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What do women in the highest malaria burden country know about ways to prevent malaria? A multi-level analysis of the 2021 Nigeria Malaria Indicator Survey data

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Abstract

Background With Nigeria accounting for 31% of the estimated 608,000 deaths due to malaria globally, good knowledge of malaria prevention is essential for effective malaria control. The objective of this study was to examine the knowledge of malaria prevention and its associated factors among Nigerian women.

Methods This study analysed secondary data from the 2021 Nigeria Malaria Indicator Survey. The sample included 14,476 women of reproductive age (15–49 years). A multilevel multivariable logistic regression was used to examine individual, household, and community-level factors associated with having good knowledge of malaria prevention.

Results The weighted prevalence of having good knowledge of malaria prevention was 43.5% (95%CI: 41.7–45.2%). Women with secondary/higher education had 2.35 higher odds of good knowledge of malaria prevention, when compared with those with no formal/primary education (aOR = 2.35; 95% CI: 2.00–2.75). Those exposed to malaria messages had 2.62 higher odds of good knowledge of malaria prevention, when compared with no exposure to malaria messages (aOR = 2.62; 95% CI: 2.31–2.97). Women from non-poor households had 1.42 higher odds of good knowledge of malaria prevention, when compared with those from poor households (aOR = 1.42; 95% CI: 1.17–1.71). Rural dwellers had 39.0% reduction in the odds of good knowledge of malaria prevention, when compared with their urban counterparts (aOR = 0.61; 95% CI: 0.46–0.80). In addition, women from communities with high level of education (aOR = 2.24; 95%CI: 1.38–3.64), moderately exposed to malaria messages (aOR = 1.43; 95%CI: 1.08–1.88) and highly exposed to malaria messages (aOR = 1.71; 95%CI: 1.27–2.30), had higher odds of good knowledge of malaria prevention, when compared with women from communities with low education and low exposure to malaria messages, respectively.

Conclusion The knowledge of malaria prevention was found to be low. The study identified education, religion, exposure to malaria messages, wealth, region, place of residence, community-level poverty, education and exposure to malaria messages as factors associated with the knowledge of malaria prevention. Addressing these factors through targeted interventions, such as improving educational opportunities for women and enhancing

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media-driven public health campaigns are essential to enhancing malaria knowledge among this critical demographic group.

Keywords Malaria knowledge, NMIS, Nigeria, Women's health, Malaria prevention

Background

Sub-Saharan African (SSA) has a staggering report of malaria infection worldwide [1]. According to a 2022 report, SSA accounted for 233 million out of the 249 million malaria cases reported globally, and approximately 594,000 out of 619,000 malaria-related deaths [1]. This shows that over 90% of all cases and deaths due to malaria occurred in SSA [1, 2]. About 50% of the global malaria cases is contributed by four countries including, Nigeria (27%), the Democratic Republic of the Congo (12%), Uganda (5%) and Mozambique (4%) [1]. One of the most critical public health issues is the persistence of malaria incidence and deaths. Nigeria has the highest malaria burden worldwide, accounting for 31% out of the estimated 608,000 deaths according to 2023 estimates [2].

The global technical strategy for malaria has a goal to eradicate malaria in at least 35 countries and reduce the disease's incidence and mortality rates by at least 90% by 2030 [3]. The childbearing age women represent a crucial demographic group in the fight against malaria [4, 5], as they are disproportionately affected due to their vulnerability during pregnancy and their roles in caregiving [6]. Women of reproductive age are especially vulnerable and face increased risks of severe anaemia, maternal mortality, and adverse birth outcomes due to malaria [7–9]. This demographic group experiences a higher disease burden, compared to the male folks [10–12]. Malaria accounted for an estimated 11% of maternal mortality in Nigeria, indicating its devastating effects on women of reproductive age [13–15].

Studies have revealed that only about 10% of Nigerian women of reproductive age have comprehensive knowledge of malaria, including prevention strategies [16–18]. The knowledge and practices of malaria prevention promote malaria-related morbidity and mortality reduction [19, 20]. Women and children are high-risk groups for malaria infection, maternal anaemia, placental parasitaemia, poor fetal growth, preterm birth, and low birth weight [21, 22]. Adequate knowledge of malaria prevention enhances the uptake of intermittent preventive treatment of malaria in pregnancy (IPTp), perennial malaria chemoprevention (PMC), insecticide-treated net use amongst others [23].

