



Biotechnology-Assisted Malaria Surveillance and Environmental Risk Assessment Among Children in Kolokuma/Opokuma, Bayelsa State, Nigeria

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ABSTRACT

Malaria remains a major public health challenge among children in sub-Saharan Africa, particularly in rural communities with poor environmental sanitation and inadequate healthcare access. This study investigated malaria prevalence among children aged 0-9 years in Kolokuma/Opokuma Local Government Area (KOLGA), Bayelsa State, Nigeria, using biotechnology-assisted surveillance approaches. The study aimed to determine malaria prevalence, evaluate the effectiveness of biotechnology-assisted diagnostic tools, assess community knowledge and practices regarding malaria prevention, investigate environmental risk factors, and compare current findings with historical malaria records between 2012 and 2022. A descriptive cross-sectional design involving 400 respondents was adopted. Rapid Diagnostic Tests (RDTs), microscopy, structured questionnaires, and environmental assessments were utilized for data collection and analysis. Findings revealed average malaria prevalence rates of 58.6% and 58.25% using RDT and microscopy, respectively. Communities with poor environmental sanitation and low KAP scores consistently recorded higher malaria prevalence. Strong relationships were observed between malaria prevalence, environmental conditions, and community preventive practices. The study concludes that biotechnology-assisted diagnostics and integrated environmental surveillance systems remain essential for sustainable malaria control. The study recommends strengthened malaria surveillance systems, improved environmental sanitation, and intensified public health education campaigns.

Key words: Malaria, Biotechnology, Surveillance, RDT, Environmental Risk Assessment, KOLGA.

INTRODUCTION

Malaria remains one of the most serious infectious diseases affecting developing countries, particularly within sub-Saharan Africa where climatic and environmental conditions favor continuous mosquito breeding and transmission of Plasmodium parasites. According to the World Health Organization (WHO, 2023), malaria continues to contribute significantly to global morbidity and mortality, with Africa accounting for the highest disease burden worldwide. Nigeria remains among the countries with the greatest number of malaria cases and malaria-related deaths globally. Children remain one of the most vulnerable groups affected by malaria due to their developing immune systems and increased susceptibility to severe complications such as anemia, cerebral malaria, organ failure, developmental delays, and mortality (WHO, 2021). Repeated malaria episodes among children adversely affect cognitive development, school attendance, and general quality of life.

Environmental conditions within the Niger Delta region such as heavy rainfall, swampy terrain, poor drainage systems, stagnant water accumulation, and high humidity create suitable breeding conditions for Anopheles mosquitoes, thereby promoting persistent malaria transmission (Adebayo & Alabi, 2021). Kolokuma/Opokuma Local Government Area (KOLGA) in Bayelsa State is characterized by these environmental conditions and continues

to experience substantial malaria burden among children. Despite several intervention programs including insecticide-treated nets (ITNs), indoor residual spraying, public health campaigns, and antimalarial treatment programs, malaria prevalence remains high in many rural communities due to inadequate healthcare access, poor environmental sanitation, poverty, and inconsistent implementation of preventive measures (Olaniran et al., 2022).

Recent advancements in biotechnology have significantly improved malaria surveillance and disease monitoring through the use of Rapid Diagnostic Tests (RDTs), laboratory microscopy, environmental assessment tools, and epidemiological data analysis. These biotechnology-assisted approaches support rapid diagnosis, disease detection, surveillance efficiency, and targeted intervention strategies, particularly in resource-limited rural settings. Community-based surveillance systems integrating diagnostic biotechnology, environmental monitoring, and public health assessment have become increasingly important in malaria control programs. Such integrated approaches provide valuable epidemiological information necessary for disease management, policy development, and sustainable intervention planning.

Based on the study, the objectives were to determine malaria prevalence among children aged 0-9 years in KOLGA; evaluate the effectiveness of biotechnology-assisted diagnostic tools in malaria surveillance; assess community knowledge, attitudes, and practices regarding malaria prevention; investigate environmental factors associated with malaria prevalence; and compare current findings with historical malaria-positive records between 2012 and 2022.

MATERIALS AND METHODS

Study Area

The study was conducted in Kolokuma/Opokuma Local Government Area (KOLGA), Bayelsa State, Nigeria. The area is characterized by tropical rainforest vegetation, high humidity, swampy terrain, seasonal flooding, and numerous stagnant water bodies that support mosquito breeding.

Study Population

The study targeted children aged 0-9 years across twenty communities within KOLGA. The estimated population of children within this age bracket was 20,066.

Sample Size Determination

The Taro Yamane formula was used to determine the sample size:

$$n = N / 1 + N(e)^2$$

Where:

n = sample size

N = population size

e = margin of error (0.05)

Substituting the values:

$$n = 20,066 / 1 + 20,066(0.05)^2$$

$$n = 392.41$$

The calculated value was approximated to 400 respondents.

Materials used during the study included Rapid Diagnostic Test (RDT) kits, light microscopes, sterile lancets, gloves, blood sample slides, structured questionnaires, environmental assessment checklists, and statistical analysis templates.

Data Collection Procedure

Blood samples were collected using sterile lancets for malaria testing. Rapid Diagnostic Tests (RDTs) were used for preliminary detection of malaria antigens, while microscopy examination was used for laboratory confirmation. Structured questionnaires were administered to caregivers and parents to assess community knowledge, attitudes, and practices regarding malaria prevention and control. Environmental assessments were also conducted to evaluate stagnant water presence, sanitation conditions, and utilization of insecticide-treated nets.

