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Plasmodium Parasitaemia among Pregnant Women in the Niger Delta Region of Nigeria

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Abstract

Introduction: Malaria is a febrile illness caused by the *Plasmodium* species. The mangrove swamp forest vegetation and high annual rainfall characteristic of the Niger Delta region of Nigeria encourage all year round transmission of malaria. This study aimed to determine the prevalence and speciation of *Plasmodium* parasitaemia among pregnant women in the Niger Delta region of Nigeria. **Methodology:** Cross-sectional study carried out in three states of the Niger Delta region; Akwa-Ibom, Delta and Rivers between April and June 2019. Study Sites were chosen by stratified random sampling. Demographic information was collected using pretested interviewer-administered questionnaires via the Open Data Kit application on android mobile phones. Diagnosis was by rapid diagnostic test (RDT) and Microscopy. Ethical approval and informed consent were obtained. Data was analyzed using the SPSS v25 software. Chi-square statistic and Fischer's exact test were used to compare data, all at a 95% confidence interval and significance level of 0.05. **Results:** Two thousand, eight hundred and twenty (2820) pregnant women were studied; 948,

992 and 880 from Akwa-Ibom, Delta and Rivers respectively. Overall prevalence of parasitaemia using RDT and Microscopy was 6.8% and 6.7% respectively. All except 1% of malaria was attributed to falciparum species. The other species were plasmodium ovale and plasmodium malariae. **Conclusion:** The prevalence of *Plasmodium* parasitaemia among pregnant women in the Niger Delta region of Nigeria has reduced considerably, giving credence to the malaria preventive strategies applied in antenatal care. When properly stored and used as recommended, malaria RDTs compare favorably with microscopy; therefore, no case of malaria should be missed due to a facility's incapability to carry out microscopic diagnosis.

Keywords

Malaria Parasitaemia, Pregnant Women, Malaria RDT, Microscopy

1. Background

Malaria is a febrile illness caused by the protozoan parasites of the genus *Plasmodium* which until recently was classified into five species: *P. falciparum*, *P. ovale*, *P. malariae*, *P. vivax* and *knowlesi*; however, current studies [1] have shown that there are two non-recombining species of *ovale* (*ovale curtisi* and *ovale wallikeri*) which are non-sympatric in nature [2]. Of all these, *Plasmodium falciparum* is the most common species in virtually all parts of Africa, accounting for up to 98% of confirmed cases in Nigeria. It is the agent of the most malignant form of malaria, usually presenting with greater morbidity and mortality, mostly among children and pregnant women [3]. *P. malariae* tends to occur as a mixed infection with *P. falciparum* [4].

Malaria is essentially a disease of the tropics and subtropics particularly the sub-Saharan African region although it has been reported in temperate areas due to migration from the tropics. It is holo-endemic in Nigeria where there is a year-round transmission. Malaria transmission is the highest in Nigeria during the rainy season which usually spans April to September, with the peak of rains between May and July. Rainfall pattern in Nigeria varies largely, with the South having more rains than the North. Annual rainfall decreases northward; rainfall ranges from about 2000 millimeters in the coastal zone (averaging more than 3550 millimeters in the Niger Delta) to 500 - 750 millimeters in the north. The far south is defined by its tropical rainforest climate, where annual rainfall is 1524 to 2032 mm (60 to 80 inches) per year. The Niger Delta is located on the Atlantic coast of Southern Nigeria encompassing an area of 20,000 km^2 and is the world's third largest wetland. The mangrove swamp forest vegetation here encourages all year-round transmission of malaria. Malaria prevalence in Nigeria thus varies widely, ranging from 14% in the South East Zone to 37% in the North West Zone [5].

Malaria remains a major public health challenge for developing countries. Nigeria bears the major portion of this burden as she accounts for 25% of the glob-

al malaria burden. Approximately 173 million (97%) of Nigeria's population is at risk of malaria [6] with greater than half a million new cases recorded in 2017 [7]. Nigeria was one of three (3) countries which had the highest estimated increases in malaria burden in 2017 compared with 2016 [7]. This is worrisome as the Nigeria Malaria Indicator Survey of 2015, had reported a decline in malaria prevalence from 42% in 2010 to 27% in 2015 [8].