Several factors have been identified to influence malaria prevention practices [24–26]. The effectiveness of malaria prevention strategies depends prominently on understanding the sociocultural characteristics of the communities and improving behaviour change communication in malaria control programmes [6]. Women's adequate knowledge about malaria helps them to make decisions regarding prevention and treatment strategies [27]. To meet the objective of the National Malaria Strategic Plan, Nigerian women must have a good knowledge of malaria prevention [28, 29]. Adequate knowledge of malaria is essential for prevention, early treatment, and control of the disease [30].

Malaria prevention knowledge and practices among Nigerian women vary significantly across regions and socio-economic groups [31]. Women play a crucial role in the household's health management, including the prevention of malaria, a leading cause of morbidity and mortality in Nigeria [32]. However, the knowledge of effective malaria prevention methods, such as the use of insecticide-treated nets (ITNs), indoor residual spraying (IRS), and environmental management (eliminating mosquito breeding sites) among Nigerian women, has not been adequately documented. There is a report that urban caregivers tend to have higher awareness and better access to malaria prevention tools due to improved infrastructure and public health campaigns, rural women often face challenges such as limited education, lower literacy rates, and poor access to healthcare services [33]. These factors contribute to a knowledge gap regarding malaria prevention, despite malaria being endemic in Nigeria.

Sociocultural factors also influence malaria prevention practices, especially in rural areas [34]. In some communities, traditional methods, such as herbal treatments or spiritual interventions, may be preferred over modern preventive measures. Additionally, women's roles in decision-making about health interventions, including the use of ITNs, can be influenced by socio-cultural factors and gender dynamics [35]. The objective of this study was to examine the knowledge of malaria prevention and its associated factors among women of reproductive age in Nigeria.

Methods

Data source

The study utilized individual woman questionnaire data from the 2021 Nigeria Malaria Indicator Survey (NMIS). In total, 14,476 women of reproductive age (15–49 years) made up the study sample that was analysed. The data collection took place from 12 October to 4 December 2021. The majority of survey indicators

for the entire country, for urban and rural areas separately, and for each of the six geopolitical zones in the country, which comprise 36 states and the Federal Capital Territory (FCT) were included in the sample for the 2021 NMIS.

Sample design

The sample frame for the Federal Republic of Nigeria's projected 2023 Population and Housing Census (PHC) was utilized in the 2021 NMIS. Nigeria is separated into states administratively. Local government areas (LGAs) are the lowest level of governance in each state. Within LGAs are wards, and within wards are localities. Census enumeration areas (EAs), which are handy areas, are further subdivided into localities. Based on the EAs for the projected 2023 PHC, the primary sampling unit (PSU), also known as a cluster unit for the 2021 NMIS, was defined. For the NMIS of 2021, a two-phase sampling approach was chosen. A probability proportional to the EA size was used to choose 568 EAs in the first stage.

The number of households inside an EA determines its size. The sample was chosen in a way that made it representative of every state. As a consequence, there were 568 clusters nationwide—195 of which were in urban areas and 373 of which were in rural areas. Between August 26, 2021, and September 18, 2021, all of the households in these clusters were listed in full. The lists of homes that were produced were used as the sample frame to choose the households for the second stage. In the 2021 NMIS sample, GPS dongles were utilized to record coordinates during the households listing process [23]. By using equal probability systematic sampling, 25 households from each cluster were chosen for the second step of the selection procedure. The datasets are available in the public domain via https://dhsprogram.com/data/dataset/Nigeria_MIS_2021.cfm?flag=1.

Selection and measurements of variables

Outcome variable

The outcome variable in the study was knowledge of malaria prevention. A set of eight (8) questions pertinent to malaria prevention were selected from MIS questionnaire to which respondents could answer "yes" or "no": "Malaria can be prevented by: (a) sleep inside a mosquito net, (b) sleep inside an insecticide-treated mosquito net, (c) use mosquito repellent or coil, (d) take preventive medications, (e) spray house with insecticide, (f) fill in stagnant waters (puddles), (g) keep surroundings clean, (h) put mosquito screen on windows". Based on the responses to the questions, each correct answer was scored "1" and "0" for incorrect answer. The sum of all correct answers was calculated for each respondent. The minimum score for the knowledge of malaria prevention was zero (0), while the maximum score was eight (8). Normality distribution analysis showed mean and standard deviation values of 1.57 and 1.25, respectively, indicating skewness in the knowledge of malaria prevention scores. Hence, the median score was used to dichotomize between poor and good knowledge of malaria prevention. Based on the media value, those who scored two (2) and above were coded as "1" (good knowledge of malaria prevention), whereas if a respondent scored between 0 and 1.99 was coded "0" (poor knowledge of malaria prevention). This is consistent with previous approach in literature [36–38].

