Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Malaria and Malarial Vaccine; Knowledge, Attitude, and Practices Among General Population in Pakistan

Waleed Tariq
Mayo Hospital
Muhammad Fazal
Primary and Secondary Healthcare Department
Rida Zahra
Lady Atchison Hospital
Hashaam Jamil
Pakistan Kidney and Liver Institute and Research Centre
Muhammad Saqlain
Quaid-I-Azam University
Alyaa Hussein Khaleel
NMC Royal Hospital
Muhammad Junaid Tahir
Shaukat Khanum Memorial Hospital and Research Centre
Kaleem Ullah
Jeelani Institute of Medical Sciences
Mahwish Ejaz
University of Lahore
Mohammed Mahmmoud Fadelallah Eljack
m.mahmmoud96@gmail.com

University of Bakht Alruda
Ali Ahmed
University of California San Diego

Research Article

Keywords: Malaria, Malaria vaccine, RTS, S/AS01, General population, Attitude, Prevention, Willingness

Posted Date: August 14th, 2025

DOI: https://doi.org/10.21203/rs.3.rs-7236184/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Introduction:

Malaria is a significant health problem in many tropical and subtropical countries. It represents a significant economic and health burden in malaria-endemic areas. WHO-approved RTS S, AS01, a pre-erythrocyte malaria vaccine, has a significant protective role in preventing transmission in moderate to high-risk regions. This study aims to assess knowledge, attitudes, and practices regarding malaria and its prevention, as well as public awareness, perception, and acceptance of the malarial vaccine.

Methods

A community-based cross-sectional study was conducted in the general population of Pakistan. A questionnaire was developed to collect data about socio-demographic characteristics, knowledge regarding malaria, attitude towards malaria prevention and care-seeking behavior, and awareness and willingness to accept the RTS, S/AS01 malaria vaccine. Univariate and multivariate logistic regression analyses were conducted to assess the association of demographic variables with the knowledge.

Results

A total of 996 participants were included, with 61.8% being male and 52.6% residing in rural areas. While 72.5% recognized malaria as a preventable disease, only 39.6% correctly identified the parasite as the causative agent. Awareness of symptoms, complications, and preventive measures was moderate. Less than half (47.0%) knew about the malaria vaccine, and only 8.2% were aware that it is recommended for children under five. Preventive practices were widely adopted, with 78.9% using mosquito nets, 81.1% applying repellents, and 84.1% removing stagnant water. Most participants (80.5%) perceived malaria as a serious disease, and 58.9% believed treatment to be effective. Willingness to vaccinate was moderate (59.2%), with 40.3% expressing concerns about side effects. Regression analysis showed that female gender, urban residence, higher education, and higher income were significantly associated with better malaria knowledge.

Conclusions

This study identified significant knowledge gaps about malaria and its vaccine, particularly in rural and lower-income populations. Strengthening awareness campaigns, improving healthcare infrastructure, and addressing vaccine hesitancy are crucial for effective malaria control. Integrating RTS, S/AS01 into routine interventions could significantly reduce the disease burden if feasibility and equitable access are ensured.

Introduction

Malaria is caused by *Plasmodium*, single-celled microorganisms that are the obligate parasites of many vertebrates and insects. (1) In 2020, there were a total of 241 million cases of malaria reported across 85 countries in regions of Africa, South Asia, and Southeast Asia, increasing from 227 million in 2019. (2) Pakistan is still among the countries that bear a significant burden in the battle against malaria, with approximately 1 million cases reported each year. (3) The mortality rate has also increased recently, most likely from disruptions to essential malaria services during the COVID-19 pandemic. (4) The parasite is transmitted to a person through the bite of infective female *Anopheles* mosquitoes. Of the five species of plasmodium, P. *vivax* and P. *falciparum* are responsible for severe infections and pose the greatest risk to public health. (3, 5)

Clinical manifestations vary from asymptomatic infection to uncomplicated malaria and even severe, complicated disease, resulting in a fatal outcome. Common symptoms of malaria include fever with shaking chills, sweating, headache, body aches, and fatigue. (6) The broad spectrum of clinical presentations and the severity of the outcome depend on the complex interactions between the host, parasite, and environmental factors. (7) Children under 5 years of age and pregnant females for the first and second time are the most vulnerable groups affected by malaria. (3) Laboratory testing using microscopy and rapid diagnostic tests (RDT) before treatment is recommended by the World Health Organization (WHO). (8) Insecticide-treated nets (ITNs), long-lasting insecticide-treated nets (LLINs), indoor residual spraying (IRS), and malaria vaccine are the mainstay of malaria control. (9) Artemisinin-based combination therapy (ACT) has become the preferred treatment due to the widespread presence of chloroquine-resistant strains of P. *falciparum*. (10) A significant breakthrough against this disease was made on 6th October 2021 when the WHO approved RTS S, AS01, a pre-erythrocyte malaria vaccine. (11) WHO recommends the use of this vaccine for the prevention of P. *falciparum* malaria infection in children under 5 years of age in settings with moderate to high transmission. (12)

