Conservation linkages of threatened medicinal plants used in traditional health care system in Pin Valley National Park, Himachal Pradesh, India

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Research

Abstract

Background: The *Amchi* system '*Sowa*-Rigpa' served as the cornerstone of local healthcare system for many years, but now is on the verge of extinction. Therefore, to maintain the long-term survival of this system, it is necessary to document utilization of medicinal plants, treatments performed, status of plants, their habitats and factors influencing the decline of this system.

Methods: A systematic field survey was performed from May 2019 to January 2020 covering all 13 villages (2270 souls in 545 households) with 12 *Amchies* in Pin Valley. *Amchies* practicing *Sowa-Rigpa* system were interviewed using semi-structured questionnaires. Knowledge Richness Index (KRI) and the Use Value (UV) were calculated to measure the knowledge on medicinal plants and the significance of the species, respectively. The vegetation sampling was performed by laying 25, 1x1m quadrats in each habitat during the peak growing season. The Pearson's correlation and Mann-Whitney U test were performed using Past 4.03 to analyze the knowledge among different age classes and different professions among practitioners.

Results: Forty-seven endangered plant species were used to treat 27 different ailments. The most common ailment was osteoarthritis (12%), while the decline in *Amchi* population was 45% in last few decades. *Amchi*es involved in government services, as well as farming, observed high knowledge as compared to others. Three critical habitats for critically threatened medicinal plants were identified in the buffer zone. People highly referred to the allopathic system (63%) followed by *Amchi* system (17%) and for both 20%.

Conclusions: The lack of income, government incentives and enthusiasm among younger generation in practicing this system may jeopardize *Sowa-Rigpas'* survival. Integration of this system with modern healthcare system, as well as additional government job possibilities and women's involvement may be effective to enhance this diminishing tradition.

Keywords: Amchi, Trans-Himalaya, Medicinal plants, Spiti Valley, *Sowa-rigpa*

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Background

Knowledge and use of medicinal plants are crucial to define cultural identities and understanding the linkage of the community to its history, land-use practices, and environmental philosophy. This knowledge helps design people-centered natural resource management activities that are important for biodiversity conservation (Lulekal *et al.* 2013). Besides traditional medicines are the most important healthcare source for the vast majority of the population (Kunwar *et al.* 2006)). Plants have been used by humans in a variety of ways from their sustenance to the development of their art, culture, and literature (Abdelhalim *et al.* 2017) and a great deal of such knowledge is occupied through the centuries of experiments and experiences in this direction (Kala 2003). The dependence on nature for survival and sustenance over the period has guided humans to discover remedies for common diseases from natural resources, especially plants (WHO 2008). The traditional knowledge held by indigenous people is an important resource that should be conserved (Tantengco *et al.* 2018). Additionally, herbal remedies are getting widespread popularity throughout the world (Balcha 2014). Traditional knowledge and resource use practices have been passed on through generations by cultural transmission about the relationship of living beings with one another and with their environment (Gadgil *et al.* 1993). Nearly 80% of the world population in developing countries is still dependent on plants derived medicines traditionally (WHO 2008, Mukherjee 2002, Bodeker *et al.* 2005, Bandaranayake 2006).

The Himalayan region has been regarded as a storehouse of Phyto resources, largely medicinal and aromatic plants (Alves & Rosa 2007). The ethno-medico-botanical studies revealed that most of the trans-Himalayan medicinal plants belong to rare, endangered, and threatened categories (Saxena *et al.* 2018). Inhere people in the high-altitude areas remained isolated due to poor accessibility and harsh climatic conditions. Over centuries people due to isolation developed their unique art, culture, and traditions of therapy. Traditional Health Care System (THCS) in the trans-Himalaya is one such tradition that had developed its healthcare system based on the available natural resources. Several professions of medicinal practice existed in the region during the pre-Buddhist era such as *Lhaba* (Shaman) and *Onpo* (astrologer); (Kala 2003). But after conversion to Buddhism such practitioners under the influence of Buddhism were overshadowed and people adopted the Tibetan health care system. This system of therapy is well known today as the Tibetan Medical System (TMS) or '*Sowa-Rigpa'* and its practitioners are titled *Amchies* (Angmo *et al.* 2012). Its spread increased along with the sermons of Lord Buddha, '*Buddha Bhikshu*' and the knowledge of Ayurveda introduced and propagated among their disciples in Ladakh, Lahaul-Spiti, Tibet and wherever they preached. Traditional healthcare practitioners are culturally inherited and important to people's livelihoods (Kunwar *et al.* 2013). The persistence of the traditional approach is the limited availability of modern healthcare treatments (Abera 2014). The traditional medicinal knowledge of plants is now subjected to loss since it has mainly been stored in the memories of elderly people and handed down mostly by word of mouth for successive generations (Giday & Teklehaymanot 2013). This documentation of local traditional knowledge through ethnomedicinal studies is important for conserving and utilizing biological resources (Muthu *et al.* 2006). Therefore, there is an urgent need to conserve this important knowledge by documenting and validating it at ground level for its sustenance. Moreover, deforestation, overexploitation, overgrazing, habitat loss, degradation, and agricultural land expansion continuously threatened traditional medicinal plants and linked knowledge (Lulekal *et al.* 2013). The changing trend and reduction in the number of *Amchies* in the traditional *Sowa-Rigpa* system in Western Ladakh have been reported (Angmo *et al.* 2012). The practice of utilizing medicinal plants in TCS is sharply declining due to a lack of education facilities, lack of knowledge, lack of interest in youth, less income, modernization, and socio-economic transformations (Lulekal *et al.* 2013, Kumar *et al.* 2015). Due to the unavailability of modern healthcare facilities people of the region rely upon *Amchies* (Bishist *et al. 2022)* Additionally due to the lack of proper management and over-exploitation medicinal plants' richness and abundance are declining (Bishist *et al. 2022)*. Further, the use of forest products by rural people is very common and forests are exploitable if not managed properly (Kunwar *et al.* 2006). The pharmaceutical industries have ruthlessly devastated the natural populations of therapeutic plants by over-extracting their resources (Kumar *et al.* 2011). Thus, it is critical to document medicinal plants and their traditional uses to prevent this knowledge from being lost (Abdelhalim *et al.* 2017). Rural people are dependent on nearby forest products and most of the forests have exploited for medicinal species if these forest areas are managed properly can serve as sustainable income sources for the local communities (Kunwar *et al.* 2006). Also, traditional practitioners are currently being eroded due to changing lifestyles, perceptions, social transformations and acculturation (Kunwar *et al.* 2013).

Pin Valley National Park (PVNP) is rich and supports several plant species used in THCS by local healers. Still, a lot of efforts are needed to explore the possibility of their use in this system of medicine (Chandrasekar & Srivastava 2005). Medicinal plants traditionally used in THCS have been reported earlier (Jain 2003, Chandrasekar & Srivastava 2003). Due to remoteness and harsh climatic conditions, this valley is separated from the rest of the world, people

are still dependent on traditional medicine (Kala & Manjrekar 1999). The increased human population, unregulated tourism, and heavy livestock grazing impacted the habitats of high-value-yielding medicinal plant species (Kala *et al.* 2003). Therefore, the present study is aimed to document the existing THCS, medicinal plants used, and habitats that are overexploited due to anthropogenic pressure.

Materials and Methods

Study area

Pin Valley National Park in Lahaul and Spiti district, Himachal Pradesh, India (31°06'40'' to 32°02'20'' N and 77°04'21'' to 7806'19'' E) is a cold desert in the North-West Himalayan region of India (Chandrasekar 2005). The Park with coarse, rocky high hills, cliffs and mountainous crevices interspersed with grassy lower slopes covers an area *ca.* 1825 km^2, out of which 675 km² area is designated as a core zone (Pandey 1991). The Park is adjoined to the Great Himalayan NP in the South-West and Rupi Baba WS in the South. The area is bounded by mountain ranges of the greater and the middle Himalaya on all sides viz., on the East by Tibet, on the South by Kinnaur, on the West by Kullu and on the North by Ladakh. The mean elevation is 4420m above sea level. The region experiences severe winters with the temperature dropping below -40 °C (Bagchi *et al.* 2003). The buffer zone of the park is inhabited by 13 villages excluding, the summer settlements (Figure 1). Pin Valley is very rich in age-old traditional culture and the people are from the *Nyingmapa* sect of the Buddhist agro-pastoral community. The area is well-known for its extensive cultural legacy, monasteries, trans-Himalayan landscape, distinctive wildlife, high mountain ranges and its status as one of the highest populated locations in the world. Most of the villages are often located along the banks of significant rivers and streams in this sparsely inhabited area. The economy of the local population is supported by agro-pastoral practices, tourism and civil government, which provide jobs and substantial subsidies.

