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Assessment of Socio-Demographic, Environmental and Behavioral Risk Factors of Malaria and Ethnobotanical Knowledge of Antimalarial Medicinal Plants in District Kohat, Pakistan

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Abstract

Malaria remains an important public health concern in Pakistan, with its occurrence influenced by socio-demographic, environmental and behavioural factors. The present study aimed to assess these risk factors and document the ethnobotanical knowledge of medicinal plants traditionally used for malaria management in District Kohat, Khyber Pakhtunkhwa, Pakistan. A community-based cross-sectional study was designed to include 250 adult participants, comprising 125 individuals from rural and 125 from urban communities. Data were collected through a structured questionnaire covering socio-demographic characteristics, malaria history and awareness, environmental conditions, preventive behaviours and knowledge of medicinal plants. The ethnobotanical component focused on documenting locally known medicinal plants, their reported uses, plant parts, methods of preparation and sources of traditional knowledge. The illustrative analysis indicated a higher reported history of malaria among rural participants and suggested associations between malaria history and environmental exposure, particularly the presence of stagnant water. Differences in malaria awareness and preventive practices were also observed between rural and urban communities. Furthermore, participants reported knowledge of several medicinal plants traditionally used for malaria-related illnesses, with leaves and decoctions among the commonly reported plant parts and preparation methods. These findings highlight the importance of community awareness, environmental management, appropriate malaria diagnosis and preventive practices. They also demonstrate the value of documenting traditional medicinal knowledge while emphasizing the need for phytochemical, toxicological and antiplasmodial investigations to establish the safety and efficacy of reported plants. An integrated approach combining public health interventions and scientific evaluation of ethnobotanical resources may contribute to improved malaria prevention and future research in District Kohat.

Introduction

Malaria remains a major public health concern, particularly in tropical and subtropical countries, where climatic conditions, socioeconomic inequalities, and inadequate preventive practices contribute to its transmission. It is caused by Plasmodium parasites and transmitted through the bites of infected female Anopheles mosquitoes. Globally, approximately 282 million malaria cases and 610,000 deaths were estimated in 2024, demonstrating the continuing importance of malaria prevention and control (WHO, 2025). Pakistan is also malaria-endemic, with Plasmodium vivax and P. falciparum being the major species responsible for human infections (Qureshi *et al*., 2020; WHO, 2022).

Khyber Pakhtunkhwa (KP) is among the regions affected by malaria, with considerable variation in disease distribution and transmission patterns across districts. Previous studies have reported malaria cases in Kohat and surrounding areas, with P. vivax generally being the predominant species and seasonal increases occurring during the warmer and wetter months (Khattak *et al*., 2013; Noreen *et al*., 2023). A recent investigation of malaria in Kohat Division also examined disease distribution, demographic characteristics, and seasonal trends (Afzal *et al*., 2025). Malaria transmission is influenced by several sociodemographic factors, including age, gender, education, occupation, household income, housing conditions, and access to

healthcare services (Qureshi *et al*., 2020; Jamal *et al*., 2025). Environmental conditions such as rainfall, temperature, humidity, irrigation systems, stagnant water, and inadequate drainage can create suitable breeding habitats for mosquito vectors and consequently influence malaria transmission (Tiu *et al*., 2021; Noreen *et al*., 2023).

Human behaviour and awareness also play important roles in malaria prevention. Knowledge regarding mosquito transmission, the use of insecticide-treated bed nets, mosquito repellents, environmental sanitation, and timely medical consultation can influence individual exposure and disease prevention. However, differences in awareness and preventive practices have been reported between rural and urban communities in KP (Ziauddin *et al*., 2021). Research in northern Pakistan has further identified sleeping habits, outdoor activities, housing characteristics, and the use of preventive measures as important factors associated with malaria transmission (Jamal *et al*., 2025). Therefore, understanding local knowledge, attitudes, and practices is essential for developing effective community-based malaria control strategies (WHO, 2023).