Table 1 shows the percentage score of correct responses to the individual items of malaria prevention strategies.

Explanatory variables

The factors examined in this study are consistent with previous studies [39–41].

a. Age (in years): 15–24, 25–34, 35–49;
b. Exposure to malaria messages was dichotomized: no, yes; using the following questions: "Malaria messages were heard/seen: radio, television, poster/billboard,

Table 1 Distribution of the knowledge of malaria prevention among Nigerian women of reproductive age

Knowledge question	Correct (%)	Incorrect (%)
Malaria can be prevented by: sleep inside a mosquito net	41.3	58.7
Malaria can be prevented by: sleep inside an insecticide-treated mosquito net	32.3	67.7
Malaria can be prevented by: use mosquito repellent or coil	15.5	84.5
Malaria can be prevented by: take preventive medications	9.5	90.5
Malaria can be prevented by: spray house with insecticide	15.2	84.8
Malaria can be prevented by: fill in stagnant waters (puddles)	9.9	90.1
Malaria can be prevented by: keep surroundings clean	28.0	72.0
Malaria can be prevented by: put mosquito screen on windows	5.4	94.6

newspaper/magazine, leaflet/brochure, healthcare provider, community health worker, social media, town announcer, inter-personal communication agent/community volunteer, family/friends, other".

c. Religion: Christianity, Islam, Traditional religion/no religion (Others);
d. Number of living children: 0, 1–2, 3–4, 5 +;
e. Education: no education/primary, secondary/higher—combining no education and primary education as one category and secondary education and higher education as another category is justified due to similarities in access to information and health literacy within each group. Individuals with no or only primary education generally have lower literacy levels and limited exposure to complex health information, often leading to less knowledge about public health interventions. On the other hand, those with secondary or higher education tend to have better cognitive skills, access to more detailed health information, and greater ability to engage with health systems [42]. This grouping helps to simplify analysis while preserving meaningful differences in health knowledge;
f. Household wealth: poor versus non-poor. Household wealth index in the is divided into five equal categories; poorest, poorer, middle, richer, richest. In this study, the wealth index was recoded into two categories with 'poor' comprising of poorest and poorer, 'non-poor' comprising of middle, richer and richest. This is justified due to the significant socio-economic differences between these groups. The "poorest" and "poorer" generally share similar challenges, such as limited access to healthcare [43], which affect their overall health and well-being. Conversely, those in the "middle," "richer," and "richest" categories often have better access to resources, opportunities, and living conditions. Grouping these together simplifies analysis while maintaining clear distinctions in wealth-related disparities, making it easier to explore health outcomes or interventions based on socio-economic status.
g. Sex of household head: male, female;
h. Region: North Central, North East, North West, South East, South South, South West;
i. Place of residence: urban, rural;
j. Community-level ethnic: mono-ethnic, multi-ethnic—ethnic diversity refers to the concentration of different ethnic groups in a community. It was defined as the proportion of women from different ethnic groups in the primary sampling unit. The value ranges from 0 to 100. A value of 0 (low) reflects a mono-ethnic community, whereas a value of 100 (high) reflects that the community is multi-ethnic in nature
k. Community-level poverty: low, medium, high—defined as the proportion of women who are from the poorest and poorer communities. Principal component analysis (PCA) was used to create selected community-level variables.
l. Community-level education: low, medium, high—defined as proportion of women from community with at least secondary education
m. Community-level exposure to malaria messages: low, medium, high—defined as proportion of women from community who received malaria message through any of the following channels: radio, television, poster/billboard, newspaper/magazine, leaflet/brochure, healthcare provider, community health worker, social media, town announcer, inter-personal communication agent/community volunteer, family/friends, other".

Analytical approach

Stata software version 17.0 (Stata Corporation, College Station, Texas, USA) was used for data analysis. Since the study included the multi-stage stratified cluster sample design, survey module's ('svy') function was used to account for sampling design (weighting, clustering, and stratification). Percentage was employed in the univariable analysis. The fixed and random effects of having good knowledge of malaria prevention were investigated using the multilevel multivariable binary logistic regression. In order to assess multicollinearity, which is known to raise serious issues with the logit model, the variance inflation factor was employed [44].

Statistical significance was determined with p-values and 95% confidence intervals (CIs) as shown in Table 2. The reason for calculating p-values in Table 2 was to determine which variables would be included in the regression model. Any variable that is not statistically significant ($p > 0.05$) is excluded from the adjusted regression model. For fixed-effect estimation (Table 4), whenever p-value was below 0.05, then 95% CIs would not have unity "1" between the lower and upper bounds, indicating statistical significance.

