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Prevalence of Malaria and Associated Factors among Boarding High School Students in Mwanza, Tanzania: A Cross-Sectional Study

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ABSTRACT

Objective: To determine the prevalence of malaria and assess selected sociodemographic, behavioral, knowledge-related, and environmental factors associated with malaria infection among boarding high school students in Mwanza, Tanzania.

Methods: A school-based cross-sectional study was conducted from July to December 2025 among 248 boarding students at Nsumba Boys High School, Bwiru Boys High School, and Bwiru Girls High School in Mwanza, Tanzania. Participating schools were selected purposively and eligible boarding students were recruited during the study period. Sociodemographic characteristics, malaria-related knowledge, preventive practices, and selected environmental factors were assessed using a structured questionnaire. Malaria infection was determined by blood-film microscopy. Data were analyzed using Stata version 17. Descriptive statistics summarized participant characteristics and malaria prevalence. Pearson's chi-square tests were used for categorical associations, with Fisher-Freeman-Halton exact tests considered for sparse tables.

Results: Among 248 students examined, 30 had microscopy-confirmed malaria infection, giving an overall prevalence of 12.1% (95% CI: 8.3–16.8%). Prevalence was 13.6% among males and 10.9% among females. Participants were aged 16–20 years; prevalence was 20.5% at age 16, 8.2% at age 17, 8.1% at age 18, 5.6% at age 19, and 22.7% at age 20. The Pearson chi-square test indicated an association between age and malaria infection ($\chi^2=11.11$, $p=0.025$); the corresponding Fisher-Freeman-Halton exact p -value was 0.0314. Prevalence was 13.9% among Form V students and 9.9% among Form VI students. No statistically significant Pearson association was observed for sex, class, school, mosquito-net-use frequency, malaria-related knowledge, or measured environmental variables. Preferred treatment source had Pearson $\chi^2=7.61$ ($p=0.055$); because of a zero cell in the school-clinic category, the exact p -value was 0.0218 and should be interpreted cautiously.

Conclusions: Malaria infection was detected in approximately one in eight boarding high school students studied in Mwanza. Age showed an association with infection, although the small number of malaria-positive observations and sparse cells limit precision. Continued malaria surveillance, prevention, health education, and prompt diagnosis among boarding-school populations are warranted.

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Introduction

Malaria is a potentially life-threatening parasitic disease caused by *Plasmodium* species and transmitted predominantly through the bites of infected female *Anopheles* mosquitoes. Human malaria is caused mainly by *Plasmodium falciparum*, *P. vivax*, *P. malariae*, *P. ovale*, and, in some settings, *P. knowlesi* [1].

Malaria remains a major global health problem, particularly in sub-Saharan Africa. The World Health Organization (WHO) World Malaria Report 2024 estimated 263 million malaria cases and 597,000 malaria-related deaths globally in 2023, with approximately 95% of malaria deaths occurring in the WHO African Region [2]. Tanzania remains one of the countries contributing substantially to the global malaria burden [2].

The WHO Global Technical Strategy for Malaria 2016–2030 provides a framework for reducing malaria morbidity and mortality through surveillance, prevention, diagnosis, treatment, and elimination interventions [3]. However, biological, environmental, behavioral, and health-system challenges continue to affect malaria control, including insecticide resistance, changes in mosquito behavior, favorable vector-breeding conditions, and gaps in access to or utilization of preventive interventions.

The Lake Zone of Tanzania, including Mwanza, is an important malaria transmission area. Entomological investigations around Lake Victoria have documented malaria vector populations and

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demonstrated the continued presence of important *Anopheles* species in areas bordering the lake [4]. Environmental characteristics, including rainfall, vegetation, water bodies, settlement patterns, and drainage, may contribute to local differences in malaria transmission.

School-aged children and adolescents represent an important population in malaria epidemiology. Although malaria-control programmes have historically emphasized children younger than five years and pregnant women, school-aged children may experience both symptomatic and asymptomatic infections and can contribute to the human reservoir of malaria parasites [7]. A nationwide analysis of school malaria surveillance in mainland Tanzania reported malaria prevalence of 11.3% among school-aged children in 2023, with the Lake Zone having the highest prevalence among geographic zones [8].

Malaria can adversely affect educational outcomes. Infection may contribute to school absenteeism, reduced concentration, impaired cognitive performance, and poor academic achievement [6,8]. Consequently, malaria control among school-aged populations has implications for both disease prevention and education.

Boarding students may experience particular exposure because of communal living arrangements. Students spend substantial periods within dormitories and school compounds and may participate in evening activities or studies during periods when malaria vectors may be active. Their risk may also be influenced by environmental characteristics of school compounds and surrounding communities and by their knowledge regarding malaria transmission, prevention, symptoms, and treatment [10].

