulnerable (Vu). Furthermore, three species fall under IUCN category including two as vulnerable (Vu) and one as threatened (T) category. Only one species, *Juglans regia* which fall under government protection list (GN) was recorded from the study area (Table 4).

Table 4. Medicinal plants under different conservation categories (A = Abundant, CAMP= Conservation Assessment Management Plan, GN = Government of Nepal, R = Rare, T = Threatened, Vu = Vulnerable)

Plant species	Family	IUCN	CAMP	GN	CITES
Alsophila spinulosa (Wall. ex Hook.) R. M.	Cyatheaceae				A II
Asparagus racemosus Willd.	Asparagaceae		Vu		
Bergenia ciliata (Haw.) Sternb.	Saxifragaceae	T			
Coelogyne corymbosa Lindl.	Orchidaceae				A II
Coelogyne cristata Lindl.	Orchidaceae				A II
Juglans regia L.	Juglandaceae			Protected	
Paris polyphylla Sm.	Melanthiaceae	Vu	Vu		
Rhynchostylis retusa (L.) Blume	Orchidaceae				A II
Rubia manjith Roxb.	Rubiaceae		Vu		
Swertia chirayta (Roxb.) Karst.	Gentinaceae	Vu	Vu		
Taxus wallichiana Zucc.	Taxaceae				A III

Informant consensus factor (FIC) and use value (UV)

The value of the informant consensus factor ranges from 0.74 to 0.93. The cough-cold has highest FIC value of 0.93 (with 141 use reports, 12 species) and ENT has lowest FIC value of 0.74 (with 46 use reports and 13 species). High FIC value means relatively fewer numbers of species used by the traditional healers for the treatment of different disorders showing higher agreement to use particular species. The average FIC value (0.87) for all ailment categories indicates the high level of consensus within the Jirel ethnic community.

The plants with highest use values (UVs) were *Paris polyphylla*, *Cirsium verutum*, *Astilbe rivularis* and *Swertia chirayita* (Table 2). These four plants were used by more than 50% of the informants in the study area as medicinal herbs. Besides medicinal significance, 4% plants were also used as a source of food and vegetables (e.g., *Asparagus racemosus*, *Dioscorea hamiltonii, Rumex nepalensis* and *Urtica dioica*), fruits (6%) (e.g., *Choerospondias axillaris, Juglans regia, Morella esculenta, Phyllanthus emblica, Rubus ellipticus, Trichosanthes tricuspidata* and *Zanthoxylum armatum*), and religious purposes (5%) (e.g., *Achyranthes bidentata*, *Artemisia indica*, *Cynodon dactylon*, *Duhaldia cappa*, *Ocimum tenuiflorum* and *Oroxylum indicum*). *Clematis buchaniana,* commonly known by '*Pinase lahara*' was an essential item required for the preparation of starter culture (*Marcha*).

Preference ranking

Most preferred five medicinal plant species used against gastro-intestinal disorders were subjected for preference ranking scores (1-5) obtained from ten informants. This shows that the most effective medicinal plants the people perceived were *Paris polyphylla*, followed by *Lindera nessiana* and *Brucea javanica* (Table 5).

Table 5. Preference ranking of medicinal plants used to treat gastro-intestinal disorders in Jirel community

Scientific name	Informants (1-10)										Total score	Rank
	1	2	3	4	5	6	7	8	9	10		
Cirsium verutum (D. Don) Spreng.	5	3	3	2	3	5	4	3	2	4	34	5
Brucea javanica (L.) Merr.	4	3	2	4	2	4	5	5	4	5	38	3
Cannabis sativa L.	4	3	4	4	4	3	2	4	5	4	37	4
Lindera nessiana (Wall. ex Nees) Kurz	4	5	3	3	5	5	3	4	5	2	39	2
Paris polyphylla Sm.	5	4	3	4	5	4	3	4	5	4	41	1

Source and transfer of traditional medicinal plant knowledge

There was a great disparity of knowledge about the use of medicinal plants among the local peoples. Majority of the respondents (31 persons) mentioned that they acquire knowledge from *Lamas/Jhakris* and elderly peoples. In particular, majority of the respondents (64%) mentioned that they acquire medicinal plant knowledge from father/ mother, and a few (4%) mentioned that they acquire knowledge from uncle/ aunt (Figure 6). Similarly, knowledge transfer route is also interesting in Jirel society. The knowledge holder (parents and elderly peoples), mainly used to transfer his/her knowledge to the first child (either son or daughter), which together account about 75%. Transfer of traditional knowledge from parent to elder son accounted for 50% followed by transfer to eldest daughter 25% (Figure 7).