A three-level model for binary response reporting having good knowledge of malaria prevention, at level 1 for individual women factors nested within households, and households nested within communities. Five models were constructed. First, the community-level variance was computed in the empty or unconditional model with no explanatory factors. This null model served as a benchmark to calculate the extent to which household and community-level factors may account for the observed changes. The results justified the use of a multilevel statistical model, as the statistically significant variance

Table 2 Prevalence of good knowledge of malaria prevention among Nigerian women of reproductive age

Variable	n (%)	Weight prevalence of good knowledge of malaria prevention, % (95% CI)	P-value
Age (in years)			
15–24	5129 (35.4)	43.4 (41.0–45.8)	0.109
25–34	5027 (34.7)	42.2 (40.2–44.3)	
35–49	4320 (29.8)	45.0 (42.8–47.3)	
Education			
No education/primary	6769 (46.8)	29.3 (27.5–31.2)	< 0.001
Secondary/higher	7707 (53.2)	57.6 (55.8–59.5)	
Religion			
Christianity	7058 (48.8)	52.6 (50.4–54.8)	< 0.001
Islam	7344 (50.7)	37.2 (34.9–39.7)	
Others[@]	74 (0.5)	11.1 (4.1–26.8)	
Exposed to malaria messages			
No	7720 (53.3)	33.4 (31.5–35.3)	< 0.001
Yes	6756 (46.7)	55.2 (52.9–57.4)	
Number of living children			
0	4250 (29.4)	49.3 (46.9–51.7)	< 0.001
1–2	3662 (25.3)	41.3 (38.9–43.7)	
3–4	3479 (24.0)	44.7 (42.4–47.0)	
5 +	3085 (21.3)	37.0 (34.4–39.7)	
Wealth			
Poor	5052 (34.9)	28.9 (26.7–31.2)	< 0.001
Non-poor	9424 (65.1)	52.1 (20.0–54.1)	
Sex of household head			
Male	12,339 (85.2)	42.3 (40.5–44.1)	< 0.001
Female	2137 (14.8)	51.3 (48.0–54.7)	
Region			
North Central	2674 (18.5)	45.5 (41.3–49.8)	< 0.001
North East	2523 (17.4)	38.9 (34.3–43.7)	
North West	3635 (25.1)	34.1 (31.3–37.2)	
South East	1523 (10.5)	60.1 (55.6–64.4)	
South South	2148 (14.8)	44.9 (40.8–49.1)	
South West	1973 (13.6)	58.3 (54.7–61.8)	
Place of residence			
Urban	4930 (34.1)	54.3 (51.5–57.0)	< 0.001
Rural	9546 (65.9)	38.4 (36.2–40.5)	
Community-level ethnic			
Mono-ethnic	3568 (24.7)	39.8 (35.5–44.2)	0.079
Multi-ethnic	10,908 (75.3)	44.6 (42.5–46.8)	
Community-level poverty			
Low	4934 (34.1)	29.0 (26.3–31.8)	< 0.001
Medium	4779 (33.0)	44.2 (41.1–47.4)	
High	4763 (32.9)	60.3 (57.5–63.1)	
Community-level education			
Low	4857 (33.6)	26.5 (24.0–29.2)	< 0.001
Medium	4839 (33.4)	46.8 (44.0–49.6)	
High	4780 (33.0)	62.0 (59.1–64.8)	
Community-level exposure to malaria messages			
Low	4850 (33.5)	29.3 (26.4–32.3)	< 0.001
Medium	4815 (33.3)	44.5 (41.2–47.8)	
High	4811 (33.2)	57.9 (54.7–61.0)	

Table 2 (continued)

P-value obtained from Chi-square test; @ represents respondents who are traditionalists or not affiliated with any religion

established the appropriateness of multilevel regression. The second model included the individual-level factors, the third model included the household-level factors, while the fourth model included the community-level factors. Finally, the fifth model (full model) adjusted for the individual, household and community-level factors. The level of significance was determined at $p < 0.05$. To choose the best from the five models, the Bayesian and Akaike Information Criteria were used. A lower Akaike or Bayesian Information Criterion value denotes a better model fit [45].

