Malaria infection and its association with socio-demographics, preventive measures, and co-morbid ailments among adult febrile patients in rural Southwestern Nigeria: A cross-sectional study

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Abstract

Objectives: The study determined the prevalence of malaria infection and its association with socio-demographics, environmental, housing, and co-morbid ailment factors.

Methods: The study was a cross-sectional of 330 consented adult febrile patients who were recruited at a tertiary health facility in rural Southwestern Nigeria. The standardized interviewer-administered questionnaire sought information on their socio-demographics, environmental, housing, and co-morbid ailment factors. Venous blood samples were collected and processed for malaria parasite detection, retroviral screening, glycated hemoglobin, and hemoglobinopathy. Data were analyzed using SPSS version 20. The strength of the association between independent and dependent variables was measured using odds ratio and 95% confidence interval with a significant level (p value <0.05).

Results: The prevalence of malaria parasitemia was 63.3% (95% confidence interval: 57.9%–68.5%). Being a farmer ($p = 0.002$), lack of formal education ($p = 0.043$), low-income earners ($p = 0.031$), presence of bushes ($p = 0.048$), stagnant water ($p = 0.042$), not sleeping under long-lasting insecticide-treated nets ($p < 0.001$), and sickle cell disease ($p = 0.041$) were significantly associated with malaria infection.

Conclusion: The study revealed that there is a high prevalence of malaria infection in rural Southwestern Nigeria. There may be a need to pay greater attention to adult populations in rural areas for malaria intervention and control programs.

Introduction

Malaria infection remains a global public health problem and a leading cause of morbidity worldwide.[1,2] Malaria infection is spread through the bites of an infected female mosquito of the Anopheles.[2] *Plasmodium falciparum* is considered the most prevalent of all plasmodia in sub-Sahara Africa (SSA).[2,3] Other malaria parasites causing disease in humans include *Plasmodium vivax*, *Plasmodium malariae*, and *Plasmodium ovale*.[3] Recent reports showed that globally, approximately 214 million cases of malaria occur per year and 3.2 billion people are at risk of the infection.[1,2] Further reports also showed that in 2017, there were 438,000 deaths

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due to malaria globally. Out of these figures, about 93% occur in World Health Organization (WHO) African region, with Nigeria accounting for the highest burden of 19%.[2,4] In Africa, malaria is responsible for about 20%–30% of hospital admissions and about 30%–50% of outpatient consultations.[5] Previous studies have documented a high prevalence of malaria throughout Nigeria.[6,7] This devastating disease affects the country's economic productivity, resulting in an estimated monetary loss of approximately 132 billion Naira (approximately US$700 million) in treatment costs, prevention, and other indirect costs.[8]

The major clinical features of uncomplicated malaria include severe headache, fever, vomiting, loss of appetite, and generalized body weakness, while severe anemia, hypoxia, and cerebral malaria constitute the common complications in severe malaria.[9] Some of these clinical features are common in some patients with co-morbidities such as diabetes mellitus, uncontrolled hypertension, malignancies, HIV infection, hemoglobinopathy, and chronic kidney disease.[9]

Although studies have shown that clinical immunity to malaria develops after exposure to parasites, at one stage in life, this immunity is only partial and may be influenced by some variations such as endemicity and other disease burdens.[7,9] Evidence suggests that some co-morbidities exert a reasonable impact on a person's immunity; therefore, factors that result in the development of partial immunity may not be adequate enough to guarantee such immunity against malaria infection.[7,9]

The major associated factors contributing to malaria transmission in SSA may include temperature, humidity, and rainfall.[5–7] Other factors include socio-demographics (such as age, gender, education, occupation, income level, and location), environmental factors (such as presence of bushes and unblocking stagnant water channels) which may enhance mosquito breeding, and housing factors (such as bricks or mud houses, absence of window nets, and not sleeping under long-lasting insecticide nets (LLINs)).[2,6] These factors have been well documented particularly in urban and semiurban communities in previous studies.[2,10,11]

In Southwestern and other parts of Nigeria, there are several approaches that have been recommended for the prevention and control of malaria in their localities.[12,13] These include the use of LLINs, insecticide sprays, mosquito repellent creams, and window nets. In pregnant women, the use of intermittent preventive treatment and prompt access to effective case management have been included.[13,14] Furthermore, community awareness, which is recognized as the cardinal tool currently used for malaria prevention strategy, is generally poor at preventing malaria cases in rural Nigeria.[14] However, education, behavioral change, and active practices regarding malaria prevention and control are well-documented and proven interventions.[14,15] Behavioral change campaigns can increase demand among the families to use and hang their nets regularly and can improve malaria prevention and control, especially in rural settings.[14–16]

Since 2000 when Nigeria adopted some of these measures against malaria, several researchers have reported the low utilization of these strategies.[12,13] A study in Southwestern Nigeria regarding the practice of malaria control in a specific area showed that the majority of respondents had household members who failed to use the control method appropriately.[13,16] Available literature on the utilization and effectiveness of malaria prevention methods in health institutions in Nigeria has been restricted to urban settings.[13–15] However, the effects of co-morbid conditions with regard to malaria transmission are rarely examined. Identifying key risk factors by socio-demographic context and incorporating the effect of preventive measures and co-morbid conditions are crucial for the effective implementation of prevention and health intervention programs.[17]

