Journal: Texila International Journal of Public Health
Publisher: Texila International Journal
ISSN: 2520-3134
Volume 14 Issue 1, 2026
DOI: 10.21522/TIJPH.2013.14.01.Art005

Malaria Epidemiology and Control among Under-Five Children in Northeastern Nigeria

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Abstract

In Nigeria, malaria continues to be a leading cause of morbidity and mortality among children under five, with disproportionate effects in areas affected by violence. The findings and discussion of a doctoral thesis conducted in the Jere Local Government Area (LGA), Borno State, are presented in this study as a publication-ready synthesis. Multistage cluster sampling was used to gather data from 235 families with children under 5 through a community-based cross-sectional study. Sociodemographic traits, malaria episodes, preventive measures, treatment-seeking behavior, and surveillance performance were all evaluated using structured questionnaires that were modified from WHO and DHS assessments. To assess community outreach and reporting completeness, facility-based surveillance records were examined. SPSS version 26 was used to perform logistic regression analysis, chi-square tests, and descriptive statistics. Over 95% of households reported at least one malaria episode in the six months prior, indicating a persistently high malaria burden. Insecticide-treated nets (ITNs) and indoor residual spraying (IRS) were reported to have high preventive coverage; however, symptom-based evaluation was a major component of diagnostic confirmation. Despite widespread community awareness of government and non-governmental organization efforts, surveillance outreach and home visits by medical professionals were scarce. There was no statistically significant correlation found between the incidence of malaria and the age of caregivers. The results show a dichotomy between persistent hyperendemic transmission and high knowledge and reported preventative coverage. Achieving significant reductions in the malaria burden among children under five in conflict-affected areas requires bolstering community-based case detection, expanding surveillance reach, and strengthening diagnostic confirmation.

Keywords: *Control Measures, Malaria Epidemiology, Nigeria, Surveillance, Under-five Children.*

Introduction

Malaria is a major global public health concern, especially in sub-Saharan Africa, where the majority of malaria-related deaths occur in children under five [1]. Nigeria is the country with the largest malaria burden worldwide, accounting for over 25% of cases and roughly 33% of malaria-related deaths [2]. Due to protracted conflict, population dislocation, starvation, and compromised health services, northeastern Nigerian states like Borno face increased vulnerability. Malaria transmission is steady in Jere Local Government Area, which is part of the Maiduguri metropolitan axis. It seasonally intensifies during the rainy season. Malaria prevalence among children under five is still high despite the recurrent application of control measures such ITN distribution, IRS campaigns, and community education. Understanding the local epidemiology, effectiveness of surveillance mechanisms, and

Received: 24.12.2025 ***Accepted: 02.02.2026*** ***Published on: 31.03.2026***
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utilization of control measures is critical for tailoring context-appropriate interventions [4].

Local variability is frequently obscured by national and state-level malaria data, especially in LGAs affected by violence. This study summarizes solid empirical data from Jere LGA to guide child health policy, surveillance enhancement, and malaria control initiatives in comparable humanitarian contexts. The epidemiological pattern of malaria among children under five in Jere LGA is described in this paper, along with an evaluation of the effectiveness and use of household-level malaria control measures, the performance of malaria surveillance and community outreach initiatives, and the socioeconomic impact of malaria on households with children under five.

This study looks at three closely related topics: control (prevention, treatment, and programmatic responses), surveillance (how cases and trends are identified and measured), and epidemiology (who is infected, where, and when). The study can address disease burden, drivers of transmission (such as household and school exposures, immunity gaps, and care-seeking behavior), and the efficacy of control measures like insecticide-treated nets (ITNs), seasonal malaria chemoprevention when applicable, prompt diagnostic testing, and treatment by concentrating on schoolchildren under five, a group that is biologically more vulnerable to severe malaria and frequently less able to access prompt care. Linking individual-level outcomes (cases, severe disease, deaths) with system-level performance is made possible by framing the investigation around epidemiology, surveillance, and control [5].

The causes, prevalence, and practical remedies for malaria differ depending on the area, making public health issues context-dependent. Nigeria has the highest malaria burden in the world, accounting for a significant portion of cases and deaths worldwide, according to national-level data. As a result, national policy, funding, and program priorities (such as the National Malaria Strategic Plan) significantly influence the resources and interventions available at subnational levels [6]. To guide measurement of malaria burden, preventive coverage, and surveillance system performance in Jere LGA, key epidemiologic and surveillance indicators were defined. Table 1 summarizes the core indicators used in this study, their definitions, data sources, and analytical purpose.