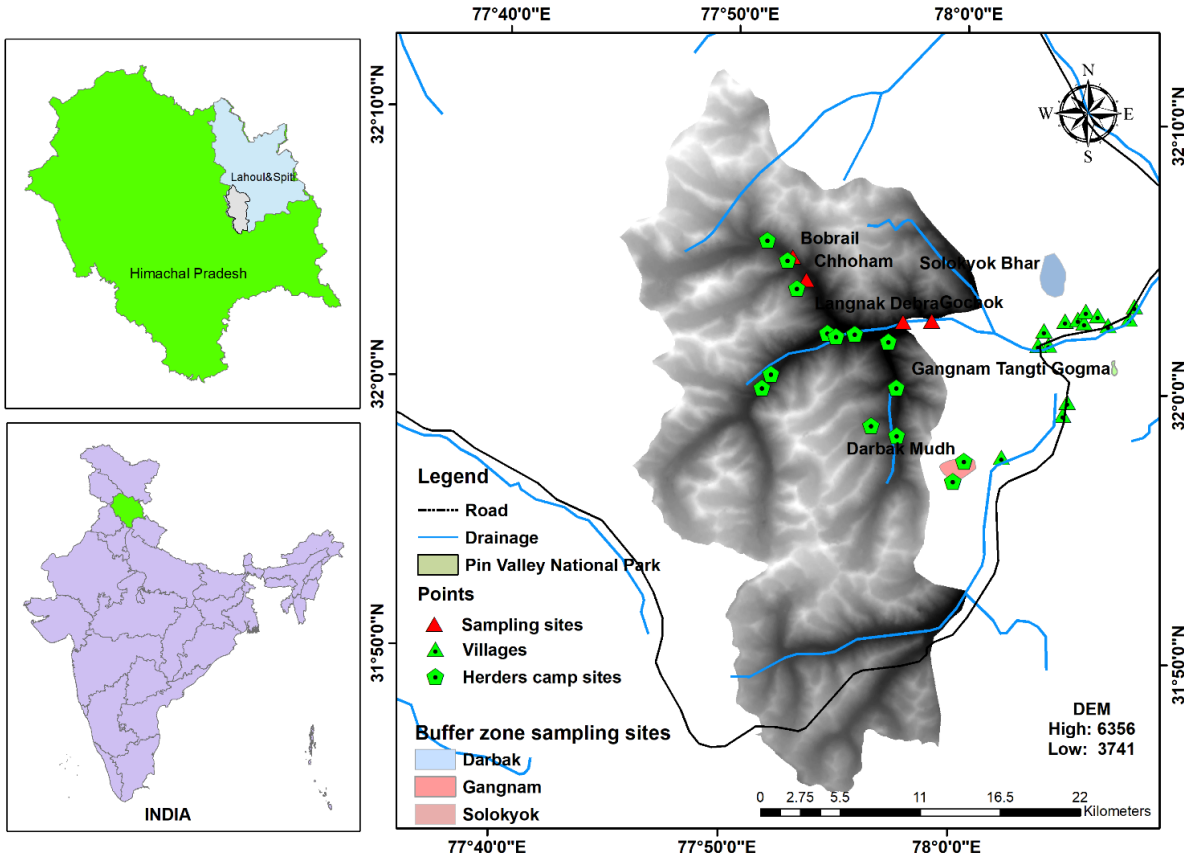

Figure 1. Location map of Pin Valley National Park, Himachal Pradesh.

Data collection

Before selecting the study area, a literature review and reconnaissance surveys were conducted. Following a reconnaissance survey, it was discovered that the PVNP is rich in biodiversity and culture but is highly under anthropogenic pressure due to people's reliance on natural resources for livestock grazing and other resources such as fuel, fodder, and medicinal plant collection (Bhatnagar & Manjrekar 1997, Bhagchi 2003, Ghoshal 2017).

The traditional culture of the healthcare system in Pin valley is the richest (45.5%), of the total *Amchies* in the valley when compared with other regions of the valley through literature and reconnaissance survey (Kala & Manjrekar 1999). The valley is also rich in floral diversity but under high anthropogenic pressure (Kala 2000). Therefore, to understand the nature of people's dependency on natural resources and to identify the crucial habitats which are under pressure were selected. The survey was conducted in 13 villages viz., Kungri, Mudh, Sagnam, Bhar, Tangti Gogma, Tangti Yogma, Khar, Teling, Todnam, Gulling, Seling, Chud and Mikkim with 545 households of Pin Valley NP. Exam,ples for the research setup and important species are given in Plates 1-3

Sampling was carried out between May 2019 - January 2020. The data was collected through an ethnomedicinal assessment based on a questionnaire survey and an ecological assessment based on sampling plots (Figure 2). Semi-structured questionnaire survey with open-ended and closed-ended questions was conducted to record perceptions on the status of the THCS. In-depth interviews and focus group discussions were conducted with individual *Amchi* to gather primary information on medicinal plants and their uses (Bernard 2006, Martin1995). The interview for ethnomedicinal use was conducted focusing on *Amchies* only because in the reconnaissance survey we found locals did not engage in traditional healthcare practice, therefore, locals were considered only for the perception-based survey. All the respondents, *Amchies* (N=12) and locals (N=130) were randomly interviewed in door-to-door surveys in various (13) villages.

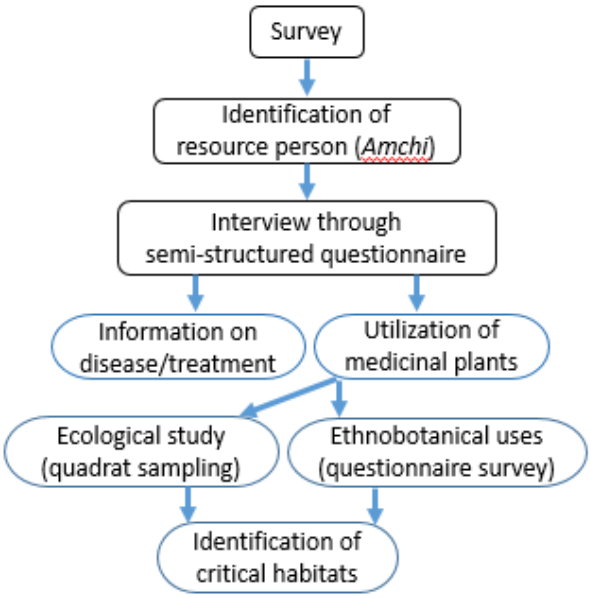

Figure 2. Schematic diagram representing study design.

To assess the traditional knowledge among various age groups, respondents were categorized into four age classes i.e., 40-50 years, 51-60 years, 61-70 years and above 70 years. The demographic information of respondents regarding age, education, income, and occupation type was recorded. A participatory approach was conducted in the local language (*Spitian)* and information on plants with their uses and methods used for medicinal preparations were discussed using standard methods (Martin 1995, Angmo *et al.* 2012) followed by a group discussion on issues related to the present *Amchi* system and the causes influencing the THCS. Secondary data on the seasonal prevalence of diseases was gathered from the Sagnam Primary Healthcare Centre (PHC).

