Prevalence of Malaria among Children under Five Years in the Niger Delta Region of Nigeria

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Authors' contributions

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ABSTRACT

Background: Malaria still remains an overwhelming cause of morbidity and mortality among children under five years of age, especially in sub-Saharan Africa. The aim of this study was to determine the prevalence of *Plasmodium* parasitemia among children below 5 years of age in Akwa-Ibom, Delta and Rivers States, located in the Niger Delta region of Nigeria.

Methodology: A cross sectional study of 2630 children, selected by multistage sampling from Akwa-Ibom, Delta and Rivers States of Nigeria between April and June 2019. Parasitological diagnosis was by *Plasmodium falciparum* histidine-rich protein 2-based malaria rapid diagnostic test (RDT) and microscopy of giemsa-stained blood smears. Demographic information was collected using soft copies of pretested interviewer-administered questionnaires via the Open Data Kit application installed on android phones. Data analysis was performed using the statistical software SPSS version 25. Frequency, percentages, and Chi-square test were used to interpret data at a confidence interval of 95% and a p-value less than 0.05 was regarded as statistically significant.

Results: A total of 2630 children less than 5 years old were included in the study, 1016 from Akwa-Ibom and 807 each from Delta and Rivers states respectively. Malaria parasitaemia was detected in 230 (8.6%) and 198 (7.4%) children by RDT and microscopy, respectively. RDT used in this survey has high diagnostic accuracy (98.8%) compared to microscopy.

Conclusion: The study shows a decline in the prevalence of malaria in children under 5 years. It also demonstrates the reliability of the RDTs in the diagnosis of malaria. The use of RDTs is thus further recommended especially in peripheral centers where the access to skilled microscopists and laboratory infrastructure may be lacking.

1. INTRODUCTION

Malaria is a life-threatening, acute febrile parasitic disease transmitted by the bite of an infected female Anopheles mosquito [1]. The most implicated species causing human infections in sub-Saharan Africa is *Plasmodium falciparum* [2]. Children below five years of age and pregnant women are particularly vulnerable to the severe forms of the disease. Despite global efforts, it remains an overwhelming cause of morbidity and mortality among children under five years, especially in sub-Saharan Africa [1]. The World Health Organization 2020 World Malaria report estimates the global incidence of malaria in 2019 as 229 million with Nigeria contributing 27% of this figure [3]. Globally, malaria caused about 409 000 deaths in 2019, 67% of which were children under 5 years [3]. Among these countries with malaria deaths, Nigeria's mortality rate was the highest (23%) [3]. The Nigeria Demographic and Health Survey of 2018 reported the prevalence of malaria in children below 5 years as 23% [4]. Within the Niger Delta, Rivers State had a prevalence of 8.2% and Akwa Ibom State was 29% [4].

Malaria is endemic in Nigeria and the ecology of the Niger Delta region supports all-year transmission [5]. It remains among the commonest reasons for admission into the children's emergency ward [6-7]. Even with how high the incidence of malaria is in Nigeria, there is still the potential to miss cases of severe malaria based on clinical signs and symptoms alone [8]. Efforts to reduce the morbidity and mortality of malaria starts with an accurate diagnosis of the condition. Therefore, the World Health Organization recommends that a parasitological confirmation of malaria be made before treatment is commenced, unless the resources are unavailable or the turnaround time for the test exceeds 2 hours [9-10]. Cases with a negative test result may then be reassessed for other causes of fever [10].

Microscopy is one of the oldest means of making a laboratory diagnosis of malaria [11]. With microscopy, it is possible to detect all species of *Plasmodium,* as well as determine the parasite load. The World Health Organization's (WHO) recommendation is for both thick and thin blood films to be stained with the alcohol-based Romanowsky, Giemsa [12]. A thick blood film is performed to determine the presence or absence of the malaria parasite and allows for parasite quantification, while a thin blood film allows *Plasmodium* species identification. However, the accuracy of this method relies heavily on the skill of the microscopist. It is an extremely sensitive

method when performed by skilled professionals and is still the gold-standard for malaria diagnosis [13]. Microscopy also allows for the measurement of response to treatment, identification of the presence of gametocytes and has low concurrent costs once the infrastructure is available [10].