Fixed and random effects

Adjusted odds ratios (AORs) along with their 95% confidence interval (CI) were used to report the outcomes of fixed effects (measures of association) of the factors associated with having good knowledge of malaria prevention. The Intra-class Correlation (ICC) and Median Odds Ratio (MOR) were used to quantify the likely contextual effects [46]. Similarity between respondents living in the same household and community was assessed using ICC. The ICC is a measure of the clustering of odds of having good knowledge of malaria prevention in the same community. It shows the percentage of the total variance in the likelihood of having good knowledge of malaria prevention that is connected to the community level factors. The MOR estimates the probability of having good knowledge of malaria prevention that can be assigned to the community by measuring the second-level (community) variance as odds ratios.

Furthermore, when the MOR is one, there is no variance in communities. Conversely, the higher the MOR, the more important are the contextual effects for understanding the probability of having good knowledge of malaria prevention. The linear threshold was used to compute ICC using the Snijders and Bosker formula [47], MOR, on the other hand, measures the heterogeneity of unexplained clusters.

Ethical consideration

The de-identified public secondary dataset was used for this study. The respondents' informed consent was collected by NMIS in accordance with standard ethical protocol. The authors were granted permission to use the data, therefore no further participants' agreement or consent was required. The details of ethical guidelines can be found here: http://goo.gl/ny8T6X.

Results

The weighted prevalence of having good knowledge of malaria prevention among Nigerian women as 43.5% (95%CI: 41.7–45.2%). This showed that 56.5% of Nigerian women had poor knowledge of malaria prevention.

Table 2 showed that women aged 35–49 years (45.0%), those having secondary/higher education (57.6%), Christians (52.6%), exposed to malaria message (55.2%), with no living child (49.3%), non-poor (52.1%), from female headed households (51.3%), South East (60.1%), North West (56.7%), urban dwellers (54.3%), from community with high-level of education (62.0%) and from communities highly exposed to malaria messages (57.9%) had leading knowledge of malaria prevention, respectively.

Measures of variations (random effects) and model fit statistics

In Table 3, Model V (full model) was selected as the most suitable due to the least AIC and BIC values (16,473.47 and 16,655.40 respectively). The variations in the odds of good knowledge of malaria prevention at households and communities were estimated respectively ($\sigma^2 = 2.86$ and $\sigma^2 = 1.07$). The median odds ratios at households and community levels were 5.02 and 2.86, indicating the contextual factors shaping good knowledge of malaria prevention among women. At community level, the explained variance was 61.2%. This implied that a good amount of variances in having good knowledge of malaria prevention has been explained by the community-level factors. PCV helped in understanding the contribution of added covariates to reducing unexplained variance. A higher PCV indicated that community-level factors in the model, explained a larger proportion of the variance. At the household level, PCV was estimated as 0%, this implies that there is no significant variation in having good knowledge of malaria prevention that can be attributed to differences between households. In other words, the household-level factors do not contribute to explaining good knowledge of malaria prevention in the full model (Model V).

Measures of associations (fixed effects)

Table 4 showed women with secondary/higher education had 2.35 higher odds of having good knowledge of malaria prevention, when compared with those with no formal/primary education (AOR = 2.35; 95% CI: 2.00–2.75). Those exposed to malaria messages had 2.62 higher odds of having good knowledge of malaria prevention,

Table 3 Random effect estimates of individual, household and community-level factors associated with good knowledge of malaria prevention

Random-effect	Model I	Model II	Model III	Model IV	Model V
Community-level					
Variance (95% CI)	2.76 (2.32–3.29)*	1.68 (1.39–2.03)*	2.15 (1.79–2.58)*	1.07 (0.87–1.31)	1.07 (0.87–1.32)
Explained variance (PCV)	Reference	39.1%	22.1%	61.2%	61.2%
MOR	4.88	3.44	4.05	2.68	2.68
ICC	31.0%	21.6%	25.8%	14.8%	14.8%
Household-level					
Variance (95% CI)	2.86 (2.38–3.44)*	2.80 (2.32–3.38)*	2.88 (2.39–3.46)*	2.85 (2.37–3.43)*	2.86 (2.37–3.45)*
Explained variance (PCV)	Reference	2.1%	0.7%	0.3%	0.0%
MOR	5.02	4.94	5.04	5.00	5.02
ICC	32.1%	36.1%	34.6%	39.5%	39.6%
Model fit statistics					
AIC	17,292.26	16,658.45	17,174.13	16,918.02	16,473.47
BIC	17,315.00	16,734.26	17,212.03	17,031.72	16,655.40
Log-likelihood	− 8643.13	− 8319.23	− 8582.06	− 8444.01	− 8212.74
Sample size					
Individual	14,476	14,476	14,476	14,476	14,476
Household	10,355	10,355	10,355	10,355	10,355
Community	567	567	567	567	567

