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Prevalence of Plasmodium Parasites Among Clinically Malaria Suspected Febrile Patients in Katsina State

***[1]Yusuf Ado, [2] Abdulhamid Ahmed, [3] Joshua Babalola Balogun, [1] Hamza Khalid Usman, [1] Chinedu Mba, [1] Chinedu Mba, [4]Mahmoud Inusa Yandutse, [1]Ibraheem Akeem Oluwasina, [1] Shunom Gandu, [5] Ibrahim Hamza Kankia, [1] Usman Lawal and [6] Sadiya Nasir**

[1]Medical Laboratory Department, National Obstetric Fistula Centre, Babbar-Ruga, Katsina.
[2]Department of Biological Sciences, Faculty of Natural and Applied Sciences, Umaru Musa Yar`adua University.
[3]Department of Animal and Environmental Biology, Federal University Dutse, Jigawa State.
[4]Chemical Pathology Department, Federal Teaching Hospital, Katsina.
[5]Biochemistry Department, Faculty of Natural and Applied Sciences, Umaru Musa Yar`adua University, Katsina.
[6]Obstetrics and Gynaecology Department, National Obstetric Fistula Centre, Babbar-Ruga Katsina.

*Corresponding authors' email: yusufado@gmail.com Phone: +2348069223578

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ABSTRACT
Malaria is the leading parasitic disease in human morbidity and mortality, imposing a substantial medical, psychological, and economic burden in Nigeria. This cross-sectional study evaluated malaria prevalence among clinically suspected malaria patients and determined demographic factors associated with the disease across four hospitals in Katsina State. A total of 353 blood samples were examined. The results revealed an overall prevalence of 32%. Daura FMC had the highest prevalence (35%), followed by Katsina GH (34%), Funtua GH (28.9%), and TUY MCH (28%). No significant association was found between hospital location and malaria prevalence ($\chi^2 = 1.362$, $p = 0.714$). The highest infection rate was observed in patients aged 21–30 years (13.6%), while the lowest was in those aged ≥41 years (0.28%). This association was not statistically significant ($\chi^2=3.837$, $p=0.428$). Patients with secondary-level education showed the highest infection rate (28.9%), while those with informal education had the lowest (9.3%). However, no significant correlation was found ($\chi^2=7.779$, $p=0.051$). Urban residents exhibited a slightly higher prevalence (19.5%) than rural dwellers (12.5%), but the difference was not significant ($\chi^2=0.633$, $p=0.426$). Infections between females (18.4%) and males (13.6%) were, however, statistically significant ($\chi^2=5.64$, $p=0.018$). Fever (99%) and headache (90%) were the most common symptoms among positive patients, with strong statistical associations ($p<0.001$). Seasonal analysis showed higher prevalence during October–November (39.9%) compared to July–September (26.0%), with nearly twice the odds of infection (OR=1.86, 95% CI: 1.15–2.55, $p=0.016$). The findings highlight demographic and symptomatic influences on malaria prevalence, requiring targeted interventions.

Keywords: Katsina, Malaria, Microscopy, Parasites, Prevalence

INTRODUCTION

Malaria remains the most important parasitic disease globally in terms of morbidity and mortality, with Sub-Saharan Africa being the worst hit (WHO, 2024). The parasite comprises a diverse group of over 250 *Plasmodium species* that infect primates, birds, rodents, and reptiles (Gozalo *et al.,* 2024). *Plasmodium vivax, P. malariae, P. falciparum,* and *P. ovale* are commonly linked with malaria in humans *(*Menkin-Smith *et al*., 2023).

Malaria infection is acquired when a vulnerable person is bitten by a female Anopheles mosquito (Arora *et al*., 2023). Blood transfusion and contaminated needles may also transmit malaria (WHO, 2024). The first symptoms of the disease are nonspecific; it often starts with a minor headache, lethargy, fatigue, abdominal discomfort, muscle and joint pains, usually followed by fever, chills, perspiration, anorexia, and vomiting (Fikadu and Ashenafi, 2023). The disease affects both young and adults; however, young children, pregnant women and girls, travellers, and people with HIV or AIDS are often the most vulnerable groups and are at a significantly higher risk of experiencing severe complications and mortality from the disease (Oyerogba *et al*., 2023; CDC, 2024; WHO, 2024).