Table 1. Surveillance and Epidemiologic Indicators

Indicator	**Definition / Data source**	**Purpose**
Confirmed malaria incidence (per 1,000 under-5s)	Laboratory-confirmed cases reported / population	Primary outcome
Test positivity rate (TPR)	Positive tests / total tests (facility & community)	Transmission intensity & testing coverage
LLIN ownership (%)	Households with ≥1 LLIN / total households (survey)	Exposure reduction proxy
LLIN use among under-5s (%)	Under-5s who slept under LLIN previous night	Intervention uptake
SMC coverage (%)	Proportion of eligible children receiving SMC per round	Preventive measure (seasonal)
Reporting timeliness (%)	Reports submitted on time / expected reports	Surveillance performance

Reporting completeness (%)	Reports received / expected reports	Surveillance performance
Stockout days (RDTs/ACTs)	Days without commodity / period days	Health system capacity

Methodology

A community-based cross-sectional study was conducted in Jere LGA, Borno State, Nigeria. The LGA comprises peri-urban and rural settlements with a high proportion of internally displaced persons. The study population consisted of caregivers of children under five years residing in selected communities. A multistage cluster sampling technique yielded 235 eligible households. One under-five child per household was selected as the index child. The data were collected using a structured questionnaire adapted from WHO malaria surveillance tools and the Nigeria Demographic and Health Survey. Sections included sociodemographic characteristics, malaria history, preventive practices, treatment-seeking behavior, and awareness of malaria interventions. The routine malaria surveillance data were abstracted from primary health care facilities and LGA health offices to assess reporting completeness, timeliness, and community-level surveillance activities. The data were then analyzed using SPSS version 26. Descriptive statistics summarized frequencies and proportions. Associations between malaria occurrence and explanatory variables were examined using chi-square tests, with statistical significance set at $p < 0.05$. the ethical approval was obtained from the relevant institutional review board. Informed consent was obtained from all participating caregivers prior to data collection.

Result Presentation

Sociodemographic Characteristics of Respondents and Under-Five Children

Figures 1, present the age, sex, marital status, and caregiver–child relationship of respondents. The dominance of caregivers aged 26-35 years reflects the peak reproductive and caregiving age group in northeastern Nigeria. This age structure implies that malaria-related decision-making is concentrated among young adults who may simultaneously face economic precarity and high caregiving responsibilities. The high proportion of female respondents (mothers) aligns with national Demographic and Health Survey findings, where women are the primary health decision-makers for young children. Whereas Table 2 presents the distribution of common malaria symptoms among under-five children (multi-response).

Table 2 presents the distribution of common malaria symptoms among under-five children. Fever, vomiting, and loss of appetite (38.1%) were the most frequently reported symptom combination, followed by fever, vomiting, and weakness (10.5%), and fever, vomiting, weakness, and loss of appetite (7.1%).

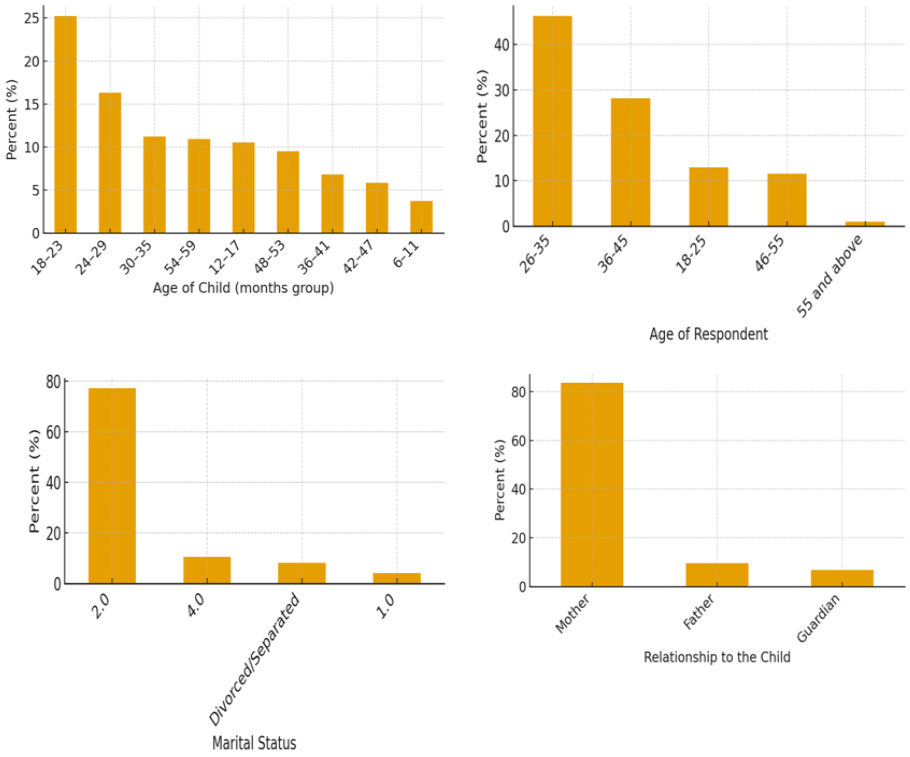

Figure 1. Present the (a) Age of Respondents, (b) Relationship to Child, (c) Age of Child (d) Marital Status of Respondents

Table 2. Distribution by Common Malaria Symptoms (Multi-Response)