Rapid diagnostic tests (RDTs) are immunochromatographic assays with monoclonal antibodies targeted at specific *Plasmodium* antigens such as the histidine-rich protein 2 (HRP2), *Plasmodium* lactate dehydrogenase (pLDH) and aldolase. Its non-reliance on technical expertise, laboratory infrastructure and electricity make it suitable for use in resource-poor settings [13]. Some of these RDTs are specific for *P. falciparum* and target the PfHRP2 antigen, others are pan-sensitive to PfHRP2, pLDH and aldolase thereby enabling *P. falciparum* infection to be distinguished from mixed parasite infections [13]. However, the use PfHRP2-based tests is limited by its inability to differentiate between current and past infections due to the persistence of the PfHRP2 antigen for several weeks after treatment [10]. Also, with reports of PfHRP2 deletions, some infections may be missed if PfHRP2 RDTs are used solely in diagnosis of malaria.

Although other tools such as PCR, microarrays, loop-mediated isothermal amplification (LAMP), nucleic acid sequence–based amplification (NASBA) are available for malaria diagnosis, they are mostly employed for research purposes.

The purpose of this study was to determine the prevalence of *Plasmodium* parasitaemia among children below 5 years of age in three states of the Niger Delta region of Nigeria using both microscopy and RDT.

2. METHODS

2.1 Study Design

A descriptive, cross-sectional study.

2.2 Study Population and Sample

A minimum sample size of 1,848 children under five was calculated using Cochran formula, based on a prevalence of 19% from the 2015 Nigeria Malaria Indicator Survey [14], degree of precision of 0.02 and a 20 percent markup to take care of non-response. Participants were recruited using a multistage sampling technique.

Stage 1: three states in the Niger Delta were selected by simple random sampling. Stage 2: stratified sampling was employed in the selection of two (2) local government areas (LGAs) from the three (3) major senatorial zones in each state, making a total of six LGAs per state. Stage 3: Cluster sampling for facility selection was performed using computer-generated random numbers to select two (2) facilities in each of the smaller senatorial zones and four (4) facilities in the largest senatorial zone of each of the states. The sample size was then distributed proportionately according to the patient load of each facility. All children who presented to the facility for any health-related matter, and whose parent(s) gave informed consent in writing, were included in the study. Data was collected over a period of two weeks in each local government area.

2.3 Data Collection

Trained research assistants and microscopists were employed for data collection, phlebotomy, and laboratory procedures. Soft copies of pre-tested interviewer-administered questionnaires were used to collect demographic information from the parents/caregivers via the Open Data Kit (ODK), an open-source data collection android app installed on android phones.

2.4 Malaria Diagnosis

Diagnosis was made using rapid diagnostic tests and microscopy. One milliliter of venous blood was collected from each participant. A rapid diagnostic test was carried out immediately using the Histidine rich protein 2-based SD Bioline Malaria Ag Pf test kit (Standard Diagnostics Inc., USA) according to the manufacturers' instructions. A pair each, of both thick and thin blood smears were made on glass slides and stained using 3% Giemsa stain. Each of these were read by two independent microscopists blinded to the results of the other. A patient was said to be positive if either RDT or microscopy demonstrated the presence of malaria parasites.

2.5 Data Analysis

Data analysis was performed using the statistical software SPSS version 25. Frequency, percentages, and the Chi-square test were used to interpret data. A confidence interval of 95% was used and a p-value less than 0.05 was regarded as statistically significant. Decisional

analyses were made with sensitivity, specificity, positive and negative predictive values using two-by-two tables with microscopy as the gold standard for diagnosis.