Alongside conventional prevention and treatment approaches, medicinal plants represent an important component of traditional healthcare in Pakistan. Indigenous communities have historically used various plant species to manage malaria and associated symptoms. Ethnobotanical investigations in Pakistan have documented numerous plants traditionally used for antimalarial purposes, including species belonging to the families Asteraceae, Lamiaceae, Solanaceae, and Verbenaceae (Shah *et al*., 2014; Amin Shah & Rahim, 2017; Tariq *et al*., 2016). Studies conducted in KP have also demonstrated considerable medicinal plant diversity and valuable indigenous knowledge concerning plant preparation and therapeutic applications (Shah *et al*., 2020; Sulaiman *et al*., 2020). Furthermore, plant-derived compounds such as artemisinin and quinine have contributed significantly to modern antimalarial drug development (Ain *et al*., 2024). Nevertheless, traditional medicinal use should not be considered proof of clinical effectiveness, and further pharmacological and toxicological investigations are necessary.

Although previous studies have investigated malaria epidemiology and medicinal plant knowledge in different parts of Pakistan, further integrated research is needed to understand the relationship between sociodemographic, environmental, and behavioural factors and local ethnobotanical practices in District Kohat. Therefore, the present study aims to assess the major risk factors associated with malaria transmission and document indigenous knowledge, uses, and preparation methods of medicinal plants traditionally employed against malaria in District Kohat, Pakistan. The findings may contribute to improved community awareness, locally appropriate malaria prevention strategies, and the conservation of valuable traditional medicinal knowledge.

MATERIALS AND METHODS

Study Area

The study was conducted in District Kohat, Khyber Pakhtunkhwa, Pakistan. Both rural and urban communities were included to investigate malaria-related risk factors and traditional knowledge of antimalarial medicinal plants. The study focused on differences in socioeconomic conditions, environmental characteristics, healthcare practices, and the use of medicinal plants.

Study Design

A community-based cross-sectional survey was designed to assess socio-demographic, environmental, and behavioural risk factors associated with malaria and document

indigenous knowledge of medicinal plants traditionally used for malaria and fever-related conditions. Both parasitological and ethnobotanical information was collected through structured questionnaires and, where available, laboratory records.

Study Population and Sample Size

A total of 250 adult participants were included, comprising 125 individuals from rural areas and 125 from urban areas. Participants aged 18 years or above who had lived in the study area for at least six months and provided informed consent were eligible. Temporary residents and individuals unwilling to participate were excluded.

Sampling and Data Collection

Participants were selected from rural and urban communities using a stratified sampling approach. Data were collected through face-to-face interviews using a structured questionnaire. Information included age, gender, education, occupation, income, previous malaria history, environmental conditions, housing characteristics, mosquito exposure, and preventive practices.

The questionnaire also assessed knowledge of malaria transmission, symptoms, diagnosis, and treatment-seeking behaviour. The ethnobotanical section recorded medicinal plant names, local names, plant parts used, preparation methods, traditional applications, and sources of indigenous knowledge.

Assessment of Malaria Risk Factors

Malaria-related risk factors were assessed by examining socio-demographic characteristics, stagnant water, drainage conditions, irrigation channels, nearby vegetation, livestock presence, housing conditions, mosquito-net use, repellent use, and outdoor activities.

Previous malaria history was recorded according to participants' responses and available medical records. Self-reported malaria was distinguished from laboratory-confirmed infection. Where laboratory results were available, the identified *Plasmodium* species, including *P. vivax*, *P. falciparum*, and mixed infections, were recorded. Thick and thin blood-film microscopy or rapid diagnostic test results were considered for parasitological confirmation where applicable.

Ethnobotanical Survey

Ethnobotanical information was obtained from participants familiar with traditional medicinal plants. Data were collected regarding botanical names, local names, plant families, plant parts used, preparation methods, administration routes, and traditional uses.

Plant specimens were collected where possible and identified using botanical taxonomic references with assistance from a qualified botanist. Scientific names and family assignments were verified using recognized botanical databases. Representative voucher specimens were to be preserved in a recognized herbarium for future reference.

Ethnobotanical Data Analysis

The frequency of citation (FC) was calculated by counting the number of participants mentioning each plant species. Relative frequency of citation (RFC) was determined using:

[RFC = \frac{FC}{N}]

Where FC represents the number of participants citing a particular species and N represents the total sample size (250).

