Research Article

Gaps in Malaria Vector Control: Insights from Community Practices in Aba North LGA, Abia State, Nigeria

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ABSTRACT
Malaria remains a major public health burden in Nigeria, with transmission persisting in urban and peri-urban areas despite control efforts. Effective control depends not only on biomedical interventions but also on community knowledge, practices, and environmental conditions. This study examined malaria-related knowledge, household control practices, and ecological risk factors influencing vector abundance in Aba North Local Government Area (L.G.A.), Abia State, Nigeria. A cross-sectional survey was conducted using structured questionnaires administered to households, complemented by environmental observations of breeding habitats and housing structures. Data were analyzed to assess knowledge levels, preventive practices, and perceived challenges to malaria vector control. While most respondents correctly identified mosquitoes as malaria vectors, knowledge of breeding habitats and preventive measures was limited. Household control strategies were dominated by insecticide sprays, untreated nets, and repellents, with low utilization of insecticide-treated nets (ITNs) and no adoption of biological control methods. Concerns about health risks and declining efficacy of insecticides were reported by 65% of respondents, and 74% were unaware of existing government or NGO-led interventions. Environmental surveys revealed stagnant water, blocked drains, and poorly constructed houses that favored mosquito breeding and human-vector contact. Findings underscore gaps in community awareness, equitable access to effective tools, and engagement in integrated vector management (IVM). Strengthening health education, ensuring subsidized ITN and IRS coverage, and linking malaria control with housing, sanitation, and urban planning are essential. Addressing these gaps through policy-supported, multi-sectoral interventions will enhance malaria elimination efforts in the region.

Keywords: Aba North; *Anopheles;* Community practices; Malaria; Nigeria; Vector control

INTRODUCTION

Malaria has consistently remained a global health nightmare to date. In 2022 alone, 249 million cases were reported, compared to 244 million cases in 2021 (WHO, 2024). Most malaria deaths lie within Sub-Saharan Africa, with Nigeria always at the lead. It factually remains one of Nigeria's most pressing public health challenges, accounting for an estimated one-quarter of global malaria cases and a significant proportion of under-five mortality, outpatient visits, and hospitalizations across the country (AP News, 2024; Reuters, 2024; Okorie *et al.*, 2011). Although control efforts, such as the mass distribution of long-lasting insecticidal nets (LLINs) and intermittent

preventive treatment, have contributed to reductions in transmission in recent years, progress has stalled, and the urbanization of malaria has emerged as a growing threat (Fillinger and Lindsay, 2011; Xu *et al*., 2023).

In rapidly urbanizing areas like Aba North L.G.A. in Abia State—an urban enclave exhibiting environmental challenges such as poor drainage and solid waste accumulation—mosquito breeding sites abound, perpetuating malaria risk (Okorie *et al*., 2011). Despite widespread distribution of ITNs, barriers such as discomfort, difficulty of use, and socio-cultural factors often limit their effectiveness, highlighting the fact that net ownership does not always translate to proper usage (The Guardian, 2014).

Effective malaria control now requires comprehensive and locally tailored strategies. Nigeria's National Malaria Strategic Plan (2021–2025) emphasizes Integrated Vector Management (IVM)—a multi-pronged framework combining environmental sanitation, chemical methods like indoor residual spraying (IRS) and larviciding, biological control, and community-based education (Federal Ministry of Health, 2023). Nevertheless, limited capacity for entomological surveillance and weak coordination between research and policy implementation constrain the effectiveness of these interventions (Obembe *et al*., 2024).

Community behavior and perceptions also shape intervention success. Studies in urban areas have shown high awareness of malaria causation, but low uptake of preventive tools such as insecticide-treated nets, and widespread reliance on insecticide sprays and traditional treatment methods (Adedotun *et al*., 2010; Merga *et al*., 2025). Additionally, in many urban and informal settlements, first-line care for malaria often comes from informal providers, influenced by factors such as affordability and accessibility (Ogunwale *et al*., 2024).