Common malaria symptoms (multi-response)	Frequency	Percentage (%)
Fever, Vomiting, Loss of appetite	112	38.1
Fever, Vomiting, Weakness	31	10.5
Fever, Vomiting, Weakness, Loss of appetite	21	7.1
Fever, Weakness, Loss of appetite	20	6.8
Fever, Chills, Loss of appetite	17	5.8
Fever, Chills, Weakness	14	4.8
Fever, Weakness	11	3.7
Fever, Vomiting	7	2.4
Fever, Vomiting, Chills, Weakness	7	2.4
Fever, Vomiting, Chills, Weakness, Loss of appetite	7	2.4
Fever, Loss of appetite	5	1.7
Fever	5	1.7
Fever, Vomiting, Chills	5	1.7
Fever, Chills	4	1.4
Fever, Vomiting, Chills, Loss of appetite	4	1.4
Fever, Vomiting, Weakness, Diarrhoea	3	1
Fever, Chills, Weakness, Loss of appetite	3	1
Fever, Vomiting, Diarrhoea	3	1
Weakness	2	0.7
Fever, Weakness, diarrhoea	1	0.3
Fever, Vomiting, Chills, Weakness, Diarrhoea	1	0.3

Loss of appetite	1	0.3
Fever, Weakness, Diarrhoea	1	0.3
Vomiting, Chills, Loss of appetite	1	0.3
Fever, Chills, Diarrhoea	1	0.3
Vomiting, Weakness, Loss of appetite	1	0.3
Fever, Weakness, Loss of appetite, Diarrhoea	1	0.3
Fever, Vomiting, Loss of appetite, Diarrhoea	1	0.3
Fever, Vomiting, Loose stool	1	0.3
Vomiting	1	0.3
Fever, Weakness, Loss of appetite,	1	0.3
Fever, Vomiting, Chills, Loss of appetite, Diarrhoea	1	0.3

Figure 2 shows the educational attainment of the respondents, where most of the respondents had primary (1) or secondary education (2), with a small proportion attaining tertiary education (3 and 4). Statistically, lower educational attainment has been associated in multiple Nigerian studies with reduced uptake of confirmed diagnostic testing and delayed treatment-seeking.

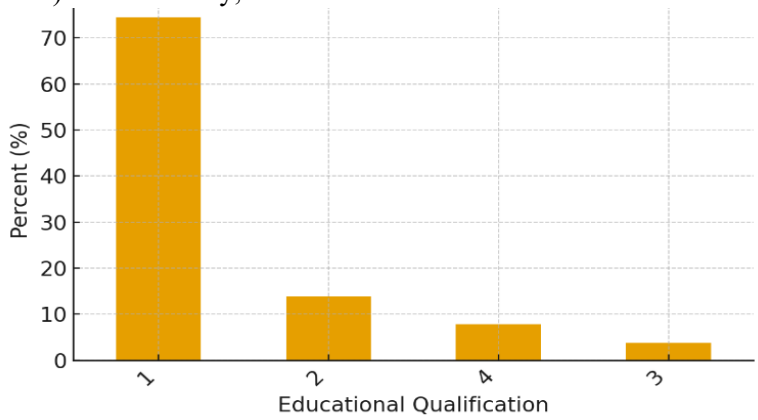

Figure 2. Shows the Educational Attainment of the Respondents

Figure 3, present the occupational status of the respondents, which revealed that 82.7% of respondents were engaged in informal or artisanal occupations. This occupational profile suggests unstable income streams, which may constrain consistent access to healthcare and preventive commodities despite nominal availability through public programs.

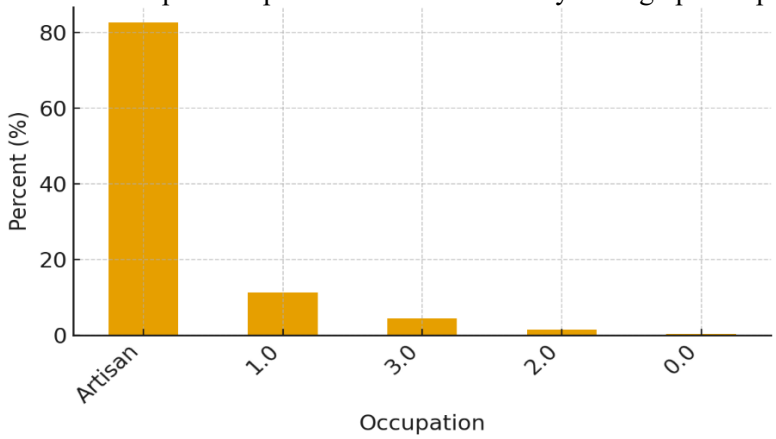

Figure 3. Present the Occupational Status of the Respondents

Figure 4 shows a monthly household income distribution of the respondents, which lead to further contextualizes malaria vulnerability. A large proportion of households earned below the national minimum wage threshold, placing them at heightened risk for malaria exposure due to substandard housing, overcrowding, and limited capacity to absorb recurrent healthcare costs.