Amchies collect medicinal plants mostly between 3500 and 5000 m asl across various habitats in the alpine pastures and were selected for sampling. A stratified random sampling approach was adopted to determine the status of medicinal plant species by laying 25 quadrats of 1x1 m^2 in each sampling site following Rawat *et al.* (2005) during the peak growth period, i.e., July-September. Besides guided field walks, the key informants were employed to collect voucher specimens of each medicinal plant species. The field identification was done through literature and by engaging local *Amchi* during the field visits. The collected plant specimens were identified at W.A. Rodgers Herbarium, Wildlife Institute of India (WII), Dehradun and the specimens were deposited for future reference at WII. Information related to anthropogenic pressure on critical habitats and climate change was collected based on *Amchis'* perception from all 13 villages.

Data Analysis

The mean density of each medicinal plant species was calculated within its habitat types. The conservation status of the medicinal plant species was cited (Kala 1999, Kumar *et al.* 2016, CAMP workshop report 1998, Negi *et al.* 2018, IUCN red list data).

Knowledge Richness Index (KRI)

The richness of knowledge concerning medicinal plants was evaluated by the Knowledge Richness Index (KRI) following Abera (2014) and Negi *et al.* (2017) using the formula:

$$KRI = 1/\sum Ji2$$

where, Ji = Ri/Rui, Ri is the record of species (Si) mentioned by the informants (Ii), Rui is the total record of species (Si) mentioned by the unit (ui), and a unit is a group of informants in the study. The KRI values range from 0 to infinity; lower KRI values indicate higher knowledge of medicinal plants by the respondent. The relationship between age and plant species known to the informants was analyzed using the Pearson Coefficient (PC). To know the relationship between the type of occupation and knowledge of MPs, the participants were grouped into three types of professions: healing with government jobs (N=4), healing with agriculture practices (N=7), and healing with monk profession (N=1).

The values for farmers and government job healers were compared by a Mann-Whitney test / two-tailed test using the software Past 4.03. Due to a single informant, the data for Monk *Amchi* could not be compared.

Use Value (UV)

The UV of a plant species was calculated following Phillips *et al.* (1994) to know the relative importance of species using the formula:

$$UV = \Sigma U/n$$

where U is the number of use reports cited by each informant for a given plant species and n is the total number of informants that were interviewed. High use values depict many use reports for a plant, implying that the plant is important and approach zero (0) when there are few reports related to its use.

Results

Status of Amchies

Presently 12 *Amchies* practice THCS among 2270 souls from 545 households representing 13 villages of Pin Valley (Table 1). Demographic data on *Amchi* shows that the majority of *Amchies* were between 40-50 and 61-70 years (42% in each category), 51-60 years and above 70 years (8% in each category). The literacy status of *Amchi's* reveals that 50% (N=6) of *Amchies* had education up to a middle (6^{th} to 8^{th} standards), while the remaining 50% (N=6) were primarily educated or illiterate. All respondents were men and there was no record of a female practitioner in the history of Pin valley. Based on their occupation *Amchies* can be identified as (i) healing with agriculture practices, (ii) healing with government jobs, and (iii) healing with the monk professions. Most of them are dissatisfied with their jobs and are unwilling to continue because of a lack of income and job opportunities.

Table 1. Traditional knowledge of *Amchies* on plants.

Age group	Amchi (#)	Knowledge (%)
40-50	5	80
51-60	1	96
61-70	5	70
Above 70	1	66

Knowledge among healers across professions and age

An evaluation of the role of work activities based on different occupation types and its effect on knowledge of medicinal plants revealed that the *Amchies* whose occupation connected to the healing practices with a government job, as well as farming had higher knowledge than that of the people who practice farming with healing only. The reason for higher knowledge in healers with government jobs as well as farming may be due to high literacy and exposure and the connection with their traditional *Amchi* practices. It was found that the healers with government jobs have a higher mean value than healers with farming (38.50±1.94 and 26.86±2.47) and it was statistically significant (Man Whitney U test) as {Z observed value (2.088) > Z critical value (1.960)} at 95% confidence level (0.05%). *Amchi* monk occupation type could not be compared for the Mann-Whitney U test due to individual informants. Knowledge Richness Index (KRI) was observed as 0.35 for healers with government jobs, for *Amchies* involved in farming 0.38 and *Amchi* Monk it was observed highest with a value of 1. The overall observed KRI value of all informants was 0.2±0.38.

The level of plant knowledge of individual informants (N=12) was correlated with age, which was positively correlated but non-significant (R^2 = 0.0652). The percentage of recorded plants that each *Amchi* age class knew was used to calculate their level of knowledge (Table 1). Even though there was only one informant (*Amchi* monk),

i.e., age group of 51-60 years showed higher knowledge. This may be attributed to a higher Buddhist research standard, as the *Amchi* literature is focused on the Tibetan Medicinal System written in 'Tibetan literature. People from outside Spiti visit the *Amchies* for treatment and to address long-standing health issues. The lower percentage of information among those over 70 years old could be due to a single informant in this age group, but other factors such as the informant's mood at the time of response, time, a memory so on, could also be blamed for the knowledge variance.

Plant parts used

During the present course of documentation and field survey, a total of 69 plant species were recorded from the buffer (Gangnam, Solokyok, and Darbak) and core zones (Chhoham, Langnakdebra, Gochok) of the PVNP. These sites are mostly accessed by *Amchies* for medicinal plant collection. Twenty-seven medicinal plant species were used by local *Amchies* to cure different types of ailments in the region. Different parts of plants used for traditional health care practices, which included root and stem (14% each), leaves (26%), flowers (38%), and seeds (8%; Table 2).

Table 2. Plant parts are used for various ailments by *Amchies* in Pin Valley.

Plant part	Percent use
Leaf	26
Stem	14
Root	14
Flower	38
Seed	8

The plants commonly used by local *Amchies* and their use values are given in Tables 3 & 4. In the traditional *Amchi* system, it was found that the taxonomy is uncertain (Angmo *et al.* 2012) and *Amchies* use a different name for the same plant in different regions, e.g. *Dactylorhiza hatagirea* shoot part is called '*Chhunpa*' and root part is *'Angbo-Lakpa'* (Table 4).

Table 3. Medicinal plants used by *Amchies* and their use-values.

Species	Local name	Use report	Use value
Rhodiola tibetica (Hook. f. & Thomson)	**Atongkarpo** (aerial part), **Solomarpo** (root)	12	1.0
Malva pusilla L.	**Champa**	12	1.0
Codonopsis clematidea (Schrenk) Cl.	**Lududh Dorje Nakpo, Kumik**	12	1.0
Primula macrophylla D. Don	**Kyeltche**	12	1.0
Bistorta affinis (D. Don.) Greene	**Lagang**	12	1.0
Waldhemia stoliczkai Ostenf.	**Lukmik**	12	1.0
Saussurea bracteata Decne.	**Pangtsidovo**	12	1.0
Geranium pratense L.	**Polomendok**	12	1.0
Nepeta longibracteata Benth.	**Parbatta**	12	1.0
Crementhodium ellisii (Hook f.) Kitam	**Rekon**	12	1.0
Hyssopus officinale L.	**Tangu**	12	1.0
Hippophae rhamnoides L.	**Tarkuk**	12	1.0
Crepis tenuifolia Babcock & Stebbins	**Tsathi**	12	1.0
Aconitum heterophyllum Wall.	**Bonkar**	11	0.92
Oxyria digyna (L.) Hill	**Chumsa**	11	0.92
Delphinium brunonianum Royle	**Jakotpoe**	11	0.92
Ferula jaeschkeana Vatke	**Kyet** (whole plant), **Tunak (seed)**	11	0.92