The bulk (94%) of all malaria deaths in 2018 occurred in the WHO African Region with pregnant women and children bearing the greatest impact. Children aged under 5 years are the most vulnerable group and accounted for 67% (272,000) of all malaria deaths globally. The West African sub-region where Nigeria is located was one of two sub-regions in Africa with the highest prevalence (35%) of exposure to malaria infection in pregnancy. Pregnant women in this region had the highest prevalence of low-birth-weight children (872,000, 16%) due to malaria in pregnancy [7].

Among the many possible complications of malaria in pregnancy, the most critical are maternal anaemia and delivery of low-birth-weight babies with the associated complications [3]. Beyond financial implications, the indirect costs of malaria cannot be quantified including the long-term effect on cognitive function and educational attainment in children [9] [10]. This situation is worsened by the scourge of multi-drug resistance resulting from improper diagnosis, self-medication, and improper treatment, including use of sub-optimal and incomplete doses of antimalarials.

Light microscopic examination of Giemsa-stained blood films has been recommended by WHO for use in diagnosis of malaria where adequate support for its use is available. Light microscopy however is quite limited in Nigeria especially in rural, hard to reach or poorer settings, as well as where trained personnel are not available. Rapid diagnostic tests on the other hand, are lateral flow devices designed based on antigen-antibody interactions for the qualitative diagnosis of malaria parasite antigens in blood. The target antigens for which RDTs have been designed include the histidine rich protein 2 (HRP2) expressed by *Plasmodium falciparum* and/or *Plasmodium* lactate dehydrogenase (pLDH) expressed by all human *Plasmodium* species [11].

This study aimed to determine the prevalence of *Plasmodium* parasitaemia among pregnant women in three states of the Niger Delta region of Nigeria, the distribution of the *Plasmodium* species causing infection and determine the diagnostic efficacy of RDT compared with microscopy.

2. Materials and Methods

This was a cross-sectional study carried out among pregnant women in three states of the Niger Delta region of Nigeria, Akwa-Ibom, Delta, and Rivers states between April and June 2019. Eligible participants were those who were attending antenatal care at public or private health facilities in the state.

A sample size of 758 per state was calculated using the sample size formula for single proportion with 27% prevalence rate of malaria from the 2015 Nigeria

Malaria indicator survey [8], a degree of accuracy of 0.05% and 95% confidence interval, 20% non-response rate and a multiplication factor of two (2) to compensate for design effect. Stratified sampling was employed to select two local government areas (LGA) each from the three senatorial zones, making a total of six local governments. Computer generated table of random numbers was used to select two heath facilities from two zones and four from the largest zone to get eight health facilities. The sample size was then distributed across these facilities in a proportionate manner based on average antenatal clinic attendance. Systematic sampling was used to select pregnant women from each of the selected health facilities based on sampling interval calculated by dividing the average antenatal attendance by the allocated sample size per facility. Data collection spanned two weeks. Research assistants, data collectors and microscopists were trained on the study protocol for standardization of data collection and laboratory processes. Information was collected using pretested interviewer administered questionnaires using a mobile data collection tool, the Open Data Kit (ODK) on android devices

One millilitre of venous blood was collected from each woman. A rapid diagnostic test was immediately performed using the SD Bioline Malaria Ag P.f Kit (Standard Diagnostics Inc., USA) according to manufacturers' instruction and thereafter, two thin and thick blood smears were made on two clean glass slides per woman. Smears were stained using freshly prepared 3% Giemsa stain and examined for the *Plasmodium* species, stage, and density according to World Health Organization's recommendations. Each one of a participant's blood films was read by two independent microscopists. Each microscopist attached to a specimen was blind to the result of the other microscopist. A patient was reported as positive if either one or both tests were interpreted as positive. All patients with infection were managed according to standard of care. Ethical approval was obtained from the ethical boards of the states and facilities and informed consent was obtained from participants before each interview.