Pakistan is one of the countries in the WHO Eastern Mediterranean region where malaria is endemic. (13) It represents a major threat to public health here since 98 percent of inhabitants (205 million people) live in malaria-endemic regions and are at risk of acquiring the infection. (14) In 2021, suspected cases of malaria reported were 2.6 million, which increased considerably in the first 8 months of 2022 to 3.4 million cases. (15) Vast areas of Pakistan were hit by devastating floods in June of 2022, affecting more than 33 million people and debilitating the fragile health infrastructure of the country. Thereafter, a sudden upsurge in the number of suspected cases of malaria was observed. More than 78% of all the confirmed cases in the country were reported from flood-ravaged areas. (16) Pakistan is also under severe threat from climate change. Rising temperatures due to global warming are also feared to alter the dynamics of mosquito-borne diseases. Since mosquitoes are poikilotherms whose body temperature varies with that of their environment, climate change can affect both the distribution and intensity of malarial outbreaks. This has resulted in recent epidemics of vector-borne diseases like dengue and chikungunya, which were previously non-existent in this region. (17, 18) Climate crisis and the current situation of floods along with poverty, limited access to health facilities, lack of availability of

antimicrobial drugs, insufficient knowledge, and poor adhesion to life-saving malaria prevention tools and interventions like limited use of vector control measures have put a large population at risk including pregnant women and children, especially in underdeveloped calamity hit areas. (3)

Despite ongoing efforts to control malaria, it remains a significant economic and health burden globally, particularly in malaria-endemic regions like Pakistan. Effective prevention and intervention strategies depend on community awareness, engagement, and evidence-based policymaking. However, there is a lack of comprehensive data on the population's knowledge, attitudes, and practices (KAP) regarding malaria and its vaccine in Pakistan. Understanding these aspects is crucial for designing targeted health education programs and policy interventions. This study aims to address this gap by assessing the KAP of both rural and urban populations, providing a foundational framework for future interventions, including the potential introduction of the RTS, S/AS01 malaria vaccine.

Methodology

Study Design and Setting

A cross-sectional study was conducted in the general population of Pakistan from October 12, 2022, to November 11, 2022, and a STROBE checklist was followed to report this study. Participants from all provinces of Pakistan—Punjab, Sindh, Balochistan, Khyber Pakhtunkhwa, Azad Jammu and Kashmir (AJK), and Gilgit-Baltistan (GB)—representing both urban and rural areas, were included in this study to ensure diverse socioeconomic and geographic representation. The sample size was calculated using Raosoft's sample size calculator, with the parameter set at a 99% confidence interval (CI), a 5% margin of error, and a 50% response distribution. Based on these inputs, the minimum required sample size was 664 participants. To account for potential non-response rates, the sample size was increased by 50%, resulting in a final target of 996 participants. A consecutive non-probability sampling was used to recruit participants for the study.

Questionnaire Designing

After a thorough literature review, a questionnaire was developed for this study in two languages, Urdu and English (Available as supplementary material) (3, 8, 20, 21). The relevancy and simplicity of the questionnaire were confirmed by the experts in clinical research and public health, and were finalized by the authors after a detailed discussion. This questionnaire was reviewed by experts from community medicine, public health, and infectious disease for face validation, relevance, and clarity of individual sections to improve some details. A total of 37 questions were included, except for the demographics, with 16, 12, and 9 questions regarding attitude, knowledge, and practices regarding malaria and malaria vaccine.

The questionnaire was comprised of demographics such as age, gender, education, residence, monthly family income, and number of people living in the house. Furthermore, the recent diagnosis of malaria in the last six months of participants and households was also inquired about. The knowledge section

regarding malaria was comprised of the kind of disease, gold standard investigation, mode of transmission, causative agent, favorable breeding site for mosquitoes, common symptoms of the disease, complications, and prevention of malaria. The knowledge of malaria vaccines included the availability of vaccines worldwide and in Pakistan, and the age group suitable for vaccination. The knowledge section had a total of 12 questions; for each correct answer, a score of 1 was given, and a total score of 6 or more was considered good knowledge.

To assess the attitude of participants towards malaria and the malaria vaccine, a 5-point Likert scale was used. The practice section regarding prevention from malaria was comprised of the usage of mosquito nets, mosquito repellent sprays, and lotions, covering exposed body parts, removing stagnant water, and using window screens. The practice of seeking treatment and educating others regarding malaria was also included. For willingness towards the malaria vaccine, participants were asked about their willingness to vaccinate themselves and their children, their willingness to pay for the malaria vaccine, and to encourage and educate others about the malaria vaccine.

Data Collection

Data collection was conducted through two modalities: online Google forms and manual form filling. The online Google forms were forwarded through friend and family circles by social media platforms commonly used in the country as WhatsApp, Facebook, Instagram, and Twitter. Written informed consent was obtained from all participants before data collection. For participants who completed the questionnaire online, consent was documented through a mandatory consent statement at the beginning of the form, which participants had to agree to before proceeding. For in-person data collection, participants signed a written consent form. The manual filling of forms was done by the patients and their attendants presenting in the private clinics of the authors and their colleagues. Later on, all the data was entered into Google Forms. A pilot study was conducted among the 40 participants from the population under study, and the Cronbach's alpha was reported to be 0.72; these responses were not included in the final analysis.

Data Analysis

Data was initially entered in Microsoft Excel and then imported to IBM Statistical Package for Social Science (SPSS) version 24 for inferential statistics. Descriptive measures, i.e., mean and standard deviations, were calculated for quantitative variables, and categorical variables were expressed as frequencies and percentages. The normal distribution of data was assessed by plotting data on histograms. The socio-demographic variables were compared with knowledge via univariate and multivariate logistic regression analysis. Results were expressed as odds ratio (OR) and adjusted odds ratio (aOR) with a confidence interval (CI) of 95%. A p-value < 0.05 was considered statistically significant.