Nigeria stands as the most affected country with malaria, having approximately 68 million cases and 194,000 deaths reported in 2021. The country contributes nearly 27% to the total global malaria cases (SMO, 2024). Transmission risk persists nationwide throughout the year. Approximately 97% of the population is at risk of infection, with only 3% living in malaria-free highlands (Sparkle, 2015). Though the incidence is most severe in the northern and north-eastern regions (WHO, 2022). Malaria has been responsible for around 60% of outpatient visits and approximately 30% of hospitalisations among children under five years old. It also contributes to an estimated 11% of maternal mortality (Olasehinde *et al.,* 2010).

Quick and precise diagnosis can never be overemphasised in the effective management of malaria, and this can only be achieved when there is an operative and practical diagnostic method for global malaria control (Kolekang *et al*., 2022). Clinical diagnosis of malaria by medical practitioners is a common practice that is widely documented. In this method, the diagnosis of malaria is syndromic, where the patient is assumed to have malaria based on clinical history, signs, and/or symptoms, and on physical findings at examination (Shahbodaghi and Rathjen, 2022). Consequently, this

presumptive diagnosis, in many cases, has been demonstrated to be alarmingly inaccurate (Li *et al*., 2022; Okereke *et al*., 2025).

From the causative organism point of view, various biological-based diagnostic methods have been developed over the years, ranging from the routine Giemsa stain microscopic method, Immunochromatography (Rapid diagnostic tests), to molecular-based diagnostics (CDC, 2020; Oyegoke *et al*., 2022; Okereke *et al*., 2025). Microscopic examination remains the gold standard for laboratory confirmation of malaria (Orokia *et al*., 2020; Okereke *et al*., 2025). In most endemic areas, microscopic slide examination of peripheral blood has been the most widely used test for malaria diagnosis (Kozycki *et al.,* 2017).

This study aims to determine the prevalence of Plasmodium among symptomatic febrile patients suspected of malaria. The objective is to determine the specific *Plasmodium species* responsible for malaria infections in the study population using microscopy, and to identify any socio-demographic factor(s) associated *with Plasmodium species* infections in Katsina State. The null hypothesis assumes that there is no any specific *Plasmodium species* responsible for malaria infections in the study population using microscopy, and there is no any identifiable socio-demographic factor(s) associated *with Plasmodium species* infections in Katsina State.

MATERIALS AND METHODS

Study Area and Sampling Site

Katsina State has three senatorial zones. Four hospitals were purposively selected for samples collection. Federal Medical Centre (FMC) Daura, and Funtua General Hospital (FTA GH) were selected to represent the Daura and Funtua senatorial zones, respectively, while Katsina General Hospital (GHK) and Turai Umaru Yar'adua Maternal and Children Hospital (TUYMCH), represented the Katsina senatorial zone.

Ethical clearance, with reference number 877, was obtained from the ethical and human research committee of the Katsina State Ministry of Health. Structured questionnaires were used to obtain relevant information from the participants. Informed consents, both written and oral, were obtained from all participating subjects by the standards of human experimentation, and the Helsinki Declaration of 1975 (WMA, 2024). These were done via informed consent of medical history and provisional diagnosis. Physical examinations as well as verbal questions were asked, after which the patients were referred to the laboratory for confirmation of their ailments.

Sample Size

The sample size was determined using a standard formula for prevalence studies, based on the previously reported (Ado *et al*., 2021) prevalence rate (29.8%) relevant to the study population, as follows:

$n = \frac{z^2pq}{d^2}$ (Daniel and Cross, 2018)

Where;

n = Number of samples required, z = the standard normal deviation at a 95% confidence interval = 1.96

p = Expected proportion in population based on previous studies estimated to have malaria in Katsina State = 29.8% (0.298) (Ado *et al*., 2021).

q = 1.0 − P = 0.702 d = degree of accuracy desired; at a confidence level of 95 %, the margin of error is 0.05

Therefore, n = (1.96)2 × 0.298 × 0.702 / (0.05)2 ≈ 321; the minimum sample required is 321 patients. To make up for the non-response, an additional 32 (10% of 321) patients were enrolled in the study. A total of 353 patients suspected of malaria were purposively sampled and recruited into the study after providing informed consent.