Data was presented using summary statistics (frequency and percentages) and analyzed using the SPSS version 25 software. The Chi-square statistic and Fischer's exact test were used for inferential analysis. Decisional analysis using a two-by-two table was done with sensitivity, specificity, positive and negative predictive values, and test accuracy, using microscopy as the gold standard. All analyses were done at a 95% confidence interval and a significance level of 0.05.

3. Results

A total of two thousand, eight hundred and twenty (2820) pregnant women were studied; nine hundred and forty-eight (948) from Akwa-Ibom state, nine hundred and ninety-two (992) from Delta state and eight hundred and eighty (880) from Rivers state.

3.1. Sociodemographics

Study participant's sociodemographic information is shown on **Table 1**. Across

Table 1. Socio-demographic characteristics of study participants.

	Akwa Ibom (n = 948), %	Delta (n = 992), %	Rivers (n = 880), %	Total (n = 2820) %
Age groups				
19 - 29 years	551 (58.12)	486 (48.99)	372 (42.27)	1409 (50.0)
30 - 39 years	384 (40.51)	472 (47.58)	483 (54.89)	1339 (47.4)
40 - 49 years	13 (1.37)	34 (3.43)	25 (2.84)	72 (2.6)
Marital status				
Married	891 (93.99)	954 (96.17)	860 (97.73)	2705 (95.9)
Divorced	1 (0.11)	2 (0.20)	1 (0.11)	4 (0.14)
Single	54 (5.70)	35(3.53)	17 (1.93)	106 (3.8)
Widowed	2 (0.21)	1 (0.10)	2 (0.23)	5 (0.18)
Education				
No formal education	3 (0.32)	4 (0.40)	0 (0.0)	7 (0.25)
Primary	42 (4.43)	43 (4.33)	3 (0.34)	88 (3.1)
Secondary	459 (48.42)	484 (48.79)	293 (33.30)	1236 (43.8)
Tertiary	444 (46.84)	461 (46.47)	584 (66.36)	1489 (52.8)
Occupation				
Civil servant	80 (8.44)	40 (4.03)	80 (9.09)	200 (7.1)
Farmer	12 (1.27)	9 (0.91)	8 (0.91)	29 (1.0)
Public servant	71 (7.49)	49 (4.94)	72 (8.18)	192 (6.8)
Self-employed	228 (24.05)	185 (18.65)	159 (18.07)	572 (20.3)
Teacher	111 (11.71)	109 (10.99)	117 (13.30)	337 (12.0)
Trader	321 (33.86)	432 (43.55)	252 (28.64)	1005 (35.6)
Others	125 (13.19)	168 (16.94)	192 (21.82)	485 (17.2)

the three states, half of the study population was aged 19 - 29 years (1409; 50.0%), had tertiary education 1489 (52.8) and were either traders 1005 (35.6) or self-employed 572 (20.3).

3.2. Prevalence of Plasmodium Parasitaemia

The detection rate of *Plasmodium* parasitaemia by RDT and Microscopy is shown in Figure 1.

A total of 191 persons (6.8%) tested positive for malaria using RDT compared with 188 (6.7%) who tested positive using microscopy Figure 1.

The highest prevalence of malaria using RDT was found in Akwa-Ibom (8.3%) state while the lowest prevalence was from Delta state (5.6%). Microscopy revealed the highest prevalence of malaria from Rivers State (8.4%) while Akwa-Ibom had the lowest prevalence (3.5%).