Despite evidence of malaria transmission among school-aged populations in Tanzania, limited information is available concerning malaria infection specifically among boarding high school students in Mwanza. Therefore, this study determined the prevalence of malaria and assessed selected sociodemographic, behavioral, knowledge-related, and environmental factors associated with malaria infection among boarding high school students in Mwanza, Tanzania.

Materials and Methods

Study design and setting

A school-based cross-sectional study was conducted from July to December 2025 among boarding students attending Nsumba Boys High School, Bwiru Boys High School, and Bwiru Girls High School in Mwanza, Tanzania. The selected schools are located within Nyamagana and Illemela districts. Mwanza is situated in northwestern Tanzania on the southern shores of Lake Victoria. The surrounding ecological environment includes water bodies, vegetation, and human settlements that may provide conditions suitable for malaria-vector breeding and transmission [4].

Study Population

The study population consisted of boarding students enrolled at the selected high schools during the study period.

Eligibility criteria

Students were eligible if they were enrolled as boarding students at one of the selected schools, were available during the study period, provided informed consent or assent as applicable, and agreed to provide a blood sample. Students were excluded if they had received antimalarial treatment or had been prescribed antimalarial medication within four weeks preceding blood-sample collection.

Sample size determination

The minimum sample size was calculated using the Kish–Leslie formula [5]: $n = Z^2 p(1-p)/d^2$, where Z was 1.96 for a 95% confidence level, p was the estimated malaria prevalence of 19.2% reported among school-aged children in Tanzania [6] and d was a desired margin of error of 5%. Using these parameters, the minimum calculated sample size was 239 students. A total of 248 students participated in the study.

Sampling procedure

The participating schools were selected purposively. Eligible boarding students were subsequently recruited from the selected schools during the study period until the available study sample was reached.

Data collection

Data were collected using a structured questionnaire and laboratory investigation. The questionnaire collected information on sociodemographic characteristics, malaria-related knowledge, preventive practices, selected environmental exposures, and malaria-related history. Variables assessed included age, sex, school, class level, mosquito-net use, malaria symptoms, perceived mode of malaria transmission, perceived preventability of malaria, preferred treatment source, presence of bushes or tall grass around the school environment, and proximity to large water bodies. Written informed consent was obtained from participants, with assent and appropriate guardian or school authorization procedures applied where required.

Laboratory Procedures

Malaria microscopy

Capillary blood was obtained by finger prick using a sterile lancet. Thick blood films were prepared on clean glass slides, allowed to air-dry, and stained with Giemsa according to standard laboratory procedures. Slides were examined microscopically under oil immersion using a 100× objective. A blood film was considered positive when *Plasmodium* parasites were observed and negative when no parasites were observed after examination of at least 100 high-power fields [11].

Quality assurance

Reagents were checked before use, blood films were prepared and stained according to standard laboratory procedures, and microscopy was performed by trained laboratory personnel.

Study variables

The primary outcome variable was *Plasmodium* infection, defined as detection of *Plasmodium* species by blood-film microscopy. Explanatory variables included sex, age, class level, school, mosquito-net use, malaria symptoms, perceived mode

of malaria transmission, perceived preventability of malaria, preferred treatment source, presence of bushes or tall grass, and distance from large water bodies.

Statistical analysis

Data were entered into Microsoft Excel and analyzed using Stata version 17. Descriptive statistics were used to summarize participant characteristics and malaria prevalence. Categorical variables were summarized using frequencies and percentages. Associations between malaria infection and categorical explanatory variables were assessed using Pearson's chi-square test. Where expected frequencies were small, the Fisher-Freeman-Halton exact test was used as a sensitivity analysis. Statistical significance was assessed at the 5% level. The 95% confidence interval for overall malaria prevalence was calculated using the exact binomial method.

Ethical considerations

Ethical approval was obtained from the CUHAS/BMC Research Ethics Committee (No. 3677/2025). Permission to conduct the study was obtained from the relevant regional and district health authorities and participating schools. Participants were informed about the purpose and procedures of the study, potential risks including minor discomfort associated with finger-prick blood collection, and anticipated benefits. Participation was voluntary, and participants could withdraw without penalty. Confidentiality was maintained using unique study identification numbers rather than participant names.

Results

Sociodemographic characteristics

A total of 248 boarding high school students participated. Females constituted 55.6% (138/248) and males 44.4% (110/248). More than half were in Form V (137; 55.2%), while 111 (44.8%) were in Form VI. By school, 138 (55.6%) participants were from Bwiru Girls High School, 60 (24.2%) from Bwiru Boys High School, and 50 (20.2%) from Nsumba Boys High School. Participant characteristics are summarized in Table 1.

Table 1: Sociodemographic characteristics of study participants.