Based on the total hospital bed capacity, the number of samples collected per hospital was as follows:

Table 1: Sample Collection by Hospital

Hospital	Location	Number of samples collected
General Hospital Funtua (GHFTA)	Funtua	90
Federal Medical Centre Daura (FMCD)	Daura	80
Umaru Musa Yar'adua Teaching Hospital (TUYMCH	Katsina	60
General Hospital Katsina (GHKTN)	Katsina	123
Total		353

Samples Collection

A vein-puncture technique was adopted during the sample collection (WHO, 2016), 5 mls of blood were aseptically drawn from each participant and dispensed into well-labelled EDTA containers. Thick blood smears were made for each patient. The blood films were appropriately stained with 3% Giemsa stain. Each of the samples was then microscopically screened for the presence of the Plasmodium parasite (WHO, 2016). Collection and processing were performed simultaneously over six months, from May to November 2024.

Microscopic Analysis

Thick and thin blood smear preparations were carried out following the standardised protocols established by WHO (2017) and CDC (2020). All smears were subsequently stained using Giemsa stain. For thin film preparations, fixation in absolute methanol was performed before the staining process, as recommended by WHO (2017). Once prepared, each slide was subjected to microscopic examination to detect the presence of malaria parasites, in accordance with the guidelines outlined by WHO (2016).

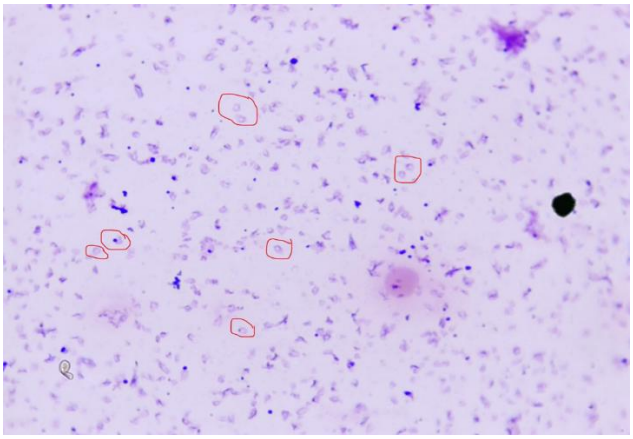

Figure 1: Giemsa-Stained Thick Film, Showing *Plasmodium falciparum*

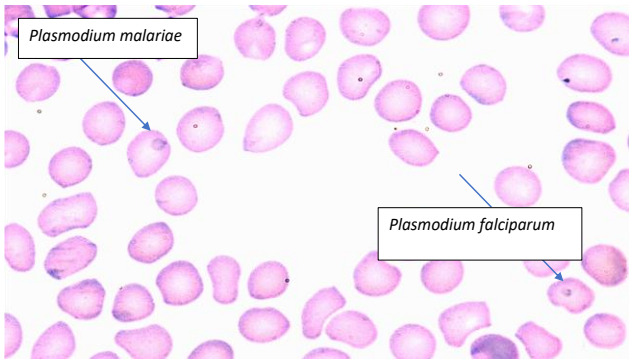

Figure 2: *Plasmodium malariae and P. falciparum* (Thin Blood Film Slide)

Statistical Analysis

Data analyses were conducted using SPSS. Chi-squared, Mann-Whitney U, and Kruskal-Wallis tests were appropriately applied to assess associations between categorical variables; p-values < 0.05 were considered significant.

RESULTS AND DISCUSSION

Results

Table 2 presents the malaria prevalence across the four selected hospitals in the state. Overall, 32% (113/353) of the patients were found to harbour malaria parasites in their blood samples.

