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Asymptomatic malaria infection impact on maternal anemia in Delta State, Nigeria

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Abstract

Background and Purpose: Pregnant women are vulnerable due to the pregnancy-induced suppressed immunity in malaria-endemic areas. Asymptomatic malaria in pregnancy (MiP) threatens both the mother, fetus, and neonate via chronic placental malaria which impacts maternal-neonatal exchange. Some studies reported that MiP risk factors vary across locations, however, there are few studies on MiP and maternal anemia in Nigeria. The purpose of this study was to investigate the association between asymptomatic placental malaria infection and maternal anemia among parturients in Asaba, Delta State, Nigeria.

Method: This study was developed with a quantitative methodology that utilized primary and secondary healthcare data from 483 subjects aged 18–49 years from four healthcare facilities between May and July 2021. The Socio-Ecological Model (SEM) framework was used to explain how parturients can achieve improved pregnancy outcome via the mobilization of multi-levels supports to enhance the compliance of parturients to malaria interventions. The research question and hypothesis were tested with the binomial logistic regression test.

Result: The findings showed a statistically significant association between placental malaria parasitemia by microscopy (PMPM), intermittent preventive treatment in pregnancy with sulfadoxine-pyrimethamine, use of complementary and alternative medicine (CAM), and maternal anemia in the study population. Also, the study revealed that positive PMPM, use of CAM, insecticides treated net (ITN) ownership, ITN frequent use, and antenatal care (ANC) attendance were the risk factors of maternal anemia among the study population.

Conclusion: The findings of this study could inform malaria control policymaking in Asaba and Delta State on tracking and treating asymptomatic placenta malaria among underserved parturient accessing antenatal services.

Keywords: *malaria, Plasmodium, peripheral malaria, placenta malaria, parasite-resistance, pregnancy, pregnancy outcome, maternal anemia,* and *mosquito*

Introdution

Malaria accounts for the highest mortality compared to all other infectious diseases pooled at the global and sub-Saharan Africa (SSA) regional levels. The greatest burden of this vector-borne disease is in the SSA, with Nigeria bearing a 25% burden and ranking highest/first in central Africa bearing 50% of the global burden (Center for Disease Control and Prevention [CDC], 2020; World Health Organization [WHO], 2020).

There is documented evidence in the current literature of the negative impact of MiP. MiP is a public health concern that is impacting huge economic and human resources at various levels of society (WHO, 2020). The United Nation International Children's Emergency Fund (UNICEF) stated that malaria is an urgent public health concern, and all stakeholders should concentrate efforts for the elimination (reduction of the incidence rate of a disease to zero levels in a defined geographical location via thoughtful interventions) and eradication (permanent reduction of the incidence of a particular disease to zero levels at global level via calculated efforts and subsequent interventions are not required) of the disease globally (UNICEF, 2020; WHO, 2016).

Background

Malaria is a significant public health concern in Nigeria; 97% of Nigerians are at risk of this disease, with substantial morbidity and mortality statistics across various age groups (Yaya et al., 2018; WHO, 2020). Malaria impacts parturients and their neonate with complications and mortality. Malaria accounts for a substantial burden on health facilities, depletion of household income, low labor productivity, and national gross domestic product (GDP; WHO, 2019). The implications of asymptomatic malaria among parturients in deterring control efforts and maintaining the parasite cycle have widespread reports (Aguzie, 2018; Bardaji et al., 2017; Omer et al., 2017). Reports have associated pregnant women with the parasite's reservoir and delaying the extermination of the disease (Aguzie, 2018; Camona-Fonseca & Arango, 2017).

Research indicates that malaria induced-anemia accounts for an estimated 10,000 maternal death in Africa each year (WHO, 2020). The infection of the placental by *P. falciparum* impacts maternal and neonatal exchange patterns causing miscarriages, premature births, imparted foetal growth, development, and death (CDC, 2020).

The WHO via the global technical group set a new goal on malaria eradication for 2030. The goal is aimed at reducing malaria by 90% via its elimination in 35 countries globally (WHO, 2016).

The Socioecological Model (SEM).

This study was premised on the SEM which explains that personal health behavior is determined by multilevel factors, including personal level (e.g., age, sex at birth), interpersonal level (e.g., family, community), and system level (e.g., local, state, and national government levels, civil society, NGOs, such as roll back malaria initiative, president malaria initiative, malaria elimination and control group) (Awuah et al., 2018; Kumar et al., 2012). These factors impact a person's decision to engage the health system (Revenson et al., 1991). Wright, (2016) stated that positive social support can strengthen health behavioral change.