Results

Baseline characteristics

A total of 996 responses were received, yielding a response rate of 76.3%. Among the participants, 61.8% (616) were male and 38.2% (380) were female. The majority of the participants, 57.8% (576), were under 25 years of age. The study sample consisted of 57.8% (576) married and 42.8% (420) unmarried participants. More than half of the respondents (52.6%, n = 524) resided in rural areas, while 63.0% (628) had formal education up to the Intermediate level (11-12th class). A significant proportion (60.2%, n = 600) belonged to the lower-income group, with a monthly family income of less than 50,000 PKR (178.38USD). The number of family members varied in the study, with family members of less than 4 members accounting for 48.0% (478) of the study population. (Table 1)

Table 1
Baseline demographics.

Variables	Characteristics	Frequency (%)
Age	< 25 years	576 (57.8%)
	25–50 years	386 (38.8%)
	> 50 years	34 (3.4%)
Gender	Male	616 (61.8%)
	Female	380 (38.2%)
Marital status	Married	576 (57.8%)
	Unmarried	420 (42.2%)
Residence	Rural	524 (52.6%)
	Urban	472 (47.4%)
Education	Postgraduation	106 (10.6%)
	Graduation	298 (29.9%)
	Intermediate	224 (22.5%)
	Matric	306 (30.7%)
	Primary/Middle	32 (3.2%)
	No Formal Education	30 (3.0%)
Monthly Family Income	Less Than 50000 PKR	600 (60.2%)
	50000–100000 PKR	176 (17.7%)
	More Than 100000 PKR	220 (22.1%)
Number of people living in house	1 to 4	478 (48.0%)
	5 to 9	314 (31.5%)
	More than 9	204 (20.5%)
Has anyone in your household been diagnosed with malaria infection? (less than 6 month)	No	606 (60.8%)
	Yes	390 (39.2%)
Have you been diagnosed with malaria? (less than 6 months)	No	606 (60.8%)
	Yes	390 (39.2%)

Variables	Characteristics	Frequency (%)
PKR: Pakistani Rupee.		

Knowledge about Malaria

Of the 996 participants, 39.2% (390) of the participants stated that they or someone from the household had been diagnosed with malaria in the last six months. Regarding malaria awareness, the majority of participants, 72.5% (722), correctly identified malaria as a preventable disease. However, only 39.6% (394) accurately recognized the parasite as the causative agent, while 53.0% (528) knew that mosquito bites serve as the primary mode of transmission. The gold standard for malaria diagnosis—microscopic examination of blood—was correctly identified by 51.0% (508) of participants. Moreover, 66.5% (662) acknowledged stagnant water as a favorable breeding site for mosquitoes. Awareness of common symptoms, complications, and preventive measures was 53.2% (530), 53.4% (532), and 66.7% (664), respectively.

Knowledge about the Malaria vaccine

When asked about the malaria vaccine (RTS, S/AS01), 47.0% (468) knew that it is available only in a few countries (Sub-Saharan Africa). However, only 8.2% (82) were aware that the vaccine is exclusively for children under five years of age. Regarding vaccine availability, 47.8% (476) correctly stated that it is not available currently in Pakistan and is not a part of any vaccination program in the country. (Table 2)

Table 2
Knowledge questions.

Variables		Frequency (%)
What kind of disease is malaria?	Contagious, preventable and non curable	170 (17.1%)
	Fatal, contagious and curable	26 (2.6%)
	Non contagious, non preventable and non relapsing	78 (7.8%)
	Preventable, curable and relapsing	722 (72.5%)
What is gold standard diagnostic test for malaria?	Blood Culture	58 (5.8%)
	CBC	328 (32.9%)
	Microscopic examination of blood	508 (51.0%)
	PCR	102 (10.2%)
How do you think Malaria spreads to humans?	Drinking unclean water	284 (28.5%)
	Eating contaminated food	162 (16.3%)
	Mosquito bite	528 (53.0%)
	Through respiratory droplets	22 (2.2%)
What do you believe is the causative agent of Malaria?	Bacteria	318 (31.9%)
	Fungus	40 (4.0%)
	Parasite	394 (39.6%)
	Virus	244 (24.5%)
Most favorable breeding sites for mosquito?	Houses	68 (6.8%)
	Running water	110 (11.0%)
	Stagnant water	662 (66.5%)
	Waste material	156 (15.7%)
What do you think are the most common symptoms of Malaria?	Bleeding from nose ,gums and anus	178 (17.9%)
	Cough ,flu and difficulty in breathing	76 (7.6%)
	Fever, headache, shaking chills and muscle and joint pain	530 (53.2%)
	Vomitting and diarrhoea	212 (21.3%)
How malaria can be prevented?	Avoiding contact with malaria patient	68 (6.8%)

Variables		Frequency (%)
	Sleeping in mosquito net, using insecticide spray and mosquito repellent lotions	664 (66.7%)
	Washing hands before eating	234 (23.5%)
	Wearing facemask	30 (3.0%)
What are complication of Malaria?	Blood in stools, ulcer and perforation in intestines	62 (6.2%)
	Hemoglobin in urine, anemia, seizures of coma	532 (53.4%)
	Liver failure, jaundiceand gallbladder stones	218 (21.9%)
	Pneumonia, difficulty in breathing	184 (18.5%)
What do you know about availability of malaria vaccine (RTS, S)?	Available all over the world	274 (27.5%)
	Available for research purposes only	160 (16.1%)
	Available only in few countries(Sub- Saharan Africa)	468 (47.0%)
	Not available	94 (9.4%)
For which age group malaria vaccine (RTS, S) is currently used?	Adults	478 (48.0%)
	All age groups	320 (32.1%)
	Children less than 5	82 (8.2%)
	Pregnant females	116 (11.6%)
Is malaria vaccine (RTS, S) available in Pakistan?	No	476 (47.8%)
	Yes	520 (52.2%)
Is it a part of vaccination program in Pakistan?	No	500 (50.2%)
	Yes	496 (49.8%)
CBC: Complete blood count; PCR: Polymerase chain reaction.		

