Urban Malaria in Imo State, Nigeria: Prevalence, Spatial Distribution, Demographic Determinants, and Diagnostic Performance in Three Senatorial Zones

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Abstract

Malaria remains a major public health concern in Nigeria, including urban settings where its burden is often underestimated. This study assessed the prevalence and demographic determinants of malaria in three urban zones of Imo State—Orlu, Owerri, and Okigwe. A cross-sectional survey involving 400 participants was conducted between January and March 2024. Venous blood samples were analyzed using both rapid diagnostic tests (RDTs) and Giemsa-stained microscopy. Data were categorized and analyzed by age, sex, occupation, and parasite density. Microscopy confirmed an overall prevalence of 34.5%, with Orlu recording the highest rate (38.0%) and Okigwe the lowest (30.0%). Children aged 0–10 years were the most affected group (52.8%), and parasite densities ranged from 1,000 to 7,000/µL, indicating moderate infection levels. Females exhibited a slightly higher prevalence (35.0%) than males (33.9%). RDTs showed reduced sensitivity compared with microscopy, underscoring the need for accurate diagnostic tools in surveillance programs. The findings demonstrate that malaria transmission persists in urban areas of Imo State despite control efforts. Strengthening diagnostic accuracy, improving environmental management, and implementing targeted community interventions are crucial to reducing the urban malaria burden. Continuous monitoring of demographic and ecological risk factors is recommended to guide effective urban malaria control strategies.

Keywords: Malaria, Urban transmission, Imo State, Diagnostics, Epidemiology

Introduction

In tropical and subtropical regions, malaria remains a significant public health issue; sub-Saharan Africa bears the brunt. This illness is primarily caused by a parasite. It results from the bites of infected female Anopheles mosquitoes, specifically Plasmodium falciparum (World Health Organization [WHO], 2020). An estimated 249 million cases occur worldwide, and the WHO African Region accounts for over 94% of these cases. Nigeria alone contributes around 27% of all cases and 31% of malaria-related deaths (Severe Malaria Observatory, 2024). Traditionally, malaria has been linked to rural areas where poor housing, limited healthcare access, and ideal mosquito breeding conditions facilitate its spread. However, this rural focus is quickly changing. Rapid urbanization in Africa is altering disease patterns and challenging the idea that urban areas are less prone to malaria (Doumbe-Belisse et al., 2021). Projections suggest that nearly 70% of Africa's population will live in cities by 2050 (United Nations [UN], 2018), leading to new epidemiological challenges. Nigeria is one of the countries experiencing the fastest urbanization rates on the continent. Due to population growth, migration, and infrastructure development, cities in Imo State, such as Owerri, Orlu, and Okigwe, are expanding rapidly. Urbanization can improve housing and healthcare access, but it often occurs chaotically and poorly managed. This results in crowding in informal settlements, poor waste disposal, inadequate drainage, and other environmental conditions that favor mosquito breeding (Bhattarai et al., 2020; Agegnehu et al., 2018). These conditions promote ongoing malaria transmission even in urban areas.

There is also evidence that certain Anopheles species, usually found in rural regions, such as Anopheles arabiensis, are adapting to urban environments by using contaminated and artificial breeding sites (Awolola et al., 2002; Jones et al., 2012). Along with increased rural-urban migration and growing urban vectors like Anopheles stephensi, this ecological flexibility makes malaria management more challenging in urban settings (Samson et al., 2015).While Nigeria significantly contributes to the global malaria burden, there is a notable lack of awareness about malaria transmission in its cities, particularly in states like Imo. Most epidemiological research focuses on rural or peri-urban areas, leaving urban malaria patterns largely unknown and underexplored. Additionally, health inequities and inadequate infrastructure complicate the implementation of effective control measures in urban Nigeria (Utzinger et al., 2004).