Table 2: Distribution of *Plasmodium species* Among the Four Individual Hospitals and the Total Malaria Prevalence Among all Patients Examined Using Microscopy

Hospital	DRA FMC	FTA GH	KTN GH	TUY MCH	Total	Species Prevalence
Total Samples	80	90	123	60	353	
P.falciparum Only	28	25	42	14	109(30.88%)	96.5%
P.malariae Only	-	-	-	2	2(0.5%)	1.8%
P.falciparum + *P.malariae*	-	1	-	1	2(0.5%)	1.8%
Total Positive	28	26	42	17	113	
Prevalence/Hospital (%)	35%	28.9%	34.1%	28.3%		
Prevalence/Total Patients (%)	7.9%	7.4%	11.9%	4.8%	32.0%	

$\chi 2$ =1.362. The p-Value is 0.714

Individually, the highest malaria prevalence was recorded at Daura FMC, out of the total 80 patients examined, 35% were found to harbour Plasmodium parasites in their blood samples. This was followed by Katsina G.H, with a prevalence of 34% from the 123 patients screened at the Centre. Funtua G.H recorded a prevalence of 28.9% out of the 90 malaria-suspected patients examined. TUY MCH recorded the least prevalence of malaria infection with 28% from the 60 patients examined. However, the chi-square statistic between hospitals and the malaria prevalence was 1.362, with a p-value of 0.714.

Relatively, Katsina GH had the highest prevalence of 11.9% (42 patients) out of the total 353 patients examined. This was followed by Daura FMC and Funtua GH, with the relative prevalence of 7.9 % (28 patients) and 7.4% (26 patients), respectively. TUY MCH scored the lowest prevalence relative to other hospitals, with 4.8% (17 patients). In total, out of the 353 patients examined, 32% (113) were found to harbour malaria parasites in their blood samples.

Plasmodium falciparum recorded the highest prevalence; of the total 113 infected patients, 109 (96.5%) were infected solely with *P. falciparum.* Two patients were infected with *P.*

malariae, accounting for 1.8%. Mixed infections with *P. falciparum* and *P. malariae* were observed in 2 patients, also representing 1.8% prevalence.

Table 3 presents a detailed malaria distribution by age groups. Patients within the age bracket of 21-30 years had the highest prevalence of 13.6% out of the total 353 patients examined. The age group of 11-20 years came second, with a prevalence of 7.6%. The age group of 0-10 years had 80 patients, out of which 27 were tested positive, equivalent to 7.6% malaria prevalence. Malaria prevalence of 3.96% was registered by the age cluster of 31-40 years, whose total number of patients was 94. The fewest cases were recorded from the age group of 41 years and above, out of the total number of 7 patients, only 1 tested positive (0.28% prevalence). The chi-square statistic between age group and malaria prevalence is 3.8373, with a *p*-value of 0.428468.

Table 3: Malaria Prevalence by Age Groups Using Microscopy

AGE (Years)	Number Examined	Malaria positive	Prevalence
1-10	80	23	6.5 (%)
11-20	94	27	7.6 (%)
21-30	127	48	13.6 (%)
31-40	45	14	3.96 (%)
≥41	7	1	0.28 (%)
TOTAL	353	113	32(%)

The Chi-Square ($\chi 2$) Statistic is 3.8373. The *p*-Value is 0.428468

Table 4 gave an insight into the prevalence of malaria based on the educational levels of the patients. The proportion of patients with a secondary level of education was the most affected by the parasite, having a prevalence of 14.7% from the 353 patients examined. Around 7.6% that tested positive were patients that have tertiary level of education. The lowest prevalence was recorded from children below school age and some adults who had no formal education, who scored a similar prevalence of 4.8% each. The chi-square between the educational background of the patients and the malaria prevalence was 7.779, with a *P*-value of 0.50808.

Table 4: Distribution of Malaria Based on the Level of Education, Using Microscopy

Level of education	Number examined	Number positive	Prevalence (%)
Primary	83	17	4.8
Secondary	154	52	14.7
Tertiary	66	27	7.6
Non	50	17	4.8
Total	353	113	32%

The Chi-Square ($\chi 2$) Statistic is 7.779. The *p*-Value is 0.051

Table 5 gave an insight into the prevalence of malaria in relation to the gender of the patients from the 4 hospitals. Females were more infected than males in all the hospitals, with Katsina GH having the highest prevalence of 6.8%. This was followed by females from TUY MCH and Funtua GH, with a prevalence of 4.5% each. The lowest prevalence of females infected was in TUY FMC, having a prevalence of 2.5%. Generally (shown in Table 5), females recorded a higher prevalence of 18.40% (65/353) than males, who secured 13.6% (48/353). The chi-square statistic between the malaria prevalence and the gender of the patients is 6.198. The *p*-value is 0.0128.