Malaria prevention practices

Among the participants, 78.9% (n = 786) reported using mosquito nets while sleeping, while 81.1% (n = 808) applied mosquito repellent lotions. A significant majority (84.5%, n = 842) covered exposed body parts to prevent mosquito bites, and 82.3% (n = 820) used mosquito sprays indoors. Additionally, 84.1% (n = 838) practiced stagnant water removal, and 82.1% (n = 818) installed window screens to prevent mosquito entry. Most participants (84.5%, n = 842) visited a clinic when experiencing malaria-like

symptoms such as fever and chills. Furthermore, 83.1% (n = 828) actively promoted malaria prevention and treatment awareness, while 79.1% (n = 788) participated in anti-malarial campaigns (Table 3)

Table 3
Malaria preventive measures.

Variables		Frequency (%)
Use mosquito nets during sleep	No	210 (21.1%)
	Yes	786 (78.9%)
Mosquito repellent lotions	No	188 (18.9%)
	Yes	808 (81.1%)
Mosquito sprays indoor	No	176 (17.7%)
	Yes	820 (82.3%)
Cover exposed body parts	No	154 (15.5%)
	Yes	842 (84.5%)
Remove stagnant water	No	158 (15.9%)
	Yes	838 (84.1%)
Window screens	No	178 (17.9%)
	Yes	818 (82.1%)
Go to clinic when having fever with chills	No	154 (15.5%)
	Yes	842 (84.5%)
Educate and promote others for malaria prevention and treatment	No	168 (16.9%)
	Yes	828 (83.1%)
Participate in antimalarial campaign	No	208 (20.9%)
	Yes	788 (79.1%)

Attitude about Malaria

The majority of participants (80.5%, n = 802) perceived malaria as a fatal disease, while 61.5% (n = 612) believed it to be preventable. Half of the respondents (50.2%, n = 502) considered themselves at risk of contracting malaria, and 80.6% (n = 802) recognized that poor sewerage and sanitation contribute to a higher risk of outbreaks. When asked about treatment, 58.9% (n = 586) expressed confidence in its effectiveness, and 61.3% (n = 610) believed proper treatment could prevent complications.

Attitude about malaria vaccination

Regarding the malaria vaccine, attitudes were mixed. While 58.0% (n = 578) believed the vaccine to be effective, and 56.0% (n = 558) thought it could reduce complications and mortality in children, 40.3% (n = 402) expressed concerns about potential side effects. Despite these concerns, a majority of respondents were receptive to vaccination: 60.7% (n = 605) were willing to receive the vaccine if it became available in Pakistan, and 59.2% (n = 590) were willing to vaccinate their children. Additionally, 79.9% (n = 796) were open to promoting and educating others about the vaccine, and 72.7% (n = 724) expressed willingness to pay for it (Table 4)

Table 4
Attitude.

Parameters	Agree N (%)	Disagree N (%)	Neither Agree Nor Disagree N (%)	Strongly Agree N (%)	Strongly Disagree N (%)
Is malaria a fatal disease?	516 (51.8%)	56 (5.6%)	126 (12.7%)	286 (28.7%)	12 (1.2%)
Do you think malaria is a preventable disease?	450 (45.2%)	112 (11.2%)	94 (9.4%)	162 (16.3%)	178 (17.9%)
Are you at risk of getting malaria?	432 (43.2%)	140 (14.1%)	192 (19.3%)	70 (7.0%)	162 (16.3%)
Do you think mosquito net and insecticide spray are useful to prevent malaria?	438 (44.0%)	112 (11.2%)	104 (10.4%)	156 (15.7%)	186 (18.7%)
Is there an increased risk of malaria outbreaks in areas with poor system of sewerage and sanitation or areas affected by blood?	394 (39.6%)	66 (6.6%)	96 (9.6%)	408 (41.0%)	32 (3.2%)
Is treatment available against malaria effective?	440 (44.2%)	108 (10.8%)	154 (15.5%)	146 (14.7%)	148 (14.9%)
Taking proper treatment of malaria can prevent from complication?	442 (44.4%)	92 (9.2%)	148 (14.9%)	168 (16.9%)	146 (14.7%)
Is malaria vaccine effective against the disease prevention?	468 (47.0%)	102 (10.2%)	188 (18.9%)	110 (11.0%)	128 (12.9%)
Can malaria vaccine reduce the complications and death rate in children?	458 (46.0%)	102 (10.2%)	182 (18.3%)	100 (10.0%)	154 (15.5%)
Are you afraid that adverse effects of vaccine might outweigh the benefits of vaccine?	324 (32.5%)	186 (18.7%)	236 (23.7%)	78 (7.8%)	172 (17.3%)
The anti-malarial vaccination campaign should be carried out to prevent malarial outbreaks	460 (46.2%)	74 (7.4%)	152 (15.3%)	152 (15.3%)	158 (15.9%)
If the malaria vaccine become available in Pakistan, will you vaccinate yourself?	489 (49.1%)	83 (8.3%)	124 (12.4%)	116 (11.6%)	184 (18.5%)
Will you vaccinate children against malaria?	470 (47.2%)	122 (12.2%)	138 (13.9%)	120 (12.0%)	146 (14.7%)

Parameters	Agree N (%)	Disagree N (%)	Neither Agree Nor Disagree N (%)	Strongly Agree N (%)	Strongly Disagree N (%)
Will you promote and educate others regarding usage of malaria vaccine?	510 (51.2%)	34 (3.4%)	156 (15.7%)	286 (28.7%)	10 (1.0%)
Will you pay for malaria vaccine?	504 (50.6%)	64 (6.4%)	160 (16.1%)	220 (22.1%)	48 (4.8%)