Methodology

This was a cross-sectional, hospital-based study conducted in three urban LGAs of Imo State:

Owerri Municipal, Orlu, and Okigwe, representing the three senatorial districts of the state, between April and July 2024. Geographically, Imo falls wholly within the moist tropical forest belt with an average annual rainfall of approximately 2,000 mm, a temperature range of 22 °C to 30 °C, and vegetation that supports mosquito breeding and malaria transmission. Consecutive recruitment of 600 participants was made through outpatient clinics at Owerri Specialist Hospital, Orlu Teaching Hospital, Okigwe General Hospital, and Ivory Clinic, Okigwe. The target population included all age groups, and informed consent was sought before enrollment. Sample size was determined using the Lemeshow formula, assuming an 18.7% prevalence of malaria, 95% confidence level, and 5% margin of error. About 5 ml of venous blood was collected from each participant into EDTA tubes and stored at 2–8 °C. RDTs and microscopy were done using the CareStart™ Malaria Pf (HRP2) Ag test kit in accordance with manufacturer instructions. Thick and thin blood smears were prepared; thin films were fixed in methanol, while all slides were stained with 10% Giemsa for 10 minutes. All slides were examined microscopically under ×100 oil immersion, while parasite density was estimated using the following WHO formula: [(Number of parasites × 8,000) ÷ Number of leukocytes counted.] Two microscopists independently verified results, and a blinded senior technologist reviewed all positive slides and 10% of the negatives for quality control. Ethical approval was given by the Ethics Committee, Imo State University. Additional clearance was obtained from the Ministry of Health and management of hospitals where the survey was carried out. Participation was voluntary and confidential.

RESULTS

1. Demographic Characteristics of Participants

A total of **600 participants** were enrolled across the three urban zones of Imo State: Orlu, Okigwe, and Owerri. Females constituted **57.7%**, while males were **42.3%** (Table 1). The age distribution was skewed towards younger populations, with **11–30 years** comprising **56.9%** of the sample. Most respondents were **students (30.8%)**, followed by **farmers (22.3%)**, and **others (27.0%)** in miscellaneous occupations. Educational attainment was high: **50.8%** had tertiary education, and **25.7%** secondary. Marital status showed near parity between **married (38.7%)** and **unmarried (40.8%)**, while all participants identified as **Christians**.

Table 1. Demographic Characteristics of Study Participants (n = 600)

Variable	Category	Frequency	Percentage (%)

Variable	Category	Frequency	Percentage (%)
Sex	Male	254	42.3
	Female	346	57.7
Age (years)	0–10	36	6.0
	11–20	169	28.2
	21–30	172	28.7
	31–40	83	13.8
	41–50	52	8.7
	≥51	88	14.7
Occupation	Farmers	134	22.3
	Students	185	30.8
	Health Workers	50	8.3
	Civil Servants	69	11.5
	Others	162	27.0
Education	Primary	81	13.5
	Secondary	154	25.7
	Tertiary	305	50.8

Table 2. Overall Malaria Prevalence

The overall malaria prevalence by microscopy was **34.5% (207/600)**, with **no significant difference between males (33.9%) and females (35.0%)** ($p > 0.05$). Among the three urban zones, **Orlu** recorded the highest prevalence (**38.0%**), followed by **Owerri (35.5%)**, and **Okigwe (30.0%)** (Table 2). Despite these differences, regional variation was statistically insignificant ($p = 0.227$).

Table 2B. Malaria Prevalence by Zone and Sex

Zone	Males Infected (%)	Females Infected (%)	Total Infected (%)
Orlu	37.9	38.1	**38.0**
Owerri	37.5	34.2	**35.5**

Zone	Males Infected (%)	Females Infected (%)	Total Infected (%)
Okigwe	25.3	33.1	**30.0**
Total	33.9	35.0	**34.5**

Table 3. Community-Level Variation in the different zones

Marked community-level differences were observed within each zone.

- **Orlu** had hotspots like **Mgbee (50.0%)**, **Umuaka (50.0%)**, and **Umuna (46.7%)** (Table 3a).
- **Okigwe** showed lower rates, with **Amucha** as low as **22.7%** (Table 3b).
- **Owerri** communities such as **Ikeduru (45.5%)** and **Amawon (46.7%)** recorded high prevalence (Table 3c).