Clematis orientalis L.	**Nyakrail**	11	0.92
Myricaria squamosa Desv.	**Humbu**	10	0.83
Rumex dentatus L.	**Lung shoma**	9	0.75
Corydalis govaniana Wall.	**Tongsil**	9	0.75
Dactylorhiza hatagirea D. Don	**Angbolakpa**	8	0.67
Bupleurum falcatum (L.)	**Tukar**	6	0.5
Gentianella moorcroftiana (Wall. ex. D. Don.) Airy Shaw	**Tikta**	4	0.33
Hyoscyamus niger L.	**Duklang**	4	0.33
Rheum moorcroftianum Meissn.	**Dukshu**	4	0.33
Bergenia stracheyi Hook. f. & Thomson	**Gatikpa**	4	0.33
Arnebia euchroma Royle ex Benth	**Khamet**	4	0.33
Taraxacum officinale Wigg.	**Sershen**	4	0.33
Thermopsis inflata Camb.	**Kyelma**	4	0.33
Aquilegia fragrance Benth.	**Lududh Dorje**	4	0.33
Plantago major Lour.	**Lung naram**	4	0.33
Rosa webbiana Wall. ex. Royle	**Saveemendok**	4	0.33
Gentianopsis paludosa Hook. f.	**Baltik**	3	0.25
Gentianopsis detonsa (Rottb.) Ma.	**Chaatik**	3	0.25
Aconitum violaceum Jacq. ex Stapf.	**Bonkar nakpo** (whole plant), **Dutsiloma** (flower)	3	0.25
Ephedra gerardiana Wall. ex. Stapf	**Tsedum**	3	0.25
Pisum sativum L.	**Dekatik, Tenma mendok**	2	0.17
Epilobium angustifolium L.	**Jakangba**	2	0.17
Aconogonum tortuosum D. Don	**Nyalo**	2	0.17
Gentiana tianschanica Rupr. ex Kusn.	**Sumchutikta**	2	0.17
Carum carvi L.	**Zeeranakpo**	1	0.08
Rheum emodi Wall. ex Meissn.	**Lachhu**	1	0.08
Unknown A	**Monchharva**	8	0.67
Unknown B	**Rachakpa**	6	0.5
Unknown C	**Ribuksup**	3	0.25
Unknown D	**Taksha**	1	0.08

Use of animal parts

Animal parts are rarely used by the *Amchies* in Pin Valley for the treatment of various ailments. Being a Buddhist community hunting is negligible in the entire Spiti region. So, sometimes they buy animal parts from other commercial markets like Delhi etc. and the costliest used organs in traditional medicine are Musk deer's pod and Elephant's gall bladder. The current study revealed that the cost of a musk pod is around INR 15000-16000/- per kg, *Aconitum heterophyllum* INR 7000/- per kg and Lal Pathar (Rock debris', locally called *Tsal*) INR 7000/- per kg in open markets. *Amchies* mentioned that this was one of the reasons for the decline as they had to pay a lot from their pockets and in return, they get nothing. They have good knowledge of the use of different animal organs (Table 5). If available, they use human gall bladder and flesh only, if death is due to war, suicide, or any other unnatural cases, because in these cases the status of a dead body would be in certain chemical changes, useful for a patient who is/are suffering from psychological disorders or epilepsy. Animals used in the *Amchi* system include Bear, Deer, Ibex, Rabbit, Rhino, Sheep, Snow leopard and Common leopard, Yak, Tibetan woolly hare and human flesh.

Table 4. Plant parts used and their use in various ailments in *Sowa-Rigpa* system in Pin Valley National Park.

Family	Botanical name	Local name	Medicinal properties	Part used	Status (IUCN)
Apiaceae	*Bupleurum falcatum* L.	**Tukar, Heybomo**	Stomachache, gastrointestinal-related problems	Seeds	LC
	Carum carvi L.	**Zeerakarpo**	Common cold, indigestion	Seeds	LC
	Ferula jaeschkeana Vatke	**Kyet (whole plant) Tunak (seed)**	Lung infection, blood disease (Mukpu), fever, headache, indigestion, jaundice, liver tonic	Seeds	VU
Asteraceae	*Crementhodium ellisii* (Hook. f.) Kitam.	**Rekon**	Diabetes, food poisoning, jaundice	Leaves, flowers	-
	Crepis tenuifolia Babcock & Stebbins	**Tsathi**	Gout, wounds, tonic, diabetes, food poisoning	Shoots	-
	Saussurea bracteata Decne.	**Pangtsidovo**	Cough, throat infection, cold	Shoots	EN
	Taraxacum officinale Wigg.	**Sershen mendok**	Dry throat infection, stomach problems	Shoots	LC
	Waldhemia stoliczkai Ostenf.	**Lukmik (Goat eye)**	Blood pressure, blood disease, diabetes, dysentery, headache	Flowers	-
Boraginaceae	*Arnebia euchroma* Royle ex Benth.	**Khamet, Dimukritsos**	Blood diseases (Mukpu), cancer, ulcer, menorrhagia, hair fall	Roots	EN
Campanulaceae	*Codonopsis clematidea* (Schrenk) Cl.	**Kumic, Lududh Dorje nakpo**	itching, skin diseases, knee joint problems, cancer, blood diseases, intestinal abnormalities	Flowers	-
Crassulaceae	*Rhodiola heterodonta* (Hk. f. &Th.) Boriss.	**Tsolomarpo**	Cold, cough, throat infection	Shoots	VU
Elaeagnaceae	*Hippophae rhamnoides* L.	**Tarkuk**	Cold, scurvy, immune system, fight cancer cells, skin disorders, for healthy liver, digestion, reduce depression, menopause, dry eyes, reduce inflammation	Berries, leaf extract	Lr-Nt
Ephedraceae	*Ephedra gerardiana* Wall. ex. Stapf	**Tsedum**	Gout, respiratory disorder, tiredness	Seeds	EN
Fabaceae	*Pisum sativum* L.	**Tenma Nyonbo**	Kidney, joint problems, blood pressure	Flowers	LC
	Thermopsis inflata Camb.	**Qualwa chhuthup**	Edema, liver and indigestion problems	Flowers, pods, seeds	-
Fumariaceae	*Corydalis govaniana* Wall.	**Tongsil**	Blood disease, cancer, intestinal abnormalities, blood pressure	Flowers, Leaves	-
Gentianaceae	*Gentiana tianschanica* Rupr. ex Kusn.	**Tikta**	Jaundice, other liver-related disorders, liver tonic	Shoots	-
	Gentianella moorcroftiana (Wall. ex. D. Don.) Airy Shaw	**Chaktik**	Jaundice, other liver-related disorders, liver tonic	Shoots	-
	Gentianopsis detonsa (Rottb.) Ma.	**Tikta**	Nausea, cough, fever, headache	Shoots	-
	Gentianopsis paludosa Hook. f.	**Tikta**	Jaundice, other liver-related disorders, liver tonic	Shoots	-

Geraniaceae	*Geranium pratense* L.	**Polomendok**	Lung problems, dysentery, diarrhea, Asthma	Flowers	-
Lamiaceae	*Hyssopus officinale* L.	**Tangu**	Cold, gout, liver-related problems, improve digestion	Shoots	DD
	Nepeta longibracteata Benth.	**Parbatta**	Liver disorders, Jaundice, cold	Flowers, leaves	-
Malvaceae	*Malva pusilla* Sm.	**Champa**	Kidney problems, urinary diseases,	Shoots	-
Onagraceae	*Epilobium angustifolium* L.	**Jashingba**	Abdominal pain	Shoots	-
Orchidaceae	*Dactylorhiza hatagirea* D. Don	**Wangpo lakpa**	Gout, wounds, tonic, dysentery, body internal heat	Roots, Flowers	CR
Plantaginaceae	*Plantago major* Lour.	**Lung-naram**	Diarrhea, dysentery, vomiting	Shoots	LC
Polygonaceae	*Oxyria digyna* (L.) Hill	**Chumtsa**	Gastric, constipation	Shoots	-
Polygonaceae	*Rheum emodi* Wall. ex Meissn.	**Lachu**	Indigestion, abdominal diseases, wounds	Rhizomes, roots	NT
	Rheum moorcroftianum Meissn.	**Dukshu**	Joint pain, skin diseases	Rhizomes, roots	NT
	Rumex dentatus L.	**Shoma**	Gout	Roots	-
	Aconogonum tortuosum D. Don	**Nyalo**	Intestinal problems	Leaves, Flowers	-
	Bistorta affinis (D. Don.) Greene	**Retharam**	Dysentery, ulcer, stomach problems	Shoots	-
Primulaceae	*Primula macrophylla* D. Don	**Kyetche**	Gastric, stomach problems, blood diseases, breast cancer, nausea	Leaves, flowers	-
Ranunculaceae	*Aconitum heterophyllum* Wall.	**Bonkar karpo**	Diabetes, oily food indigestion problems	Shoots	CR
	Aconitum violaceum Jacq. ex Stapf.	**Bonkar nakpo**	Cough, black sputum	Shoots	CR
	Aquilegia fragrans Benth.	**Langdey Kumik, LududhDorje**	Joint pains due to cold, skin diseases, swelling	Flowers	-
	Clematis orientalis L.	**Nyakrail**	Skin related problems mostly applied to animals	Flowers	-
	Delphinium brunonianum Royle	**Jakotpoe**	Diarrhea, fever, gout, other joint problems (in local terms Lum and Chherwa)	Shoots	VU
Rosaceae	*Rosa webbiana* Wall. ex. Royle	**Dukshu**	Headache, earache, nerve pain	Flowers	-
Saxifragaceae	*Bergenia stracheyi* Hook. f. & Thomson.	**Gatikpa**	Edema, contagious diseases, inflammation of lungs, swelling of limbs, menorrhagia	Roots, Flowers	VU
Solanaceae	*Hyoscyamus niger* L.	**Duklang, Langthantse**	toothache, asthma	Seeds	VU
Tamaricaceae	*Myricaria squamosa* Desv.	**Humbu**	Diabetes, food poisoning, menorrhagia	Flowering spikes, young shoots	-