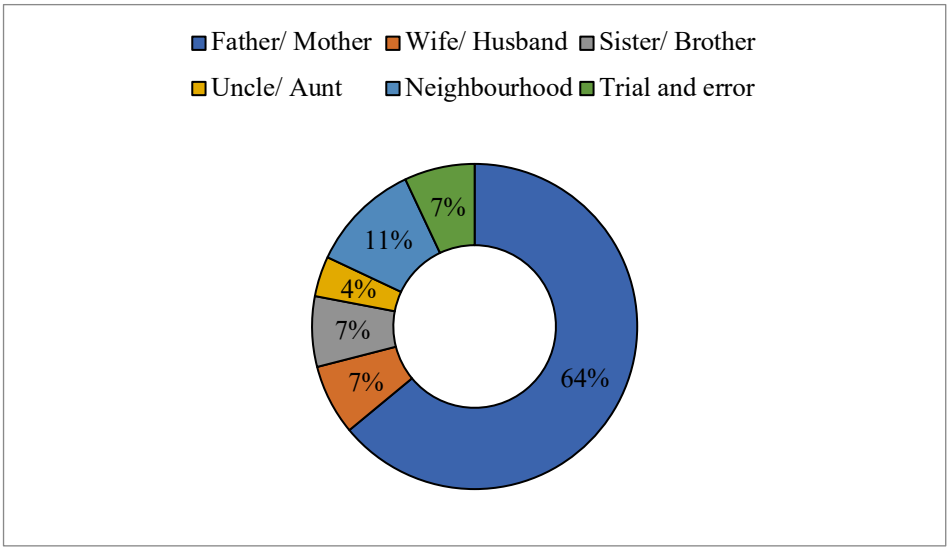

Figure 6. Frequency of source of knowledge on the practice of traditional medicines