ANOVA confirmed significant differences among communities ($p < 0.05$), suggesting that local environmental and infrastructural conditions strongly influence malaria transmission.

Table: Malaria Prevalence (%) by Community and Zone

Zone	Community	Male (%)	Female (%)	Total (%)
Orlu	Orlu Town	40.0	33.3	36.0
	Njaba	33.3	37.5	35.7
	Nkwere	33.3	28.6	30.8
	Nwangele	33.3	37.5	35.7
	Ohaji Egbeme	40.0	50.0	44.4
	Umuna	53.8	41.2	46.7
	Okporo	33.3	33.3	33.3
	Mgbee	40.0	66.7	50.0
	Amaifeke	37.5	28.6	33.3
	Nkume	25.0	66.7	42.9
	Awo Idemmiri	25.0	66.7	42.9

Zone	Community	Male (%)	Female (%)	Total (%)
	Eziama	25.0	28.6	26.7
	Amaigbo	45.5	28.6	36.0
	Umuaka	33.3	66.7	50.0
	Subtotal (Orlu)	**37.9**	**38.1**	**38.0**
Okigwe	Eziachi	31.8	35.3	33.9
	Umuna-Okigwe	33.3	33.3	33.3
	Okigwe Town	20.0	31.6	26.5
	Ihube	23.1	31.6	28.1
	Eziama	22.2	35.3	30.8
	Amucha	12.5	28.6	22.7
	Subtotal (Okigwe)	**25.3**	**33.1**	**30.0**
Owerri	Umuguma	38.7	25.4	29.8
	Obinze	50.0	41.7	44.4
	Avu	33.3	44.4	38.9
	Ihiagwa	40.0	40.0	40.0
	Ikeduru	40.0	50.0	45.5
	Amakohia	28.6	40.0	33.3
	Amawon	42.9	50.0	46.7
	Umuoronjo	33.3	42.9	38.5
	Umuonyeche	25.0	40.0	33.3
	Subtotal (Owerri)	**37.5**	**34.2**	**35.5**

Age- and Sex-Specific Prevalence

Malaria prevalence exhibited a **U-shaped age pattern**, highest among children **0–10 years (52.8%)** and adults **≥51 years (37.5%)** (Table 4). Adolescents (11–20 years) had the lowest prevalence (**27.8%**). Gender variation was inconsistent across age groups: females were more affected in childhood and older adulthood, while males had slightly higher prevalence in adolescence

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Table 4. Malaria Prevalence by Age and Sex (n = 600)

Age (years)	Males Infected (%)	Females Infected (%)	Total (%)
0–10	50.0	54.5	**52.8**
11–20	35.1	24.1	**27.8**
21–30	27.7	35.2	**33.1**
31–40	30.0	41.9	**36.1**
41–50	37.5	50.0	**40.4**
≥51	33.9	43.8	**37.5**

Occupational and Educational Influences

Occupation-related variation was evident (Table 8).

- **Students** had the highest prevalence (**38–44%**), particularly in **Owerri (44.3%)** and **Orlu (38.7%)**.
- **Farmers** showed moderate infection levels (**29–33%**).
- **Civil servants and health workers** had relatively low prevalence, likely due to better housing and preventive awareness. No significant correlation was found between occupation and malaria ($p > 0.05$).

Educational level was inversely related to malaria prevalence (Table 9). Individuals with **no or primary education** recorded higher rates (**40–46%**) than those with **tertiary education (31–35%)**, indicating that **education may contribute to preventive behavior and health awareness**, though not statistically significant ($p > 0.05$).