Given the persistence of *Anopheles* mosquito populations in such settings and the incomplete penetration of structured vector control measures, the present study investigates what community-level, environmental, and institutional factors influence malaria vector control effectiveness in Aba North Local Government Area, Abia State. The goal is to inform more effective, integrated, and sustainable interventions tailored to urban Nigerian contexts.

MATERIALS AND METHODS

Study Area

The study area Aba North Local Government Area of Abia State, Nigeria is located at 5°20'N and 7°19'E. It has an area of 23 km^2 and a population of 107,488 at the 2006 census (Nigeria Galleria, 2021). Aba North, an integral part of Ngwa land, consists of indigenes and migrants from other parts of the state who reside in Aba for entrepreneurial and other purposes (Nigeria media, 2022). Aba North Local Government Area is predominantly inhabited by a people, whose culture is characterized by strong communal ties, vibrant informal economic activities, and a high level of population mobility. The area is largely urban, with residents engaged mainly in trading, small-scale manufacturing, artisanal work, and other informal-sector occupations. Social interactions often extend into the evening hours, with outdoor activities such as trading, social gatherings, and religious meetings commonly occurring at night, thereby increasing human–mosquito contact.

Environmental conditions in Aba North L.G.A. favor malaria transmission through the proliferation of mosquito breeding habitats. The area is characterized by poor drainage infrastructure, frequent water stagnation, and indiscriminate disposal of solid waste, which often blocks drainage channels and creates pools of standing water. Open gutters, potholes, abandoned containers, and poorly managed refuse dumps provide suitable larval habitats for Anopheles mosquitoes, particularly during the rainy season.

Study Design

This study employed a cross-sectional survey-based design to assess malaria vector control measures in Aba North LGA, Abia State. Random sampling method was used to ensure representative coverage of households across the area, considering variations in geographic, socioeconomic, and environmental factors. Specific sites were selected based on the prevalence of malaria cases and proximity to mosquito breeding sites, ensuring that both high-risk and low-risk areas were included for comprehensive data collection.

Data collection

The data collection method was based on using structured questionnaires to gather information on malaria vector control strategies in Aba North LGA. Two hundred structured questionnaires were administered to households to collect data on the

knowledge, attitudes, and practices of the participants regarding malaria vector control. The questionnaires were designed to consist of two parts: Part A related to the socio-demographic background of participants, and Part B on basic knowledge about malaria (modes of transmission and symptoms) as well as the attitude towards malaria prevention and control practices.

Collection of Mosquito Samples Using Pyrethrum Spray Catch (PSC)

This study was conducted from June to December 2024 across 10 households to assess indoor resting mosquitoes. Mosquito collection was done using the Pyrethrum Spray Catch (PSC) method between 6:00 and 9:00 am, following the standard WHO protocol (Kurmi *et al.,* 2024). Selected households were sprayed with a Top Rank insecticide. White sheets were spread on the floor to collect mosquitoes that fell after spraying. Door and windows were shut and after fifteen minutes, all mosquitoes that had fallen on the sheets were recovered with forceps and stored in Eppendorf tubes.

Morphological identification of collected mosquito

The collected mosquitoes were then identified according to the morphological keys of Gillies and D eMeillon (1968), Gillet (1972) and Gillies & Coetzee (1987).in the laboratory of Zoology and Environmental Biology and counted to determine the density and composition of vector species in the area.

Data Analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS), version 30.0.0. Chi-square (χ^2) tests were employed to assess associations between categorical variables. Statistical significance was determined at a 95% confidence level ($p < 0.05$).