Factors of good knowledge

Univariate and multivariate logistic regression analyses revealed that female participants demonstrated significantly higher levels of good knowledge compared to males [OR = 11.894, aOR = 4.645, p-value < 0.001]. Similarly, urban residents had greater awareness of malaria than their rural counterparts [OR = 9.403, p-value < 0.001, aOR = 1.763, p-value = 0.008]. Education and income levels also played a crucial role, as participants with a graduate-level education [OR = 8.632, p-value < 0.001, aOR = 3.570, p-value = 0.022] and those earning more than 100,000 PKR per month [OR = 16.126, aOR = 4.850, p-value < 0.001] exhibited significantly better knowledge. Additionally, households with 5–9 members were associated with higher levels of malaria-related knowledge, showing statistical significance [OR = 8.045, aOR = 3.119, p-value < 0.001]. (Table 5)

Table 5
Regression.

Variables	Knowledge		OR	95% CI	P-Value	aOR	95% CI	P-Value
	Poor	Good						
Gender								
Male	496 (83.5%)	120 (29.9%)	Ref	-	-	Ref	-	-
Female	98 (16.5%)	282 (70.1%)	11.894	8.774–16.124	< 0.001	4.645	3.117–6.923	< 0.001
Age (in years)								
< 25	462 (77.85%)	114 (28.4%)	0.173	0.085–0.352	< 0.001	0.518	0.208–1.287	0.157
25–50	118 (19.9%)	268 (66.7%)	1.590	0.777–3.255	0.205	0.797	0.329–1.933	0.615
> 50	14 (2.4%)	20 (5.0%)	Ref	-	-	Ref	-	-
Marital Status								
Married	312 (52.5%)	264 (65.7%)	1.729	1.331–2.246	< 0.001	1.494	0.989–2.257	0.057
Unmarried	282 (47.5%)	138 (34.3%)	Ref	-	-	Ref	-	-
Residence								
Rural	434 (73.1%)	90 (22.4%)	Ref	-	-	Ref	-	-
Urban	160 (26.9%)	312 (77.6%)	9.403	6.991–12.648	< 0.001	1.763	1.159–2.681	0.008
Education								
No formal education	22 (3.7%)	8 (2.0%)	Ref	-	-	Ref	-	-
Primary/Middle	22 (3.7%)	10 (2.5%)	1.250	0.415–3.761	0.691	1.516	0.387–5.942	0.551
Matric	264 (44.4%)	42 (10.4%)	0.438	0.183–1.047	0.063	1.079	0.351–3.317	0.894
Intermediate	174 (29.3%)	50 (12.4%)	0.790	0.332–1.883	0.595	2.111	0.694–6.427	0.188
Graduation	72 (12.1%)	226 (56.2%)	8.632	3.684–20.227	< 0.001	3.570	1.201–10.611	0.022

Variables	Knowledge		OR	95% CI	P-Value	aOR	95% CI	P-Value
	Poor	Good						
Gender								
Post-graduation	40 (6.7%)	66 (16.4%)	4.537	1.846–11.154	0.001	1.089	0.347–3.421	0.884
Monthly income in PKR								
< 50000	486 (81.8%)	114 (28.4%)	Ref	-	-	Ref	-	-
50000-100,000	62 (10.4%)	114 (28.4%)	7.839	5.412–11.354	< 0.001	1.639	1.000–2.686	0.050
> 100,000	46 (7.7%)	174 (43.3%)	16.126	10.988–23.667	< 0.001	4.850	2.907–8.091	< 0.001
Number of people living in household								
1–4	324 (54.5%)	154 (38.3%)	1.949	1.312–2.894	0.001	1.584	0.887–2.831	0.120
5–9	106 (17.8%)	208 (51.7%)	8.045	5.300–12.212	< 0.001	3.119	1.734–5.609	< 0.001
> 9	164 (27.6%)	40 (10.0%)	Ref	-	-	Ref	-	-

PKR: Pakistani Rupee.

Knowledge questions (n = 12) comprises of 1 mark per correct answer. A cut off > 6 marks would implies good knowledge.

Discussion

Malaria Burden and Knowledge Gaps

This study highlights the persistent burden of malaria in the study population, with 39.2% of participants reporting that they or a household member had been diagnosed with malaria in the past six months. This prevalence aligns with findings from Vanlahirata et al. in North East India, where 56.7% of households had a history of malaria infection. (22) It indicates that malaria is a significant health problem in the region. This information also suggests that the study population has experienced recent exposure to malaria and may be at risk for ongoing transmission of the disease, especially in the context of the existing flood situation. The study results are in line with the WHO World Malaria Report 2021, which categorizes Pakistan as a high-burden community with an estimated 4.2 million cases of malaria annually. (23)

The high burden of malaria in the study population also indicates that current malaria prevention and control strategies are insufficient to contain the transmission and prevalence of the disease, and there is a need for effective and targeted public health interventions. Despite the high burden, only 53.0% of participants correctly identified the means of transmission, 53.2% recognized symptoms, and 51.0% were aware of diagnostic methods. Moreover, a substantial proportion (39.6%) incorrectly attributed malaria to bacteria, viruses, or fungi, highlighting critical knowledge gaps.. Similar misconceptions were reported in studies from rural Sindh, Pakistan, where only 17.9% and 25% of participants in Dadu and Badin, respectively, knew that malaria transmission peaks post-rainfall. Likewise, Reham et al. found that in Bahawalpur, only 14.4% of parents of malaria-infected children knew the disease was caused by protozoa. These findings emphasize the need for targeted public health interventions to improve malaria awareness. (32, 33)