VU: vulnerable, EN: endangered, NT: near Threatened, CR: Critical endangered, Lr-Nt: low risk threatened, LC: Least concern, DD: Data deficient

Table 5. Animal parts used in *Amchi* system.

Animal name	Animal part	Uses	Use form
Bear	Gall bladder	Liver problems	After drying mashed along with other ingredients to form a powder and is taken with lukewarm water as described by Amchies
Deer	Antler	Drying pus	Mashed with other ingredients and taken in the form of powder
Human	Gall bladder and Flesh (only if the death is unnatural) i.e., caused by accident, suicide or war)	Poison, Epilepsy, Blood vomiting, Menorrhagia	After drying mashed with other ingredients and taken in the form of powder
Ibex	Meat	Diarrhea, Jaundice	Soup
Rabbit	Leg, Heart	Blood pressure, psychological problems	Soup
Rhino	Horn	Liver problems	Mashed with other ingredients and taken in the form of powder
Sheep	Gall bladder	Diabetes	After drying mashed with other ingredients and taken in the form of powder
Snow leopard	Tongue	Tongue related diseases	Rub on infected parts
Tiger, leopard	Tongue	Tongue related diseases	Rub on infected parts
Yak	Heart, Gall bladder, Blood	Blood pressure, psychological problems	Dried blood mixed with other components in powder form
Tibetan wooly hare	Meat	Blood pressure, psychological problems	After drying mashed with other ingredients and taken in the form of powder

Prominent health issues treated by *Amchies*

Twenty-seven types of prevalent health issues treated by *Amchies* in Pin Valley are shown in (Figure 3).

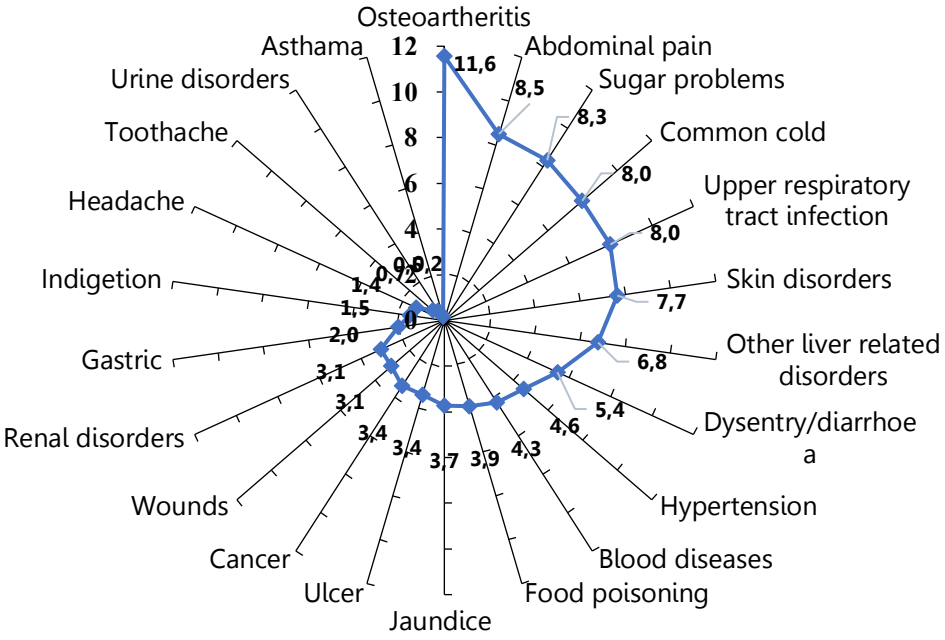

Figure 3. Prevalent health issues treated by *Amchies* in Pin Valley.

As per *Amchi's* report osteoarthritis (11.6%) is the most common ailment followed by Abdominal pain (8.5%), sugar problem (8.3%), and common cold and upper respiratory tract infection (8.0% each). A severe winter climate and poor living standard of locals mostly cause the common cold and upper respiratory tract problems are the general perception of most of the *Amchies*. The problems related to the liver are the other severe health issue in Pin Valley and other regions of Spiti. The diseases like dysentery/diarrhea, respiratory, eye diseases and seasonal injuries varied, and maximum reported during the winter season followed by autumn, spring and minimum cases were reported in summer as per the OPD report of Primary Health Center, Sagnam (2018; Figure 4).

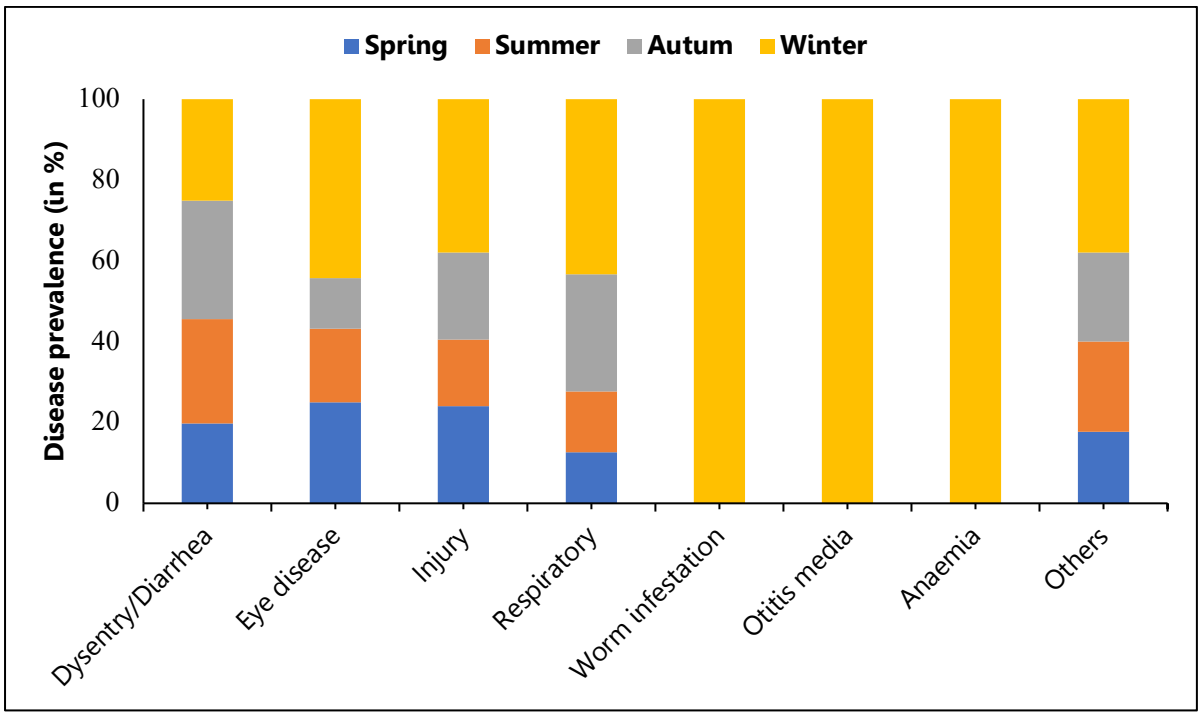

Figure 4. Seasonal diseases prevalence according to the data from Primary Health Care Center Sagnam 2018.