3. RESULTS

A total of two thousand, six hundred and thirty (2630) children between 0 and 59 months of age were included in the study; one thousand and sixteen (1016) in Akwa-Ibom state and eight hundred and seven (807) each in Delta and Rivers states respectively.

Their age and gender distribution are displayed in Table 1 below.

The distribution of positive tests by microscopy and RDT in the entire sample population is shown in the figure below.

4. DISCUSSION

In all three states sampled, most of the subjects were below two (2) years of age. Since recruitment was performed within health facilities, the demography is in keeping with studies that demonstrate a higher number of visits to the clinics and children's emergency wards in younger children [6]. It could also reflect a greater health seeking behavior of caregivers of younger children.

Table 1. Age and gender distribution of children by state

	Akwa Ibom (n =1016), %	Delta (n = 807), %	Rivers (n = 807), %	Total
Age				
< 2 years	820 (80.7)	605 (75.0)	623 (77.2)	2048
>2 < 5 years	196 (19.3)	202 (25.0)	184 (22.8)	582
Gender				
Male	515 (50.7)	434 (53.8)	435 (53.9)	1384
Female	501 (49.3)	373 (46.2)	372 (46.1)	1246

Table 2. Distribution of RDT and Microscopy results by state

Results		Akwa Ibom (n =1016), %	Delta (n = 807), %	Rivers (n = 807),%	Total (n=2630), %
RDT	Positive	90 (8.9)	109 (13.5)	31 (3.8)	230 (8.6)
	Negative	926 (91.1)	698 (86.5)	776 (96.2)	2400 (89.6)
Microscopy	Positive	55 (5.4)	67 (8.3)	76 (9.4)	198 (7.4)
	Negative	961 (94.6)	740 (91.7)	731 (90.6)	2432 (90.8)

Overall, more malaria infections were detected by RDT when compared to microscopy, however there was no significant difference (chi-square = 2.60, p = 0.106)
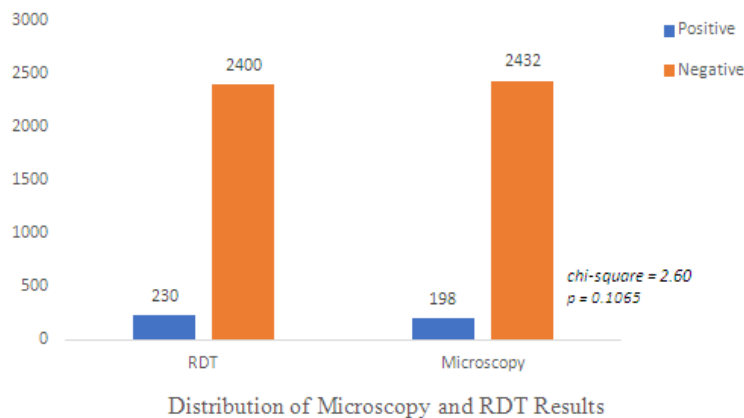

Distribution of Microscopy and RDT Results

Fig. 1. Distribution of microscopy and RDT results
There was no significant difference in the distribution of positive tests by microscopy and RDT among the sample population (chi-square = 2.60, p = 0.106)

Table 3. Comparison of diagnostic accuracy of mRDT compared to microscopy

Test (RDT)	Disease (Microscopy)		
	Yes	**No**	**Total**
Yes	198 (a)	32 (b)	230 (a+b)
No	0 (c)	2400 (d)	2400 (c+d)
Total	198 (a+c)	2432 (b+d)	2630 (a+b+c+d)
Sensitivity		a/(a + c)	100.0%
Specificity		d/(b + d)	98.7%
Positive predictive value		a/(a + b)	86.1%
Negative predictive value		d/(c + d)	100.0%
Prevalence of the disease		(a+b)/(a+b+c+d)	8.7%
Accuracy* (extent of correct classification)		(a + d)/(a + b + c + d)	98.8%