Most efforts toward malaria prevention, management, and control are targeted under five children, pregnant women, and their unborn babies. Those in the older age groups are not adequately considered in most of these programs, amounting to some kind of obvious neglect in those of older age groups. To the best of our knowledge, there is an observed paucity of data on these factors and malaria parasite prevalence among adult patients in rural Southwestern Nigeria. This study is aimed to determine the prevalence of malaria infection and to investigate its association with socio-demographics, environmental, housing, and co-morbid ailment factors among adult febrile patients who presented to a tertiary health care facility in rural Southwestern Nigeria. This is with a view to designing and implementing appropriate effective control measures that would contribute to the global elimination of malaria infection in rural Southwestern Nigeria. Furthermore, a better understanding of the relationship between malaria infection and socio-demographic factors related to poverty is needed because the financial protection necessary to combat this menace is a major challenge for people in rural Southwestern Nigeria.[12,14,18]

Materials and methods

Study area: The study was carried out from May to July 2021 at the institution's family medicine clinic. The study site is in a tropical rain forest in rural Southwestern with climatic and environmental conditions that support malaria transmission throughout the year. It has a total land area of $332\,km^2$, and as of the last population census of 2006, it had a total population of 159,114 with an annual growth rate of 3.2%.[19] The inhabitants of the area are engaged majorly in farming and trading activities while few others in the formal sector are the working population and retirees. In the study area, malaria transmission occurs throughout the year. However, malaria peak season occurs during the wet season with *P. falciparum* being the major causative agent.[12] The institution offers secondary and tertiary care to the people in the locality and its neighborhood states. The institution was accredited for the training of resident doctors in family medicine and other core clinical specialties.

Study design: This was a hospital-based descriptive cross-sectional that was carried out from May to July 2021.

Study population: This comprised adult febrile patients aged 20 years and above and who presented to a family medicine clinic.

Inclusion criteria: This included consented adult febrile patients (with an axillary temperature $\geqslant 37.5°C$) and other clinical symptoms of malaria, whose ages were 20 years and above.

Exclusion criteria: Respondents who required urgent treatment or have a major psychiatric illness and could not follow the study protocol. Also, those currently on treatment for malaria or had just been treated for malaria within 3 weeks prior to the recruitment of this study.

Sample size determination: This was determined using the Araoye formula[20]

$$n = Z^2 P \frac{(1-P)}{d^2} \quad \text{and} \quad nf = \frac{n}{1 + \frac{n}{N}} \quad \text{with a prevalence } (P)$$

of 66.7%[21] in Nigeria at 5% margin of error and 95% confidence interval
where $n =$ minimum sample size when the population (N) of the participants in the study area was greater than 10,000 over a period of 1 year and nf is the minimum sample size when the population (N) of the participants was less than 10,000. From the medical records of febrile patients with malaria, N was 3900 in 2019 and $Z = 1.96\%$. Therefore, the minimum sample size nf was 314. To allow for unexpected data losses, an attrition of 5% was added and the sample size was 330.

Sampling technique: A systematic random sampling technique was used to recruit the 330 respondents who fulfilled the inclusion criteria. The medical record of patients with malaria parasitemia at the family medicine clinic showed that in the year 2019, an average of 15 patients were seen daily. This translated to 75 patients per week (Monday–Friday) and 975 (sample frame) patients over a period of 3 months (13 weeks) that the study was conducted. Using the formula, $k = N/n$, where k is the sample interval, N is the sample frame (975), and n represented the minimum sample size of 330. Therefore, k was approximately 3. The first respondent on each clinic day was chosen by simple random sampling and thereafter, every third respondent was chosen by systematic random sampling until the sample size of 330 is attained. A sticker was placed on each of the selected folder to avoid re-sampling at the subsequent clinics.

Ethical clearance and considerations

The Ethics and Research Committee of the institution approved the study (ERC/2020/08/25/402A). Information about the objectives and the procedure of the study was duly explained to the respondents after which they were made to sign a written informed consent. This was either by appending signature or thumb printing. An independent interpreter who served as legal guidance assisted those respondents who could not read or write to translate the questionnaire from English language to their local languages. Back translation to English language was subsequently done to maintain response consistency. The respondents were told that they were free to refuse or disengage participation at any time without losing any benefit of care or favor to those that participated. Confidentiality and privacy were ensured throughout the study. The study was at no cost to the respondents. The reporting of this study conforms to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[22] All patients' details have been de-identified.

Recruitment procedure: The data were collected using a pretested standardized semistructured interviewer-administered questionnaire which was developed by the researchers. The questionnaire was pretested on 25 adult febrile patients, who presented at the family medicine clinic of a tertiary hospital which is located at about 30 km from the study center. The pretesting that lasted 3 days was to show how applicable the questionnaire was and its feasibility. The questionnaire was modified to address the challenge(s) that were observed in the pretest and validity assessment. The time taken to complete the questionnaire was about 10 min.