3.3. Distribution of Malaria Parasite Species

Figure 2 shows that majority (99%) of infected women had *P. falciparum*

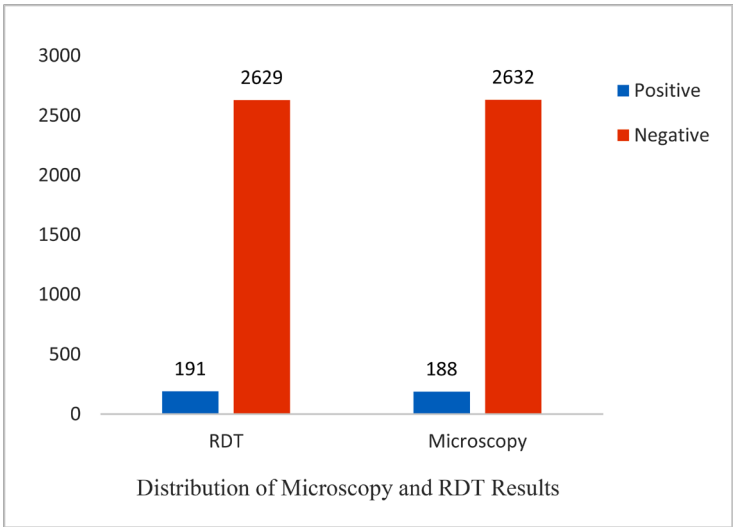

Figure 1. Distribution of microscopy and RDT results.

Table 2. State-based distribution of diagnostic outcome.

Results		Akwa Ibom n = 948, (%)	Delta n = 992, (%)	Rivers n = 880, (%)	Total n = 2820, (%)
RDT	Positive	79 (8.3)	56 (5.6)	56 (6.4)	191 (6.8)
	Negative	869 (91.7)	936 (94.4)	824 (93.6)	2629 (93.2)
Microscopy	Positive	33 (3.5)	81 (8.2)	74 (8.4)	188 (6.7)
	Negative	915 (96.5)	911 (91.8)	806 (91.6)	2632 (93.3)

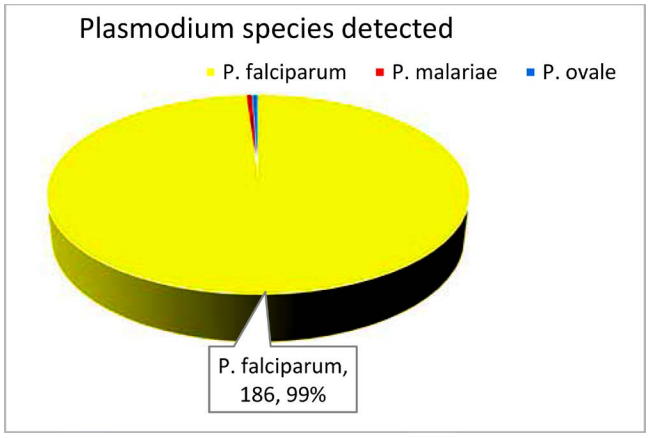

Figure 2. Distribution of *Plasmodium* species detected.

Table 3. Distribution of Species detected in the different States.

Specie	Akwa Ibom	Delta	Rivers	Fischer's Exact
P. falciparum	32 (96.9)	81 (100.0)	73 (98.7)	
P. malariae	1 (3.1)	0 (0.0)	0 (0.0)	6.26 (p = 0.1.80)
P. ovale	0 (0.0)	0 (0.0)	1 (1.35)	
Total	**33 (100.0)**	**81 (100.0)**	**74 (100.0)**	

Table 4. Comparison of diagnostic accuracy of mRDT compared to Microscopy.

Test (RDT)	Disease (Microscopy)		Total
	Yes	No	
Yes	188 (a)	3 (b)	191 (a + b)
No	0 (c)	2629 (d)	2629 (c + d)
Total	188 (a + c)	2632 (b + d)	2820 (a + b + c + d)
Sensitivity		a/(a + c)	100.0%
Specificity		d/(b + d)	99.9%
Positive predictive value		a/(a + b)	94.8%
Negative predictive value		d/(c + d)	100.0%
Prevalence of the disease		(a + b)/(a + b + c + d)	6.8%
Accuracy* (extent of correct classification)		(a + d)/(a + b + c + d)	99.9%

parasitaemia while Table 3 shows the species distribution according to states.

3.4. Diagnostic Accuracy

An analysis of the diagnostic accuracy of the RDT test compared to microscopy showed that RDT used in this survey has high diagnostic accuracy (99%) compared to microscopy Table 4.