RESULTS

Socio-demographic Characteristics of Study Respondents

Out of the 200 questionnaires analyzed, the mean age of respondents in years was 40 ± 7.19, whereas the median was 43.0. The majority of the respondents were youths (18- 30yrs) (54; 27.0%) followed by those aged 31-40(50; 25.0%), 41-50 years (43; 21.5%), 1-60 years (40; 20.0%) and the least were those aged 60 and above (13; 6.5%). Those who are married were highest among the respondents (103; 51.5%) followed by the singles (64; 32.0%) with the least being those divorced (10(5.0%). Most of the respondents lived in a bungalow (50; 25.0%), however, the least number of them lived in a one room, 1 and 4-storey buildings (6; 3.0%). There was a significant difference in all the socio-economic characteristics with p < 0.05, except for gender, with the p value > 0.05. The socio-demographic characteristic of respondents is summarized in Table 1 below.

Knowledge and practices related to mosquito control Currently in Place in Aba North L.G.A, Abia State

From Table 2 below it can be seen that the majority of the respondents use more than one method to control mosquitoes. The most common methods utilized by respondents are 'Cutting bushes and grasses around the house' (150; 75.0%), 'draining stagnant water' (150;65.0%), 'Screening of windows with net' (145; 72.5%), covering the body with clothes (135;67.5%)', 'use of insecticide's (130; 65.0%), 'sleeping every night under the net (130;65,0%)', 'clearing of gutters (120; 60.0%)' and 'sleeping with closed windows' (110; 55%). Burning coil/grasses as repellent had the least value (50; 25.0%).

Efficiency of the Methods

The result in Table 3 showed that the respondents preferred the various control methods for different reasons, but readily available (150; 75.0%) was the most pronounced reason for choice and use of methods. A substantial number of respondents used methods 'because they are cheap' (145; 72.5%). Others preferred methods that 'prevent contact with mosquitoes' (130; 65%), whereas a handful of respondents were particular about the 'negative impacts of insecticides' (130; 65%) (Table 3). The Majority of the respondents (148; 74.0%) were not aware of any recent government/NGO mosquito control intervention within Abia State.

Table 1: Socio-Demographic characteristics of respondents

ARIABLES	NUMBER (%)	P-value
Age (years)		0.00
18 – 30	54 (27)	
31 – 40	50(25)	
41- 50	43(21.5)	
51 – 60	40(20)	
Above 60	13(6.5)	
TOTAL	**200(100)**	
Marital Status		0.00
Single	64(32)	
Married	103(51.5)	
Divorced	10(5)	
Widowed	23(11.5)	
TOTAL	**200(100)**	
Gender		0.08
Male	115(57.5)	
Female	85(42.5)	
TOTAL	**200(100)**	
Location		0.00
Uratta	62(31)	
Osusu	47(23.5)	
Eziama	42(21)	
Umungasi	35(17.5)	
Nwala	4(2)	
Umuokpor	7(3.5)	
Faulks Road	3(1.5)	
TOTAL		
Type of Building		0.00
Bungalow	50(25)	
Self-contain	45(22.5)	
2 storey building	9(4.5)	
3-bedroom flat	27(13.5)	
3 storey building	10(5)	
2 rooms	15(7.5)	
1 storey building	6(3)	
4 storey building	6(3)	
1 room	6(3)	
1 bedroom flat	20(10)	
Native compound	6(3)	
TOTAL	**200(100)**	
How many persons live in your house?		0.00
1	64(32)	
2	20(10)	
3	13(6.5)	
4	10(5)	
5	30(15)	
6	40(20)	
7	10(5)	
8	5(2.5)	
9	5(2.5)	
10	3(1.5)	
TOTAL	**200(100)**	
How many persons live in your room?		0.00
1	95(47.5)	
2	85(42.5)	
4	20(10)	
TOTAL	**200(100)**	
Do you know that mosquitoes transmit malaria pathogens		0.00
Yes	160(80)	
No	40(20)	
TOTAL	**200(100)**	

Table 2: Knowledge and practices on mosquito control among respondents in Aba North L.G.A, Abia State