Table 5. Malaria Prevalence (%) by Occupation and Education Level across Urban Zones of Imo State

Zone	Variable	Category	Male (%)	Female (%)	Total (%)
Orlu	**Occupation**	Farmers	33.3	—	33.3
		Students	42.9	35.0	38.7
		Health Workers	—	40.0	40.0

Zone	Variable	Category	Male (%)	Female (%)	Total (%)
		Civil Servants	—	50.0	50.0
		Others	36.7	32.0	34.5
	Education	No Education	40.0	50.0	40.0
		Primary	40.0	50.0	45.7
		Secondary	36.0	33.3	36.4
		Tertiary	37.5	33.3	35.3
Okigwe	**Occupation**	Farmers	31.3	33.3	32.6
		Students	23.1	40.0	33.3
		Health Workers	23.1	27.3	25.7
		Civil Servants	15.4	22.7	20.0
		Others	29.2	40.0	35.2
	Education	No Education	20.0	33.3	28.0
		Primary	20.0	37.5	30.8
		Secondary	26.3	27.5	27.1
		Tertiary	27.5	36.0	32.2
Owerri	**Occupation**	Farmers	36.8	25.6	29.3
		Students	43.5	44.7	44.3
		Civil Servants	42.1	—	42.1
		Others	26.3	29.4	28.3
	Education	No Education	—	60.0	60.0
		Primary	45.0	—	45.0
		Secondary	35.0	40.0	37.5
		Tertiary	35.0	30.0	31.5
Total	—	—	**33.9**	**35.0**	**34.5**

Diagnostic Method Comparison

Microscopy detected significantly more infections than RDTs across all zones ($p < 0.0001$).

In **Orlu**, microscopy found **38.0%**, while RDTs identified only **9.1%**.

In **Okigwe**, RDTs detected **11.9%**, microscopy **30.0%**.

In **Owerri**, RDTs found **14.9%**, microscopy **35.5%**.

Overall, microscopy was **three times more sensitive** than RDT, reinforcing its importance in surveillance and epidemiological research.

Table 6. Comparison of Diagnostic Methods by Zone

Zone	RDT (%)	Microscopy (%)	Combined (%)
Orlu	9.1	38.0	30.8
Okigwe	11.9	30.0	25.5
Owerri	14.9	35.5	30.3

Summary of Key Findings

Overall malaria prevalence: **34.5%**, with **no significant sex or regional differences**.

Children under 10 years and **elderly adults** bore the highest burden.

Microscopy remains the superior diagnostic method.

Educational attainment and **occupation** influence infection patterns.

Local community conditions are major determinants of malaria risk.

Discussion

The observed 34.5% malaria prevalence by microscopy emphasizes the ongoing burden of malaria in urban Imo State, Nigeria. Even if urbanization is sometimes linked to decreased malaria transmission because of better housing, drainage, and healthcare facilities, these results prove that malaria still exists in urban areas. The observed prevalence is somewhat less than the previously recorded 38.0% in Orlu and significantly less than the 53% reported among patients at the Federal Mohammed & Oda, 2024; Medical Centre, Owerri. These disparities emphasize spatial variation in malaria incidence within the state, influenced by ecological, infrastructural, and socioeconomic circumstances (Doumbe-Belisse et al., 2021; Hay et al., 2005).

Regional and Community-Level Variations

With 38.0%, Owerri had the highest prevalence; Ok igwe recorded the lowest at 30.0%. As recorded in the Otamiri River Basin of Uwalaka et al., 2020, Imo
State. Though somewhat lower, Owerri's popularity persists owing to infrastructure flaws, uncontrolled urban growth,
and inadequate garbage management. On the other hand,
Okigwe's somewhat reduced frequency points to fe wer vector environments; however, further ecological studies are required to confirm this. These results are consistent with those of other African cities including Addis Ababa, Brazzaville, and Douala, where malaria incidence fluctuates greatly within and across communities according Local environmental and infrastructural circumstances (Agegnehu et al., 2018; Trape et al., 1987; Jones et al., 2012).