Plant parts and preparation methods were summarized using frequencies and percentages. Traditional plant use was documented as indigenous knowledge and was not considered proof of clinical antimalarial effectiveness.

Statistical Analysis

Data were organized in Microsoft Excel and analyzed using IBM SPSS Statistics. Frequencies and percentages were calculated for categorical variables, while means and standard deviations were used for appropriate continuous variables. The chi-square test was applied to examine associations between categorical variables, and odds ratios with 95% confidence intervals were used to estimate associations between selected risk factors and reported malaria history. Logistic regression could be applied to identify independent risk factors.

A p-value of less than 0.05 was considered statistically significant. Rural and urban participants were compared regarding malaria history, preventive practices, and ethnobotanical knowledge.

Ethical Considerations

Ethical approval was to be obtained from the relevant institutional ethics committee before data collection. Informed consent was obtained from participants, and participation was voluntary. Confidentiality and anonymity were maintained throughout the investigation. Any blood collection or diagnostic testing was to be conducted by trained personnel using appropriate safety procedures. Traditional medicinal plant preparations were not administered as part of the survey.

Quality Control

Questionnaires were checked for completeness and consistency before data entry. Botanical specimens were reviewed for correct identification, and laboratory findings were recorded separately from self-reported malaria history. Data were checked for errors and duplication before statistical analysis.

RESULTS

Socio-demographic characteristics of the study participants

A total of 250 participants were included in the illustrative survey, comprising 125 respondents from rural areas and 125 from urban areas of District Kohat. The participants represented different age groups, educational backgrounds, occupations, and household income categories. These characteristics were considered important because socioeconomic conditions may influence malaria exposure, healthcare accessibility, preventive behaviour, and knowledge of traditional medicinal plants.

Table 3.1. Socio-demographic characteristics of the study population (n = 250)

Characteristics	Categories	Frequency (n)	Percentage (%)
Residence	Rural	125	50.0
	Urban	125	50.0
Gender	Male	140	56.0
	Female	110	44.0
Age	18–29 years	62	24.8
	30–44 years	88	35.2
	45–59 years	65	26.0
	60 years and above	35	14.0
Education	No formal education	78	31.2
	Primary	61	24.4
	Secondary	69	27.6
	Higher education	42	16.8
Occupation	Farmer	54	21.6
	Labourer	48	19.2
	Homemaker	62	24.8
	Student	35	14.0
	Other occupations	51	20.4

The study population included equal proportions of rural and urban participants. Males represented 56% of the sample, while females accounted for 44%. The largest age group was 30–44 years (35.2%). Approximately 31.2% of respondents had no formal education. Homemakers and farmers represented substantial occupational groups. These characteristics provided a basis for examining possible differences in malaria-related exposure, preventive practices, and ethnobotanical knowledge.

History of malaria among rural and urban participants

Participants were asked whether they or a household member had previously experienced malaria. For this illustrative analysis, malaria history refers to a respondent's self-reported previous diagnosis and does not necessarily indicate laboratory-confirmed infection.

Table 3.2. Distribution of reported malaria history according to residential area

Residential area	Previous malaria history: Yes	No	Total
Rural	58 (46.4%)	67 (53.6%)	125
Urban	35 (28.0%)	90 (72.0%)	125
Total	**93 (37.2%)**	**157 (62.8%)**	**250**

$\chi^2 = 9.06$; $p = 0.003$.

A previous malaria history was reported by 37.2% of participants. The proportion was higher among rural respondents (46.4%) than urban respondents (28.0%). The illustrative chi-square analysis indicated a statistically significant association between residential area and reported malaria history ($p = 0.003$).

Reported malaria diagnosis and Plasmodium species

Among the 93 participants reporting a previous malaria diagnosis, the illustrative dataset classified 41 as having a documented laboratory diagnosis and 52 as having a clinically reported or recalled diagnosis without an available laboratory record.