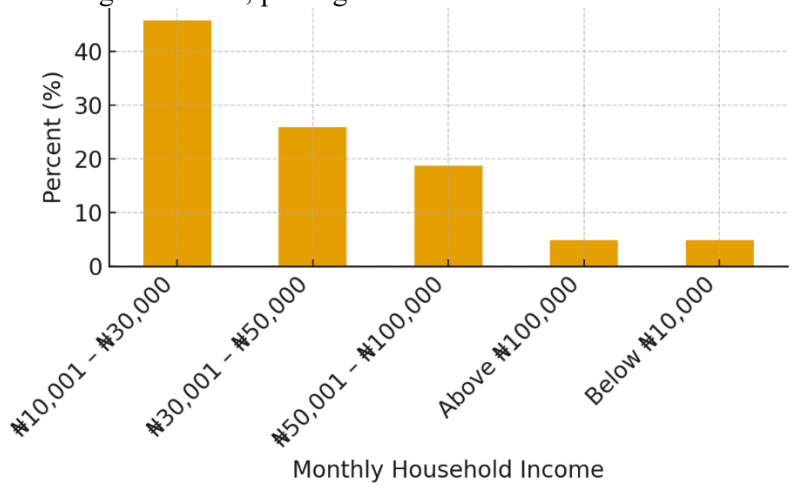

Figure 4. Shows a Monthly Household Income Distribution of the Respondents

Figure 5 shows the household size and number of under-five children indicate cumulative exposure risk, as households with multiple young children experience repeated malaria episodes within short timeframes.

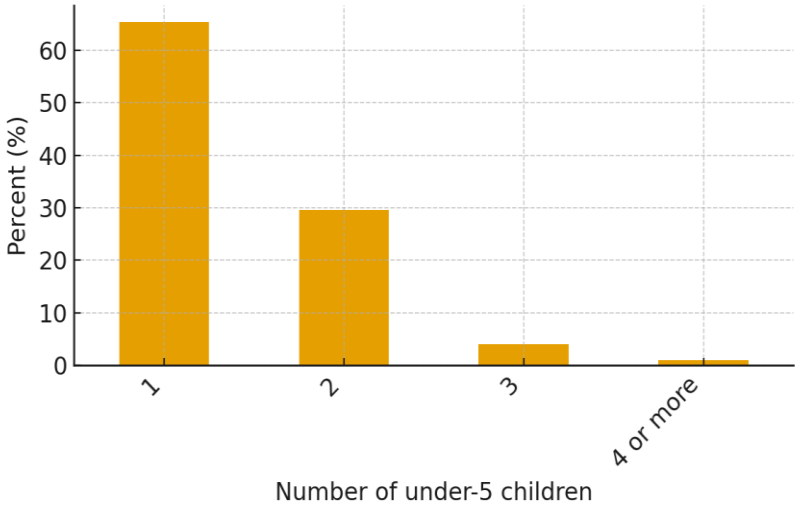

Figure 5. Shows the Household Size

Prevalence, Frequency, and Temporal Pattern of Malaria

Table 3 shows the association between monthly household income and malaria occurrence in the past six months. A statistically significant association was observed ($\chi^2 = 15.20$, $p = 0.004$), indicating higher malaria incidence among lower-income households.

Figure 6, shows that the vast majority of children (95.9%) had experienced malaria within the past six months, while only 4.1% had not.

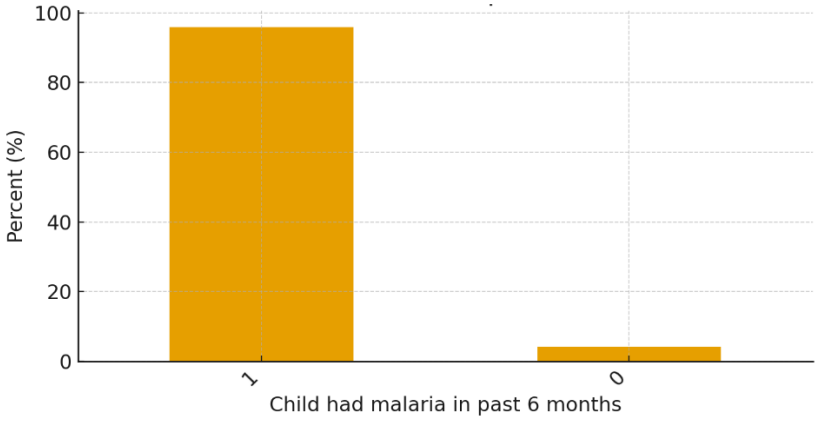

Figure 6. Child had Malaria in the Past 6 Months

Occupation significantly influenced malaria incidence. Farmers and traders reported higher incidence, while civil servants and salaried workers reported fewer cases.

Table 3. Association between Monthly Household Income and having had Malaria in the Past 6 Months

Monthly Household Income	**0**	**1**	**Had malaria in the past 6 months**
Above N100,000	3	11	
Below N10,000	1	13	
N10,001 - N30,000	3	132	
N30,001 - N50,000	1	75	
N50,001 - N100,000	4	51	
Chi2			15.20353
p-value			0.004297
CramerV			0.227404

Figure 7, reveals that 58.2% of the children had malaria one to two times per year, 40.5% experienced three to five episodes, and 1.4% had more than five attacks annually, which is determine to be one to two attacks per year however, a non-trivial proportion of children experienced three or more episodes annually. From an epidemiological perspective, repeated episodes within short intervals suggest intense vector–human contact and limited interruption of transmission cycles. Such frequency also increases cumulative risks of anaemia, malnutrition, and developmental impairment.