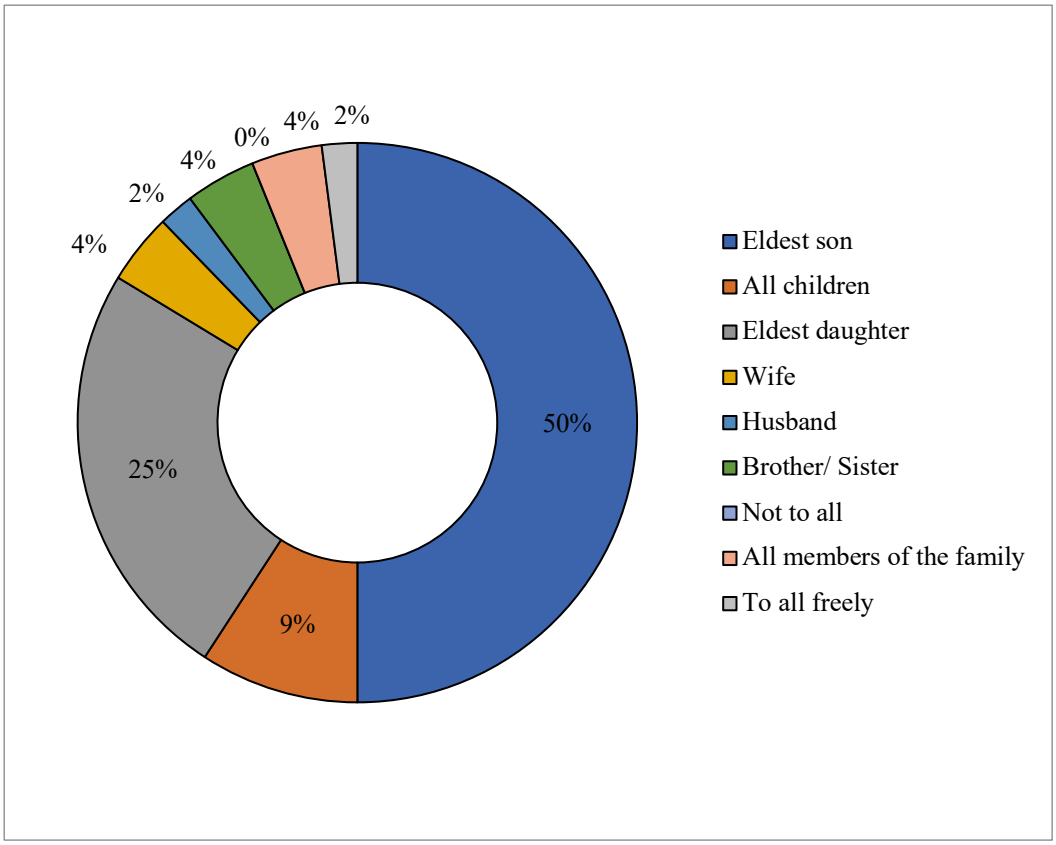

Figure 7. Knowledge transfer routes of medicinal plants

Major threats to medicinal plants and associated knowledge

From the responses of Jirel informants, over-harvesting/ premature harvesting, deforestation and road construction were recorded as the major threats for medicinal plants in the study area, which accounted for about 80%. Remaining threats include fire (9%), invasive alien plant species (7%) and others (4%). Overharvesting and premature harvesting was related to trade of medicinal plants. These factors seems threatening and destructive; major reason for the decline of medicinal plants in the study area.

Based on the preference ranking, abandonment of traditional herbal practices, loss of traditional healers, and youth unwillingness to traditional practices were seen as major factors than non-sharing nature of healers, improvement of health-care facilities, and out-migration to the decline of traditional knowledge associated with medicinal plants in Jirel community (Table 6).

Table 6. Threats to knowledge of medicinal plants in Jirel community, based on priority ranking (values: 1 = least threat, 5 = highest threat)

Threats to knowledge in the Jirel community	**Informants (1-10)**										**Total**	**Rank**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
Abandonment of traditional herbal practices	5	3	4	5	3	4	5	5	4	5	43	1st
Improvements in modern healthcare facilities	3	2	3	3	1	2	4	2	2	3	25	5th
Loss of traditional healers	4	5	4	3	4	4	5	4	5	3	41	2nd
Non-sharing nature of healers	3	2	4	3	3	4	2	3	2	4	30	4th
Out-migration	1	2	2	1	3	1	2	2	4	1	19	6th
Youth unwillingness to traditional practices	4	4	3	4	3	4	5	3	3	4	37	3rd

Discussion

Plant diversity and uses; life forms, ailments treated and mode of preparation

This study revealed the rich traditional knowledge of Jirel people to treat different health disorders. In terms of plant families, Asteraceae, Lamiaceae, and Rosaceae stood dominant showing concordance with other studies conducted in Nepal and elsewhere (Bhandari *et al.* 2021; Bhatt *et al.* 2021; Bhattarai 2020; Bussmann and Glenn 2010; Debbarma *et al.* 2017; Khan *et al.* 2018; Ojha *et al.* 2020; Šavikin *et al.* 2013). However, some ethnobotanical studies had shown Fabaceae as dominant plant families (Bastakoti 2019; Dhami 2008; Kunwar *et al.* 2019; Uprety *et al.* 2011). Being one of the largest families of seed plants worldwide, the members of Asteraceae are frequently occurring in the community.

Traditional use of many species for the healthcare shows their sound knowledge towards plant harvesting, remedy preparation, and their proper utilization. The diversity of plants reported in this study is higher than species reported by Shrestha and Dhillion (2003) who recorded only 58 species of medicinal plants from mixed communities of Boch, Dolakha. This difference might be due to the heterogeneity of traditional knowledge about the use of medicinal plants in the study area. In Nepal, traditional knowledge of medicinal plants varies significantly within or between cultural communities even living adjacent to each other (Ghimire *et al.* 2004).