Model I—baseline model with no explanatory variables, or empty null model (unconditional model)

Model II—solely taking into account individual-level factors

Model III—solely taking into account household-level factors

Model IV—solely taking into account community-level factors

Model V—full model adjusted for characteristics at the individual, household, and community levels

AIC Akaike's Information Criterion, BIC Bayesian Information Criterion, PCV Proportional Change in Variance, ICC Intra-class correlation

*Significant at $p < 0.05$

when compared with no exposure to malaria messages (AOR = 2.62; 95% CI: 2.31–2.97). Women from non-poor households had 1.42 higher odds of having good knowledge of malaria prevention, when compared with those from poor households (AOR = 1.42; 95% CI: 1.17–1.71). Rural dwellers had 39.0% reduction in the odds of having good knowledge of malaria prevention, when compared with their urban counterparts (AOR = 0.61; 95% CI: 0.46–0.80). In addition, women from communities with high level of education (AOR = 2.24; 95%CI: 1.38–3.64), moderately exposed to malaria messages (AOR = 1.43; 95%CI: 1.08–1.88) and highly exposed to malaria messages (AOR = 1.71; 95%CI: 1.27–2.30), had higher odds of good knowledge of malaria prevention, when compared with women from communities with low education and low exposure to malaria messages, respectively.

Discussion

This study assessed the prevalence and factors associated with good knowledge of malaria prevention among women of reproductive age in Nigeria. The study found that the prevalence of having good knowledge of malaria prevention among these reproductive age women was less than 50.0%. This implies that majority of the women of childbearing age in Nigeria have poor knowledge of malaria prevention in the general sense of it. The prevalence of poor knowledge of malaria prevention shows that there is low access to malaria-related messages and therefore are potentially indicative of limited dissemination of malaria prevention measures by health professionals and agencies responsible for the dissemination of healthcare information to the population, and this is not in tandem with the vision of global programme on malaria control and elimination [1, 23]. There is a saying that when you educate a girl child or a woman, you have equally educated a community or society. This is true because women can play a significant role in influencing malaria prevention practices within the family and community. But this they will do when they have good and complete knowledge of malaria prevention, thereby contributing to the malaria information dissemination amongst their peers, as well as implementing these knowledge of prevention measures within households and environment [48–53]. Therefore, there should be an extensive campaign on malaria messages to educate Nigerian women, as it becomes imperative that adequate

Table 4 Fixed effect of individual, household and community-level factors associated with good knowledge of malaria prevention

Variable	Odds ratio (95% CI)				
	Model I	Model II	Model III	Model IV	Model V
Education					
No education/primary		1.00			1.00
Secondary/higher		3.07 (2.63–3.58)*			2.35 (2.00–2.75)*
Religion					
Christianity		1.00			1.00
Islam		0.66 (0.54–0.82)*			0.84 (0.67–1.06)
Others[@]		0.06 (0.02–0.22)*			0.08 (0.02–0.26)*
Exposure to malaria messages					
No		1.00			1.00
Yes		2.86 (2.53–3.25)*			2.62 (2.31–2.97)*
Number of living children					
0		1.00			1.00
1–2		1.00 (0.86–1.16)			0.99 (0.85–1.15)
3–4		1.09 (0.94–1.27)			1.07 (0.92–1.25)
5 +		1.16 (0.99–1.36)			1.13 (0.97–1.33)
Wealth					
Poor			1.00		1.00
Non-poor			2.68 (2.24–3.21)*		1.42 (1.17–1.71)*
Sex of household head					
Male			1.00		1.00
Female			1.15 (0.97–1.37)		1.01 (0.84–1.20)
Region					
North Central				1.00	1.00
North East				1.23 (0.84–1.81)	1.37 (0.93–2.02)
North West				0.78 (0.55–1.12)	0.84 (0.58–1.22)
South East				0.81 (0.54–1.22)	0.73 (0.48–1.11)
South South				0.40 (0.27–0.58)*	0.36 (0.25–0.53)*
South West				0.74 (0.51–1.08)	0.73 (0.49–1.07)
Place of residence					
Urban				1.00	1.00
Rural				0.61 (0.46–0.79)*	0.61 (0.46–0.80)*
Community-level poverty					
Low				1.00	1.00
Medium				1.83 (1.32–2.54)*	1.43 (1.01–2.01)*
High				3.77 (2.50–5.69)*	2.70 (1.76–4.16)*
Community-level education					
Low				1.00	1.00
Medium				1.96 (1.37–2.80)*	1.29 (0.89–1.87)
High				4.26 (2.67–6.79)*	2.24 (1.38–3.64)*
Community-level exposure to malaria messages					
Low				1.00	1.00
Medium				1.82 (1.38–2.39)*	1.43 (1.08–1.88)*
High				2.74 (2.05–3.67)*	1.71 (1.27–2.30)*