Table 5: Malaria Distribution Based on Gender by Hospitals, Using Microscopy

Hospital	Positive		Negative	
	Male (% Prevalence)	Female (% Prevalence)	Male	Female
DRA FMC (80)	12 (3.4%)	16 (4.5%)	36	16
FTA GH (90)	10 (2.8%)	16 (4.5%)	36	28
KTN GH (123)	18 (5.1%)	24 (6.8%)	48	33
TUY MCH (60)	8 (2.3%)	9 (2.5%)	16	27
Total	48 (13.59%)	65 (18.41%)	136	104

The Chi-Square ($\chi 2$) Statistic is 5.64. The *p*-Value is 0.018

As tabulated in Table 6, patients who came from Urban areas at Katsina GH, Daura FMC and Turai MCH were more infected, with a prevalence of 7.9%, 5.7% and 3.1%, respectively. While rural-bound patients at Funtua GH were more affected, with a prevalence of 4.5%. Generally, patients from urban areas turned out to be more infected with malaria, having a prevalence of 19.5% (69/353), than the patients from rural areas, who had a prevalence of 12.5% (44/353) (Table 6). The chi-square statistic between the malaria prevalence and the residence of the patients is 0.6325, with a *p*-value of 0.426433.

Table 6: Malaria Distribution Across the Hospitals Based on the Residence of the Patients

Hospital	Urban		Rural		Total
	Positive	Negative	Positive	Negative	
DRA FMC	20 (5.7%)	35	8 (2.3%)	17	80
FTA GH	10 (2.8%)	35	16 (4.5%)	29	90
KTN GH	28 (7.9%)	53	14 (4.0%)	28	123
TUY MCH	11 (3.1%)	34	6 (1.7%)	9	60
Total	69 (19.5%)	157	44 (12.5%)	83	353

The Chi-Square Statistic is 0.6325. The p-Value is 0.4264

Table 7. Around 99% of all the 113 malaria-positive patients complained of fever as the main clinical reason for malaria suspicion. Headache was another compounding issue, where it occurred to 90% of the positive patients. Body aches and fatigue were reported by 35%, followed by nausea/vomiting that was experienced by 30% of the positive patients. Feelings of coldness/chills and sweating were reported by 12% and 11.5% of the patients, respectively. Anaemia and jaundice were, respectively, observed on 4% and 1.80% of the infected patients. The association was quite significant, though with various degrees, between malaria and all the symptoms presented, excluding jaundice.

Table 7: Association between Malaria and Clinical Symptoms

Symptoms	POS. (Total)	NEG. (Total)	% Positivity	*P*-value (0.05)
Fever	112	232	99%	0.00000
Headache	102	176	90%	0.00000
Nausea/ Vomiting	34	17	30%	0.00000
Chills	14	7	12%	0.00006
Sweating	13	22	11.5%	0.00002
Anemia	5	4	4.0%	0.00316
Body aches/ Fatigue	39	67	35%	0.00000
Jaundice	2	3	1.8%	0.10200

Table 8 compares the median of the waiting times (days) before seeking care at the clinics among Negative and Positive malaria patients across the four hospitals. Positive patients from TUY MCH seek quicker hospital attention (2 days) than those from other hospitals. The trend was followed by Daura FMC and Funtua GH, with a median of 3 days each. Positive patients who attended Katsina GH generally spend more days (4.5 days) with the symptoms before visiting the hospital