Data collection instruments: Data were collected using the standardized interviewer-administered questionnaire and a data collection form. The questionnaire sought information about the respondents' socio-demographic characteristics (such as age, gender, education, occupation, income level, and location), environmental factors (such as the presence of bushes and unblocking stagnant water channels), and housing factors (such as bricks or mud houses, use of window nets, and sleeping under the LLINs). Other data were collected through screening for the following co-morbidities; hypertension, diabetes mellitus, hemoglobin type abnormality, and human immunodeficiency virus (HIV 1 and 2).

Clinical parameters of the respondents

(a) *Blood pressure (BP)*: Using a good Accosson brand of mercury sphygmomanometer, a senior resident doctor in the department measured the blood pressure of the respondents twice after about 5 min apart. The mean BP of $\geqslant 140/90$ mmHg was considered as hypertension or self-reported treatment of hypertension with antihypertensive medication taken in the previous 2 weeks.[23]

(b) *Sample collection*: By means of the intravenous route, about 10 mL of blood samples of the respondents was obtained with the assistance of a hospital phlebotomist. The blood samples were transferred into an ethylenediaminetetraacetic acid (EDTA) bottle to prevent blood coagulation.

1. *Microscopy*: The blood films (thin and thick) for malaria parasitemia were prepared on clean, dry microscope glass slides and were allowed to dry. The thin smear was fixed in methanol and both smears were stained with 2% Giemsa BDH Laboratory supplies; Poole BH 15 ITD England.[24] The microscopy was used to view the slides at $100\times$ magnification. The staining, counting, and grading of the parasite density were done in accordance with the authorized standard operating procedure for thin and thick films.[24] A senior scientist was recruited to examine the slide for quality control.[24]

2. *Glycated hemoglobin (HbAIc)*: Using a sample of blood collected, HbAIc was determined immuno-chemically on DCA 2000; HbAIc autoanalyzer using kits supplied by the Boehringer Mannheim (Germany) autoanalyzer.[25] Accuracy of the test result was ensured using commercially prepared standards and control samples. HbAIc $\geqslant 6.5\%$ was recorded as undiagnosed diabetes mellitus.[26]

3. *HIV screening*: Two-step algorithms were used in performing the HIV screening test. Determine™ (Abbott Laboratories, IL, USA) HIV reagent was used to screen all specimens. Non-reactive samples were reported as HIV negative. Reactive samples were confirmed using STAT PAK™ 1 and 2 test kit (Chembio Diagnostic System Inc., USA), and specimens in the STAT PAK™ test were reported as positive for HIV 1, HIV 2, or both.[27] Specimen positive in Determine™ and negative in STAT PAK™ were reported as discordant. The true sero-status of each of these samples was determined using Enzyme-Linked Immuno-Sorbent Assay (ELISA) and Polymerase Chain Reaction (PCR) at the laboratory department.

4. *Determination of abnormal genotype*: The genotype of each respondent was determined as described by Ochei and Kolhatkar.[28] About 1 ml of blood samples were withdrawn from the EDTA bottle and centrifuged at 2500 r/min for 5 min. The supernatant was then discarded and packed cells were washed with normal saline three times. The red cells were lysed by adding an equal volume of distilled water and one-quarter (1/4) of toluene followed by a drop of 3% KCN after the final wash. It was then mixed properly. The respondents who had abnormal hemoglobin genotype (SS or SC) were recorded as having co-morbidity.

Treatment of the respondents

All malaria-positive individuals were arranged to see their clinician where they were treated with the standard medication according to the national malaria drug policy. Also, respondents identified with co-morbidity were counseled by a principal investigator, a physician, on lifestyle modification and treatment compliance. They were thereafter scheduled for follow-up in line with the hospital protocols on the management of co-morbid ailments

Some definitions

For the definition of socio-demographic, environmental, and housing factors, see our supplementary material.[29,30]

Statistical analysis: Data collected were checked, cleaned, and entered into EPI Info Version 7.0 and were exported to SPSS version 22.0 for analysis. Bivariate analysis was conducted to ascertain the prevalence of malaria compared to socio-demographic factors, the prevention methods, and the co-morbid conditions of the respondents. The chi-square test of independence at p value < 0.05 was explored to assess any significant association between malaria parasitemia test results and socio-demographics, prevention methods, and co-morbid conditions in terms of p value. Based on significant association with the results, variables were chosen for the multivariate analysis.[31] The multiple logistic regression model was chosen to identify the significant determinants for malaria, and the results were presented in terms of adjusted odds ratios (AORs) that controlled for multiple confounders (with 95% confidence interval). A multiple logistic regression was explored in the analysis of these data because the outcome variable has a binary response of malaria positive or negative results. This outcome variable was re-coded as "0" for respondents who did not have malaria and "1" for those who had malaria. Both AORs and p value < 0.05 were considered for finding the single and covariates effects in the model.[17]

Results

A total of 330 respondents were screened during the study period. The distribution according to socio-demographic characteristics showed that the majority of the respondents 130 (39.4%) were young adults within the ages of 21–40 years. The mean age of the respondents was 45.9 ± 19.9 years (range: 21–88 years). There were more males (201, 60.9%) than females (129, 39.1%). Many of the respondents were farmers 90 (27.3%), and the majority had formal education 298 (90.3%), were rural dwellers 196 (59.4%), and were of low-income earners 196 (59.4%), Table 1.