Variables	Number (%)	P-value
1. Use of Insecticides		0.00
Yes	130(65.0)	
No	70(35.0)	
TOTAL	200(100.0)	
2. Do you sleep every night under the net		0.00
Yes	130(65)	
No	70(35)	
TOTAL	**200(100)**	
3. Sleeping with windows closed		0.25
Yes	110(55)	
No	90(45)	
TOTAL	**200(100)**	
4. Screening of windows with net		0.00
Yes	145(72.5)	
No	55(27.5)	
TOTAL	200(100.0)	
5. Burning coil/grass as repellent		0.00
Yes	50(25)	
No	150(75)	
TOTAL	**200(100)**	
6. Cutting bushes and grasses around the home		0.00
Yes	150(75.0)	
No	50(25.0)	
TOTAL	200(100.0)	
7. Draining of Stagnant water		0.00
Yes	150(75.0)	
No	50(25.0)	
TOTAL	200(100.0)	
8. Clearing gutters		0.02
Yes	120(60.0)	
No	80(40.0)	
TOTAL	200(100.0)	
9. Covering body with clothes		0.00
Yes	135(67.5)	
No	65(32.5)	
TOTAL	200(100.0)	
10. Rub repellent cream on the body		0.00
Yes	60(30.0)	
No	140(70.0)	

Table 3: Reasons for the control methods utilized by respondents

Reasons	Number (%)	P – value
1. **Because of the negative health impacts of insecticides**		0.00
Yes	130(65.0)	
No	70(35.0)	
TOTAL	200(100.0)	
2. **Because it prevents contact with mosquito**		0.00
Yes	130(65.0)	
No	70(35.0)	
TOTAL	200(100.0)	
3. **Because it is very effective**		0.25
Yes	110(55.0)	
No	90(45.0)	
TOTAL	200(100.0)	
4. **Because it is cheap**		0.00
Yes	145(72.5)	
No	55(27.5)	
TOTAL	200(100.0)	
5. **Because it is easy to use and not time wasting**		0.00
Yes	50(25.0)	
No	150(75.0)	
TOTAL	200(100.0)	
6. **Because it was recommended**		0.00
Yes	143(71.5)	
No	57(28.5)	
TOTAL	200(100.0)	
7. **Because it is readily available**		0.00
Yes	150(75.0)	
No	50(25.0)	
TOTAL	200(100.0)	
8. **I can't say**		0.00
Yes	72(36.0)	
No	128(64.0)	
TOTAL	200(100.0)	
9. **Because I have no alternative**		0.00
Yes	135(67.5)	
No	65(32.5)	
TOTAL	200(100.0)	
10. **Are you aware of government organization or non-government organization intervention in mosquito control in your area**?		
Yes	148(74.0)	0.00
No	52(26.0)	
TOTAL	200(100)	

Malaria Vector Control interventions existing in Aba North L.G.A

Out of the 200 respondents, 148 gave a positive response to awareness of different interventions from either governmental or non-governmental organizations for the control of malaria vectors in Aba North L.G.A as shown in Table 4. 60 (30.5%) are aware of application of insecticides, 40 (27.0%) responded positively to being aware of net/repellents distribution, 30(20.3%) responded positively to awareness creation on malaria parasite and control measures whereas 18(12.2%) responded to the fact that although they are aware of past government intervention but nothing was been done currently.

New Intervention that could Bridge the Gap in Protection

Respondents preferred novel interventions that could aid in bridging the gap in protection of humans from the malaria parasite ranged from improved health infrastructure 70(35.0%) followed by social and financial support 60(30.0%), Integrated vector management (IVM) 30(15.0%) with the least being biological larva control and enhanced community education/ awareness 20(10.0%) as shown in Table 5.

Result of the Pyrethrum Spray Catch (PSC)

The result of the Pyrethrum Spray Catch (PSC), reveals that the genus *Anopheles* were the most frequently caught (219) followed by the genus *Culex* (126) across 14 sampling day (Table 6).