Patients who tested negative for TUY MCH and Funtua GH on average spent 3.0 days before seeking medical attention at their respective hospitals. Negative patients at Katsina GH generally wait for 3.0 days before visiting clinics. Daura FMC recorded negative patients who used to wait for up to 5.0 days, longer than any hospital before visiting the clinics. Mann-Whitney U test statistics for comparing Positive and Negative Cases Within Each Hospital indicated p-values of 0.001 and 0.03 for Daura FMC and TUY MCH, respectively. However, the p-values of association between positive and negative patients versus the symptom's duration for Katsina GH and Funtua GH were, respectively, 0.12 and 0.45. Association of Negative Results Between All Hospitals using the Kruskal-Wallis Test gave a p-value of <0.001. Equally, the association of Positive Results Between All Hospitals using the Kruskal-Wallis Test gave a p-value of <0.001.

Table 8: Comparison of the Duration of Symptoms (days) for Positive vs. Negative Patients in Each Hospital

Hospital	Positive (Median)	Negative (Median)	Calculated p-value
Daura FMC	3.0	5.0	0.001
Funtua GH	3.0	3.0	0.450
Katsina GH	4.5	4.0	0.120
TUY MCH	2.0	3.0	0.030
Calculated *p*-value	*p*-value <0.001	*p*-value <0.001	

Table 9 gave an insight into the relationship between rainfall patterns and Malaria prevalence. All 353 samples were collected over a period of five months, from July to November 2024. The monthly Prevalence ranged from 24.6% in August to 40.0% in October. Months of July, August, and September had lower prevalence values of 28.2%, 24.6%, and 25.0% respectively. while October and November showed marked increases (40% and 39.7%, respectively). A chi-square test for trend across the five months showed no statistically significant difference ($\chi 2 = 5.12$, $p = 0.275$). Grouping the data based on malaria prevalence between the heavy rainy months (July–September) and the succeeding months of much less rainfall (October–November) showed that, of the 200 patients tested during July-September, 52 were infected with malaria. This resulted in a prevalence of 26.0%. Positive cases during October and November showed a significantly higher prevalence. Out of 153 patients tested, 61 were found to be positive (39.9%). Statistical testing confirmed a significant association between July-September and October-November, with malaria prevalence ($\chi^2 = 6.04$, $p = 0.016$). The odds (odds ratio) of testing positive for malaria were 1.89 times higher in the months of October-November compared to the rainy months of July-September (OR = 1.86, 95% CI: 1.15–2.55, p = 0.016).

Table 9: Relationship Between Rainfall Patterns and Malaria Prevalence

Hospital	Symptoms	July	August	September	October	November	Total
DRA FMC	Positive	5	4	4	7	8	28(35%)
	Negative	11	10	9	10	12	52
FTA GH	Positive	4	3	4	8	7	26(29%)
	Negative	15	12	14	12	11	64
KTN GH	Positive	7	6	7	12	10	42(34%)
	Negative	16	17	18	16	14	81
TUY MCH	Positive	4	2	2	3	6	17(28%)
	Negative	9	7	10	7	10	43
	Total Positive	20	15	17	30	31	113(32%)
	Total Negative	51	46	51	45	47	240
	Total Samples	71	61	68	75	78	
	Prevalence by Month	28.2%	24.6%	25.0%	40.0%	39.7%	
	Prevalence by Total Patients	5.7%	4.2%	4.8%	8.5%	8.8%	

Association Between Monthly Malaria Prevalence and Hospitals: $\chi 2 = 5.12$, p-Value = 0.275. Malaria Prevalence in Relation to Seasonal Variation Between Months of July-September and October-November: $\chi 2 = 6.04$, p-value = 0.016. (OR = 1.86, 95% CI: 1.15–2.55)

Discussion

The research revealed an overall *Plasmodium* parasite prevalence of 32% among 353 clinically suspected malaria patients across the four hospitals studied. This indicates that nearly one-third of patients presenting malaria-like symptoms were confirmed positive, emphasising malaria as a significant public health concern in the region. The prevalence rate aligns with findings from similar malaria-endemic regions, where clinical suspicion often correlates with confirmed cases (WHO, 2024). Ehidiamhen *et al* (2024), in their study on the Prevalence of Malaria Parasites among Febrile Patients in a Teaching Hospital in South East Nigeria, identified that 78% of the studied population were positive.