The prevalence of malaria parasitemia was 63.3% (Table 2).

There was no statistically significant association between the respondents' ages and malaria infection. The results showed that the majority 88 (67.7%) of respondents who tested positive for malaria infection were young adults between the ages of 20 and 39 years (Chi-square (χ^2) = 2.388; p = 0.303). However, a statistically significant association was observed between malaria infection and the occupation of respondents (χ^2 = 76.734, $p < 0.001$). The results showed that those who were unemployed had the highest prevalence

Table 1. Socio-demographic characteristics of respondents.

Variable	Frequency (N = 330)	Percentage (%)
Age (in years)		
20–39	130	39.4
40–59	125	37.9
60 and above	75	22.7
Mean age ± SD	45.9 ± 19.9	
Range	21–88	
Sex		
Male	201	60.9
Female	129	39.1
Occupation		
Farmer	90	27.3
Artisan	72	21.8
Trader	64	19.4
Unemployed	50	15.2
Civil servant	54	16.4
Education		
Informal	32	9.7
Formal	298	90.3
Domicile		
Rural	196	59.4
Urban	134	40.6
Income level		
Low (≤US$1.90/day)	196	59.4
High (>US$1.90/day)	134	40.6

Table 2. Prevalence of malaria parasitemia the respondents.

Variable	Frequency (N = 330)	Percentage (%)
Prevalence of malaria parasitemia		
Positive	209	63.3
Negative	121	36.7
95% CI for the prevalence of malaria	*57.9%–68.5%*	

(96.0%). Also, the majority of the respondents who had no formal education 27 (84.4%) tested positive for malaria and a significant association was found between malaria parasitemia and level of education ($\chi^2 = 6.756$; $p = 0.009$). Furthermore, a significant association was found between malaria infection and respondents' level of income ($\chi^2 = 19.445$; $p < 0.001$). The results showed that respondents with low income had the highest percentage (176, 69.8%; Table 3).

In the same vein, a significant association was found between malaria infection and the vegetation around the respondent houses ($\chi^2 = 9.089$; $p < 0.003$). The results showed that the respondents whose houses were surrounded by bushes had the highest prevalence (72.5%). Similarly, there was a statistically significant difference between malaria infection and having stagnant water around the respondents' houses ($\chi^2 = 5.561$; $p < 0.018$). The results showed that respondents whose houses were surrounded by stagnant water had the highest prevalence (70.3%). Also, there was a statistically significant difference between malaria infection and the respondents' attitude to the use of LLINs ($\chi^2 = 34.803$, $p < 0.001$). The results showed that respondents who did not sleep under LLINs had the highest prevalence (72.9%) (Table 4).

Similarly, among the 330 respondents who were screened, 66 (20.0%) had co-morbidity. There was a statistically

significant difference between the prevalence of malaria infection and the type of co-morbid ailments in the respondents, ($\chi2 = 8.493$, $p = 0.037$). The results showed that respondents who harbored HIV/AIDS and sickle cell disease were observed to have higher prevalence of 64.3% and 66.7%, respectively. Table 5.

The multivariate logistic regression model showed that the respondents who were farmers were 5.009 times more likely to have malaria infection as compared to the respondents who were civil servants (AOR = 5.009; $p = 0.002$). The analysis of odds ratios also verified that the respondents who had no formal education (AOR = 3.179; $p = 0.043$) were more prone to have malaria than those with formal education. Similarly, the respondents who were of lower income were 2.311 times more likely to have malaria infection (AOR = 2.311; $p = 0.031$) than those with higher income. With regard to prevention against malaria infection, the respondents whose houses were surrounded by bushes (AOR = 2.848; $p = 0.048$) and stagnant water (AOR = 2.986; $p = 0.042$) were more susceptible to malaria compared to their counterparts whose houses were not surrounded by bushes and stagnant water, respectively. It was also found that the probability of having malaria was more likely among the respondents who did not sleep under LLINs (AOR = 3.697; $p < 0.001$), as compared to the respondents who slept under LLINs. Furthermore, the results also showed that the respondents who had sickle cell disease (AOR = 8.00; $p = 0.041$) were more prone to have malaria compared to the respondents who were hypertension (Table 6).

Discussion

The study revealed an overall prevalence of 63.3% of malaria infections among adult febrile patients attending a tertiary health care facility in rural Southwestern Nigeria. This is consistent with previous studies conducted in other parts of rural Nigeria.[21,32] The relatively high prevalence of malaria infection reported in this study might relate to the prevailing study duration, climatic, and environmental conditions that support the breeding of the vector of the parasite. This study was conducted during the peaks of wet season. Our finding was higher than the reported prevalence of 35.7% found among patients in Kaduna, Northwestern Nigeria, and 36.6% found among patients in Plateau, Northern-central Nigeria.[33,34]

Table 3. Association between socio-demographic characteristics and malaria parasitemia in the respondents (N = 330).