Characteristic	n	%
Sex		
Male	110	44.4
Female	138	55.6
Class		
Form V	137	55.2
Form VI	111	44.8
School		
Bwiru Girls High School	138	55.6
Bwiru Boys High School	60	24.2
Nsumba Boys High School	50	20.2
Total	248	100.0

Prevalence of malaria

Of the 248 students examined by blood-film microscopy, 30 were positive for malaria parasites, giving an overall prevalence of 12.1% (95% CI: 8.3–16.8%). The remaining 218 students (87.9%) were negative.

Malaria prevalence by sociodemographic characteristics

Malaria prevalence was 13.6% among males and 10.9% among females ($\chi^2=0.44$, $p=0.507$). All participants were aged 16–20 years. Prevalence was 20.5% at age 16 (8/39), 8.2% at age 17 (4/49), 8.1% at age 18 (5/62), 5.6% at age 19 (3/54), and 22.7% at age 20 (10/44). Pearson's chi-square indicated an association between age and malaria infection ($\chi^2=11.11$, $p=0.025$). Because one expected cell was below 5, the Fisher-Freeman-Halton exact test was also considered and gave $p=0.0314$. Prevalence was 13.9% among Form V students and 9.9% among Form VI students ($\chi^2=0.90$, $p=0.342$). By school, prevalence was 10.9% at Bwiru Girls High School, 15.0% at Bwiru Boys High School, and 12.0% at Nsumba Boys High School ($\chi^2=0.67$, $p=0.715$).

Malaria prevalence and mosquito-net use

Mosquito-net-use frequency was reported as always by 129 students, occasionally by 109 students, and never by 10 students. Malaria prevalence was 12.4% among those reporting always-use, 12.8% among occasional users, and 0% among never-users. The Pearson chi-square test showed no statistically significant association between net-use frequency and malaria infection ($\chi^2=1.44$, $p=0.486$). The small number of students reporting never-use limits precision.

Malaria-related knowledge and environmental factors

Among students who identified mosquito bites as the mode of transmission, prevalence was 12.0%, compared with 15.1% among those who attributed malaria to 'bad air'; none of the 12 students who identified drinking dirty water was malaria-positive. The Pearson chi-square statistic was 2.10 ($p=0.350$). Students reporting bushes or tall grass had a prevalence of 14.1%, compared with 11.4% among those who did not report these features ($\chi^2=0.31$, $p=0.576$). Prevalence was 15.8% among students within 50 m of a large water body, 11.8% among those 51–100 m away, and 6.7% among those more than 100 m away ($\chi^2=1.58$, $p=0.455$). None of these Pearson associations was statistically significant.

Preferred treatment source

Preferred treatment source was reported as clinic by 70 students, health centre by 58, hospital by 80, and school clinic by 40. Malaria prevalence was 11.4%, 17.2%, 15.0%, and 0%, respectively. The Pearson chi-square test gave $\chi^2=7.61$ ($p=0.055$). Because the school-clinic category contained no malaria-positive observations, the Fisher-Freeman-Halton exact test was also examined and gave $p=0.0218$. This difference illustrates the sensitivity of inference to the method used for sparse tables; the result should therefore be interpreted cautiously rather than as evidence of a causal relationship.

Summary of associations

Table 2 presents the observed frequencies and Pearson chi-square statistics. Exact-test p-values are additionally shown for sparse tables in which they were considered.

Table 2: Factors associated with malaria infection among boarding high school students.

Variable	Positive n	Negative n	Pearson χ^2	Pearson p	Exact p*
Age: 16 years	8	31	11.11	0.025	0.0314
17 years	4	45			
18 years	5	57			
19 years	3	51			
20 years	10	34			
Sex Male	15	95	0.44	0.507	
Female	15	123			
Class: Form V	19	118	0.90	0.342	
Form VI	11	100			
School: Bwiru	15	123	0.67	0.715	
Girls	9	51			
Bwiru Boys	6	44			
Nsumba Boys					
Net: Always	16	113	1.44	0.486	
Occasionally	14	95			
Never	0	10			
Symptoms			4.36	0.225	0.2136
All symptoms	12	127			
Fever and chills only	18	88			
Fever and headache	0	1			
Fever, headache, chills, joint pain	0	2			
Transmission:			2.10	0.350	0.4038
Bad air	8	45			
Drinking dirty water	0	12			
Mosquito bite	22	161			
Malaria preventable:			0.35	0.556	0.6217
No	7	41			
Yes	23	177			
Treatment:			7.61	0.055	0.0218
Clinic	8	62			
Health center	10	48			
Hospital	12	68			
School clinic	0	40			
Bushes/tall grass:			0.31	0.576	21
No	21	163			
Yes	9	55			
Distance to water:			1.58	0.455	0.4946
≤50 m	9	48			
51–100 m	19	142			
>100 m	2	28			

*Exact p-values were used as sensitivity analyses for sparse contingency tables. Pearson p-values remain the primary values specified in the analysis plan.