Most health issues were reported during winter due to harsh weather conditions, among them, worm infestation, otitis and anemia cases were reported only in the winter season. Among gender, the prevalence of diseases was similar in men and women across the seasons, while it was drastically higher during the summer season in children (Figure 5). *Amchies* have made a huge contribution to society by curing these diseases since time immemorial. Kala (2003) reported that 60% and 80% of public health in Ladakh and Lahaul-Spiti is looked after by *Amchies*, whereas Angmo *et al.* (2012) reported 30% of public health care is taken by *Amchies* in Ladakh.

Dependency and Factors affecting THCS

The decline in THCS in Pin Valley is attributed to various factors. *Amchies* and local people's perceptions revealed that the decline in *Amchi* practice was due to a lack of income and employment change in occupation and a lack of traditional language knowledge (Figure 6). Before the establishment of modern health care centers, people were entirely dependent on THCS for medicines and treatments, whereas now they are more reliant on modern medicines (63%) than on *Amchi* (17%), and both *Amchi* and modern medicine are used to treat the ailments (20%).

Medicinal plant collection

The collection of medicinal plants lasts for 2-3 months only during the peak growing season and during this period *Amchies* collect medicinal plants from meadows, riverbeds, agriculture fields and nearby agriculture fields. Of the total *Amchies* surveyed, 42% of *Amchies* revealed that they are actively engaged in medicinal plant collection, and the rest 58% only diagnose the patient. Almost 90% of informants revealed that the availability of medicinal plants is becoming less in their habitats as compared to the past. So, they have changed their collection pattern and biennially they collect *ca.* 13.20±2.93 kg (dry weight). However, they collect medicinal plants regularly from agricultural and nearby non-agricultural fields.

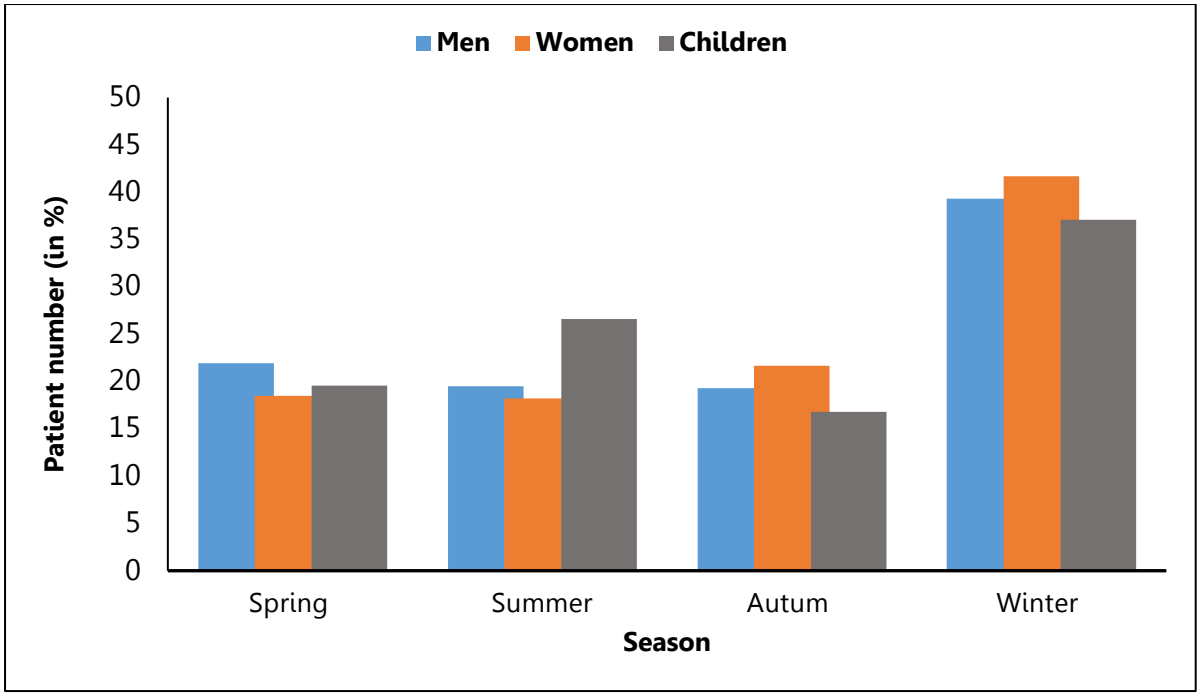

Figure 5. Disease prevalence among Men, Women and Children as per Primary Health Care center Sagnam (Report, 2018).

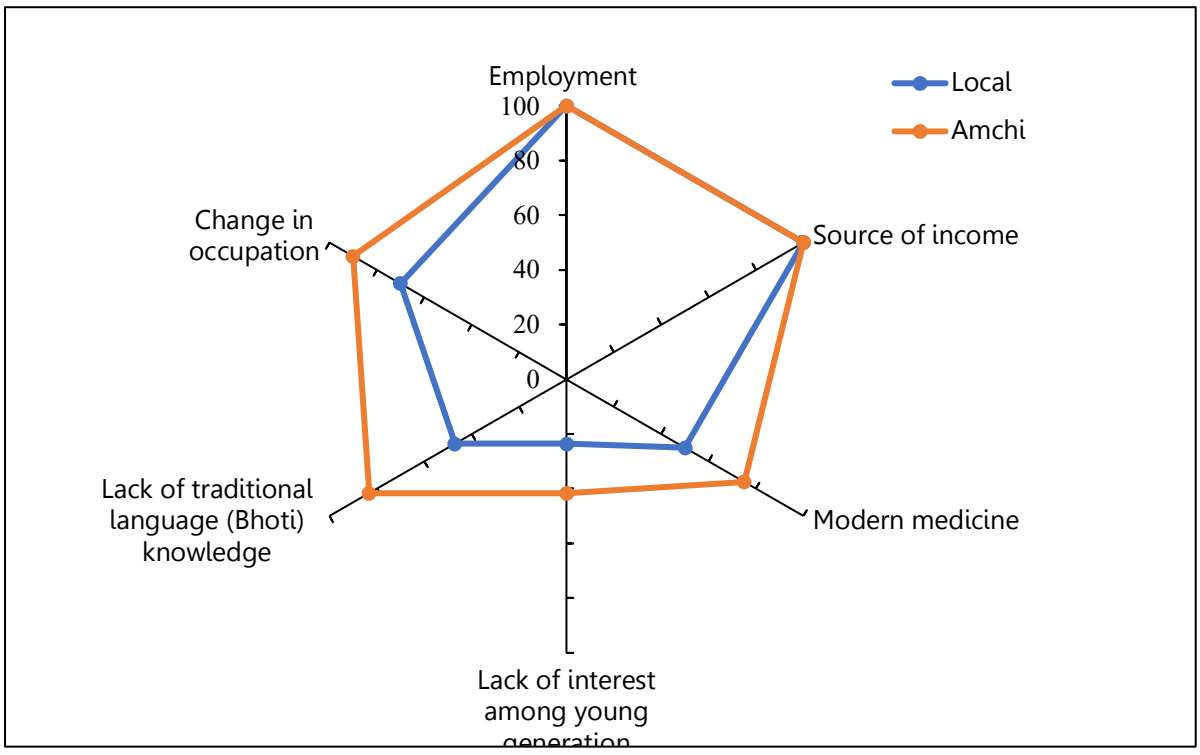

Figure 6. Factors influencing the traditional *Amchi* system.