Age- and sex-related trends

The prevalence showed a U-shape: while older persons (>51 years) also suffered a great burden, children between 0 and 10 had the highest prevalence (52.8%). (37.5%). Adolescents (11–20 years) reported the lowest prevalence at 27.8%. These results fit the increased sensitivity of children as a result of undeveloped immunity (Awosolu et al., 2021; WHO, 2020) and the slow fading of immunity. among older adults (Utzinger et al., 2004). The less prevalence among teenagers corresp onds with the slow gaining of partial immunity via repeated exposure, a trend noted in peri-urban Nigeria (Awosolu et al., 2021). Overall prevalence was roughly equal between men—
33.9% in males and 35.0% in women—confirming that sex was not a major predictor of infection, consistent with countrywide malaria profiles (Sever Malaria Obs

Density of parasites

With clustering between 2,001 and 4,000/μL, parasite density
analysis revealed just modest parasitaemia (1,000–7,000 parasites/μL) with
no occurrences surpassing 10,000/μL. This suggests continuous endemic
transmission instead of big epidemics. In peri-urban regions of southwestern Nigeria, where modest densities prevail, similar results have been noted (Awosolu et al., 2021). The lack of hyperparasitaemia might indicate early access to therapy preventing progression to severe cases among city inhabitants or partial immunity (Awolola et al., 2002). diagnostic imbalances
One notable result was
the difference in diagnosis between microscopy and fast diagnostic testing (RDTs). While RDTs reg

istered only 9.1–14.9%, microscopy found prevalence ranging from 30–38%. This difference shows that RDTs can significa ntly underestimate the malaria burden and underline s the great sensitivity of microscopy, especially for modest parasitaemia. Plasmodium falciparum HRP2 gene deletions, which are becoming more common in Nigeria (Ukaegbu et al., 2024), can account for false negatives. Statistical tests validated the technique of diagnosis. $p < 0.0001$ is the only important predictor of infection detection. These results support WHO's (2020) advice that microscopy ought to stay the golden standard for monitoring, RDTs can be utilized for quick case management.

socioeconomic causes

Malaria prevalence was much influenced by socioeconomic

situations. The most impacted population were stud ents, especially in Owerri (44.3%) and Orlu (38.7%), reflecting exposure from crowded school environments, inadequate housing, and poor compliance to preventative measures. Heal th professionals and civil servants demonstrated zon e-specific variations: in Orlu, high infection rates (50.0% and 40.0%) were found in female civil servants and health workers; in Among these, Okigwe had the lowest prevalence (20.0% and 25.7%), perhaps as a result of more access to preventive care. Farmers registered moderate prevalence over regions, consistent with occupational exposure in peri-urban locations.ervatory, 2024).

Education became a major factor: people without or with only a basic education had the highest infection rates—up to 60% among uneducated women in

Owerri. Prevalence, however, decreased gradually with more education. This is consistent with results showing that education improves timely treatment-seeking behavior, malaria knowledge, and preventative measures (Okeke et al., 2021; Bhattarai et al., 2020). Prevalence was unaffected by religious association as all participants were Christians. Though earlier research indicates religio n may indirectly influence preventative habits (Jone s et al., 2012), this homogeneity stopped evaluation of cultural or faith-

based variances in prevention strategies.

Comparative West African History

The results from Imo State fit urban malaria epidemiology all throughout West

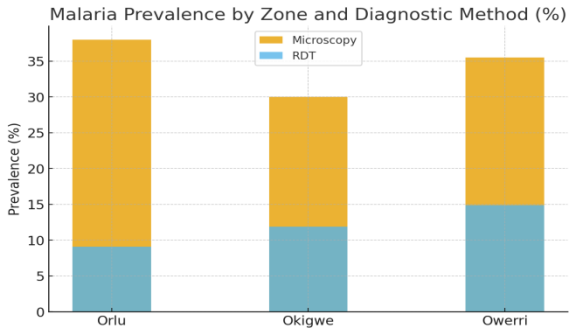
Africa. Prevalence in densely inhabited communities in Lagos, Nigeria, is estimated at about 30%, fueled by inadequate drainage and informal housing (Samson et al., 2015). Prevalence is around 20–25% in urban areas in Accra, Ghana, but is higher in peri-urban margins where sanitation is poor (Doumbe-Belisse et al., 2021). Prevalence in Douala, Cameroon, varies from 15% in

planned areas to above 40% in informal settlements (Jones et al., 2012). These parallels highlight how malaria is still a major urban health issue in Africa, with local ecological and socioeconomic circumstances driving transmission risk. Imo State follows this pattern: despite existing healthcare infrastructure, urbanization sans good planning keeps transmission alive.