Table 4: Intervention in Mosquito Control in Aba North L.G.A

Variable	Number (%)	p-value
Sharing of insecticide	60(30.5)	0.00
Sharing of net/repellent	40(27.0)	
Awareness creation	30(20.3)	
Nothing has been done yet	18(12.2)	
Total	**148(100)**	

Table 5: Preferred Interventions that could Bridge the Gap in Protection

Variable	Number (%)	p-value
Health infrastructure	70(35.0)	0.00
Integrated vector management	30(15.0)	
Enhanced Awareness creation	20(10.0)	
Environmental Management programs	60(30.0)	
Biological larval control	20(10.0)	
Total	**200(100)**	

Table 6: Number of mosquitoes caught per night using Pyrethrum Spray Catch (PSC)

Day	*Anopheles*	*Culex*
1	18	10
2	15	7
3	18	11
4	16	9
5	14	8
6	17	9
7	14	12
8	17	10
9	20	9
10	14	8
11	12	6
12	13	7
13	15	9
14	16	11
TOTAL	**219**	**126**

DISCUSSION

This study assessed mosquito abundance, socio-demographic characteristics, and community knowledge and practices related to malaria vector control in Aba North L.G.A., Abia State, Nigeria. The findings revealed a higher abundance of Anopheles mosquitoes compared to Culex species, indicating sustained malaria transmission risk despite the urban setting. Although community awareness of malaria transmission was generally high, preventive practices were largely driven by affordability and accessibility rather than adherence to recommended integrated strategies. Environmental sanitation measures were \widely practiced, yet structured government-led

interventions and community engagement were notably limited. Together, these findings highlight a mismatch between knowledge, practice, and institutional support, with important implications for urban malaria control.

The Pyrethrum Spray Catch (PSC) revealed that *Anopheles* mosquitoes (n=219) were more frequently collected than *Culex* mosquitoes (n=126). This finding underscores the continued epidemiological relevance of *Anopheles* species as primary malaria vectors in the region. Previous studies in southeastern Nigeria and other parts of sub-Saharan Africa have consistently reported the predominance of *Anopheles gambiae* complex and *Anopheles funestus* in malaria transmission (Okorie *et al.*, 2015; Oyewole *et al.,* 2010). The persistence of Anopheles mosquitoes in urban and peri-urban areas may be attributed to poor drainage systems, unplanned urban expansion, and the availability of numerous artificial breeding sites, which undermine conventional vector control efforts and sustain malaria transmission.

Although *Culex* mosquitoes are less important for malaria transmission, their abundance is noteworthy. *Culex quinquefasciatus* is a known vector of lymphatic filariasis and arboviruses (Simonsen *et al.*, 2014). Their presence also reflects poor urban sanitation, blocked drains, and stagnant wastewater, which provide suitable breeding grounds (Adeleke *et al.,* 2010). Thus, while malaria risk is primarily driven by *Anopheles*, the nuisance and potential disease burden posed by *Culex* cannot be ignored.

The majority of respondents were between 18–50 years of age, representing the most productive segment of the population. This finding is significant because malaria morbidity in this age group directly impacts economic productivity and household stability (WHO, 2023). A relatively high proportion of respondents were married (51.5%), suggesting household-level exposure and risk of intra-familial malaria transmission.

Awareness of malaria transmission was high, with 80% of respondents identifying mosquitoes as the vector. This aligns with findings in other Nigerian and West African settings (Adesina *et al*., 2020; Afolabi *et al*., 2021). However, awareness alone may not always translate into effective preventive practices, as knowledge-behavior gaps remain common in malaria-endemic regions (Obembe *et al.,* 2014).

Respondents reported using multiple mosquito control measures, with environmental management strategies such as clearing bushes (75%), draining stagnant water (75%), and cleaning gutters (60%) being the most common. These methods align with Integrated Vector Management (IVM) principles recommended by WHO (2017), which emphasize environmental sanitation and community participation as sustainable approaches.