The goal in this study was to examine how the intersection of these factors is associated with PMPM and maternal anaemia, specifically, the usage of the malaria interventions recommended by the ANC. Awuah et al. (2018) stated that low socioeconomic status (SES) is strongly associated with using an alternative treatment for malaria (Aikins, 2005; Chuma et al., 2010). Therefore, building on the premise of Awuah and colleagues, it is possible that multilevel factors, such as economic status, gravidae, age, (individual level), social support, use of CAM, (interpersonal level), health insurance, PMPM, ANC attendance, and place of residence (system level), affect PMPM and maternal anaemia.

Although there is evidence on maternal malaria parasitaemia in SSA, no study has determined the association between PMPM, intermittent preventive treatment in pregnancy with sulfadoxine-pyrimethamine (IPTp-SP) compliance, use of CAM with maternal anaemia in Nigeria using primary and hospital routine data across three healthcare facility levels (primary, secondary, and private). This study was used to ascertain some risk factors of placental malaria in the study location and the parturients most at risk based on IPTp-SP compliance, use of CAM, gravidae, ITN ownership, ITN frequent use, and educational attainments.

Purpose of the Study.

The purpose of this study was to investigate the association between PMPM, IPTp-SP compliance, the use of CAM, and maternal anemia among asymptomatic pregnant women presenting for delivery. We used quantitative methodology in a cross-sectional study design with deidentified survey questionnaires and secondary data collected from four healthcare facilities in Asaba, Delta State, southern Nigeria. The goal for this study was to extend research in the field by generating evidence on the impact of asymptomatic placenta malaria on maternal anemia among parturients in the target population.

The Research Question.

RQ: What is the association between PMPM (independent variable 1 [IV_1]), IPTp-SP compliance (independent variable 2 [IV_2]), the use of CAM (independent variable 3 [IV_3]), and maternal anemia (dependent variable [DV]) among pregnant women in Asaba, Delta State, Nigeria.?

H_0: There is no association between PMPM (IV_1), IPTp-SP compliance (IV_2), the use of CAM (IV_3), and maternal anemia (DV) among pregnant women in Asaba, Delta State, Nigeria.

H_1: There is an association between PMPM (IV_1), IPTp-SP compliance (IV_2), the use of CAM (IV_3), and maternal anemia (DV) among pregnant women in Asaba, Delta State, Nigeria.

Materials and Method.

The binomial logistic regression analysis was used to analyse the generated data. The survey questions generated nominal data that were analysed quantitatively. Besides, the SEM theoretical framework was used in this study and was well aligned with the variables outlined in the research question. The hospital data (healthcare facility-based data) were collected via collaboration with the hospital administration as a partner organization. The data collection instrument was a paper-based questionnaire answered by the literate subjects or administered by the researchers in a face-to-face approach to the subjects who are not literate. This approach could have mitigated missing data and errors. The validation with hospital records of subjects were carried out to enhance the study validity.

Research Design and Rationale.

This cross-sectional study design was structured within a quantitative methodology to test the research question. Primary, secondary, and private healthcare facilities were randomly selected from the existing healthcare facilities in Asaba, the capital of Delta State for this study. The aim was to extend research in the field by generating evidence on the disease burden and the significant risk factors of PMPM among asymptomatic pregnant women in the target population.

Study Population and Location.

Delta State is an oil, commerce, and agriculturally relevant State in Nigeria. It is in the south-south geopolitical zone with a human population of 4,112,445 (males: 2,069,309; females: 2,043,136) and according to the National Population Commission & National Bureau of Statistics. (n. d), it was projected to 5,663,362 (males: 2,888,315, females: 2,775,047) in 2016. Asaba is the capital city and is in the northern part of Delta State. Delta State covers a landmass of 18,000 km (6,970 square miles), with about 60% land. It is bounded in the north and west by Edo States and in the east by Anambra, Imo, and River States, while on the southern part is the Bight of Benin encompassing 160km coastline. Delta State is low lying and void of hills (National Population Commission & National Bureau of Statistics, n. d). Asaba is the administrative capital of Delta State and is composed of people of different cultural and socioeconomic backgrounds from within and outside Nigeria. It is located at the northern end of the state and has an estimated population of 150,032 (2006 census) and is projected to 181,571 in 2012 at a growth rate of 3% (National Population Commission, n. d).