Threats to habitats

Darbak, Solokyok and Gangnam are the sites most accessed by local *Amchies* for medicinal plant collection from the buffer zone of PVNP. In the entire Spiti valley, two rare and endangered medicinal plant species (*Aconitum violaceum* and *Picrorhiza kurrooa*) were found only in Darbak at 4300 m asl (Kala 1999). The present study revealed that the Darbak is the most accessed and highly grazed area by seasonal migratory livestock (goat and sheep *ca.* 800-1200 and donkey 5-6) during the peak summer season i.e., mid-June to mid-September when vegetation is in its full bloom along with local free-ranging livestock (yaks and horses) only graze there. According to *Amchies*, the medicinal plants growing in the area were impacted by migratory livestock grazing, as responded by saying that

when they visited the area for medicinal plants collection, they could not even identify the plants because the shoot parts had been browsed/grazed by livestock. During our field visit with local *Amchies* for a botanical survey we met with one of the local Nun, who narrated the area 'Six-seven years ago this area was full of medicinal plants' fragrance, but since local villagers started to lend pastures for herders only, livestock smell left instead of medicinal plants' fragrance'. She shared her emotions saying 'whenever she goes there for the collection of medicinal plants, she felt like crying because of overgrazing and the destruction of these habitats. In the present study, *Aconitum violaceum was* found only in this region and very rare in number (6-7 individuals) in an area of *ca.*370-400 m^2. The buffer zone namely Gangnam, Darbak and Solokyok of the NP support very rich, diverse, and critically threatened medicinal plants as compared to the core zone of NP (Table 6). The average density of individual species in the buffer zone was highest for *Bistorta affinis* (3.25±1.71 individuals m^{-2}) and lowest for *Gentianella pludosa* and *Lamium rhomboideum* (0.1±0.1 individuals m^{-2} each), whereas in the core zone highest for *Bistorta affinis* (0.69±0.29 individuals m^{-2}) and the lowest for *Delphinium brunonianum* (0.05±0.07 individuals m^{-2}); Table 6). *Rhodiola tibetica, Nepeta longibracteata, Geranium pretense, Waldhemia stoliczka* and *Bergenia stracheyi* were found in all the sites in the buffer zone, while other species had restricted distribution among sites within the buffer zone. *Amchies* rarely collect medicinal plants from the core zone. But overstocking livestock (goat and sheep) *ca.* 6500-7000 (personal observation) by migratory herders called 'Maalwalas' is a big threat to vulnerable plant species. During the peak growing season, a group of 6 herds invaded the Core zone and grazed it for 2-3 months. *Amchies* perception revealed that the greatest threat to medicinal plants' habitats is decreased snowfall (41%), livestock grazing (35%) and fragmentation of pastureland (24%).

Table 6. The status of medicinal plants in the core and buffer zones of Pin Valley National Park. The conservation status of the medicinal plants was cited from (Kala1999; Kumar et al. 2016, CAMP workshop report 1998; Negi et al. 2018).

Species	**Average density (individuals m-2)**		**Conservation status**
	Core zone	**Buffer Zone**	
Aconitum heterophyllum	-	0.88±0.22	Critically endangered
Aconitum violaceum	-	0.15±0.15	Critically endangered
Aquilegia fragrans	-	0.28±0.02	-
Arnebia euchroma	0.20±0.07	0.15±0.15	Endangered
Bergenia stracheyi	0.11±0.13	0.48±0.12	Vulnerable
Bistorta affinis	0.69±0.29	3.25±1.71	-
Bupleurum falcatum	-	0.15±0.15	Least concern
Codonopsis clematidea	-	0.2±0.2	-
Crementhodium ellisii	-	0.4±0.4	-
Delphinium brunonianum	0.05±0.07	0.9±0.9	-
Epilobium angustifolium	-	0.85±0.33	-
Gentiana tianschanica	-	0.43±0.06	-
Gentianella moorcroftiana	-	0.33±0.06	-
Gentianopsis paludosa	-	0.1±0.1	-
Geranium pratense	0.10±0.08	0.53±0.26	-
Hyssopus officinale	0.52±0.17	0.85±0.37	Data deficient
Lamium rhomboideum	0.29±0.13	0.1±0.1	-
Nepeta longibracteata	0.24±0.11	0.62±0.26	-
Oxyria digyna	-	0.4±0.2	-
Picrorhiza kurroa	-	0.5±0.5	Endangered
Primula macrophylla	-	0.4±0.4	-
Rheum spiciforme	-	0.20±0.20	Vulnerable
Rheum webbianum	0.23±0.08	0.23±0.06	Vulnerable
Rhodiola tibetica	-	0.38±0.06	-
Saussurea bracteata	-	0.43±0.18	Endangered
Taraxacum officinale	-	0.40±0.20	Least concern
Waldhemia stoliczkai	-	0.22±0.02	-

Discussion

Indigenous knowledge of traditional medicine mainly involving the use of natural plant resources still exists and plays a significant role in meeting the primary healthcare needs of the tribal people (Devi *et al.* 2013). It will also strengthen culture by recognizing traditional knowledge of medicinal plants and providing a scientific basis for it (Tantengco *et al.* 2018). The age-old traditional healthcare practices are still relevant and are followed by communities across the countries (Kala 2017). Local communities in western Ladakh are still dependent on various THCS for their health care viz., *Amchis*, *Akhons* and *Shamans* in western Ladakh. Among these three systems, the *Amchi* system or *Sowa-Rigpa* is the most prevalent, ancient, and scientifically based system (Angmo *et al.* 2022). The *Amchis* harvest medicinal herbs and the parts used in the THCS are fully reliant on the natural resources (Kala 2005). The level of knowledge of each *Amchi* was measured based on the number of recorded plants that they knew and the uses of the medicinal plants for different ailments (Namtak 2018, Angmo *et al.* 2022), which has been validated in the current study. Because of the public reliance on THCS in the past, *Amchies* were accorded a high level of respect in their societies. As a result, during the peak season of agriculture work, members of each household assist *Amchies* (Kala 2002). At the state level, most of the hepatitis cases are reported from the Spiti region (Sharma *et al.* 2018). The people in Pin Valley NP are still dependent on traditional medicine due to remoteness and harsh climatic conditions, as the valley is separated from the rest of the world (Kala & Manjrekar 1999). Still, a lot of efforts are needed to explore the possibility of their use in this system of medicine (Chandrasekar & Srivastava 2005). The increased human population, unregulated tourism and heavy livestock grazing are the main causes of habitat deterioration. The lack of interest among the youth in pursuing this profession indicates that the *Sowa-Rigpa* system of medicine is declining as reported by Blaikie (2009) and similarly, the traditional knowledge of the Ayta community is slowly fading away due to modernization and the influence of non-Ayta communities (Tantengco *et al.* 2018).