Variable	Malaria		Total, N (%)	χ^2	p value
	Positive, n (%)	Negative, n (%)			
Age (years)					
20–39	88 (67.7)	42 (32.3)	130 (39.4)	2.388	0.303
40–59	73 (58.4)	52 (41.6)	125 (37.9)		
60 and above	48 (64.0)	27 (36.0)	75 (22.7)		
Sex					
Male	128 (63.7)	73 (36.3)	201 (60.9)	0.027	0.870
Female	81 (62.8)	48 (37.2)	129 (39.1)		
Occupation					
Farmer	76 (84.4)	14 (15.6)	90 (27.3)	76.734	<0.001
Artisan	23 (31.9)	49 (68.1)	72 (21.8)		
Trader	34 (53.1)	30 (46.9)	64(21.8)		
Unemployed	48 (96.0)	2 (4.0)	50 (15.2)		
Civil servant	28 (51.9)	26 (48.1)	54 (16.4)		
Education					
Informal	27 (84.4)	5 (15.6)	32 (9.7)	6.756	0.009
Formal	182 (61.1)	116 (38.9)	298 (90.3)		
Domicile					
Rural	129 (65.8)	67 (34.2)	196 (59.4)	1.281	0.258
Urban	80 (59.7)	54 (40.3)	134 (40.6)		
Income level					
Low (≤US$1.90/day)	176 (69.8)	76 (30.2)	196 (59.4)	19.445	<0.001
High (>US$1.90/day)	33 (42.3)	45 (57.7)	134 (40.6)		

Table 4. Association between environmental/home factors and malaria parasitemia in respondents (N = 330).

Variable	Malaria		Total, N (%)	χ^2	p value
	Positive, n (%)	Negative, n (%)			
Bushes around houses					
Yes	103 (72.5)	39 (27.5)	142 (43.0)	9.089	0.003
No	106 (56.4)	82 (43.6)	188 (57.0)		
Stagnant water around houses					
Yes	104 (70.3)	44 (29.7)	148 (44.8)	5.561	0.018
No	105 (57.7)	77 (42.3)	182 (55.2)		
House type					
Mud	114 (67.1)	56 (32.9)	170 (44.8)	2.096	0.148
Bricks	95 (59.4)	65 (40.6)	182 (55.2)		
Window nets					
Yes	173 (62.5)	104 (37.5)	277 (83.9)	0.573	0.449
No	36 (67.9)	17 (31.1)	53 (16.1)		
Ownership of ITNs					
Yes	128 (60.4)	84 (39.6)	212 (64.2)	2.231	0.135
No	81 (68.6)	37 (31.4)	118 (35.8)		
Sleeping under ITNs					
Yes	34 (37.8)	56 (62.2)	90 (27.3)	34.803	<0.001
No	175 (72.9)	65 (27.1)	240 (72.7)		

ITNs: insecticide-treated nets.

However, a study carried out across the six geopolitical regions of the country in 2010 concluded that the prevalence of malaria was higher in Southwestern Nigeria compared to Northern Nigeria.[35] This variation may be due to differences in locations, climatic conditions, and environmental factors.[21] The finding in this study showed that the prevalence of malaria infection across the different age groups is of major concern, though, not statistically significant. The results

Table 5. Association between co-morbid ailments and malaria parasitemia in the respondents (N = 330).

Variable	Malaria		Total, N (%)	χ²	p value
	Positive, n (%)	Negative, n (%)			
Type of chronic medical ailment	n = 27	n = 39			
Hypertension	4 (20.0)	16 (80.0)	20 (30.3)	8.493	0.037
Diabetes	10 (38.5)	16 (61.5)	26 (39.4)		
HIV/AIDS	9 (64.3)	5 (35.7)	14 (21.2)		
Sickle cell disease	4 (66.7)	2 (33.3)	6 (1.8)		

Table 6. Multivariate logistic regression model for factors that were significantly associated with malaria parasitemia.

Variable	COR	95% CI		p Value	AOR	95% CI		p Value
		LB	UB			LB	UB	
Occupation								
Farmer	5.041	2.309	11.007	<0.001	5.009	1.812	13.847	0.002
Artisan	0.436	0.210	0.903	0.024	1.053	0.447	2.479	0.906
Trader	1.052	0.510	2.173	0.890	2.680	0.845	6.698	0.069
unemployed	22.286	4.914	101.072	<0.001	3.339	0.971	12.550	0.057
Civil servant (ref)	1.000				1.000			
Education								
Informal	3.442	1.289	9.191	0.009	3.179	1.137	10.778	0.043
Formal (ref)1	1.000				1.000			
Income level								
Low (≤$1.90/day)	3.158	1.871	5.331	<0.001	2.311	1.080	4.945	0.031
High (>$1.90/day) (ref)	1.000				1.000			
Bushes around houses								
Yes	2.043	1.280	3.262	0.003	2.848	1.048	4.589	0.048
No (ref)	1.000				1.000			
Stagnant water around houses								
Yes	1.733	1.095	2.743	0.018	2.986	1.091	6.699	0.042
No (ref)	1.000				1.000			
Sleeping under ITNs								
Yes (ref)	1.000				1.000			
No	4.434	2.656	7.403	<0.001	3.697	1.892	7.223	<0.001
Chronic medical ailment								
Hypertension (ref)	1.000				1.000			
Diabetes	2.500	0.648	9.652	0.177	1.265	0.341	4.899	0.878
HIV/AIDS	7.200	1.532	33.848	0.009	2.745	0.415	5.647	0.374
Sickle cell disease	8.000	1.061	60.326	0.030	8.000	1.025	7.333	0.041