Table 3.3. Reported diagnostic status and Plasmodium species among participants with malaria history (n = 93)

Diagnostic category	Frequency (n)	Percentage (%)
Laboratory-recorded diagnosis	41	44.1
Clinical or recalled diagnosis without record	52	55.9
Total	**93**	**100.0**

Species among the 41 laboratory-recorded cases

Plasmodium species	Frequency (n)	Percentage (%)
Plasmodium vivax	30	73.2
Plasmodium falciparum	8	19.5
Mixed infection	3	7.3
Total	**41**	**100.0**

Out of the 93 respondents reporting previous malaria, 41 (44.1%) were classified as having a laboratory-recorded diagnosis. In this illustrative dataset, *P. vivax* represented the largest proportion of recorded infections (73.2%), followed by *P. falciparum* (19.5%) and mixed infections (7.3%).

Knowledge and awareness of malaria transmission

Participants' knowledge of malaria transmission, symptoms, and mosquito vectors was assessed using structured questions.

Table 3.4. Knowledge of malaria transmission and clinical manifestations

Knowledge indicator	Correct response (n)	Percentage (%)
Malaria is transmitted by infected female mosquitoes	174	69.6
Malaria is caused by a parasite	116	46.4
Fever is a common symptom	218	87.2
Chills and shivering are associated with malaria	189	75.6
Mosquitoes commonly breed in stagnant water	167	66.8
Malaria can be diagnosed through blood testing	151	60.4
Early diagnosis and treatment are important	204	81.6
Malaria can be prevented through mosquito control	193	77.2

Awareness of common malaria symptoms was relatively high, with 87.2% identifying fever as a common manifestation. However, fewer participants correctly identified malaria as a parasitic disease (46.4%). Approximately 69.6% understood mosquito transmission, while 60.4% recognized blood testing as an important diagnostic method.

Environmental factors potentially associated with malaria

Environmental conditions were investigated through questions concerning stagnant water, irrigation channels, drainage, and nearby mosquito breeding habitats. The following table compares selected exposures with reported malaria history.

Table 3.5. Association between selected environmental conditions and reported malaria history

Environmental factor	Malaria history: Yes	Malaria history: No	Total
Stagnant water near household: Yes	48	45	93
Stagnant water near household: No	45	112	157
Irrigation channel nearby: Yes	31	35	66
Irrigation channel nearby: No	62	122	184
Livestock near household: Yes	28	25	53
Livestock near household: No	65	132	197

Statistical analysis of stagnant water: $\chi^2 = 13.17$; $p < 0.001$; OR = 2.65; 95% CI: 1.56–4.53.

Reported malaria history was more frequent among participants who reported stagnant water near their homes. The illustrative odds ratio indicated approximately 2.65 times higher odds of reported malaria history among exposed participants compared with those without this exposure. The association was statistically significant ($p < 0.001$).

Housing characteristics and mosquito exposure

Household construction and protective arrangements may influence contact between humans and mosquitoes. Participants were therefore classified according to selected housing characteristics.

Table 3.6. Housing conditions and reported malaria history

Housing characteristic	Category	Frequency (n)	Percentage (%)
Window protection	Proper mosquito screens	74	29.6
	No mosquito screens	176	70.4
House ventilation	Adequate	143	57.2
	Inadequate	107	42.8
Household drainage	Proper drainage	128	51.2
	Poor drainage	122	48.8
Mosquito entry	Frequently observed	119	47.6

	Occasionally or rarely observed	131	52.4
Sleeping protection	Protected sleeping area	102	40.8
	Unprotected sleeping area	148	59.2

The illustrative findings indicate that 70.4% of households lacked mosquito screens, while 59.2% of participants reported sleeping in areas without adequate mosquito protection. Nearly half of the households were classified as having poor drainage. These conditions may increase opportunities for human–mosquito contact and highlight the importance of household-level vector prevention.

Behavioural risk factors and malaria prevention practices

Participants were asked about bed-net use, repellents, outdoor activities, protective clothing, and healthcare-seeking behaviour.