Factors Influencing Malaria Knowledge

Knowledge levels were significantly influenced by gender, residence, and socioeconomic status. Female participants demonstrated higher malaria knowledge compared to their male counterparts (OR = 11.894, aOR = 4.645, $p < 0.001$), consistent with findings from Ethiopia, South Africa, and Senegal, where women were more informed about disease prevention.(21, 24, 25). Similarly, Khan et.al reported that females had a more positive attitude and preventive behavior towards COVID-19 than their male counterparts in Punjab, Pakistan. (26) This could be explained by the roles and responsibilities of women in society, where women take care of their families, including caring for diseased family members and providing opportunities to acquire more information on healthcare issues, resulting in the exchange of information and better knowledge. (25)

Urban residents also exhibited better knowledge than rural participants (OR = 9.403, aOR = 1.763, $p = 0.008$), likely due to greater access to information sources, better healthcare facilities, and higher literacy rates. (27, 28) However, rural populations are disproportionately affected by malaria, underscoring the urgent need to expand educational outreach in these regions. (29) Prior research has shown that increasing awareness in rural areas can significantly reduce malaria morbidity and mortality, particularly among vulnerable groups such as pregnant women and children. (30)

Socioeconomic status was another crucial determinant. Participants with higher education levels (OR = 8.632, aOR = 3.570, $p = 0.022$) and monthly incomes exceeding 100,000 PKR (OR = 16.126, aOR = 4.850, $p < 0.001$) had significantly better malaria knowledge. Lower economic status is often associated with limited healthcare access, restricted educational opportunities, and reduced exposure to public health campaigns, all of which contribute to poor disease awareness. These findings highlight the importance of integrating malaria education into broader poverty alleviation programs.

Attitudes Toward Malaria and Vaccine Acceptance

Overall, attitudes toward malaria prevention and treatment were generally positive, with 80.5% acknowledging malaria's fatal potential, 61.5% recognizing its preventability, and 58.9% believing in the

efficacy of treatment. Despite these encouraging figures, only 60.7% expressed willingness to receive a malaria vaccine if it becomes available in the future, with 40.3% citing concerns about potential adverse effects of vaccination.

Knowledge about the RTS, S/AS01 malaria vaccine was particularly poor, with only 8.2% aware that it is recommended for children under five years old. Nonetheless, 59.2% of participants were willing to vaccinate their children, echoing findings from Tanzania, where only 11% had vaccine awareness, yet 94.5% expressed willingness to use it (31) Similar trends have been observed with other vaccines, such as the HPV vaccine, where only 28.3% had awareness but 76.9% were willing to receive it (32) These results suggest that knowledge alone is not the sole determinant of vaccine acceptance, and public trust, cost, and accessibility also play significant roles, especially in lower-middle-income countries such as Pakistan. (33)

Preventive Practices

Encouragingly, the majority of participants reported practicing malaria prevention measures. 78.9% used mosquito nets, 82.3% applied mosquito sprays indoors, and 84.1% eliminated stagnant water—strategies that align with WHO-recommended interventions. Interestingly, despite low malaria knowledge levels, preventive behaviors were well-adopted, particularly in rural areas. It is observed that preventive practices relating to malaria, like sleeping in mosquito nets and using herbal remedies to treat malaria, may be deeply ingrained in the culture and passed on to generations. Access to the primary level of healthcare facilities may also lead to acceptable knowledge and practices that provide education and support around prevention and treatment rather than knowledge about the disease itself. It should be emphasized here that although good preventive practices can help mitigate malaria transmission, comprehensive knowledge remains essential for long-term disease control. Misconceptions about malaria etiology could hinder effective treatment-seeking behavior and compliance with control measures. Therefore, enhancing health education alongside existing interventions is crucial to achieving sustainable malaria prevention.

Barriers to Malaria Vaccine Uptake

Our study found that 59.2% of participants were willing to get the malaria vaccine, but several barriers still exist. Many people were worried about side effects and had doubts about vaccine safety, similar to general vaccine hesitancy in Pakistan. The cost of vaccination is still a major issue, especially for lower-income families. Another key barrier was a lack of trust in medical authorities, which has affected vaccination efforts for diseases like polio and COVID-19 in the country.

In Pakistan, polio vaccination campaigns have long faced resistance due to widespread misinformation, religious beliefs, and distrust in the healthcare system (34). Rumors about the polio vaccine causing infertility or being part of foreign conspiracies have fueled hesitancy, leading to refusals and violent attacks on healthcare workers. Similar patterns of distrust and misinformation could pose challenges to the acceptance of a malaria vaccine. Without targeted efforts to build public confidence and address

vaccine-related fears, misinformation could continue to limit vaccination coverage and hinder malaria prevention efforts. Addressing these barriers requires a multi-pronged approach, including community engagement, culturally sensitive awareness campaigns, and financial support mechanisms. The barrier to the cost of vaccination highlights the need for assistance from national and international stakeholders to cover the cost of implementing this program. Additionally, involving local healthcare workers as trusted sources of information could help improve vaccine acceptance and uptake.

Public Health Implications and Recommendations

Findings from this study underscore the need for targeted malaria education campaigns, particularly in rural and low-income populations. To improve malaria prevention and vaccine acceptance, we recommend strengthening community-based health education to correct misconceptions about malaria, its transmission, symptoms, and treatment. Expanding healthcare services in underserved areas is essential for early diagnosis, timely treatment, and vaccine accessibility. Increased financial support from national and international organizations could help subsidize vaccine costs, making immunization more affordable. Addressing vaccine hesitancy through awareness campaigns that provide accurate information, tackle safety concerns, and involve trusted community leaders can build public trust. Integrating malaria control efforts into poverty alleviation programs, such as education funding and microloans, could further improve awareness and prevention while supporting vulnerable communities.