AOR: adjusted odd ratio; CI: confidence interval; COR: crude odd ratio; LB: lower boundary; ref: reference category; UB: upper boundary.

suggest that if the retirement age within the study location is set at 60 years, then, at any given time, the majority (67.7% for ages 21–40 and 58.4% for ages 41–60) of the active workforce suffers from malaria infection. The overall effect may result in reducing their efficiency and contributing to their low productivity. These findings revealed that malaria continues to be a leading cause of morbidity and mortality in rural settings. Therefore, innovative and effective interventions to control malaria should be identified and implemented in this community.[21]

The findings in this study revealed that farming increased the odds of malaria infection among the studied population.

This is consistent with the reports of other studies.[10,36] This could be due to the fact that farming enhances human-vector contact.[10,36] Besides, many farmers have keyed into some water-related projects involving the creation of reservoirs for the purpose of irrigating farms to improve their yields. Despite the economic significance of these projects, these reservoirs also serve as a breeding ground for mosquitoes to thrive.[36]

The lack of formal education was found to contribute to a higher risk of malaria among the studied population. This is consistent with previous reports in Nigeria that showed that malaria is more common among people with low literacy.[17,37]

This may be due to lack of information and ignorance of the preventive measures among these sets of patients. Even, when they are aware of the preventive measures and their interventions, they may be unable to implement and manage them appropriately.[17,37] The lack of education may also influence other variables like income and occupation which were also associated with malaria risk.

In the same vein, low-income earners doubled the odds of malaria among this population. This is consistent with previous reports from other studies in Nigeria that showed that malaria is more common among people of lower socio-economic status.[21,38] Malaria and poverty are mutually inclusive as malaria is reported to be common in developing countries.[21,38,39] This may be due to their poor housing and environmental factors that increase their exposure to frequent mosquito bites.[21,38] Other studies have attributed low socioeconomic factors to poor access to quality health care services for prevention, diagnosis, and treatment.[21,40] Despite the high LLINs distribution, low socioeconomic factor at both the community and household levels was a significant risk factor for malaria infection in rural Northwestern Tanzania.[39]

Higher prevalence was also found among the respondents whose houses were surrounded by bushes and stagnant water. These findings were consistent with data obtained from various studies in Nigeria and other SSA.[10,21,38] The bushes and stagnant water have been found in previous studies to be reservoirs of breeding grounds for mosquitoes, thereby enhancing human–vector contact.[10,36] These findings suggest that effective environmental sanitation, geared toward the clearing of bushes and gutters should be intensified. This intervention may reduce the spread of mosquitoes, thereby reducing the incidence of malaria in rural settings.[21,38]

Similar to other studies, this study also revealed that failure to use LLINs was found to be associated with increased malaria infection. This is consistent with previous studies in Nigeria.[21,41] The use of LLINs is considered one of the most cost-effective interventions against malaria in endemic areas and is associated with a significant reduction in malaria morbidity and mortality.[10] Despite the high number of respondents in this study who possessed LLINs (57.0%), only half of the respondents (27.3%) stated that they used them. This poor utilization is consistent with previous studies in Nigeria[10,21,42] and other SSA countries.[17,43] A report from a national study in Nigeria revealed an observed gap between ownership and use of LLINs and revealed that only 28.7% of the population had one LLIN in the household.[44] Considering the role of LLINs against the spread of malaria infection in endemic areas, the findings of this study call for regular and sustained distribution of free LLINs in this rural community to reduce the incidence of malaria infection.

In this study, HIV/AIDS has no significant association with malaria infection. This finding was opposite to the reports of other studies that found a significant association between HIV/AIDS and malaria infection.[45,46] Therefore, further research is recommended to identify the magnitude of association between malaria infection and HIV/AIDS in SSA to fully understand the relevance and cause of these findings.

In addition, hemoglobin sickle cell disease respondents were found to be significantly associated with malaria infection in this study. This is consistent with reports of other studies.[6,47] The increased odds of malaria infection among these respondents may be due to their weak immunity and improper use of recommended interventions against malaria.[42] However, a study by Suchdev et al. in Kenya found no significant association between malaria infection and respondents with sickle cell diseases.[48]

Finally, in view of the above findings on factors that were significantly associated with the risk of malaria infection in this study, the government should provide awareness to rural dwellers on how to identify and remove mosquito-breeding sites within their locations from time to time. Also, government should make available the distribution of additional free mosquito bed nets and fumigation while also enforcing the available law on frequent public sanitation.

Limitations

First, the cross-sectional nature of the study design does not allow ascertaining the causal association between the outcome variables and potential contributing factors. Multivariate analysis cannot exclude unmeasured confounders, and association does not mean causality. Information collected from the respondents was self-reported and might be subjective by recall bias when highlighting the association between malaria infection and socio-demographics and preventive methods adopted. Also, exposure to malaria infection might still have differed among the studied population considering the endemic malaria transmission in rural Southwestern Nigeria. Therefore, ultimate corroboration would need a prospective longitudinal study controlling for exposure. Despite these limitations, the study generates distinctive information regarding factors that were significantly associated with malaria infection in rural Southwestern Nigeria. These findings may be helpful to formulate further strategies for malaria intervention.