Individual results indicated Daura FMC to have recorded the highest prevalence (35%), followed by Katsina GH (34%), Funtua GH (28.9%), and TUY MCH (28%). While cumulatively, Katsina GH had the relatively highest prevalence, with 11.9% (41/353). The lowest was TUY MCH, with 4.8% (17/353). However, the chi-square test (χ^2=1.362, p=0.714) indicated no statistically significant association in prevalence between hospitals. The differences may be due to random variation rather than institutional or geographic factors.

The highest malaria infection was observed in young adults (21–30 years), with a prevalence of 13.6%. This may likely be due to factors like increased outdoor exposure, occupational activities, or lower use of preventive measures, such as lesser insecticide-treated net usage, compared to older age groups. The lowest prevalence (0.28%) was found in individuals ≥41 years, probably due to acquired immunity or reduced exposure. According to Ehidiamhen *et al* (2024), the age group 31 - 40 years constituted the greatest proportion of the population with malaria parasite infection. Children (0–10 years) had a prevalence of 6.5%, consistent with high vulnerability in endemic areas (Oluwafemi *et al*., 2023). The lack of statistical significance (χ^2=3.837, p=0.428) suggests that while trends exist, age alone may not be a decisive risk factor. This is in contrast to Noland *et al*. (2014), who observed that even though there was no significant relationship between malaria and age, malaria infection was more common among children within the age bracket of 5–9 years.

Patients with a secondary level of education had the highest infection rate (14.7%). This was followed by those with a tertiary level of education. Those with primary education or who had none had the lowest prevalence (4.8%, each). The findings somehow challenged the assumptions that higher education correlates with better malaria prevention practices (Nkem *et al*., 2006). The contradiction may be due to occupational exposure or testing bias if more educated individuals seek care earlier. The non-significant p-value (χ^2=7.779, p=0.051) suggests education level alone is not reliable enough to predict infection.

Females had a significantly higher prevalence (18.4%) than males (13.6%) (χ^2=6.198, p=0.018). Indoor exposure to mosquitoes, especially during household chores and child care, may be a contributing factor to this occurrence. In the same vein, hormonal or immunological factors influencing susceptibility, greater care-seeking behaviour among women, leading to more testing, may also be a contributing factor. The findings agree with Nas *et al*. (2017), Quaresima *et al*. (2021), Okiring *et al*. (2022), and Ehidiamhen *et al.* (2024), who independently concluded that the highest prevalence occurred in females. Awosolu *et al* (2021), on the other hand, found that males had a higher malaria prevalence than females.

Urban residents had a higher prevalence (18.3%) than rural dwellers (10.0%), but the association was not significant (χ^2=0.633, p=0.426). This agreed with typical trends where urban areas, with poorer infrastructure and more mosquito breeding sites, show higher malaria rates (Chiziba *et al*., 2024). The research, however, disagreed with the findings of Jean-Claude *et al*. (2024), who discovered that rural populations are more prone to malaria infection than urban dwellers. The minimal difference here may suggest rural transmission hotspots or comparable exposure risks.

Fever (99%) and headache (90%) were the most common symptoms, with highly significant associations (p<0.001). Body aches/fatigue (35%), nausea/vomiting (30%), and chills/sweating (~12%) were also prevalent. Jaundice (1.8%) and anaemia (4%) were rare but important severe malaria indicators. The strong link between fever/headache and malaria supports their use as key diagnostic indicators, though overlapping symptoms with other diseases, such as typhoid, may often lead to misdiagnosis (Birhanie *et al*., 2014).

Overall, results showed that malaria-positive patients tend to visit hospitals earlier, compared to malaria-negative patients, particularly in certain hospitals. This may suggest that patients infected with malaria may experience more severe or recognisable symptoms, prompting earlier healthcare-seeking behaviour, whereas patients with other febrile illnesses may delay hospital visits, possibly due to milder or confusing

symptoms. The findings are consistent with those of Mboera *et al*. (2006) and Deressal (2007), who reported that patients with malaria often present to hospitals earlier because of severe symptoms, particularly high fever and chills, which are readily recognized by both patients and their caregivers. Onwujekwe *et al.* (2008), on the other hand, found no significant difference between the timing of hospital visitation by malaria-positive vs. malaria-negative patients. The difference may be due to financial barriers and lack of transportation, which can similarly influence all patients.