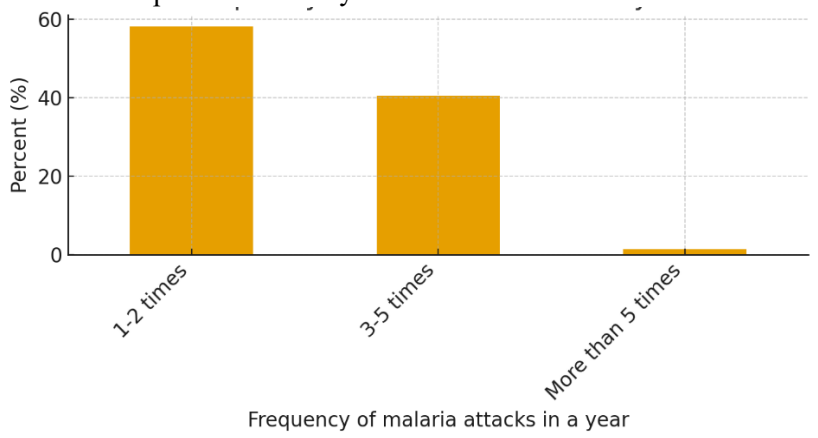

Figure 7. Frequency of Malaria Attacks in a Year

Diagnostic Modalities and Treatment-Seeking Behaviour

As indicated in Figure 8, 76.2% of caregivers relied on symptom-based diagnosis rather than laboratory confirmation. Statistically, this reliance significantly inflates reported malaria incidence and reduces specificity in surveillance data. Symptom overlap with other febrile illnesses common in under-five children introduces misclassification bias, which undermines both individual case management and population-level surveillance accuracy.

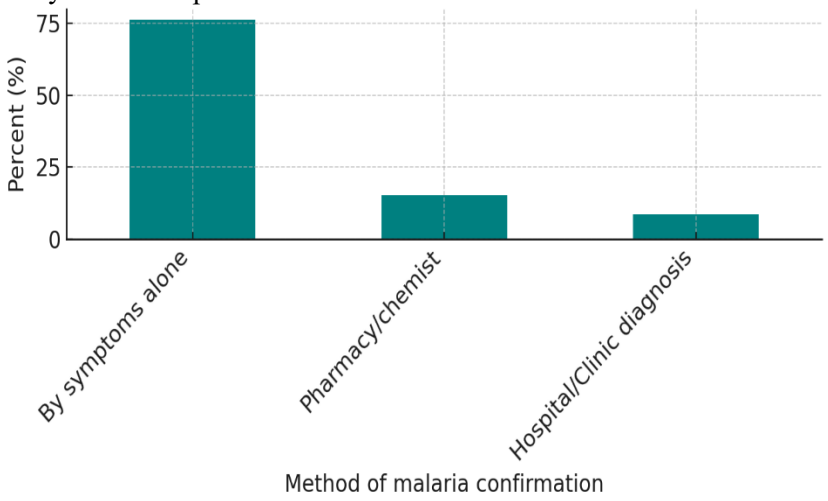

Figure 8. Method of Confirmation

The treatment-seeking patterns in Figure 9, reveal a mixed health-seeking pathway. While primary health centres were frequently utilized, a substantial proportion of caregivers sought care from patent medicine vendors. This duality reflects accessibility constraints, perceived quality of care, and out-of-pocket cost considerations. The use of informal providers has implications for treatment quality, adherence to national guidelines, and antimicrobial resistance.

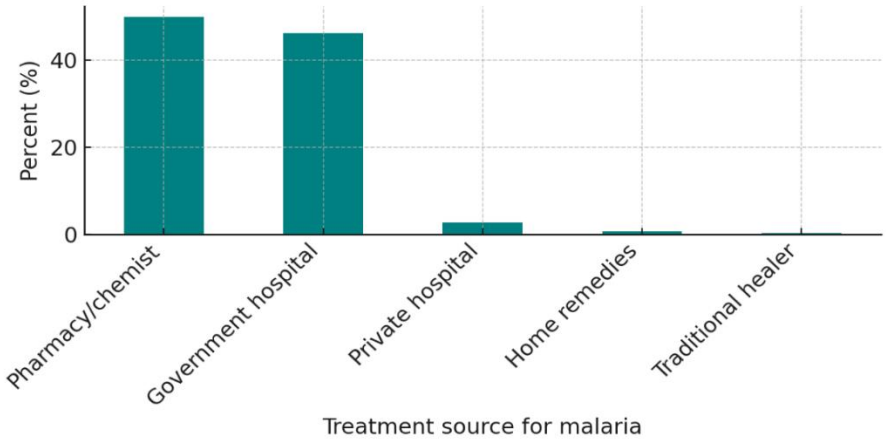

Figure 9. Treatment Source for Malaria

Ownership, Access, and Utilization of Insecticide-Treated Nets (ITNs)

Figure 10, reveals that 95.6% of children regularly slept under insecticide-treated nets (ITNs), 2.7% used them occasionally, while 1% and 0.7% rarely or never used them, respectively. This is reflecting the impact of mass distribution campaigns. Chi-square analyses showed no statistically significant differences in reported ITN use by age,

education, marital status, occupation, or income, indicating equitable nominal coverage. However, statistical uniformity in reported use does not equate to uniform protective efficacy. High malaria prevalence despite high ITN coverage suggests gaps in correct usage, physical condition of nets, sleeping arrangements, or vector resistance. These findings imply that ITN effectiveness in this setting is moderated by contextual and behavioural factors not captured by ownership metrics alone.