The Jirel community of Dolakha district mostly harvests herbaceous plants for remedy preparation. This result is similar to the studies in various parts of Nepal (Budha-Magar *et al.* 2020; Luitel *et al.* 2014; Ojha Khatri *et al.* 2021; Rokaya *et al.* 2010; Shrestha *et al.* 2014; Shrestha and Dhillion 2003; Uprety *et al.* 2010). The selection of herbaceous plants for remedy preparation might be due to their high effectiveness, easy to harvest, transport and prepare remedies in comparison to other life forms (Luitel *et al.* 2014; Mallik *et al.* 2020; Singh *et al.* 2012; Stepp and Moerman 2001; Uprety *et al.* 2010). Also, several studies have proven that herbs contain a higher concentration of secondary metabolites of therapeutic potential (Bhat and Karim 2010; Khanal *et al.* 2021; Mishra *et al.* 2014).

Jirel people of the study area prepare a different form of herbal formulations. Paste and juice were the most common preparation modes, and roots and leaves were the most commonly used plant parts also reported from other studies in Nepal (Budha-Magar *et al.* 2020; Shrestha *et al.* 2014) and elsewhere (Shivasankari *et al.* 2014; Srithi *et al.* 2009; Tefera and Kim 2019; Teklehaymanot and Giday 2007). The frequent usage of roots and leaves for the remedy preparation has a scientific logic, as numerous plants store highly active compounds in roots and leaves, and these compounds confer significant antibacterial and antioxidant properties (Joshi *et al.* 2020; Khanal *et al.* 2020; Kunwar *et al.* 2009; Sai *et al.* 2019). However, excessive collection of roots is unsustainable compared to leaves and fruits, which may lead to destruction of the whole plant, therefore, plants with small populations are more vulnerable to extinction (Ghimire 2008; Murad *et al.* 2013).

In Jirel community of Dolakha district, out of 11 human ailments recorded, the most common ailments treated were gastrointestinal disorders followed by skeleton-muscular problems, fever, and headache, and cut and wounds. This finding is consistent with many case studies in Nepal (Adhikari *et al.* 2019; Kunwar *et al.* 2010b; Luitel *et al.* 2014; Pangeni *et al.* 2020; Rokaya *et al.* 2010; Tamang *et al.* 2017) and elsewhere (Bieski *et al.* 2015; Bussmann and Glenn 2010; Kichu *et al.* 2015; Mechaala *et al.* 2021; Šavikin *et al.* 2013; Teklehaymanot and Giday 2007). However, eye problems and snakebites are less common ailments treated in the Jirel society. Thirty-three species belonging to 29 families were reported to treat gastro-intestinal ailments, with members of the families Asteraceae, Rosaceae and Rutaceae (2 species each) as most frequently used. Review of ethnobotanical studies in Nepal has shown that plant species of Angiosperms families such as Asteraceae, Lamiaceae, Fabaceae and Rosaceae were particularly effective against gastro-intestinal problems (Rokaya *et al.* 2014). Gastrointestinal disorders continue to be a major health challenge worldwide (Bussmann and Glenn 2010), especially in developing countries like Nepal. The prevalence of these disorders in the study area might be due to the lack of awareness, poor water supply conditions, lack of sanitation, and poor nutrition, and dependence of most of the people on the labor-intensive works. Most of the local peoples in remote localities of Nepal have suffered from such types of ailments. Similar types of health issues are also prevalent in the Chepang and Tamang community of Nepal (Luitel *et al.* 2014; Tamang *et al.* 2017). Similarly, other ailments such as skeleton-muscular problems, fever and headache, cut and wounds are also prevalent in the Jirel community as in other cultural communities of Nepal (Pradhan *et al.* 2020; Thapa 2020). Skeleton-muscular problems included joint pain, body ache, bone dislocation and fracture. Twenty-nine species from 23 families were reported to be use in the treatment of this ailment. The most commonly used species were the members of families Rosaceae (3 species), Asparagaceae (2 species), Lamiaceae (2 species) and Saxifragaceae (2 species). Medicinal plants like *Asparagus racemosus*, *Astilbe rivularis*, *Prunus cerasoides*, *Phyllanthus emblica*, *Oroxylum indicum*, *Urtica dioica*, *Viscum album*, and *Paris polyphylla* were highly preferred for the treatment of