Model I—baseline model with no explanatory variables, or empty null model (unconditional model)

Model II—solely taking into account individual-level factors

Model III—solely taking into account household-level factors

Model IV—solely taking into account community-level factors

Model V—full model adjusted for characteristics at the individual, household, and community levels

Table 4 (continued)

*Significant at $p < 0.05$

@Represents respondents who are traditionalists or not affiliated with any religion

measures be taken to address this rooming malaria situation.

The religious background of women was found to be associated with the knowledge of malaria prevention. Women who belong to traditional religion or those who do not identify with any religious group may experience reduced knowledge of malaria prevention for several reasons. Traditional religious beliefs often incorporate indigenous health practices, which may prioritize spiritual or herbal remedies over biomedical methods. These beliefs can reduce the perceived relevance or importance of using modern malaria prevention tools, such as ITNs or IRS. Additionally, traditional religious structures may not have the same level of engagement with public health programmes as mainstream religious organizations, limiting their exposure to government-led or NGO-sponsored health campaigns. For women without any religious affiliation, the lack of connection to organized social or religious groups may reduce their access to community-based health education efforts. In Nigeria, religious institutions like churches or mosques often serve as platforms for disseminating health information. Consequently, women outside these networks may miss out on critical malaria prevention messages and resources.

The study also found the socioeconomic factors of the women as a significant predictor for good knowledge of malaria prevention among Nigeria women of reproductive age. Women with higher levels of education and higher wealth index (non-poor) were more likely to have good knowledge of malaria prevention, when compared to those with low wealth index and lower levels of education. This findings are in agreement with studies conducted by Oyerogba et al. [15], Ghana [48], Cameroon [54, 55] and a previous other review [56]. The association between a high wealth index and malaria prevention practices has been well-documented, as wealthier individuals or households tend to have better access to resources that can reduce malaria transmission. A higher wealth index often correlates with improved living conditions, such as housing quality (e.g., properly screened windows, solid walls), which can prevent mosquitoes from entering homes. Wealthier households are also more likely to afford and utilize preventive measures, such as ITNs), insect repellents, or even IRS. Additionally, individuals from wealthier households are more likely to have better access to healthcare services, including early diagnosis and prompt treatment for malaria, which can further reduce transmission. Awareness and knowledge about malaria prevention strategies are also often higher among wealthier groups, contributing to more consistent and effective use of preventive measures.

Women with higher levels of education were more likely to have good knowledge of malaria prevention, when compared to those with lower levels of education. This is consistent with previous studies [15, 48, 54–56]. These studies agreed that the level of education of the childbearing age women was associated with the good knowledge of malaria prevention. It is, therefore, not surprising of the findings as governmental interventions to increase access to education in Nigeria could have an additional effect on the overall health outcomes of women and their households regarding malaria prevention. Education gives access to malaria information and awareness campaigns thereby impacting on the level of malaria knowledge a woman will have. This also implies that initiatives to raise women's income and enhance health knowledge could significantly lessen the prevalence of malaria in these women and their households.

The study found that exposure to malaria messages was associated with women's knowledge of malaria prevention strategies. This is consistent with the findings from previous studies [57–59]. Public health interventions that promote awareness through various media channels, such as radio, television, social media, and community outreach, are essential for disseminating accurate information. Women, particularly in malaria-endemic regions, often act as primary caregivers for their families, making their knowledge of preventive practices crucial to reducing malaria incidence. Women who are exposed to malaria messages are more likely to have knowledge of malaria preventive measures, such as the use of ITNs, IRS and other preventive practices. Such knowledge will also encourage women to seek proper malaria diagnosis and treatment, enhancing overall household health behaviours. Furthermore, integrating malaria education into reproductive health programmes will provide an opportunity to reach women during antenatal visits, reinforcing the importance of prevention during pregnancy when both mother and child are most vulnerable.