Poor management, harvesting in the early stage and overexploitation leads to a decline in species richness and abundance (Bishist *et al.* 2022). However, overexploitation, habitat destruction, overgrazing, increasing tourism, environmental degradation, and unsustainable utilization of rare and highly valued medicinal plants from the wild are the major threat to their existence (Devi *et al.* 2013). It has been also noticed that due to the easy availability of modern facilities these valuable rich heritages of knowledge are lost by the inhabitants. As a result, there is an urgent need to preserve this vital knowledge by documenting and validating it at the ground level to ensure its survival (Rathore *et al.* 2019). Similarly, Angmo *et al.* (2022) also reported that the *Amchies* number is rapidly declining due to the knowledge gap among young generations, lack of income, government incentives, education and awareness about the importance of THCS in schools and among local people resulting in the dwindling of the practice, particularly in the lower Indus valley. However, overexploitation, habitat destruction, overgrazing, increasing tourism, environmental degradation, and unsustainable utilization of rare and highly valued medicinal plants from the wild are the major threat to their existence in nearby Kibbar WS (Devi *et al.* 2013). Due to the introduction and spread of conventional healthcare systems, declining interest and acceptance among the younger generation and rampant out-migration of people are the main causes of traditional knowledge decline (Negi *et al.* 2017), which is also happening in Pin Valley NP. Due to the poor socio-economic conditions of *Amchies* in Ladakh, some of them got an allowance from the Government of India to keep the tradition alive (Angmo *et al.* 2022). But in our study, *Amchies* did not get any government incentive because they are not registered with the Government Institutions or if some of them are registered, they do not aware of any Government Schemes. The *Amchi* medical system is communally, culturally and environmentally close to the people in Ladakh and further development of this system could strengthen the healthcare sector of this area (Rather 2015). In 1998, local *Amchies* came together to form the '*Spiti Bhot Amchi Sangh*'; Manjrekar 1998) but the Sangh later became inactive due to the irresponsibility of elected Sangh members (*Amchies* perception). In the history of Pin Valley so far, no women have been involved in this traditional practice (personal observation), the reason may be due to the active involvement of women in agricultural and other household practices in which men are less involved or they are more involved with outside activities for income generation and family care. Whereas, in Ladakh, women are involved in this tradition (Angmo *et al.* 2012). In 1998, there was a total of 55 *Amchies* in the entire Spiti region, of which 25 (45%) were from the Pin Valley only (Kala & Manjrekar 1998). But at present, it has been noticed that their number has sharply declined by almost half (48%) in Pin valley. This shows that if this important traditional health practice will not be sustained and conserved it would vanish by 2050 as per the expected declining trend.

Conclusions

The current study provides comprehensive information on the traditional ethnomedicinal use practices and the status of medicinal plants in PVNP. Traditional healthcare practices are still prevalent in remote rural areas and play an important role in the primary healthcare system. However, despite the existence of such an effective THCS,

gradually the number of practitioners declined due to a lack of income, government job opportunities in this tradition, less interest and acceptance among younger generations, and modernization and availability of allopathic medical facilities. The study recommends promoting and preserving the *Amchi* system and managing the critical habitats of high medicinal value areas in PVNP.

Recommendations

- An effective way to preserve this traditional system is to integrate and involve womenfolk in THCS. The initiation of practicing this system in monastic institutions could be an effective way to preserve this tradition for future vis-to-vis improving the better health care system in the valley. Because the literature followed by the *Amchies* is written in Tibetan literature and the same is being followed in the monastic institutions. Therefore, it will be easier to learn this traditional system, for which Government must provide incentives to local *Amchies* for the promotion of this tradition.
- The endangered medicinal plants like *Aconitum violaceum* and *Picrorhiza kurrooa* in the Darbak area are subject to considerable anthropogenic pressure due to grazing and trampling by migratory livestock. To curb the anthropogenic pressure on natural resources, an appropriate management approach would be required.
- Due to agricultural land expansion and other human activities like an inappropriate road cutting etc., pastureland fragmentation is a severe issue in the Pin Valley, has to be seriously taken up.
- Future research on identifying High Conservation Value (HCV) regions must be done for the conservation of medicinal plant species that are critically endangered.
- To reduce strain on pasturelands and other HCV sites, migratory livestock numbers must be strictly regulated in Pin Valley NP.

Declarations

List of abbreviations: THCS: Traditional Health Care System, PVNP: Pin Valley National Park, KRI: knowledge Richness Index, UV: Use Value.
Ethics approval and consent to participate: All participants provided oral prior informed consent.
Consent for participation: All persons shown in images gave their consent for publication.
Availability of data and materials: Not applicable.
Competing interests: The authors declare that they have no competing interests.
Funding: The study was funded by NATCOM-III project of MoEF & CC, Govt. of India, New Delhi.
Authors contribution: Kalzang Targe: Data collection, formal analysis, writing - original draft, figures and tables preparation. Salvador Lyngdoh: Review and editing. Rainer W. Bussmann: Review and editing. Bhupendra Singh Adhikari: Conceptualization, figures and review.
Declaration of competing interest: The authors declared no potential conflicts of interest.

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Group discussion on climate change and threats to pasturelands with the local community

An interview session with local *Amchi* during field medicinal plants survey

Laying out plots for vegetation sampling

Vegetation survey on rocky habitat

Plate 1. Discussion on climate change and threats to pasturelands' with local community

Local livestock (Yak) grazing during peak growth of vegetation

Fodder collection by local people

Migratory herders (Maalwala) livestock grazing

Endangered medicinal plants collected by *Amchies*

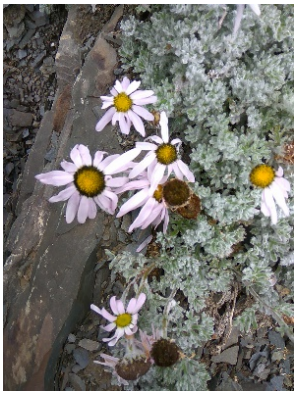
Plate 2 Different types of anthropogenic pressure on medicinal plants' rich habitats

Gentiana tianschanica

Gentianella moorcroftiana

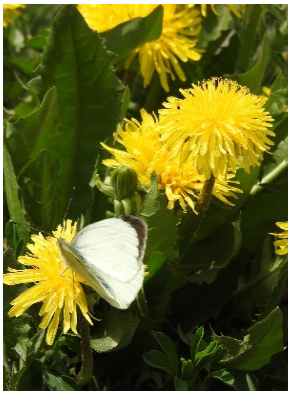
Aquilegia fragrans

Crementhodium ellisii



Waldhemia stoliczkai

Rheum spiciforme



Taraxacum officinale

Saussurea bracteata

Aconitum heterophyllum

Ferula jaeschkeana

Pedicularis bicornuta

Codonopsis clematidea

Plate 3. Important medicinal plants used in THCS by *Amchies* in Pin Valley National Park

Annexure I: Questionnaire survey in Pin Valley National Park

Village..... G.P ..... G.P.S ..... Name.....
Age..... M/F.....
APL/BPL/IRDP..... Occupation..... Annual income..... Family size.....
Total Household.....
Total Population.....

Other sources of income:
Livestock..... Agriculture.....
Respondent's family details:

Sr. No	Name	Age	Sex	Education	Relation pattern	Designation	Annual income
Total family members							

Livestock details:

Species	Goat	Sheep	Dzo	Dzomo	Horse	Donkey	Yak	Other	Remark
Self									
Village									

Amchi medical system

Name..... Age..... M/F..... APL/BPL/IRDP.....
Village.....G.P..... GPS.....
Occupation..... Annual income.....
Table-Medicinal plants used in the traditional healthcare system

Sr. No.	Disease type	Plant used	Part used (Stem, root, leaf, seed)	Collection method	Use method	Conservation status of plant	Harvesting time & season	Habitat and Threats
1								
2								
3								

Table-Animal body parts used in the traditional healthcare system

Sr. No.	Animal name	Animal status: slain or deceased	Body part used	Use method	Disease type
1					
2					
3					

Appendix II: Local people's attitude/perception

1. Do you go to higher meadows for medicinal plants collection (Y/N) If yes, distance from the village (in km) and name of the area.....
2. What are the problems/threats to medicinal plant-rich alpine meadows for their sustainable growth?
   (A) Human disturbance
   (B) Pasture Degradation
   (C) Livestock grazing
   (D) Climate change

3. Area used for livestock grazing (name) .....
4. Do you select pasture in rotation for livestock herding? (Y/N) If not, did you see any intensive grazing impact on pasture?
   Comment.....
5. How much livestock is taken to the pasture where medicinal plants are found?

Livestock	Yak	Horse	Dzomo/Dzo	Donkey	Goat	Sheep	Others	Remark
Self								
Village								

6. Annual livestock grazing (in month)
.....

7. Do migratory herders come to your village? (Y/N), if yes, how many herds and for how long?
.....

8. Name of pastures where they herd their livestock?
.....

9. Is there any effect on vegetation by migratory livestock herding? If, yes explain.
.....

10. Do you or your villagers lend pasture to migratory herders? (Y/N) If yes, how many pastures?
.....

11. Is there any change in meadows/pastures in the last (1-2) decade? If yes reason?
.....