skeleton-muscular problems, which is supported by other studies as well (Shrestha *et al.* 2016; Tamang *et al.* 2023). Fever and headache are among the most prevalent problems in Jirel community. They use 19 medicinal plants to cure this ailment. Some commonly used plants against fever and headache were *Astilbe rivularis*, *Centella asiatica*, *Swertia chirayita*, and *Terminalia chebula* which is in accordance with other studies (Ambu *et al.* 2020; Bisht *et al.* 2013; Kumar *et al.* 2019). Similarly, 18 medicinal plants from 15 families were reported to be used against cut and wounds. The most commonly used species were the members of families Orchidaceae (3 species) and Asteraceae (2 species). Three orchid species, *Coelogyne cristata*, *Coelogyne corymbosa* and *Rhynchostylis retusa* and members of Asteraceae- *Ageratina adhenophora* and *Artemisia indica* were most commonly used for curing cut and wounds. Although we recorded only 3 plant species (*Oxalis corniculata*, *Plantago major* and *Trichosanthes tricuspidata*) used against snakebites, we consider this information as significant finding because local healers believe that these plants are among the highly effective medicinal plants for snakebites. In general, *Paris polyphylla*, *Swertia chirayita*, *Cirsium verutum* and *Astilbe rivularis* were highly cited species of the study area. They are used for a wide range of conditions such as gastrointestinal disorders, skeleton-muscular problems, fever, and headache.

Large number of Jirel informants claimed that they treat most of the common ailments by the use of single species at household level. But serious complications (for example, fracture) were found to be treated by the use of several plants species. The local people believe that various parts of same species have different medicinal effectiveness and uses. Similarly, different parts of different plants with various life forms have similar medicinal application. Therefore, they apply several plant species/parts to treat a single ailment. For instance, to treat bone fracture, paste was prepared by mixing two or more different parts of plants (bark of *Morella esculenta*, *Osyris wightiana*, *Prunus cerasoides*, *Schima wallichii,* and roots of *Duhaldia cappa*, *Urtica dioica*), which is considered as most effective than applying the paste of single plant. Similar practices are found around the world (Ambu *et al.* 2020; Karous *et al.* 2021; Kidane *et al.* 2018; Tefera and Kim 2019).

Informant consensus factor (FIC) and Use values (UVs)

The FIC value provides the important clue to identify the most efficacious plants and common diseases in the study area. The value of informant consensus factor ranges from 0.74 to 0.93 with an average of 0.87. This result indicates that knowledge about the therapeutic use of medicinal plants is well distributed among the local Jirel peoples. Higher FIC value indicates that higher diversity of medicinal plants was used by the local Jirel peoples to treat various ailments. High consensus among the Jirel informants might be due to the greater exchange of information about plants within Jirel peoples in the study area as they are living adjacent and there was no language barrier. As Jirel are minor indigenous group residing in the localities of Jugu, Dolakha, there is higher possibility of exchanging knowledge between them. Similar results were found in the study conducted in Tamang ethnic group of Nepal (Shrestha *et al.* 2014).

Cough-cold has highest FIC value followed by cut and wounds, fever, headache, skeleton muscular problems and gastrointestinal disorders. Cough-cold had 141 use reports and 12 species were used for treating this ailment. Among them, *Ocimum tenuiflorum* and *Centella asiatica* had higher informant consensus. Informants showing high knowledge of these plants signify that the traditional plant-based practice of human ailments treatment, which they have learned from their ancestors, is still alive in the Jirel community. Such consensus is also still prevalent in other cultural communities of Nepal (Budha-Magar *et al.* 2020; Malla *et al.* 2015; Shrestha *et al.* 2014).

Paris polyphylla (UV = 0.98), *Cirsium verutum* (UV = 0.96), *Astilbe rivularis* (UV = 0.92), and *Swertia chirayita* (UV = 0.92) were highly preferred medicinal plants by the Jirel peoples. The higher preference to these species might be due to their multiple uses, easy to prepare remedies, and proven effectiveness by multiple trial process. Local people were found to be more confident to use remedy prepared from these species. In Nepal, *Paris polyphylla*, *Swertia chirayita,* and *Astilbe rivularis* are popular medicinal plants harvested and used (Bhattarai 2018; Malla *et al.* 2015; Shrestha *et al.* 2016; Thapa 2012). These medicinal species also have high demand for trade; therefore, they are harvested from the wild and are the good income generating source (Edwards 1996; Pyakurel *et al.* 2019, 2017).