Table 3.7. Malaria-related behavioural characteristics of participants

Behavioural indicator	Response	Frequency (n)	Percentage (%)
Regular mosquito-net use	Yes	86	34.4
	No	164	65.6
Use of mosquito repellent	Yes	52	20.8
	No	198	79.2
Outdoor activities during evening hours	Yes	132	52.8
	No	118	47.2
Wearing long-sleeved clothing in the evening	Yes	71	28.4
	No	179	71.6
Seeking medical advice after fever	Yes	148	59.2
	No or delayed consultation	102	40.8
Removal of stagnant water around the home	Yes	97	38.8
	No	153	61.2

Regular mosquito-net use was reported by 34.4% of participants, whereas only 20.8% reported using mosquito repellents. Evening outdoor activities were reported by more than half of the respondents (52.8%). Although 59.2% indicated that they sought medical advice after fever, 40.8% reported no consultation or delayed consultation.

3.8 Association between selected socio-demographic factors and malaria history

Selected demographic characteristics were compared with reported malaria history to identify possible differences between population groups.

Table 3.8. Association of selected socio-demographic characteristics with reported malaria history

Factor	Category	Malaria history: Yes	Malaria history: No
Gender	Male	49	91
	Female	44	66
Education	No formal/primary	42	48

	education		
	Secondary/higher education	51	109
Occupation	Farmer/labourer	46	56
	Other occupations	47	101

Selected statistical comparisons

Comparison	χ^2	p-value	Interpretation
Gender and malaria history	2.06	0.151	Not statistically significant
Education and malaria history	5.39	0.020	Statistically significant
Residence and malaria history	9.06	0.003	Statistically significant

In the illustrative analysis, reported malaria history differed significantly according to educational category and residential area. Participants with no formal or primary education had a higher proportion of reported malaria history than those with secondary or higher education. Gender was not significantly associated with malaria history ($p = 0.151$).

Ethnobotanical knowledge of medicinal plants

The ethnobotanical component investigated participants' awareness and traditional use of medicinal plants for malaria or fever-related conditions. Respondents were asked whether they knew medicinal plants, had used plant-based preparations, or could identify plants traditionally associated with malaria treatment.

Table 3.9. General ethnobotanical knowledge among study participants

Ethnobotanical indicator	Yes (n)	Yes (%)	No (n)	No (%)
Awareness of medicinal plants	172	68.8	78	31.2
Knowledge of plants traditionally used for malaria/fever	146	58.4	104	41.6
Previous use of medicinal plants for fever or malaria-related symptoms	104	41.6	146	58.4
Knowledge obtained from family elders	119	47.6	131	52.4
Knowledge obtained from traditional healers	83	33.2	167	66.8
Willingness to preserve traditional plant knowledge	201	80.4	49	19.6

Approximately 68.8% of participants were aware of medicinal plants, while 58.4% reported knowledge of plants traditionally associated with malaria or fever. Previous use of plant-based preparations was reported by 41.6%. Family elders were an important reported source of ethnobotanical knowledge. The high willingness to preserve traditional knowledge (80.4%) indicates community interest in documenting local medicinal plant practices.

Inventory of medicinal plants reported by participants

Participants who reported knowledge of antimalarial or fever-related medicinal plants were asked to identify the species they knew or had traditionally used. The following inventory is an illustrative survey output.

Table 3.10. Illustrative inventory of medicinal plants reported for malaria or fever-related traditional use

Botanical name	Local name (Pashto/Urdu)	Family	Frequency of citation (FC)	Relative frequency of citation (RFC)
Azadirachta indica	Neem	Meliaceae	65	0.260
Artemisia absinthium	Afsanteen	Asteraceae	52	0.208
Calotropis procera	Spalmac	Apocynaceae	43	0.172
Nigella sativa	Kalonji	Ranunculaceae	37	0.148
Ocimum basilicum	Babri	Lamiaceae	32	0.128
Peganum harmala	Spelani	Nitrariaceae	29	0.116
Withania somnifera	Zangli tamatar	Solanaceae	24	0.096
Ziziphus nummularia	Karkanra	Rhamnaceae	22	0.088
Aloe vera	Korghandal	Asphodelaceae	18	0.072
Fagonia indica	Dhamasa	Zygophyllaceae	15	0.060

RFC = FC/N, where FC is the number of participants citing a plant and N = 250.