Rainfall variation expressed a modest influence on the malaria prevalence. The results showed a significantly higher prevalence in October and November (39.9%) compared to the rainier months of July, August, and September combined (26.0%), with nearly two-fold greater odds of infection in October and November. Female mosquitoes lay eggs in water, and these eggs hatch into larvae in the water, followed by pupae development, and finally emerge as adult mosquitoes (CDC, 2023). During the peak of the rainy season (July, August and September), fast-flowing water disrupts mosquito larvae development by washing them away, temporarily reducing breeding sites and thereby reducing vector density in certain areas. However, the rain also creates new water bodies. In October and November, the stagnant waters in drainage systems and other waterlogged pools provide ideal, long-lasting breeding grounds for mosquitoes, leading to an increase in their populations and a subsequent rise in malaria cases. Human behavioural factors, notably reduced use of preventive measures, such as treated mosquito nets, may also contribute to the differences. Hospital sampling variation could also have played a role, as patient attendance may vary monthly with agricultural and social activities. The findings agree with the work of Touré *et al.* (2016), who found that malaria transmission peaks at the end of the rainy season. Also, Tigu *et al.* (2021) reported that Autumn (a period immediately after the rainy season) was identified as the highest malaria prevalence season. The work further agreed with the findings of Ekpo *et al*. (2020), who found that there was a strong relationship between the number of malaria diagnosed enrollees of NHIS and the change in temperature and rainfall.

The findings, however, disagreed with the work of Kripa *et al.* (2024) and Njotto *et al.* (2025). Their analysis revealed that the seasonal temperature pattern was more influential in malaria prevalence, though malaria cases were highest from July to November, coinciding with the main rainy season. Temperature plays a key role in malaria epidemiology, as it directly affects both the mosquito vector and the Plasmodium parasite. One important pathway is through the extrinsic incubation period (EIP) of the parasite. As temperature increases (within a biologically suitable range), the EIP shortens, meaning parasites develop faster in the mosquito midgut and salivary glands (Stopard, 2023). Consequently, more mosquitoes survive long enough to become infectious, thereby increasing transmission potential. However, the temperature–malaria relationship is nonlinear. Transmission does not rise indefinitely with warming (Zhao *et al*., 2014). Instead, it peaks around moderate temperatures (~24–26°C for *P. falciparum*) and declines when conditions become too hot (>30°C), mainly because mosquito survival decreases. Thus, warming may increase malaria risk in cooler regions and seasons, but reduce it in already hot seasons (Fatima *et al*., 2025).

CONCLUSION

This study confirms a high malaria burden among symptomatic patients, with notable variations by age, gender, and education level. While some findings align with established epidemiological patterns, others, including the high prevalence among educated individuals, warrant further investigation. Strengthening diagnostic accuracy, public health education, and targeted interventions, particularly for high-risk groups, could help reduce malaria transmission in the region.

The research has provided significant understanding into malaria prevalence and associated factors among clinically suspected patients in the four hospitals studied, but they may not fully reflect the entire population of Katsina State due to sampling limitations. Except for gender, other variables were non-significant to malaria prevalence. This may suggest that the observed patterns are not strongly influenced by hospital, age, education, or residence in this sample.

Seasonal malaria prevalence in the study area has not strictly followed the classical rainy-season peak, but extended into the early dry season. This calls for sustained malaria control and prevention measures throughout the year rather than focusing interventions only during the rainy months.

It is recommended that public health interventions and malaria awareness programmes prioritize females and young adults while promoting early care-seeking behaviour; that RDTs be made widely available in primary healthcare centres and clinics to facilitate prompt diagnosis, particularly for patients presenting with fever and headache; that healthcare workers receive training to recognize atypical malaria symptoms, such as nausea and fatigue, especially in low-transmission settings; and that sustained research and surveillance be strengthened to investigate the observed gender disparity in malaria prevalence.

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