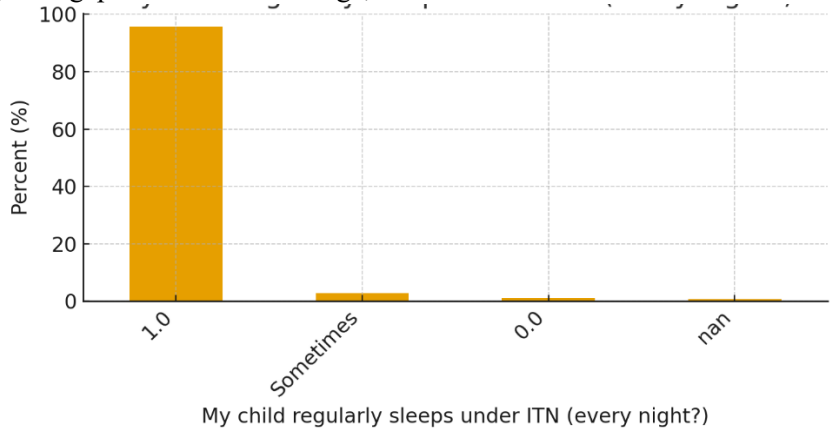

Figure 10. My child Regularly Sleeps under ITN

Table 4 summarizes other malaria preventive measures used by households. The most common combination was mosquito coil use and environmental sanitation (54.1%), followed by mosquito coil use combined with insecticide sprays and environmental sanitation (20.7%).

Table 4. Other Preventive Measures (Multi-response)

Other preventive measures (multi-response)	Frequency	Percentage
Mosquito coil, Environmental sanitation	159	54.1
Mosquito coil, Insecticide sprays, Environmental sanitation	61	20.7
Mosquito coil	16	5.4
Mosquito coil, Window/door nets, Environmental sanitation	11	3.7
Environmental sanitation	8	2.7
Insecticide sprays, Environmental sanitation	5	1.7
Mosquito coil, Window/door nets	5	1.7
Mosquito coil, Herbal prevention	4	1.4
Mosquito coil, Insecticide sprays	4	1.4
Mosquito coil, Environmental sanitation, Herbal prevention	4	1.4
Insecticide sprays, Window/door nets, Environmental sanitation	3	1
Window/door nets	3	1
Mosquito coil, Insecticide sprays, Window/door nets, Environmental sanitation	3	1
Mosquito coil, Insecticide sprays, Window/door nets	2	0.7
Window/door nets, Environmental sanitation	2	0.7
9	2	0.7
Insecticide sprays, Window/door nets	1	0.3
Mosquito coil, Insecticide sprays, Herbal prevention	1	0.3

Indoor Residual Spraying (IRS) Coverage and Perceived Effectiveness

Figure 11, indicates that indoor residual spraying (IRS) was used in 93.9% of households, while 6.1% reported no IRS use. Similar to ITNs, IRS utilization showed minimal sociodemographic differentiation. From a statistical standpoint, the lack of association between IRS coverage and reduced malaria incidence suggests either suboptimal implementation, limited residual efficacy, or rapid reinfestation due to environmental conditions and housing quality.

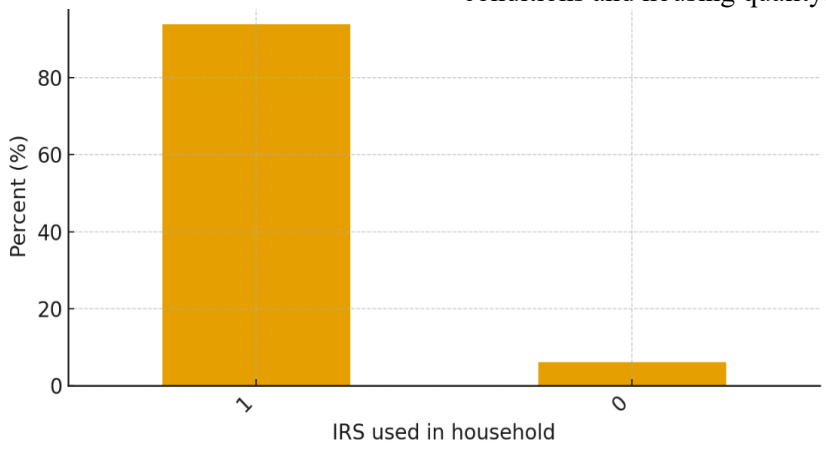

Figure 11. IRS used in the Household

Surveillance Awareness, Reporting, and Community Outreach

Figures 12 assess malaria surveillance performance which reveals that 80.6% agreed and 12.2% strongly agreed that public health officers conducted surveillance, while smaller proportions disagreed or remained neutral. In contrast, 84.4% of households reported no visit by health or surveillance officers in the previous year. This discrepancy highlights a structural weakness in active surveillance and community-based case detection.