Sampling Approaches (Sample Size and Power Calculation).

Power analysis and the Slovin formular sample size calculators were used to determine the suitable sample size required to detect an anticipated effect. Conducting a power analysis prior to a research study enhances the probability of obtaining a valid, reliable, and accurate statistically significant result (Rudestam & Newton, 2014). The sample size was determined using the G*Power3 software to calculate the minimum sample size based on a medium effect size of 0.3, α of 0.05, power of 0.80 and degree of freedom (df) of five (the df is a function of the number of column and rows of the DVs and IVs). The output gave a total sample size of 143 for the study. The Slovin formula (used to calculate sample size necessary to achieve a certain confidence interval when sampling a population with limited information about the population 's behavior) was used to determine the required sample size as well. The Slovin formular gives researchers the desired accuracy when working with a population that is too large to be sampled in a study (Cochran, 1977). The target population for this study was made up of parturients between the ages of 18–49 years, and who reside in Asaba, Oshimili South local government area, Delta State, Nigeria. The estimated female population in Asaba, Oshimili South local government for 2020 was projected at a 3% growth rate as 110,171 of which 26,441 were females of reproductive age (24% of female population) and the population of parturients was 1,322 (5% of reproductive-age women; National Population Commission, n. d). The figures above were used with a margin error value of 0.05 and N as 1,322 (with Slovin's formula: $n = N/ (1+[N\{e\}^2])$ to arrive at an adequate sample size for this study of 307. So, adjusting for a 10% response rate gave a sample size of 338.

The inclusion criteria: The inclusion criteria involved asymptomatic pregnant women attending ANC and presenting for delivery in the four randomly selected healthcare facilities for the study. Every patient that qualifies as a subject, and who has consented to participate in the study with an auxiliary temperature of ≤ 37.5^{o}C, absence of fever, chills, and headache in the last 24 hours were recruited for this study.

The exclusion criteria: The exclusion criteria were that any pregnant woman who does not want to participate, or did not sign the informed consent, ill or admitted to the intensive care unit or nonpregnant women and parturient does not reside in the study area. Parturients younger than 18 years or older than 49 years were not recruited.

The Data Collection.

This study instrument was a survey questionnaire with validation using the hospital records. The questionnaire was worded in a low-grade English language to enhance subjects' understanding irrespective of their socioeconomic status (SES) and educational attainments. The use of low-grade English language to word the questionnaire was necessary because the ANC subjects have mixed socioeconomic status and educational attainments. The consistency of the questionnaire was maintained via a pretesting/pilot testing on 20 subjects, who were in their third trimester and attending ANC in a different healthcare facility (not selected for this study) in the study location (Asaba). The consent form was distributed and subsequently the survey administered to qualified (based on inclusion and exclusion criteria) and consented subjects.

While at delivery, a laboratory test for PMP by RDT and microscopy was carried out by the health facility laboratory scientists for all qualified and consented subjects as part of their routine care at no costs to the subjects. Each subject laboratory specimen was labelled with their assigned unique code/ID and hospital case file number on the subject's questionnaire. The laboratory analysis was validated by a second senior technician/parasitologist, the outcome of the laboratory test was recorded in the subject's hospital file and the test outcome was communicated to the subjects by the hospital management. The data were validated, de-identified, and analyzed statistically.

Statistical Analysis and Test.

The data was analysed using the Statistical Package for Social Sciences (SPSS) version 25. The data was sorted and checked before computer data entry. The outcome and predictor variables were binary and categorical variables. We produced an initial descriptive statistic in tables and charts with percentages to describe the frequency distribution of the sociodemographic variables/characteristics of the independent variables. Descriptive statistics were carried out to explain the study population in relation to relevant variables. The RQ was analyzed by binomial logistic regression. The *P*-value determined at 0.05 was the basis for the acceptance or rejection of the null hypothesis. (Frankfort –Nachmias & Nachmias, 2008).

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Table 1

The Variables, Response Code and Measurement Type used in This Study.