Preference ranking of medicinal plant species used against gastro-intestinal disorders showed that *Paris polyphylla*, *Lindera nessiana,* and *Brucea javanica* were the most preferred species. The high preference for these species could be due to the common occurrence of gastric, diarrhea, and food poisoning. *Brucea javanica* and *Lindera nessiana* were used to treat diarrhea and dysentery. Similarly, the paste of *Paris polyphylla* was used against stomach disorders. Similar use reports are also reported from different parts of Nepal (Rokaya *et al.* 2014; Thapa *et al.* 2013; Yadav and Rajbhandary 2016). The extensive use of the particular species by locals against certain disorders is due

to their effectiveness, which provides the important information about the plants efficacy; such information may be useful in further pharmacological screening process.

Source and transfer of traditional medicinal plant knowledge

Lama/Jhakris and grandparents are the main sources of traditional medicinal knowledge who transfer their knowledge to the next generation. In the study area, older respondents cited more species than young respondents. This might be due to their long experience and attachment to the environment. Many studies have shown that old-aged people are more knowledgeable about utilizing medicinal plants than young-aged people (Adhikari *et al.* 2019; Bhattarai 2017; Kunwar *et al.* 2010a).

In particular, about 64% respondents gain medicinal plant knowledge from their father/mother in the study area. This signifies that parents are the valuable knowledge transmitter within the family line of Jirel people, this result allied with other studies (Kidane *et al.* 2018; Schultz *et al.* 2020; Tefera and Kim 2019; Tibebu and Mesele 2019). There is a tradition that local Jirel people mostly share their knowledge to their eldest child, usually to their son, and hesitate to share knowledge to their daughters. They perceive that, after marriage, the daughter will spread the knowledge to her new family, which leaks the privacy of the traditional knowledge. Such a gender preferences for the transmission of traditional knowledge are also prevalent in other ethnic communities in India (Namsa *et al.* 2011) and Ethopia (Suleman and Alemu 2012; Tefera and Kim 2019).

Harvesting procedures and conservation status of medicinal plants

Underground parts were the most harvested parts in the study area making them more susceptible to extinction in the wild. Moreover, some medicinal plants (e.g., *Bergenia ciliata*, *Paris polyphylla*, *Swertia chirayita, Taxus wallichiana,* and Orchids) were threatened by premature harvesting, overharvesting, and deforestation. As these are highly traded species, there is always a pressure from collectors. Several studies have elucidated the similar challenges for the sustainability of high-valued medicinal plants resources in Nepal (Pandey *et al.* 2022; Pokhrel *et al.* 2019). Commercial harvesting is seen as more destructive than harvesting for domestic purposes, threatening both knowledge and sustainability of the plant resources in the study area. But the effort to control the overharvesting and illegal trade of medicinal plants seems very poor in the study area even the harvest is made from the community forest. Therefore, it is suggested that constant monitoring along with strict provisions should be set up for the commercial harvesters in order to control the overharvesting and lessen its impacts on medicinal plants population of the study area.

Of the total species, 11 fall under different conservation categories. This implies that the study area is rich in threatened medicinal plant species. Multiple species are included in two or more conservation categories. Among 11 species, Orchidaceae was the leading family with three species listed in CITES appendixes. Three species (*Coelogyne corymbosa*, *C. cristata*, and *Rhynchostylis retusa*) are common epiphytic orchid species of the study area. *Paris polyphylla* and *Swertia chirayita*, which are under vulnerable (Vu) category of IUCN, are not common in the study area. *Bergenia ciliata*, which is under threatened (T) category of IUCN, is also not common species in the study area. *Juglans regia* is the only species found in the study area, which is under the Government's protected list.