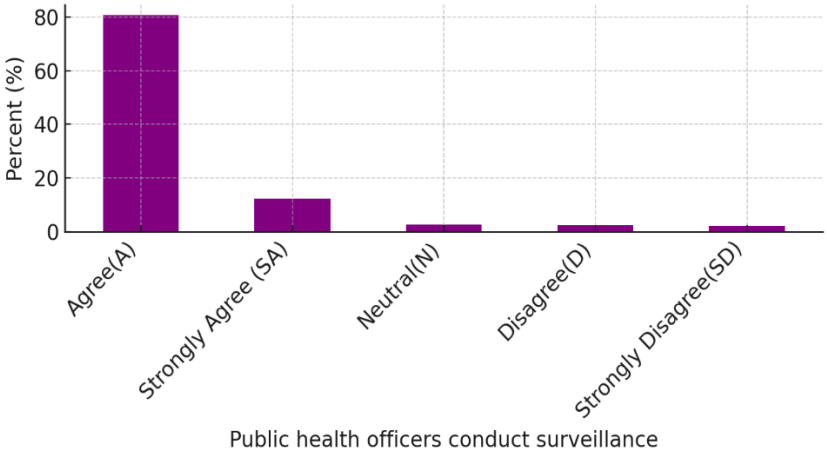

Figure 12. Public Health Officers Conduct Surveillance

Socio-Economic and Financial Burden of Malaria

Statistically, the absence of household visitation limits early case identification and contributes to reliance on passive, facility-based reporting systems, which systematically underrepresent community burden. Figure 13, shows that the average spending per malaria episode was mainly between ₦1,000-₦3,000 (58.5%), while 31.3% spent ₦3,001-₦5,000, and smaller proportions spent above ₦5,000.

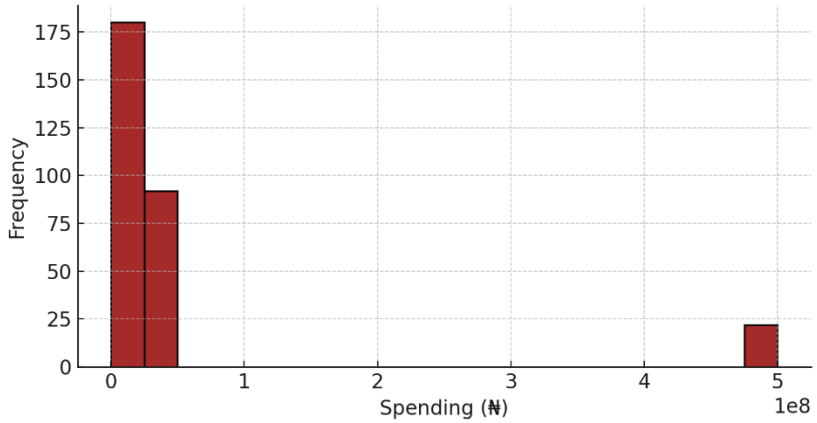

Figure 13. Average Spending on Malaria Treatment per Episode

Association Analyses and Statistical Inference

The Chi-square analysis in Table 5 shows no statistically significant association between caregiver age and malaria incidence among under-five children ($\chi^2 = 2.15$, $p = 0.708$), indicating generalized risk across age groups. Similar non-significant associations were observed for education, occupation, and income, suggesting that malaria risk in Jere LGA is generalized rather than confined to specific subgroups. This epidemiological pattern is characteristic of high-transmission settings, where universal exposure overwhelms individual-level protective factors. Age of Respondent: Younger caregivers (18–35) reported higher malaria incidence among children than older caregivers. This suggests greater vulnerability in younger households, possibly due to limited resources or less experience with prevention. Older age groups (46+) reported relatively fewer malaria cases. $\chi^2 = 2.15$, $p = 0.708$. This test is not statistically significant ($p > 0.05$). Malaria incidence does not significantly differ across age groups of caregivers in this dataset. V = 0.086, this is a very weak association between the caregiver's age and malaria incidence. Age explains little to none of the variation in malaria occurrence.

Table 5. Association between Age and Malaria Incidence

Age	0	1	Had malaria in past 6 months
18-25	2	36	
26-35	7	129	
36-45	3	80	
46-55	0	34	
55and above	0	3	
Chi2			2.150558
p-value			0.708091
CramerV			0.085527

Discussion

Malaria Burden in Nigeria, Sub-Saharan Africa, and Conflict-Affected Settings

The near-universal malaria burden found in this study is significantly higher than national prevalence estimates for Nigeria and more closely resembles patterns found in conflict-affected and humanitarian situations in the Lake Chad Basin. Despite continuous control efforts, studies from Borno, Yobe, South Sudan, and portions of the Democratic

Republic of the Congo show hyperendemic transmission in children under five [3-7]. Malaria continues to be the primary cause of death for children under five in sub-Saharan Africa, making for around 75% of all malaria deaths worldwide [1].