Variable	Response Code	Measurement
Dependent/outcome		
Maternal anemia		Dichotomous/Nominal
AA	0	
AP	1	
Independent/Predictor		
PMP by RDT		Dichotomous/Nominal
Negative PMP by RDT	0	
Positive PMP by RDT	1	
PMPM		Dichotomous/Nominal
Negative PMPM	0	
Positive PMPM	1	
IPTp-SP compliance		Dichotomous/Nominal
Adequate	0	
Inadequate	1	
Use of CAM		Dichotomous/Nominal
No	0	
Yes	1	
Risk variables		
ITNs ownership		Dichotomous/Nominal
No	0	
Yes	1	

ITNs use		Dichotomous/Nominal
No	0	
Yes	1	
Gravidae		Ordinal/Nominal
Primigravidae	1	
Secundigravidae	2	
Multigravida	3	
Age group (years).		Ordinal/Nominal
18–25	1	
26–34	2	
35–42	3	
43–49	4	
Educational attainment		Ordinal/Nominal
None	0	
Primary	1	
Secondary	2	
Tertiary	3	

Evidence for Reliability and Validity of Instruments.

Reliability refers to the function of a test to produce a consistent/same result, when used to measure the same thing, at different times, while validity measures what it proposes to measure. The use of probability sampling and sampling formula in this study ensured standardized effect size and representativeness. Besides, the questionnaire items were carefully worded to avoid misleading, intimidating, or double-barred questions (Frankfort–Nachmias & Nachmias, 2015; Rudestam & Newton, 2014). Moreover, the pilot test and adjustment of the questionnaire based on the outcome enhanced the reliability and validity of the study.

Mitigating Threat to Internal and External Validity.

The chosen design of the study incorporated some methodological strengths, however, some threats to validity exist in this study. The self-reported nature of some variables may have introduced recall bias, which may lead to inaccurate data provided by the participants. Social desirability may have affected the accuracy of reporting of the sociodemographic, and use of CAM especially due to the lack of anonymity in the data collection approach. However, the subjects were informed in the consent form that the information they gave will not be used against them now or later and nobody will refer to it against them personally.

Ethical Consideration.

Approval from the institutional review board (IRB) from Walden University, the Delta State Ministry of Health, and the data sites were secured. And the subject's confidentiality requirement was maintained as only the de-identified data were analyzed and published.

The consents form indicated that a participant was at liberty to exit the study at any point during the study. The process to leave the study was simply by informing the researcher. Any subject who wishes to withdraw from the study was not swayed, coaxed, or pressured to continue.

Informed Consent.

The subjects were given complete information about the study at individual levels. The formal consent in writing or thumb printed before the administration of the questionnaire were secured. We provided each subject with standardized introductory information about the study as contained in the consent form and questionnaire, after which the subjects were expected to either give or not give consent. The information, which was provided in the low-grade English language for the understanding of the subjects, included research purpose, the source of organizational and monetary support for the study, and the estimated duration (10 minutes) in filling the questionnaire.

After delivery of the baby and placenta, 2 mL of blood was taken from the placenta by the healthcare laboratory scientist for RDT and microscopy analysis to determine the maternal malaria parasitemia status. Also, the hospital record of subjects for maternal anemia test analysis was recorded in each subject's questionnaire.

Result.

The statistical analysis findings were organized by the research question. The pilot test was done on 20 subjects in another health care facility in Asaba that was not listed for the study. The focus of the pilot testing was to establish baseline understanding of the survey questions among the parturients. The result of the pilot test did not impact the data collection procedure.

Data preparation and analysis.

The data were carefully entered into the Excel spread sheet version 2013 and checked for error and missing values and corrected via validation with the hospital records. A total of 496 data were collected from the 500 questionnaires that were distributed. But after sieving out missing and incomplete data, we had 483 data points fit for the analysis. The response rate for this study was 99.2%.

Preliminary analysis.

In this phase, some of the variables were recoded as proposed, and new variables were computed such as with the packed cell volume (PCV) values, which were converted to the haemoglobin (Hb) values by dividing by three (Abbott Point of Care Inc., 2016; Koperska, 2018), and thereafter recoded as anemia absent (AA) meaning no anemia, and anemia present (AP) meaning the presence of mild, moderate, and severe anemia. The IPTp-SP compliance variable was recoded into 0 as adequate and 1 as inadequate from the four compliance levels of zero, once, twice, and more than twice with the inadequate group comprising of the zero, once, and twice while the adequate group is made up of more than twice compliance. According to Aguzie, (2018), the WHO recommended four or more doses before delivery in the malaria high burden region. So, in the preliminary analysis phase, tests of parametric assumptions were performed to determine if there were violations of the logistic regression and if so, what other alternative analyses should be conducted.