Conclusion

The study revealed that there is a high prevalence of malaria infection in rural Southwestern Nigeria. Being a farmer, lack of formal education, presence of bushes and stagnant water around the houses, low-income earners, not sleeping under LLINs, and genotype SS were the significant factors associated with malaria infection in this study. There may be a need to pay greater attention to the adult population living in rural areas for malaria intervention and control programs. The findings of this study would assist the stakeholders in decision-making toward improved malaria preventions and control.

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References

1. World Health Organization (WHO). *World malaria report 2018: global malaria programme*. Geneva: WHO, 2018.
2. Bate A, Kimbi HK, Lum E, et al. Malaria infection and anaemia in HIV-infected children in Mutengene, Southwest Cameroon: a cross sectional study. *BMC Infect Dis* 2016; 16: 523.
3. Eke SS, Omalu ICJ, Olayemi IK, et al. Malaria parasitaemia among patients attending general hospital, Minna, Northcentral Nigeria. *J Biosci Biotech Disc* 2018; 3: 78–82.
4. Bhatt S, Weiss DJ, Cameroon E, et al. The effect of malaria control on plasmodium falciparum in Africa between 2009 and 2015. *Nature* 2015; 526(7572): 207.
5. Fairhurst RM, Nayyar GML, Breman JG, et al. Artemisinin-resistant malaria: research challenges, opportunities, and public health implications. *Am J Trop Med Hyg* 2012; 87(2): 231–241
6. Jemimah Y, Victor O, Elizabeth A, et al. Plasmodium falciparum infection among febrile patients attending a tertiary healthcare facility in Central Nigeria: prevalence, hematologic and socio-demographic factors. *Int J Trop Dis* 2019; 2: 2.
7. Chukwuocha UM, Chukwuocha AN, Udujih OG, et al. Malaria among the geriatric population in parts of South-Eastern Nigeria: prevalence, complications and co-morbidity with non-communicable diseases. *Epidemiology* 2016; 6: 2.
8. Federal Ministry of Health. *Malaria advocacy brief for policy makers*. Abuja, Nigeria: Federal Ministry of Health, 2012.
9. Imam TS and Indabawa JI. Prevalence of anaemia associated with malaria among patients in the extreme age groups attending three selected hospitals in Kano. *Biol Environ Sci J* 2011; 4: 137–147.
10. Awosolu OB, Yahaya ZS, Haziqah MTF, et al. A cross sectional study on the prevalence, density, and risk factors associated with malaria transmission in urban communities of Ibadan, Southwestern Nigeria. *Heliyon* 2021; 7: e05975.
11. Awosolu AB, David MC, Lawal AO, et al. Pattern of malaria parasitaemia and genotype among residents of Orita Obele in Akure South Local Government area of Ondo State, Nigeria. *South Asian J Parasitol* 2019; 3(20): 1–5.
12. Ibrahim AO, Agbesanwa TA, Shabi OM, et al. Utilization and effectiveness of malaria prevention methods among pregnant women in Tertiary hospital situated in Rural Southwestern Nigeria. *Int J Sci Res* 2021; 10: 3.
13. Amase N, Dayo EL, Hellen EA, et al. Malaria parasitaemia among pregnant women possessing freely donated insecticide treated nets (ITNs) in Ado Ekiti, Nigeria. *Global J Biol Agr Health Sci* 2014; 3(1): 86–90.
14. Adegun JA, Adegboyega JA and Awosusi AO. Knowledge and the preventive strategies of malaria among migrant farmers in Ado-Ekiti Local government area of Ekiti State, Nigeria. *Am J Sci Ind Res* 2011; 2: 883–889.
15. Kilian A, Lawford H and Ujuju CN. The impact of behavior change communication on the use of Insecticide treated nets: a secondary analysis of ten post campaign surveys from Nigeria. *Malar J* 2016; 15: 1–6.
16. World Health Organization/Global Malaria Programme. Recent success and key challenges in malaria (internet), 2010, http://www.path.Org (accessed 12 April 2022).
17. Ugwu EO, Ezechukwu PC, Obi SN, et al. Utilization of insecticide treated nets among pregnant women in Enugu, South Eastern Nigeria. *Niger J Clin Pract* 2013; 16(3): 292–296.

18. Sultana M, Sheikh N, Mahumud RA, et al. Prevalence and associated determinants of malaria parasites among Kenyan children. *Trop Med Health* 2017; 45: 25.

19. Profile of Ekiti State, https://www.slideshare.net/EkitiState (accessed 18 March 2021).

20. Araoye MO.Subject selection: sample size determination In:Araoye MO (ed.) *Research methodology with statistics for health and social sciences*. Ilorin, Nigeria: Nathadex Publishers, 2003, pp. 117–118.

21. Dawaki S, Al-Mekhlafi HM, Ibrahim IJ, et al. Is Nigeria winning the battle against Malaria? Prevalence, risk factors and KAP assessment among Hausa communities in Kano State. *Malar J* 2016; 15: 351.