4. Discussion

The Demographics show that many women in the Niger Delta region get married at earlier ages though well educated. This is important because enlightenment and education of individuals are proven means of primary prevention of infectious diseases including malaria [12].

The prevalence of *Plasmodium* parasitaemia observed in the pregnant women we studied is much lower than that of other studies done previously in Rivers State and other states in the Niger Delta region of Nigeria. Which reported much higher prevalence in years past [12] [13] [14] [15]. This is very exciting as it reveals a downward trend in prevalence, an indication of the success of the malaria prevention strategies implemented among pregnant women; including intermittent preventive treatment of malaria in pregnancy (IPTp) administered during antenatal care and use of insecticide-treated bed nets as recommended by WHO and the Nigeria Malaria Elimination Program. Despite the increased prevalence observed between 2016 and 2017 in the WHO African Region, case incidence levels were reported to have declined from 294 in 2010 to 229 in 2018, representing a 22% reduction [7]. The implication is that we have obviously made remarkable progress towards the WHO Global technical strategy for malaria 2016-2030 that among other targets aims to reduce malaria case incidence by at least 90% by the year 2030. Pregnant women are an important group to focus on in this regard.

Plasmodium falciparum is the most prevalent malaria parasite in the WHO

African Region, having accounted for 99.7% of estimated malaria cases in 2018. Our study also reflects the same, with *P. falciparum* accounting for 99% of all infections in our study cohort [7].

The ease of use of RDTs and high diagnostic accuracy in comparison with Light microscopy has made their development a major contributor to malaria control globally. RDTs unlike microscopic diagnosis are quite easy to perform, do not require complex equipment, electricity supply and highly skilled personnel while providing rapid and reliable results as has been reported severally [16] [17].

Our findings also agree with reports of their comparability when used in diagnosis of acute malaria with only 0.1% difference in detection observed between both methods; RDT being higher. This difference could possibly be due to false positive result with the RDT since RDTs have been known to remain positive for a time frame of about 10 - 14 days following successful treatment of malaria. Dalrymple *et al.* showed that half of RDTs that detect the antigen histidine-rich protein II (HRP2) as was done in our study, are still positive 15 days post-treatment, with about 5% remaining positive 36 days following anti-malarial treatment [18]. An important limitation of RDTs includes not being able to detect some infections with lower parasite density as their sensitivity reduces with reducing parasite density [19] [20] [11]. Microscopy is able to overcome this as well as detect less common species such as *P. ovale and P. malariae* which RDTs may not, as seen in our study.

These findings imply that malaria prevalence in the Niger Delta is on the decline and the goal for of malaria elimination is in sight. However concerted efforts in prevention and prompt diagnosis and treatment are imperative to push the elimination efforts to its destination. In addition, RDTs were shown to be quite useful for case detection implying that its use is quite advantageous in resource limited settings and should be implemented as point of care testing at every health care service delivery setting in the country.

The strengths of this study are that it employed a large sample size across three states representing the Niger Delta region of Nigeria, and that it used both RDT and microscopy to diagnose malaria cases. The limitation of the study is its cross-sectional design and as such treatment and pregnancy outcomes were beyond the scope of the study. However cross section studies have been showed to be adequate for prevalence studies.

5. Conclusion

The prevalence of *Plasmodium* parasitaemia among pregnant women in the Niger Delta region of Nigeria has reduced considerably. This gives credence to the malaria preventive strategies applied in pregnancy. We therefore encourage the promotion of these measures as they have shown effectiveness. When properly stored and used as recommended, RDTs compare favorably with microscopy in diagnosis of malaria; therefore, no case of malaria should go undiagnosed

due to a facility's incapability to carry out microscopic diagnosis.

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Authors' Contributions

This work was carried out in collaboration among all authors. Author CAN wrote the protocol. Authors IMS, CIA, ARN, FON, OKO and CAN managed the research design, processes and co-ordination. Author OIL wrote the drafts of the manuscript and managed the literature searches. Author OM performed the statistical analysis. All authors read and approved the drafts and final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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