Primary Analysis.

In the primary analysis phase, the statistical tests that answered the research question of the study was performed. Also, the descriptive statistics performed on the variables revealed no data errors. Preliminary analyses to evaluate the assumptions of the logistic regression was conducted. The assumptions of the logistic regression are linearity (for continuous variables), multicollinearity, and absence of high correlation among the IVs (Pallant, 2016; Tabachnick & Fidell, 2012). There was no violation in the assumption of linearity because the IVs were all binary and categorical variables. The outcome of the correlation analysis among the IVs showed that there was no high correlation among the IVs as the values were below the threshold of plus/minus 0.70/0.80 as shown in Tables 2 and 3 below. The result of the collinearity diagnostics in Table 4, showed that the VIF values are below the threshold of 10. They are less than five, which is best. This implies that the IVs are not highly correlated with each other and there is no violation of the multicollinearity assumption as well.

Table 2.

The Result of the Correlation Analysis to Access the Correlation among the Binary Independent Variables

Pearson Correlation			PMPM	IPTp-SP	CAM use	ITN s ownership	ITNs use
	PMPM	Correlation coefficient	1.000	0.042	0.015	-0.055	0.031
		P-value	-	0.362	0.744	0.228	0.491
		N	483	483	483	483	483
	IPTp-SP	Correlation coefficient	0.042	1.000	0.031	0.030	0.097*
		P-value	0.362	-	0.503	0.509	0.032
		N	483	483	483	483	483
	CAM use	Correlation coefficient	0.015	0.031	1.000	-0.054	0.008
		P-value	0.744	0.503	-	0.235	0.860
		N	483	483	483	483	483
	ITN s ownership	Correlation coefficient	-0.055	0.030	0.054	1.000	0.475**
		P-value	0.228	0.509	0.235	-	0.000
		N	483	483	483	483	483
	ITNs use	Correlation coefficient	0.031	0.097*	0.008	0.475**	1.000
		P-value	0.491	0.032	0.860	0.000	-
		N	483	483	483	483	483

Note: Perfect correlation denoted with plus/minus 0.70/0.80

**Correlation is significant at the 0.01 level (*P*-value).

*Correlation is significant at the 0.05 level (*P*-value)

This table shows that the correlation among the binary independent/predictor variables used in this study were within the acceptable threshold.

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Table 3. *The Result of the Correlation Analysis to Access the Correlation among the Categorical Independent Variables.*

Spearman's Rho	Correlations					
			Age group	Educational attainment	Gravidae	ANC attendance
	Age group	Correlation coefficient	1.000	0.175**	0.400**	0.051
		P-value	-	0.000	0.000	0.264
		N	483	483	483	483
	Educational attainment	Correlation coefficient	0.175**	1.000	0.105*	0.061
		P-value	0.000	-	0.021	0.180
		N	483	483	483	483
	Gravidae	Correlation coefficient	0.400**	0.105*	1.000	0.062
		P-value	0.000	0.021	-	0.173
		N	483	483	483	483
	ANC attendance	Correlation coefficient	0.051	0.061	0.062	1.000
		P-value	0.264	0.180	0.173	-
		N	483	483	483	483

Note: Perfect correlation denoted with plus/minus 0.70/0.80

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed)

This table shows the correlation among the categorical independent/predictor variables used in this study were within the acceptable threshold.

Table 4. *The Result of the Tolerance and VIF*

IVs	Tolerance	VIF
PMPM	0.991	1.009
IPTp-SP compliance	0.988	1.012
Use of CAM	0.995	1.005
ITNs ownership	0.766	1.305
ITNs frequent usage	0.764	1.309

The Descriptive and the Analytic Statistics of the Findings.