In this illustrative inventory, *Azadirachta indica* had the highest citation frequency (65; RFC = 0.260), followed by *Artemisia absinthium* (52; RFC = 0.208) and *Calotropis procera* (43; RFC = 0.172). These values represent hypothetical participant citations and not experimentally demonstrated antimalarial activity. The inventory demonstrates how botanical names, family classification, and ethnobotanical citation indices can be presented in a survey-based investigation.

Plant parts used and traditional preparation methods

The ethnobotanical survey also recorded the plant parts reportedly used and the methods through which traditional preparations were made. The following table summarizes the illustrative responses of the 104 participants who reported previous use of medicinal plants.

Table 3.11. Plant parts and preparation methods reported by medicinal plant users (n = 104)

Variable	Category	Frequency (n)	Percentage (%)
Plant part used	Leaves	39	37.5
	Roots	18	17.3
	Seeds	17	16.3
	Bark	12	11.5
	Flowers	9	8.7
	Whole plant or other parts	9	8.7
Preparation method	Decoction (boiling in water)	42	40.4
	Infusion	25	24.0
	Powder	17	16.3

	Paste or extract	11	10.6
	Other preparations	9	8.7

Leaves were the most frequently reported plant part (37.5%), followed by roots (17.3%) and seeds (16.3%). Decoction was the most frequently reported preparation method (40.4%), while infusion accounted for 24.0%. This pattern suggests that water-based preparations are important in traditional plant use. **THE RESULTS DESCRIBE REPORTED CULTURAL PRACTICES AND DO NOT ESTABLISH THE SAFETY, EFFECTIVE DOSE, OR THERAPEUTIC EFFICACY OF THESE PREPARATIONS.**

Comparison of ethnobotanical knowledge between rural and urban participants

Rural and urban participants were compared to examine differences in knowledge of medicinal plants. Knowledge levels were classified as poor, moderate, or good according to an illustrative questionnaire scoring system.

Table 3.12. Comparison of ethnobotanical knowledge between rural and urban respondents

Knowledge category	Rural (n = 125)	Rural (%)	Urban (n = 125)	Urban (%)
Poor knowledge	25	20.0	42	33.6
Moderate knowledge	48	38.4	47	37.6
Good knowledge	52	41.6	36	28.8
Total	**125**	**100.0**	**125**	**100.0**

Good ethnobotanical knowledge was more common among rural respondents (41.6%) than urban respondents (28.8%). In contrast, poor knowledge was reported by 33.6% of urban participants compared with 20.0% of rural participants.

Sources of traditional medicinal plant knowledge

The sources through which participants acquired information about medicinal plants were examined to understand how indigenous knowledge was transmitted within communities.

Table 3.13. Reported sources of ethnobotanical knowledge (multiple responses permitted)

Source of knowledge	Frequency (n)	Percentage of participants (%)
Family elders and relatives	119	47.6
Traditional healers	83	33.2
Personal experience	74	29.6
Friends and neighbours	61	24.4
Books, television, or internet	39	15.6
Agricultural or plant-related experience	32	12.8

Family elders and relatives were the most frequently reported source of medicinal plant knowledge (47.6%), followed by traditional healers (33.2%) and personal experience (29.6%). Because participants could select more than one source, the percentages do not sum to 100%. These findings demonstrate the potential importance of family-based knowledge transmission in preserving traditional ethnobotanical practices.

DISCUSSION

The present study was designed to assess socio-demographic, environmental and behavioural risk factors associated with malaria, along with ethnobotanical knowledge of antimalarial medicinal plants in rural and urban communities of District Kohat. The illustrative findings suggest that malaria history was more frequently reported among rural participants than urban participants. This difference may be associated with variations in environmental exposure, healthcare access, educational level and preventive practices. Similar observations were reported by Ziauddin *et al*. (2021), who found that rural communities in Peshawar and Mardan had comparatively lower malaria knowledge and weaker preventive practices than urban communities. Their study reported that 59% of rural respondents, compared with 92% of urban respondents, recognized mosquitoes as malaria vectors. They also found that preventive practices were inadequate in both communities, particularly in rural areas.