The use of insecticides (65%) and insecticide-treated nets (65%) was also widespread. Insecticide-treated nets remain a cornerstone of malaria control (WHO, 2022). However, concerns about insecticide toxicity, reported by 65% of respondents, highlight growing resistance to chemical control methods due to health fears, as has been reported in Ghana, Tanzania, and other parts of Africa (Nkya *et al*., 2016; Toé *et al*., 2014). Window screening (72.5%) and sleeping with windows closed (55%) were also common preventive adaptations, consistent with reports that housing improvements significantly reduce indoor vector densities and malaria prevalence (Koudou *et al*., 2018). The reported concerns about insecticide toxicity may explain the preference for non-chemical control methods such as window screening and environmental sanitation. Similar perceptions have been linked to reduced acceptance of chemical-based interventions in other African settings, particularly where risk communication is inadequate (Nkya *et al*., 2016; Toé *et al*., 2014).

The relatively low reliance on mosquito coils and repellents (25%) may reflect cost, accessibility, or perceived ineffectiveness. Previous studies have shown that households in low-income urban areas prioritize low-cost and easily accessible preventive strategies (Okeke *et al.,* 2020).

Most respondents favored control measures that were cheap (72.5%) and readily available (75%), reflecting the socioeconomic realities of urban households. The perception of affordability and accessibility as drivers of preventive behavior has been reported in other studies in Nigeria and Ghana (Adedotun *et al.,* 2010; Afolabi *et al.,* 2021).

A significant gap was identified in community engagement: 74% of respondents reported no awareness of government or NGO-led malaria interventions. Where interventions existed, they were largely limited to insecticide and bed net distribution. This contrasts with WHO's emphasis on

sustained community education, surveillance, and integrated interventions (WHO, 2022). The limited visibility of organized programs suggests weak health system engagement in Aba North, consistent with reports of declining malaria control funding and fragmented intervention coverage in urban Nigeria (Okeke *et al*., 2020). The limited awareness of government and NGO-led malaria interventions may reflect weak community-level engagement, irregular outreach activities, and inadequate dissemination of public health information, particularly in densely populated urban neighborhoods.

Respondents emphasized the need for improved health infrastructure (35%)**,** environmental management programs (30%)**,** and integrated vector management (15%). This highlights community recognition that malaria control requires systemic solutions beyond individual efforts. The promotion of biological control methods (10%) such as larvivorous fish or microbial larvicides (*Bacillus thuringiensis israelensis*) has proven effective in reducing vector densities in African settings (Fillinger & Lindsay, 2011). The community-driven demand for broader interventions resonates with WHO's call for multi-sectoral, locally adapted malaria elimination strategies (WHO, 2022).

Overall, the findings of this study reveal critical gaps in malaria vector control within Aba North L.G.A. that carry important policy implications. First, the persistent abundance of *Anopheles* mosquitoes despite existing household measures highlights the need for sustained government-led interventions rather than reliance on individual or community-driven practices. Malaria control policies should therefore prioritize long-term, coordinated programs that integrate vector surveillance, larval source management, and adult vector suppression.

Second, the limited awareness of governmental and NGO malaria interventions (74% of respondents unaware) underscores weak community engagement and communication strategies. Policy makers must strengthen health education and behavior-change campaigns to ensure that preventive interventions reach all social strata and are widely adopted.

Third, economic and accessibility constraints influence the choice of preventive methods, with households relying mainly on cheap or readily available strategies. Malaria control policy should thus incorporate equity-sensitive approaches, such as

subsidized or free provision of insecticide-treated nets, indoor residual spraying, and affordable repellents, particularly for low-income households.