Discussion

This study assessed malaria prevalence and selected associated factors among boarding high school students in Mwanza, Tanzania. The overall prevalence of microscopy-confirmed malaria infection was 12.1% (95% CI: 8.3–16.8%). This finding

demonstrates that malaria infection remains present among adolescents attending boarding schools and supports inclusion of school-aged populations in malaria surveillance and control activities.

The prevalence observed in this study is broadly comparable with the 11.3% malaria prevalence reported among school-aged children in mainland Tanzania in 2023 [8]. Direct comparison should be made cautiously because the national study involved a broader school-aged population and used rapid diagnostic testing, whereas the present study focused on boarding high school students and used microscopy. The national analysis also reported substantial geographic heterogeneity, with the Lake Zone having the highest prevalence [8].

Malaria prevalence was somewhat higher among males than females (13.6% versus 10.9%), although the Pearson chi-square test did not show a statistically significant association. Potential explanations could include differences in outdoor activities, evening exposure, or other behavioral factors; however, these mechanisms were not directly measured in the present study and the observed difference should therefore be interpreted cautiously.

Age was the only sociodemographic characteristic showing a statistically significant association using the Pearson chi-square approach, and the exact test gave a similar result. Prevalence varied substantially across the five observed ages, from 5.6% at age 19 to 22.7% at age 20. Because only 30 participants were malaria-positive and at least one expected cell was small, the age finding should be interpreted cautiously and not as evidence of causality.

Malaria prevalence varied across the three schools, from 10.9% at Bwiru Girls High School to 15.0% at Bwiru Boys High School, with 12.0% at Nsumba Boys High School. The Pearson difference was not statistically significant. School-specific differences in dormitory conditions, drainage, vegetation, mosquito-net condition, student activities, and proximity to breeding sites were not comprehensively assessed.

Reported mosquito-net-use frequency was not statistically associated with malaria infection by Pearson's chi-square test. The absence of infections among the 10 students reporting never-use makes that estimate imprecise. The observed data should not be interpreted as evidence that mosquito nets increase or decrease malaria risk.

Most students who reported knowledge of malaria transmission correctly identified mosquito bites as the principal mode of transmission, although some attributed malaria to 'bad air' or drinking dirty water. Such misconceptions indicate that malaria education remains relevant among adolescents. Knowledge should be accompanied by practical education on consistent mosquito-net use, recognition of symptoms, prompt care-seeking, and environmental risk reduction [10].

Students reporting bushes or tall grass and those reporting proximity to large water bodies had higher observed prevalence, although neither association was statistically significant using

Pearson's chi-square tests. These observations are biologically plausible because aquatic habitats can provide breeding sites for Anopheles mosquitoes and vegetation may influence mosquito resting conditions. Entomological studies around Lake Victoria have documented malaria vectors and ongoing transmission potential [4]. However, the present study did not directly measure mosquito density, species composition, breeding-site productivity, insecticide resistance, or biting behavior.

The treatment-source analysis illustrates the importance of selecting an appropriate statistical method for sparse contingency tables. Pearson's test gave $p=0.055$, whereas the Fisher-Freeman-Halton exact test gave $p=0.0218$ because one category had no malaria-positive observations. This difference should be reported transparently. Preferred treatment source is a self-reported behavioral variable, and the cross-sectional design does not establish temporality or causation.

The study has several strengths, including laboratory-confirmed malaria diagnosis, inclusion of three boarding schools, and assessment of sociodemographic, behavioral, knowledge-related, and environmental variables. Limitations include the cross-sectional design, purposive sampling, the relatively small number of malaria-positive participants, sparse cells for several variables, lack of direct entomological measurements, limited assessment of mosquito-net condition and insecticide status, and the restricted study period. These limitations reduce statistical power and limit generalizability to other boarding students or other regions.

In conclusion, malaria infection was detected in 12.1% of boarding high school students studied in Mwanza. Age showed an association with infection, but this finding requires cautious interpretation because of sparse data and the small number of positive cases. The findings support continued malaria surveillance, prevention, health education, and prompt diagnosis among boarding-school populations.

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the CUHAS/BMC Research Ethics Committee (No. 3677/2025). Written informed consent and, where applicable, assent and guardian authorization were obtained according to the study procedures.

Data availability

The datasets generated and/or analyzed during the current study are not publicly available because they contain participant-level information and are subject to confidentiality and ethical restrictions. De-identified data may be made available from

the corresponding author on reasonable request, subject to approval by the relevant ethics committee and compliance with applicable data-protection requirements.

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