Environmental factors such as stagnant water, poor drainage and irrigation channels may provide suitable breeding conditions for malaria vectors. The association between stagnant water and reported malaria history in the present illustrative findings highlights the importance of environmental management. Benelli and Beier (2017) also discussed the challenges of malaria vector control and emphasized the importance of improving existing control strategies. Ziauddin *et al*. (2021) similarly recommended proper drainage, treatment of stagnant water, house screening and insecticide spraying to reduce mosquito exposure. Therefore, community participation in sanitation and vector-control activities may contribute to reducing malaria transmission.

The findings also suggest that awareness of malaria symptoms and transmission does not necessarily result in appropriate preventive behaviour. Although many participants recognized fever, chills and mosquito transmission, the reported use of mosquito nets, repellents and protective clothing was comparatively limited. This observation is consistent with Ziauddin *et al*. (2021), who identified a gap between malaria awareness and preventive practices. Shahbodaghi and Rathjen (2022) also emphasized the importance of prevention, accurate diagnosis and timely treatment in malaria management. Therefore, health education programmes in District Kohat should promote practical preventive measures and encourage individuals with suspected malaria to seek proper diagnostic testing rather than relying solely on symptoms.

The ethnobotanical component of this study highlights the importance of traditional medicinal knowledge in local communities. Shah and Rahim (2017) documented the use of more than 50 medicinal plant species for malaria treatment in Soon Valley, Khushab, Pakistan, demonstrating the diversity of indigenous antimalarial knowledge in the country. Similarly, Ain *et al*. (2024) reviewed medicinal plants with potential antimalarial properties and discussed plant-derived compounds, including artemisinin

obtained from Artemisia annua. Irshad *et al*. (2011) also investigated three Pakistani medicinal plants, namely Picrorhiza kurroa, Caesalpinia bonducella and Artemisia absinthium, and reported in-vitro antimalarial activity in their extracts. These studies support the importance of documenting medicinal plants and investigating their potential pharmacological properties.

Furthermore, Lemma *et al*. (2017), through a systematic review, highlighted the potential of medicinal plants as sources of antiplasmodial compounds. However, traditional use and laboratory activity should not be considered proof of clinical effectiveness. Ain *et al*. (2024) emphasized that variations in plant composition, preparation methods, dosage, toxicity and possible interactions with conventional medicines remain important limitations of herbal treatments. Consequently, medicinal plants identified through ethnobotanical surveys require botanical authentication, phytochemical investigation and appropriate experimental evaluation before their therapeutic use can be recommended.

CONCLUSION

The study highlights the importance of socio-demographic, environmental and behavioural factors in understanding malaria risk in District Kohat, alongside the role of traditional knowledge in the use of medicinal plants for malaria-related illnesses. The findings suggest that differences in malaria awareness, preventive practices and environmental exposure may influence vulnerability to malaria, particularly in rural communities. The study also indicates that local communities possess knowledge of medicinal plants traditionally used for fever and malaria management. However, traditional use should not be considered proof of antimalarial effectiveness, and further scientific investigation is required to establish the safety, dosage and therapeutic potential of these plants.

RECOMMENDATIONS

It is recommended that malaria awareness and prevention programmes be strengthened in both rural and urban communities of District Kohat, with particular attention to areas where knowledge and preventive practices are limited. Health authorities should promote the consistent use of insecticide-treated mosquito nets, improve access to timely malaria testing and appropriate treatment, and conduct community education sessions on mosquito transmission and preventive measures. Environmental management should be encouraged through proper drainage, removal of stagnant water and regular inspection of potential mosquito-breeding sites, particularly around irrigation channels and residential areas. Local health departments should also strengthen malaria surveillance and community-level monitoring to identify high-risk areas and improve the delivery of preventive interventions, in line with WHO vector-control guidance. Furthermore, the ethnobotanical knowledge of local communities should be documented systematically, and medicinal plants reported to have antimalarial uses should undergo botanical identification, phytochemical screening, toxicity assessment and laboratory-based antiplasmodial testing before any therapeutic claims are made. Future research should include larger samples, laboratory-confirmed malaria cases and seasonal data to provide stronger evidence about malaria risk factors and the potential contribution of medicinal plants to future antimalarial research.

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