An analysis of the diagnostic accuracy of the RDT test compared to microscopy showed that RDT used in this survey has high diagnostic accuracy (98.8%) compared to microscopy

The percentage of children who tested positive by either RDT or microscopy was below 15% in all the states sampled. Previous local studies have reported higher values such as 81.9% in a 2012 study by Oladeinde et al in Edo State [15], 63.3% in a 2015 study in Bayelsa State [16], 66.3% in Cross Rivers [17] and 63% in a 2019 study in Ekiti State [18]. These studies all used microscopy for parasite detection. Microscopy, although considered as the gold standard for malaria diagnosis, is heavily reliant on the expertise of the microscopist. A Tanzanian study compared the results of routine microscopy for malaria diagnosis to expert microscopy and reported 53.1% of slides positive by health facility routine microscopy but only 2.1% positive by expert microscopy [19]. This difference is quite significant. A Nigerian study that described a rigorous methodology involving confirmation by three independent microscopists who had all received a thorough training prior to their study, reported a prevalence of 16.9% in children under 5 years [20]. Also, the Nigeria Malaria Indicator Survey (NMIS), which was a household study, reported prevalence of 19% in the South-South region [14]. Both studies are likely to reflect the true prevalence rates based on the thorough description of their methods and processes. The slightly lower prevalence rates of 5.4%, 8.3% and 9.4 % in Akwa Ibom, Delta and Rivers States respectively in the current study reflect a downward trend in malaria infections in Nigeria which is consistent with global reports [3]. This trend is as a result of continued support for malaria preventive interventions including specific diagnosis and treatment [3,21].

To support the progress being made in malaria control, efforts to increase health seeking behaviors of caregivers need to be emphasized. Adekanmbi et al. reported an average of only 2.2% of sick children were taken to a health facility during their illness [22], allowing for missed opportunities for making a possible diagnosis of malaria and appropriate treatment administration. Caregivers are more likely to explore various treatment options prior to hospital presentation than reporting to a health facility at the onset of illness. Antimalarial medications are available over-the-counter in Nigeria and studies have reported that caregivers are more likely to seek for help from drug vendors and pharmacies rather than hospitals in cases of suspected malaria [23]. In other instances, treatment of malaria in children is still performed based on clinical suspicion, rather than accurate laboratory evidence of parasitaemia [20]. More so, response to therapy is seldomly verified. Thereby, antimalarial and antibiotic misuse and abuse is most likely, in the absence of parasitological diagnosis. The World Health Organization strongly recommends a parasitological diagnosis before the administration of antimalarials [24].

Both microscopy and RDTs achieve parasitological diagnosis. In this study, there was no statistically significant difference between the findings of microscopy and RDT. Malaria RDTs reported comparable sensitivity and specificity to microscopy in several other studies especially in areas endemic for *P. falciparum* [10,25-26]. Thus, for its ease of use, minimal training/ skill requirement and cost-effectiveness, the use of RDTs for diagnosis is strongly recommended at the communities and other settings where microscopic diagnosis is not feasible, if the provider is able to demonstrate the minimum competence required [24].

5. CONCLUSION

The prevalence of malaria in under-five children in the Niger delta of Nigeria, is decreasing. This

study provides useful local data for the Niger Delta and is in line with the third pillar of the World Health Organization's Global Technical Strategy for Malaria, which advocates for increased efforts in malaria surveillance. The usefulness and reliability of RDT kits for malaria diagnosis in the absence of expert microscopy is also re-enforced.

6. LIMITATION OF THE STUDY

A limitation of this study is its cross-sectional design which takes a snapshot of the population at once and does not consider seasonal variations, if present.

CONSENT

As per international standard, parental written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

Ethical approval for this study was obtained from the respective ethical boards of the states and facilities (UPTH/ADM/90/S. II/VOL.XI/676; UUTH/AD/S/96/Vol. XXI/227).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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