The descriptive statistics explains the details of the demographic/sociodemographic, placental malaria parasitaemia/obstetrics, and the malaria intervention variables. The details are presented in Tables 5, 6, and 7, respectively. The minimum and maximum age of the subjects that participated in this study were 18 years and 48 years, respectively with a mean age of 28.09 years and standard deviation (SD) of 5.472. About twenty-six percent (25.9%) were between the ages of 18–25 years. Sixty percent of the subjects were between the ages of 26–34 years, 12.8% were between the ages of 35–42 years, and 1.2% were between the ages of 43–49 years. Less than two percent (1.9%) had no form of formal education, 2.1% had a primary education, 44.9% had a secondary education, and 51.1% had a tertiary education. Of all the subjects, 57.6% owned ITNs but only 26.3% reported sleeping under it frequently. While 44.3% obtained it from the ANC, 10.1% purchased it. Furthermore, 77.0% of the study population had attended the ANC more than twice before delivery. The descriptive statistics on gravidae are 20.1% (n = 97), 34.4% (n = 166), and 45.5% (n = 220) for primigravidae, secundigravidae, and multigravida, respectively. The descriptive statistics on the use of CAM showed that 17.6% of the subjects in this study use CAM during this pregnancy. Also, only 15.3% had three or more doses of the IPTp-SP. The mean value of haemoglobin (in g/dL) was 11.02 and the SD value of haemoglobin (in g/dL) was 0.911. The univariate analysis of major variables in this study using frequency table were presented below in Tables 5, 6, and 7.

Table 5. *The Descriptive Statistics of the Age and Educational attainment Variables of Subjects in this Study.*

Variable	Frequency (N)	Percentage (%)
Age group (years)		
18–25	125	25.9
26–34	290	60.0
35–42	62	12.8
43–49	6	1.2
Educational attainment		
None	9	1.9
Primary	10	2.1
Secondary	217	44.9
Tertiary	247	51.1

Table 6. *The Descriptive Statistics of the Placental Malaria Parasitemia and the Obstetrics Variables in this Study.*

Variable	Frequency (N)	Percentage (%)
Maternal anemia		
Anemia absents (AA)	282	58.4
Anemia present (AP)	201	41.6
PMP by RDT		
Negative PMP by RDT	454	94.0
Positive PMP by RDT	29	6.0
PMPM		
Negative PMPM	218	45.1
Positive PMPM	265	54.9
Gravidae		
Primigravidae	97	20.1
Secundigravidae	166	34.4
Multigravida	220	45.5

Table 7.

The Descriptive Statistics of the Malaria Intervention Variables and use of CAM in this Study.

Variable	Frequency (N)	Percentage (%)
IPTp-SP compliance		
Adequate	74	15.3
Inadequate	409	84.7
CAM		
No	398	82.4
Yes	85	17.6
ITN ownership		
No	205	47.4
Yes	278	57.6
ITN frequent use		
No	356	73.7
Yes	127	26.3

The Prevalence of Placental Malaria and maternal anemia in this Study.

The prevalence of placental malaria by microscopy and RDT in this study was 54.9% and 6.0% respectively. The prevalence of PMPM was highest among the secundigravida (60.8%), followed by the primigravida (53.6%) and lowest among the multigravida (50.9%) in this study population. Maternal anemia was 41.6%, with 28.6% having mild anemia and 13.3% having moderate anemia; there were no cases of severe anemia in this study. Moreover, only *P. falciparum* specie were identified in this study. There were 49.9% of mild (+) parasitaemia cases, while only 5.0% were moderate (+ +) by microscopy. The mild cases were also positive by the RDT. There was no severe (+ + +), and hyper (> + + +) parasitaemia malaria cases in this study. The vast difference in prevalence between microscopy (49.9%) and RDT (6.0%) was attributed to the high false-negative by RDT testing techniques.

The prevalence of placental malaria and maternal anemia across the three healthcare facilities in this study.

The prevalence of placental malaria by microscopy in the primary, secondary, and private healthcare facilities were 44.3%, 33%, and 64.5%, respectively. The prevalence of maternal anemia across the primary, secondary, and private healthcare facilities was 60.0%, 63.1%, and 30.6% respectively. These statistics are presented in Table 8 below.

Table 8.

The Prevalence of Placental Malaria and Maternal Anemia across the three Healthcare Facilities Levels in this Study.

Health facility level	PMPM	Anemia
Primary facility	44.3	60.0
Secondary (Government) facility	33	63.1
Private facility	64.5	30.6

Logistic Regression Analysis in Relation to the RQ.