Strengths

This study provides valuable insights into knowledge, attitudes, and practices related to malaria and its vaccine, identifying key gaps that can inform future health interventions. The study included a large sample size, enhancing the generalizability and reliability of the findings. The sample closely reflects Pakistan's demographic composition, where a significant portion of the population resides in rural areas. To our knowledge, this is the first study that assessed malaria vaccine perception in the Pakistani population, making this research a valuable contribution to existing literature.

Limitations

This study had a few limitations. The convenient sampling technique introduces the potential for selection bias; however, efforts were made to recruit participants from diverse locations to minimize this effect. The utilization of online platforms across social media for questionnaire distribution, along with limited funding and resources, restricted participation from underprivileged backgrounds. While this remains a limitation, outreach through healthcare centers and local clinics was considered to enhance representation. The reliance on self-reported data may have led to social desirability bias, as participants might have responded in ways that align with social expectations. To mitigate this, standardized and anonymous questionnaires were used to encourage honest responses. Some data were collected from patients visiting the clinics of the authors and their colleagues, which may have introduced bias due to potential domineering attitudes towards the disease. However, structured data collection methods helped maintain objectivity.

Conclusion

This study revealed significant gaps in knowledge about malaria and its vaccine, particularly among rural and lower-income populations in Pakistan. However, attitudes towards malaria prevention and treatment-seeking behaviors were largely positive, reflecting cultural influences and existing community healthcare efforts. The current healthcare situation demands further improvements in infrastructure, efficient vector control measures, and better sanitation. Strengthening awareness campaigns through media announcements and educational seminars in schools and workplaces can help bridge knowledge gaps. Training physicians and healthcare workers to educate the public on malaria prevention is also crucial.

Addressing vaccine hesitancy through affordability, trust-building initiatives, and community engagement will be essential for the successful implementation of future54 malaria vaccination programs. Introducing RTS, S/AS01 into routine malaria control efforts has the potential to significantly reduce the disease burden and be highly cost-effective. However, its integration must consider feasibility, operational challenges, and equitable access, particularly in high-risk areas. With a community-centered approach and sustained public health efforts, meaningful progress toward malaria control and eventual elimination remains achievable.

Declarations

Conflict of Interest

The authors report no conflict of interest among them.

Ethical Considerations'

Before commencing the study, the ethical review certificate of the study was approved by the ethical review board of Pir Abdul Qadir Shah Jeelani Institute of Medical Sciences, Gambat, Pakistan (Reference no: IRB-22/14). We confirm that all methods were carried out following relevant guidelines and regulations. Before filling out the questionnaire, all the participants provided informed consent. Participants were assured about the confidentiality of any obtained information. The responses were kept confidential, and data from this research was managed only by researchers in this study. Results will be used only for research, and data cannot be traced back to their sources.

Consent to publication

Not applicable.

Funding

No funding was acquired for this study.

Author Contribution

W.T., M.J.T., and M.F. conceived and designed the study. W.T., M.F., R.Z., and H.J. did the data collection. W.T., M.F., R.Z., M.F., A.A., and H.J. performed the literature review and wrote the manuscript. M.S. and W.T. did data analysis. A.A., K.U., AHK, M.E., and MJT reviewed and critically revised the manuscript. All authors have approved the final manuscript.

Acknowledgement:

Not Applicable

Data Availability

The data set used and/or analyzed during the study is available from the corresponding author on reasonable request.

References

1. CDC – Malaria – About Malaria Centers for Disease Control. and Prevention: CDC; [updated 2 February 2022.
2. World Malaria Report 2021. WHO 2021.
3. Karim AM, Yasir M, Ali T, Malik SK, Ullah I, Qureshi NA, et al. Prevalence of clinical malaria and household characteristics of patients in tribal districts of Pakistan. PLoS Negl Trop Dis. 2021;15(5):e0009371.
4. Rogerson SJ, Beeson JG, Laman M, Poespoprodjo JR, William T, Simpson JA, et al. Identifying and combating the impacts of COVID-19 on malaria. BMC Med. 2020;18(1):1–7.
5. Zaman N, Haq FU, Khan Z, Uallah W, Ualiyeva D, Waheed Y, et al. Incidence of malarial infection and response to antimalarial drugs at Districts Lower Dir and Swat of Khyber Pakhtunkhwa, Pakistan. Dialogues Health. 2022;1:100035.
6. Cáceres Carrera L, Victoria C, Ramirez JL, Jackman C, Calzada JE, Torres R. Study of the epidemiological behavior of malaria in the Darien Region. PLoS ONE. 2019;14(11):2015–7.
7. Arévalo-Herrera M, Lopez-Perez M, Medina L, Moreno A, Gutierrez JB, Herrera S. Clinical profile of Plasmodium falciparum and Plasmodium vivax infections in low and unstable malaria transmission settings of Colombia. Malar J. 2015;14:1–11.
8. Qureshi H, Khan MI, Ahmad A, Awan UA, Khattak AA, Khan AA et al. Passive surveillance of malaria in pregnant women, non-pregnant women and children under 5 years of age in Bannu district, Khyber

Pakhtunkhwa Pakistan. Front Med. 2021:2151.