22. von Elm E, Altman DG, Egger M, et al. The strengthening the reporting of observational studies in epidemiology (STROBE) statement; guidelines for reporting observational studies. *Ann Intern Med* 2007; 147: 573–577.

23. Chobanian AV, Bakris GL, Black HR, et al. Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC7 report. *JAMA* 2003; 289(19): 2560–2572.

24. Monif GRG. Infectious disease: In: Baker DA (ed.) *Obstetrics and gynaecology*. 6th ed. New York: Parthenon, 2004, pp. 280–286.

25. Hiar CE. *Clinical summary report: clinical performance of DCA 2000+hemoglobin AIc system six-minute assay*. New York: Bayer Diagnostic Division, 1998.

26. American Diabetes Association. Classification and diagnosis of diabetes: standards of medical care in diabetes-2021. *Diabetes Care* 2021; 44(1): S15–S33.

27. The Joint United Nations Programme on HIV/AIDS. *Fast-track: ending the AIDS epidemic by 2030*. Geneva: UNAIDS, 2014.

28. Ochei J and Kolhalkar A. *Miscellaneous investigation in haematology, medical laboratory science, theory and practical data*. Noida, India: McGraw-Hill Publishing, 2008.

29. Degarege A, Fennie K, Degarege D, et al. Improving socio-economic status may reduce the burden of malaria in sub Saharan Africa: A systematic review and meta-analysis. *PLoS ONE* 2019; 14(1): e0211205.

30. Carter R and Karunaweera ND. The role of improved housing and living environments in malaria control and elimination. *Malar J* 2020; 19: 385.

31. Chitunhu S and Musenge E. Direct and indirect determinants of childhood malaria morbidity in Malawi: a survey cross sectional analysis based on Malaria Indicator Survey data for 2012. *Malar J* 2015; 14: 1–9.

32. Kepha S, Nikolay B, Nuwaha F, et al. Plasmodium falciparum parasitaemia and clinical malaria among school children living in a high transmission setting in Western Kenya. *Malar J* 2016; 15: 157.

33. Umaru ML and Uyaiabasi GN. Prevalence of malaria in patients attending the general hospital, Makarfi, Kaduna State, North-Western Nigeria. *Am J Infect Dis Microbiol* 2015; 3(1): 1–5.

34. Noland GS, Graves PM, Sallau A, et al. Malaria prevalence, anaemia and baseline intervention coverage prior to mass net distribution in Abia and Plateau States, Nigeria. *BMC Infect Dis* 2014; 14: 168.

35. Hay SI, Guerra CA, Tatem AJ, et al. Urbanization, malaria transmission and disease burden in Africa. *Nat Rev Microbiol* 2005; 3(1): 81–90.

36. Osaro E, Jamiu MH, Ahmed HM, et al. Effect of plasmodium parasitaemia on some haematological parameters in children living in Sokoto, Northwestern Nigeria. *Int J Clin Med Res* 2014; 1(2): 57–64.

37. Nyarko SH and Cobblah A. Socio-demographic determinants of malaria among under-five children in Ghana. *Malar Res Treat* 2014; 4: 1–6.

38. Oladele OV, Onuoha SC, Hamafyelto HS, et al. Prevalence of malaria infection among patients attending Murtala Muhammed Specialist Hospital, Kano, Nigeria. *Afr J Clin Exper Microbiol* 2018; 19(3): 214–220.

39. West PA, Protopopoff N, Rowland M, et al. Malaria risk factors in Northwest Tanzania: the effect os spraying, nets and wealth. *PLoS ONE* 2013; 8: e65787.

40. World Health Organization (WHO). *World malaria report 2014*. Geneva: WHO, 2014.

41. Fana SA, Bunza MD, Anka SA, et al. Prevalence and risk factors associated with malaria infection among pregnant women in semi-urban community of Northwestern Nigeria. *Infect Dis Poverty* 2015; 4: 24.

42. Ovadje L and Nriagu J. Multi-dimensional knowledge of malaria among caregivers: implication for insecticide net use by children. *Malar J* 2016; 15: 1.

43. Saugare LR, Weiss NS, Brentlinger PE, et al. Determinants of use of insecticide treated nets for the prevention of malaria in pregnancy: Jinja, Uganda. *PLoS ONE* 2012; 7(6): e39712.

44. Kilian A, Koenker H, Baba E, et al. Universal coverage with insecticide-treated nets—applying the revised indicators for ownership and use to the Nigeria 2010 malaria indicator survey data. *Malar J* 2013; 12: 314.

45. Bello B and Ishaleku D. Prevalence of malaria infection among people living with HIV/AIDS at Federal Medical Center Keffi, Nasarawa State, Nigeria. *J Adv Microbiol* 2018; 11: 16.

46. World Health Organization (WHO). *Guidelines for the treatment of malaria—world malaria report*. Geneva: WHO, 2012.

47. Kuesap J and Na-Bangchang K. The effect of ABO blood groups, hemoglobinopathy and heme oxygenase-1 polymorphisms on malaria susceptibility and severity. *Korean J Parasitol* 2018; 56(2): 167–173.

48. Suchdev PS, Ruth LJ, Earley M, et al. The burden and consequences of inherited blood disorders among young children in Western Kenya. *Matern Child Nutr* 2014; 10(1): 135–144.