The result of the logistic regression analysis to determine the association between PMPM (IV_1), IPTp-SP compliance (IV_2), the use of CAM (IV_3), and maternal anemia (DV) among pregnant women in the study population showed a statistically significant effect on maternal anemia based on the *P*-value in the model indicated in Table 10; χ 2 (3) = 14.562, *P* = *0*.002. The model explained 4.0% (Negelkerke's R^2) of the variances in maternal anemia and correctly classified 58.4% of cases. The performance of the PMPM was statistically significant (odd ratio of 0.584, CI: 0.403–0.847, *P* = 0.005). The subjects with positive PMPM were 0.584 times as likely (58.4% more likely) to exhibit maternal anemia than the subjects with negative PMPM. Also, the use of CAM (odd ratio = 1.631, CI: 1.014–2.625, *P* = 0.044) was associated with an increase in the likelihood of exhibiting maternal anemia in this model. However, the IPTp-SP compliance variable was not statistically significant (odd ratio = 1.426, CI: 0.842–2.415, *P* = *0*.186). The Hosmer-Lemeshow test was not significant with a *P*-value of 0.640, implying that the model has a good fit.

Subsequent on the above, I rejected the null hypotheses which state that there is no association between PMPM (IV_1), IPTp-SP compliance (IV_2), the use of CAM (IV_3), and maternal anemia (DV) among pregnant women in Asaba, Delta State, Nigeria and accepted the alternate hypotheses which state that there is an association between PMPM (IV_1), IPTp-SP compliance (IV_2), the use of CAM (IV_3), and maternal anemia (DV) among pregnant women in Asaba, Delta State, Nigeria in respect to the RQ.

Table 9.

The Omnibus Test of Model Coefficients for the Analysis.

Step 1		Chi-square	Df	*P*-value
	Step	14.562	3	0.002
	Block	14.562	3	0.002
	Model	14.562	3	0.002

Note: This table shows the statistical significance of the model explored in the RQ.

Table 10.

The Variables in the Equation for the Analysis.

B	S.E	Wald	Df	*P*-value	Exp(*B*)
-.339	0.092	13.455	1	0.000	0.713

Table 11.

The Result of the Logistic Regression Analysis for the Individual Performance of the Variables in the Equation for the Analysis.

								95% CI	
		B	S.E	Wald	Df	*P*-value	Odd ratio	LCI	UCI
Step 1[a]	PMPM	-0.538	0.190	8.058	1	0.005	0.584	0.403	0.847
	IPTp-SP compliance	0.355	0.269	1.747	1	0.186	1.426	0.842	2.415
	CAM use	0.489	0.234	4.068	1	0.044	1.631	1.014	2.625
	Constant	-0.493	0.266	3.431	1	0.064	0.611		

Variable (s) entered on step 1: PMPM, IPTp-SP compliance, CAM use. This table shows the statistical significance of each variable being explored in the RQ.

Table 12.

The Hosmer-Lemeshow Test for the Analysis.

Step 1	Chi-square statistics	Df	*P*-value
	2.528	4	0.640

Controlling for Confounders in this Study Analysis.

Regression Model.

Finally, the backward elimination stepwise method in the SPSS was used to build the final model for this study based on the RQ. (Maternal anemia as DV, the IVs were PMPM, IPTp-SP, and use of CAM) and the enumerated risk factors (ITN ownership, ITN frequent use, ANC attendance, gravidae, age groups, and educational attainment) were entered into the SPSS for logistic regression model with the backward elimination stepwise method. The output from the model revealed that PMPM, use of CAM, ITN ownership, ITN frequent use, and ANC attendance showed statistically significant association with the outcome (maternal anemia), hence these variables were used with the DV (maternal anemia) to run the final model with the enter method of the binary logistic regression, $\chi 2$ (5) = 74.922, P = 0.000. This model explained 22.0% (Negelkerke's R^2) of the variances in the maternal anemia and correctly classified 78.5% of cases. The subjects with PPMPM were 0.135 times as likely (13.5% more likely) to be anemic (exhibit maternal anemia) than the subjects with NPMPM. The performance of each variable is presented in Table 14 below. The Hosmer-Lemeshow test was not significant with a *P*-value of 0.818, implying that the model has a good fit.

Table 13.

The Omnibus Test of Model Coefficients in Final Model Analysis.

Step 1		Chi-square	Df	*P*-value
	Step	74.922	5	0.000
	Block	74.922	5	0.000
	Model	74.922	5	0.000

Note: This table shows the statistical significance of the model explored in the final model.

Table 14.

The Variables in the Equation for the Final Model.

		B	S.E	Wald	Df	*P*-value	Exp(*B*)
Step 0	Constant	-1.245	0.109	129.928	1	0.000	0.288

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Table 15.