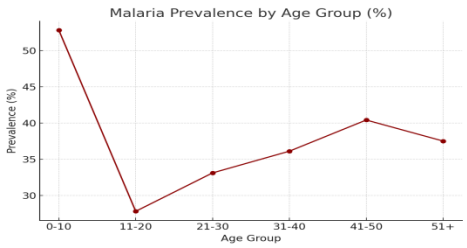
Control Consequences

Urban Imo Malaria Bad planning, stagnant water, subpar housing, and weak health education continue to be serious public health concerns fueled by state. Dealing with these issues calls for comprehensive approaches: environmental management, increased diagnostic coverage, consistent vector control, and community-based education initiatives. The introduction of the R21/Matrix-M malaria vaccine in Nigeria, significantly, provides a hopeful complement. Effective deployment in high-prevalence locations like Owerri and Orlu could significantly lower malaria-related morbidity (WHO/NIH, 2024).

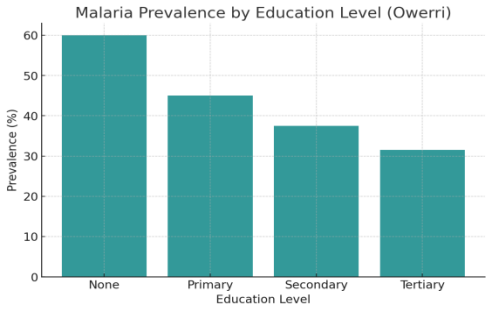
Ultimately, malaria prevalence in urban Imo State is still high, especially among youngsters, seniors, students, and people with little education. The prevalence of moderate parasitaemia implies established endemic transmission rather than major epidemics. Strengthening malaria control through integrated vector management, improved diagnostic strategies, focused health To lower the malaria burden in urban Nigeria and fit with bigger regional elimination targets, education and vaccine distribution are essential.



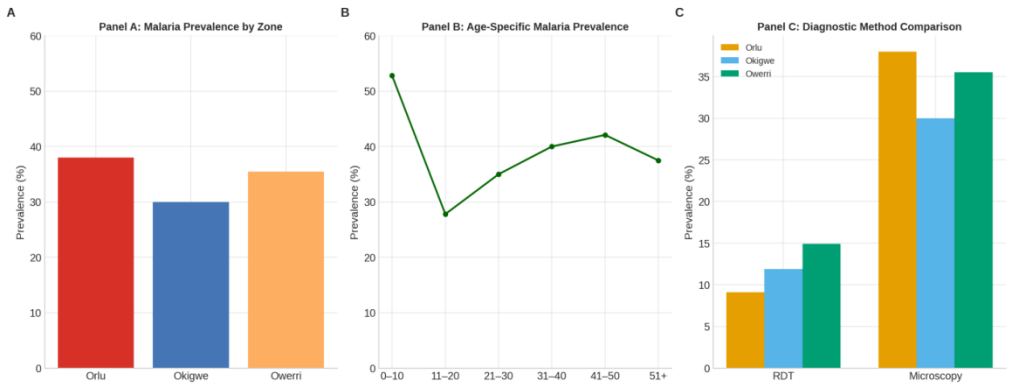
Malaria prevalence by zone and diagnostic method – showing microscopy consistently detecting more infections than RDTs.



Prevalence by age group – illustrating the U-shaped pattern, with highest burden in young children (0–10) and older adults (51+).



Prevalence by education level (Owerri example) – highlighting declining prevalence with increasing education.



combined multi-panel figure plate (A–C)

Panel A: Malaria prevalence by zone (microscopy), **Panel B**: Age-specific prevalence (U-shaped), **Panel C**: Diagnostic method comparison across zones

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