Fourth, negative perceptions of insecticides expressed by a substantial proportion of respondents (65%) suggest declining trust in chemical-based interventions. Policy frameworks must therefore integrate community sensitization on the safe use of insecticides, while simultaneously investing in alternative methods such as biological larval control and environmental management to reduce chemical dependency.

Fifth, the lack of widespread adoption of Integrated Vector Management (IVM) and biological control methods reflects gaps in both policy emphasis and community-level awareness. Policymakers should adopt and promote IVM as a central malaria control strategy, integrating housing improvement, sanitation, larval control, and judicious use of insecticides in an environmentally sustainable framework.

Finally, the structural housing deficiencies observed, such as overcrowding and poorly screened buildings, point to the need for multi-sectoral policy interventions linking malaria control to urban planning and housing policies. Collaboration between public health authorities, local government, and urban planners could promote the development of vector-proof housing and improved sanitation systems to reduce mosquito breeding and human-vector contact.

Taken together, these gaps highlight that malaria control in Aba North requires a shift from fragmented, short-term measures to sustained, integrated, and community-centered policies. Addressing these gaps will not only reduce malaria transmission but also advance Nigeria's broader goal of malaria elimination in line with the World Health Organization's Global Technical Strategy for Malaria (WHO, 2022).

This study has some limitations that should be considered when interpreting the findings. First, the cross-sectional design limits the ability to establish causal relationships between mosquito abundance, environmental conditions, and community practices. Second, mosquito collections using the Pyrethrum Spray Catch (PSC) method were limited to indoor resting mosquitoes and may not fully capture outdoor vector populations, potentially underestimating total

mosquito abundance. Third, data on knowledge and practices were self-reported and may be subject to recall bias or social desirability bias. Despite these limitations, the study provides valuable insights into the ecological and behavioral factors influencing malaria vector control in an urban Nigerian setting and offers evidence to guide context-specific interventions.

CONCLUSION

This study demonstrated that *Anopheles* mosquitoes remain the predominant malaria vector in Aba North, posing a significant transmission risk. Community awareness of malaria is high, and households employ multiple preventive measures, mainly environmental sanitation, insecticides, and insecticide-treated nets. However, government and NGO intervention programs were reported as inadequate and poorly sustained. Socioeconomic realities strongly influence the choice of control methods, with affordability and availability being key determinants.

Overall, malaria control in Aba North requires stronger institutional engagement, consistent public health interventions, and integration of environmental, biological, and chemical control measures. Without renewed investment in community-based interventions and infrastructure, malaria transmission will remain entrenched.

The following recommendations are therefore made: Government agencies should integrate environmental sanitation, larval control, and biological control methods into existing malaria programs. Encouraging the use of window and door screening, alongside improved housing design, can significantly reduce mosquito entry.

Sustained awareness campaigns on malaria prevention and risks associated with indiscriminate insecticide use should be prioritized. Community-driven sanitation and environmental management programs should be incentivized.

Federal, state, and local governments should ensure consistent distribution of insecticide-treated nets, indoor residual spraying, and access to affordable repellents. Continuous monitoring of mosquito vector populations and insecticide resistance patterns is essential for effective policy adaptation.

Authorship contribution

Chukwuebuka Mathias Ekedo: Conceptualization, Methodology, Writing- Original draft preparation, Software; Reviewing and Editing; **Akaninyene Udoh Akpan:** Conceptualization, Methodology, Writing- Original draft preparation, Reviewing and Editing; **Chukwuebuka Mathias Ekedo:** Writing- Original draft preparation, Software, Visualization, Validation, Investigation; **Ubong Bernard Essien:** Writing- Original draft preparation, Software, Visualization, Validation, Investigation; **Ubong Bernard Essien:** Writing- Original draft preparation, Visualization, Software; Investigation; **Briandavis Nnaemeka Ibediugha :**Writing- Original draft preparation, Visualization, Software; Investigation; **Ifeoma Christabel Iwuoha:**Writing- Original draft preparation, Visualization, Software; Investigation.

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