Statistical Analysis

Data obtained from the study were analyzed using descriptive statistics including percentages, mean prevalence rates, standard deviation, and Pearson correlation analysis. Statistical significance was considered at $p < 0.05$.

RESULTS AND DISCUSSION

Table 1: Malaria Prevalence Across Selected Communities

Community	RDT Positive (%)	Microscopy Positive (%)
Akaranbiri	61	59
Ayakoroama	60	58
Olobiri	60	58
Orubiri	60	58
Sampou	50	48

Source: Field Survey, 2025

The study revealed high malaria prevalence across the selected communities with average prevalence rates of 58.6% and 58.25% using RDT and microscopy respectively. Akaranbiri recorded the highest prevalence, while Sampou recorded the lowest prevalence. The high malaria prevalence observed in this study confirms that malaria remains highly endemic within KOLGA. The findings may be associated with favorable environmental conditions supporting mosquito breeding, inadequate healthcare access, and poor implementation of preventive measures. The findings agree with Okorie et al. (2020), who reported high malaria prevalence among children in rural Nigerian communities. However, the prevalence observed in this study was higher than the findings of Smith and Harris (2021), who reported lower malaria prevalence among children in urban communities.

Diagnostic Performance of RDT and Microscopy

Table 2: Diagnostic Comparison Between RDT and Microscopy

Diagnostic Method	Average Positive Rate (%)
RDT	58.6
Microscopy	58.25

Source: Field Survey, 2025

Rapid Diagnostic Tests (RDTs) and microscopy demonstrated similar prevalence outcomes across the study communities. The minimal difference observed between both diagnostic methods indicates strong diagnostic agreement and reliability. The findings demonstrate the effectiveness of biotechnology-assisted diagnostic tools in malaria surveillance and disease monitoring. These findings support Olaniran et al. (2022), who reported improved surveillance efficiency through biotechnology-assisted malaria diagnostics in rural healthcare settings.

KAP Assessment Findings

Table 3: KAP Scores and Malaria Prevalence

Community	KAP Score (%)	Malaria Prevalence (%)
Ayakoroama	80	30
Sampou	80	32
Orubiri	50	65
Akaranbiri	52	61

Source: Field Survey, 2026

The KAP assessment revealed significant variations in community knowledge, attitudes, and practices regarding malaria prevention. Communities with higher KAP scores generally recorded lower malaria prevalence. Ayakoroama and Sampou recorded the highest KAP scores and comparatively lower malaria prevalence. The findings indicate that improved community awareness and preventive practices significantly contribute to malaria reduction. Communities with better understanding of malaria prevention demonstrated improved environmental sanitation practices and increased utilization of insecticide-treated nets. These findings agree with Chukwu and Afolabi (2017), who reported that improved community awareness significantly enhances malaria prevention outcomes.

Environmental Assessment Findings

Table 4: Environmental Conditions and Malaria Prevalence

Community	Environmental Score (%)	Malaria Prevalence (%)
Ayakoroama	78	30
Sampou	76	32
Orubiri	40	65
Akaranbiri	52	61

Environmental assessment revealed substantial presence of stagnant water bodies, poor drainage systems, and inconsistent environmental sanitation practices across several communities. Communities with poor environmental conditions consistently recorded higher malaria prevalence. A strong negative correlation ($r = -0.97$) was observed between environmental sanitation and malaria prevalence. The findings support reports by Adebayo and Alabi (2021), who emphasized the role of environmental sanitation in malaria control within rural communities.

Historical Trend Analysis (2012-2022)

Table 5: Historical Malaria Trend Across KOLGA

Year	Estimated Malaria Positive Cases
2012	420
2014	523
2016	721
2018	765
2020	930

Source: Field Survey, 2025

Historical records obtained from clinics, hospitals, and chemist shops revealed persistent malaria burden throughout the ten-year review period. Although slight fluctuations and periodic reductions were observed in some communities, malaria prevalence remained consistently high across KOLGA. Communities previously identified as high-risk areas also recorded high prevalence during the current study. The persistence of malaria burden over the ten-year period suggests that existing intervention measures have not achieved complete disease control within the study area.

CONCLUSION AND RECOMMENDATIONS

The study demonstrated that malaria remains highly prevalent among children aged 0-9 years within Kolokuma/Opokuma Local Government Area. Biotechnology-assisted surveillance approaches involving Rapid Diagnostic Tests, microscopy, KAP assessments, environmental monitoring, and historical healthcare record analysis proved effective in evaluating malaria prevalence and transition dynamics findings established strong relationships between malaria prevalence, environmental conditions, and community preventive practices. Communities with poor sanitation, stagnant water accumulation, and lower KAP scores consistently exhibited higher malaria prevalence.

RECOMMENDATIONS

1. Rural healthcare facilities should strengthen biotechnology-assisted malaria surveillance systems using Rapid Diagnostic Tests and microscopy.
2. Public health education campaigns should be intensified to improve community knowledge and preventive practices regarding malaria control.
3. Environmental sanitation programs focusing on stagnant water elimination and drainage improvement should be strengthened.
4. Government agencies should improve access to insecticide-treated nets and malaria preventive resources across rural communities.
5. Collaborative intervention programs involving healthcare institutions, biotechnology agencies, and community stakeholders should be strengthened to improve malaria monitoring and disease control.

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