9. Chu CS, White NJ. The prevention and treatment of Plasmodium vivax malaria. PLoS Med. 2021;18(4):e1003561.
10. Adam I, Ibrahim Y, Gasim GI. Efficacy and safety of artemisinin-based combination therapy for uncomplicated Plasmodium falciparum malaria in Sudan: a systematic review and meta-analysis. Malar J. 2018;17(1):1–8.
11. Zehra A, Syed B, Masood F, RTS. S/AS01 Malaria Vaccine-The Next Step for a Developing Country. J Prev Med Hyg. 2022;63(1):E130.
12. Organization WH. WHO guidelines for malaria, 18 February 2022. World Health Organization; 2022.
13. Al-Awadhi M, Ahmad S, Iqbal J. Current status and the epidemiology of malaria in the Middle East Region and beyond. Microorganisms. 2021;9(2):338.
14. Khattak AA, Awan UA, Nadeem MF, Yaqoob A, Afzal MS. Chloroquine-resistant Plasmodium falciparum in Pakistan. Lancet Infect Dis. 2021;21(12):1632.
15. Islam MR, Dhar PS, Rahman MM. Recently outbreak of malaria in current world: species, etiology, life cycle, transmission, symptoms, vaccination, diagnostic tests, treatment, and complications. Int J Surg. 2023;109(2):175–7.
16. World Health Organization. (17 October 2022). Disease Outbreak News; Malaria - Pakistan [Available from: https://www.who.int/emergencies/disease-outbreak-news/item/2022-DON413
17. Mazhar K, Arsalan MH, Kazmi SJH, Khan IA. IDENTIFICATION OF POTENTIAL RISK AREAS OF MALARIA PARASITES IN PAKISTAN USING CLIMATE DATA AND GIS.
18. Jabeen A, Ansari JA, Ikram A, Khan MA, Safdar M. Impact of climate change on the epidemiology of vector-borne diseases in Pakistan. Global Biosecur. 2022;4.
19. Aerts C, Revilla M, Duval L, Paaijmans K, Chandrabose J, Cox H, et al. Understanding the role of disease knowledge and risk perception in shaping preventive behavior for selected vector-borne diseases in Guyana. PLoS Negl Trop Dis. 2020;14(4):e0008149.
20. Laurens MB, RTS. S/AS01 vaccine (Mosquirix™): an overview. Hum vaccines&immunotherapeutics. 2020;16(3):480–9.
21. Flatie BT, Munshea A. Knowledge, attitude, and practice towards malaria among people attending Mekaneeyesus Primary Hospital, South Gondar, northwestern Ethiopia: a cross-sectional study. Journal of Parasitology Research. 2021;2021.
22. Vanlalhriata C, Wankhar PT, Prakash PT, Amarthaluri C, Pautu L, Lalmalsawma P et al. Assessment of knowledge, attitude, and practices toward malaria in the Lunglei district, Mizoram, North-East India. 2024.
23. World malaria report. 2021. World Health Organization; 2021.
24. Munzhedzi M, Rogawski McQuade ET, Guler JL, Shifflett PE, Krivacsy S, Dillingham R, et al. Community knowledge, attitudes and practices towards malaria in Ha-Lambani, Limpopo Province, South Africa: a cross-sectional household survey. Malar J. 2021;20(1):1–12.

25. Gyawali N, Bradbury RS, Taylor-Robinson AW. Knowledge, attitude and recommendations for practice regarding dengue among the resident population of Queensland, Australia. Asian Pac J Trop Biomed. 2016;6(4):360–6.
26. Khan ZH, Manzoor I, Qureshi I. Gender Differences In Knowledge, Attitude And Perceptions Regarding Covid-19 among General Population Of Punjab, Pakistan. Br J Pharm Med. 2020;5:2576–86.
27. Yaya S, Uthman OA, Amouzou A, Bishwajit G. Mass media exposure and its impact on malaria prevention behaviour among adult women in sub-Saharan Africa: results from malaria indicator surveys. Global health Res policy. 2018;3:1–9.
28. Dhawan G, Joseph N, Pekow PS, Rogers CA, Poudel KC, Bulzacchelli MT. Malaria-related knowledge and prevention practices in four neighbourhoods in and around Mumbai, India: a cross-sectional study. Malar J. 2014;13(1):1–11.
29. Singh R, Musa J, Singh S, Ebere UV. Knowledge, attitude and practices on malaria among the rural communities in Aliero, Northern Nigeria. J family Med Prim care. 2014;3(1):39.
30. Kumar R, Farzeen M, Ahmed J, Lal M, Somrongthong R. Predictors of knowledge and use of long-lasting insecticidal nets for the prevention of malaria among the pregnant women in Pakistan. Malar J. 2021;20(1):347.
31. Romore I, Ali AM, Semali I, Mshinda H, Tanner M, Abdulla S. Assessment of parental perception of malaria vaccine in Tanzania. Malar J. 2015;14:355.
32. Colón-López V, Del Toro-Mejías LM, Ortiz AP, Tortolero-Luna G, Palefsky JM. HPV awareness and willingness to HPV vaccination among high-risk men attending an STI clinic in Puerto Rico. P R Health Sci J. 2012;31(4):227–31.
33. McCoy KD, Weldon CT, Ansumana R, Lamin JM, Stenger DA, Ryan SJ, et al. Are malaria transmission-blocking vaccines acceptable to high burden communities? Results from a mixed methods study in Bo, Sierra Leone. Malar J. 2021;20(1):183.
34. Tahir MJ, Saqlain M, Tariq W, Waheed S, Tan SH, Nasir SI, et al. Population preferences and attitudes towards COVID-19 vaccination: a cross-sectional study from Pakistan. BMC Public Health. 2021;21(1):1–12.