Socioeconomic Vulnerability and Structural Determinants

This study's high proportion of low-income, unemployed households supports the idea that structural factors have a significant influence on malaria transmission. Malaria risk is highly mediated by poverty, housing quality, and overcrowding, according to Nigerian research from Kano, Zamfara, and Niger States [8–10]. Displacement and informal settlements increase exposure in conflict-affected areas.

Preventive Coverage–Impact Disconnect

The high frequency of malaria that persists in Nigeria and SSA despite extensive ITN and IRS coverage is a well-documented phenomenon. Similar disconnects are reported in studies from Ghana, Tanzania, Uganda, and Ethiopia, which attribute them to vector behavioural adaptation, pesticide resistance, inconsistent net application, and net degradation [11–15]. Damaged house structures and outside evening activities further diminish the effectiveness of protection in northeastern Nigeria.

Diagnostic Practices and Surveillance Accuracy

This study's substantial emphasis on symptom-based diagnosis is consistent with findings from Sahelian and northern Nigerian contexts [16–18]. Presumptive treatment may improve access, but it also inflates malaria numbers and compromises the accuracy of diagnoses. The World Health Organization now strongly advises universal parasitological confirmation before starting therapy, highlighting its importance for the integrity of surveillance and responsible drug use.

Surveillance Gaps in Fragile and Insecure Contexts

This study's findings about inadequate community-level surveillance align with assessments of malaria surveillance systems in conflict environments. Insecurity, a lack of workers, and disjointed reporting systems are identified as the main obstacles in studies from Borno State, Somalia, and the northeastern Democratic Republic of the Congo [19–22]. Malaria control initiatives cannot react quickly to local transmission patterns in the absence of ongoing surveillance.

Economic Burden and Developmental Consequences

This study's financial burden is consistent with research from SSA and Nigeria showing that malaria causes disastrous medical costs for low-income households [23–25]. Intergenerational poverty is sustained by recurrent malaria episodes, which also cause anemia, poor cognitive development, and decreased school attendance.

Implications for Elimination Goals

Without focused initiatives for LGAs affected by violence, Nigeria's goals to eradicate malaria are unlikely to be achieved. Gains in controlling malaria are brittle and reversible in the absence of strong surveillance and resilient health systems, according to data from Rwanda, Senegal, and Zambia [26–28].

Conclusion

In Jere LGA, Borno State, malaria is still a widespread and unfair public health concern for children under five. The need for enhanced surveillance, better diagnostic confirmation, and context-sensitive control strategy execution is highlighted by the continuation of high transmission despite widespread awareness and reported preventive coverage.

Limitations

The cross-sectional design used in this investigation limited the ability to draw conclusions about the causal relationship between identified risk factors and malaria outcomes. When it comes to malaria episodes and preventive measures in particular, relying on caregiver self-report may introduce recollection and social desirability bias. Not all reported instances had independent diagnostic confirmation, and significant variables including housing quality and nutritional status were not completely controlled. When interpreting the results, these restrictions should be taken into account.

Policy Implications

The results have a number of policy ramifications. First, rather than depending exclusively on facility-based reporting, malaria control programs in LGAs affected by violence should give active community-based surveillance and diagnostic confirmation top priority. Second, actual utilization, housing conditions, and pesticide resistance must be monitored in addition to ITN and IRS techniques. Third, in order to address the multifactorial causes of transmission, malaria control must be integrated with nutrition, maternal and child health, and humanitarian services. Lastly, achieving equitable malaria reduction among children under five requires consistent investment in local monitoring capability.

In Jere LGA, Borno State, malaria is still a serious public health issue among children under five. The illness load has not decreased proportionately despite high awareness and reported preventative coverage. There is an urgent need to increase community-level participation, surveillance outreach, and diagnostic procedures.

Recommendations

In conflict-affected areas, it is necessary to scale up community-based diagnostic testing using rapid diagnostic tests, bolster active surveillance through trained community health workers, improve monitoring of actual ITN utilization and the quality of IRS implementation, and integrate malaria control with nutrition and child health programs.

Ethical Approval

The study received ethical approval from the Borno State Ministry of Health Research Ethics Committee. Informed consent was obtained from all caregivers, and confidentiality of participants was maintained throughout the study.

Data Availability

The datasets generated and/or analyzed during this study are available from the Borno State Ministry of Health upon reasonable request.

Author Contributions

Mohammed Bala Aminu (M.B.A.) conceptualized and designed the study. Data collection and analysis were conducted by M.B.A. and the research team. The author contributed to the interpretation of results, drafting, and revision of the manuscript, and approved the final version for publication.

Funding

This research was self-funded by the author.

Conflict of Interest

The author declares no conflict of interest in relation to this study.

Acknowledgement

The Borno State Ministry of Health, local school administrators, and community caregivers who contributed important information for the study are gratefully acknowledged by the author. The author also extends special thanks to the health professionals and research assistants in the Jere Local Government Area for their assistance and collaboration during data collection.

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