Major threats to medicinal plants and associated knowledge

Loss of plant diversity and traditional medicinal knowledge always remains the concern for the sustainability of the traditional knowledge in the world including Nepal (Atreya *et al.* 2018; Howes *et al.* 2020; Kunwar *et al.* 2022; Sheng-Ji 2001). According to the responses from the informants, high demand of medicinal plants for trade has caused the premature and over-harvesting of medicinal plants in the study area. Although, harvesting for domestic purposes is not so much threatening, commercial harvesting is imposing the enormous threats to the local populations of medicinal plants as in other countries (Van Wyk and Prinsloo 2018). Furthermore, habitat destruction through deforestation and road construction seems significant factor creating major threat on medicinal plants as shown in other studies as well (Battarai 1996; Budha-Magar *et al.* 2020; Joshi and Joshi 2008; Shrestha and Joshi 1996). However, fire and invasive alien species have less effect on the diversity of medicinal plants in the study area. According to the respondents, even small children (students) were hired by traders to gather medicinal plants from the forest. Therefore, there requires further conservation education to peoples in the study area.

According to Jirel peoples, abandonment of traditional herbal practices, loss of traditional healers, and youth unwillingness to traditional knowledge are the major challenges for the preservations of indigenous knowledge in the community. Due to socio-economic transformations, younger generations are less motivated towards learning

traditional knowledge from elders. Furthermore, ethnobotanical knowledge is centered to the elders and traditional healers (*Lama/Jhakris*), and those healers were no more left in the Jirel community, remaining few practitioners kept their knowledge secret, which effects on the vertical as well as horizontal knowledge transmission and ultimately threatening the indigenous knowledge in the Jirel community as also seen in other communities (Budha-Magar *et al*. 2020; Khakurel *et al*. 2021; Rajbanshi and Thapa 2019).

Furthermore, youths are attracted to modern healthcare facilities, and some have migrated from their birthplace to the cities for better opportunities. These factors together with no written record of traditional knowledge and its limited transmission methods (for example, verbal and observations) are threatening the existence of ethnobotanical knowledge as seen in most of the ethnic communities in Nepal (Bhatt and Kunwar 2020; Dhami 2008; Tamang and Singh 2014). For its preservation, documentation of Jirels traditional knowledge in written form is necessary before it completely disappear from the community. In addition, significance of indigenous knowledge and associated medicinal plants should be incorporated in the local curriculum along with conservation education.

Conclusion

Medicinal plants are an important source that has contributed greatly in Jirels traditional health care. This very first ethnobotanical study on Jirel community of Nepal has reported 111 medicinal plants species belonging to 70 families which were used to treat 11 health disorder categories. *Paris polyphylla*, *Cirsium verutum* and *Astilbe rivularis* have highest use values and frequently used in the community for various health problems. Similarly, usage of three commonly available medicinal plants (*Oxalis corniculata*, *Plantago major* and *Trichosanthes tricuspidata*) by Jirels against snakebites is the important finding. Such information needs to be validated through phytochemical investigation. Only few indigenous uses of medicinal plants have been screened for the scientific validation, yet majority of plants still remain to be screened phytochemically and validated for safe use. Thus, more ethnoscientific research including microbial, phytochemical, pharmacological and clinical investigations are necessary to secure the efficacy and safety of claimed medicinal plants. In addition, our research study has highlighted some threats to traditional knowledge of Jirel community. They are abandonment of traditional herbal practices by the socio-economic changes, loss of traditional healers, youth unwillingness towards traditional healing practices, non-sharing nature of healers and youth migration. Nevertheless, our documentation of knowledge transmission routes mainly from parents to their eldest child could have implication in protection of traditional knowledge. Thus, this study is expected to contribute to the protection of traditional knowledge and conservation of the local medicinal resources.

Declarations

Abbreviations: CAMP: Conservation Assessment Management Plan; **CITES:** Convention on International Trade in Endangered species of wild Fauna and Flora; **IUCN:** International Union for Conservation of Nature

Ethics approval and consent to participate: The research proposal was approved by the Ministry of Forest and Environment and the study permission was granted. Prior informed consent was obtained from all the respondents before taking interviews. This study affirms with the Code of Ethics of International Society of Ethnobiology.

Consent for publication: Not applicable.

Availability of data and materials: The raw data are available from the authors upon request.

Competing interests: The authors declare that they have no competing interests.

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Author's contributions: SK and APD designed the research and collected the information from the field. SK identified the plants, arranged the data, analyzed it and wrote the original draft; YU reviewed and revised the manuscript. SKG supervised the research.

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