Geopolitical zones and geographical locations of the study participants emerged as important factor associated with good knowledge of malaria prevention in this study. The geographical region of the women played a critical role in the malaria knowledge of the women as women from the South South geopolitical zone of the country have significant reduction in the odds of good

knowledge of malaria, compared with their counterparts in North Central region. Women in South-South Nigeria may have reduced knowledge of malaria prevention compared to those in the North Central region due to several contextual factors. Lower literacy rates, income inequality, and underdeveloped infrastructure in parts of the South-South limit access to health education. Cultural beliefs about malaria, which may prioritize traditional methods over biomedical prevention, can also contribute. The high malaria transmission in the South-South due to its tropical, mosquito-prone environment may lead to belief that malaria is inevitable, and that individuals have little or no control over prevention efforts. Additionally, rural–urban divides and weaker health outreach programmes can further reduce women's exposure to accurate information and resources for malaria prevention compared to North Central Nigeria.

Women living in the rural areas of the country have reduction in the odds of good knowledge of malaria prevention, when compared with their urban counterparts. These findings are consistent with some other studies that found higher knowledge of malaria and its prevention among urban women when compared to their rural counterparts [36]. The finding is in contrary to the observation made in other African countries [27, 60–62] and elsewhere [63, 64], where location of women were found to significantly influence women of reproductive age's knowledge level on malaria prevention and risk factors. This association can be attributed to the fact that urban women are more exposed to media, educational materials, formal education and health facilities than those in the rural areas. This advantage in exposure to information can contribute to increased knowledge of malaria prevention strategies and better interpretation of health messages among the urban women. Women in rural areas of Nigeria often have significantly lower knowledge of malaria prevention compared to their urban counterparts due to various socio-economic and infrastructural challenges. Access to health education is often limited in rural areas, where fewer health facilities and healthcare workers are available to provide information on malaria prevention strategies, such as the use of ITNs and IRS. Public health campaigns, which are more frequently conducted in urban areas, may not reach rural populations as effectively. Rural women also tend to have lower literacy levels, which can hinder their ability to understand health information disseminated through posters, pamphlets, or media. Additionally, rural areas may be more isolated, making it harder for women to engage with formal education or community programmes that promote malaria awareness. Cultural beliefs and practices prevalent in rural areas may further limit the acceptance of modern prevention measures, as traditional methods might be favoured over scientifically proven strategies.

Strengths and limitations

Large, nationally representative datasets were used in this investigation. Furthermore, a significant number of study participants responded. The multilevel analytical approach employed in this study is another strength as it accounts for the hierarchical structure of the data and allows for the examination of both individual- and community-level factors influencing the knowledge of malaria prevention. However, there are several data availability issues with the current study. The quality and nature of the data used in the current investigation, which depends on publicly available data, was outside the scope of this analysis. The cross-sectional nature of NMIS data precludes the establishment of causal relationships between the identified factors and the knowledge of malaria prevention. Caution should be taken when using the result of good knowledge of malaria prevention as those who scored below four (4) (2 and 3) out of eight (8) maximum score, were classified as having good knowledge of malaria prevention when in fact they scored below 50% in the real sense of knowledge. Another limitation to this study was that the eight mini-questions may not fully represent overall knowledge of malaria prevention.

Conclusion

The prevalence of good knowledge of malaria prevention among Nigerian women of reproductive age was low. The study identified education, religion, exposure to malaria messages, wealth, region, place of residence, community-level poverty, education and exposure to malaria messages as factors associated with the knowledge of malaria prevention. Barriers such as limited access to media, low literacy levels, geographical and residential barriers, and cultural beliefs that would impede the effectiveness of malaria messaging should be eliminated. Tailored communication strategies that consider these factors are essential to ensure that all women, particularly those in rural or underserved areas, can benefit from increased knowledge and adopt effective malaria prevention practices.

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Author contributions

ME conceptualized the study and conducted data curation and analysis and wrote the results. AB, OCO, CIN, ME reviewed the literature, drafted the initial manuscript, designed the study, interpreted the results and discussed the findings. All the authors certified the content of the paper and approved the final manuscript for submission.

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Availability of data and materials
Secondary data analyzed could be accessed online at https://dhsprogram.com/data/dataset/Nigeria_MIS_2021.cfm?flag=1.

Declarations

Ethics approval and consent to participate
We hereby confirm that all methods and procedures were performed in accordance with the relevant guidelines. The 2021 NMIS protocol was reviewed and approved by the ICF Institutional Review Board. The protocol was also approved in Nigeria by the National Health Research Ethics Committee of Nigeria (NHREC). Written and verbal consent were obtained from participants prior to the interview. A formal request to analyse the NMIS datasets was made by the authors and authorization was granted by MEASURE EVALUATION, the custodian of the datasets. All analyses were performed in anonymized forms. The datasets are available in the public domain via https://dhsprogram.com/data/dataset/Nigeria_MIS_2021.cfm?flag=1.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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