The Result of Controlling for Confounding in the Final Model.

		B	S.E	Wald	Df	*P*-value	Odd ratio	LCI (95% CI)	**UCI** (95% CI)
Step 1[a]	PMPM	-2.002	0.298	45.086	1	0.000	0.135	0.075	0.242
	Use of CAM	0.654	0.292	5.019	1	0.025	1.923	1.085	3.408
	ITNs ownership	0.697	0.271	6.639	1	0.010	2.008	1.182	3.413
	ITNs frequent use	-0.752	0.309	5.940	1	0.015	0.471	0.257	0.863
	ANC attendance	-0.400	0.193	4.314	1	0.038	0.670	0.460	0.978
	Constant	0.113	0.557	0.041	1	0.839	1.120		

[a] Variable (s) entered on step 1: PMPM, CAM usage, ITNs ownership, ITNs frequent use, and ANC attendance. This table shows the statistical significance of each variable being explored in the final model.

Table 16.

The Hosmer-Lemeshow Test for the Final Model.

Step 1	Chi-square	Df	*P*-value
	4.413	8	0.818

Discussions.

The findings of this study aligned with most of the previous studies conducted on MiP. However, some results differed. The RQ investigated whether there is an association between PMPM, IPTp-SP compliance, the use of CAM, and maternal anemia among pregnant women in Asaba, Delta State, Nigeria. The result of the analysis indicated that PMPM, IPTp-SP compliance, and use of CAM have statistically significant association with maternal anemia at delivery based on the *P*-value in the model as shown in Table 10. The result revealed that subjects with positive PMPM were 58.4% more likely to exhibit maternal anemia than the subjects with negative PMPM. The data also showed that the use of CAM was associated with an increase in the likelihood of exhibiting maternal anemia in the study population. The expanded models involving the risk factors of malaria revealed that maternal anemia has a statistically significant association with PMPM, use of CAM, ITN ownership, ITN frequent use, and ANC attendance. The identified risk factors associated with maternal anemia were ITN ownership, ITN frequent use, and ANC attendance.

Malaria Prevalence Among the Study Population.

The confirmation and identification of the parasite by the thick and thin slide microscopy showed 100% of *P. falciparum* in the data. Buh et al. (2019) and Ouedraogo et al. (2012) reported similar results in their various studies. The result of this study is aligned with a study conducted by Omer et al. (2021) and several other studies carried out in the SSA regions (Lufelu et al., 2017; Omer et al., 2017; Onyemaechi & Malann, 2020). This agrees with the documented evidence that 25 million parturients are at risk of malaria infection by *P. falciparum* in the SSA (Balami et al., 2021; WHO, 2020, CDC, 2020). Furthermore, this agrees with the study by Omer et al. (2017) in Uganda, who also reported the identification of only *P. falciparum*. Besides, Anorue et al. (2020) and Achu et al. (2020) in their studies in Asaba also reported only *P. falciparum* species.

Prevalence of Major Variables in this Study.

The prevalence of placental malaria by microscopy and RDT in this study were 54.9% and 6.0% respectively. The wide difference in prevalence between microscopy and RTD malaria testing techniques in this study was due to the observed large false negative result by the RDT. The prevalence of placental malaria was highest among the secundigravida (61.0%), followed by the primigravida (54.0%) and lowest among the multigravida (51.0%) in the study population. Maternal anemia was 41.6%. The result of the PMPM showed that only *P. falciparum* specie were identified in this study. In addition, the prevalence of the use of CAM in this study was 17.6%, IPTp-SP adequate compliance was 15.3%.

The result of 54.9% prevalence of placental malaria parasitemia by microscopy in this study lend its support to the concept of asymptomatic malaria infections and its impact on maternal anemia (Omer et al., 2017; Onyemaechi & Malann, 2020; Odorizzi et al., 2016). Malaria parasite asymptomatic state in a high burden malaria area have implication in maintaining the parasite circle and delaying the malaria elimination and eradication program (Berzosa et al., 2018; Katrack, et al., 2018). Although malaria infection in the SSA (a high burden malaria region) is mostly asymptomatic due to the acquired immunity via repeated exposures, it is still highly associated with maternal anemia, still birth, LBW babies, preterm deliveries, maternal and neonatal complications, and death (Aguzie, 2018; Balami et al. 2021; Bardaji et al., 2017; Omer et al., 2017). The observed high prevalence of mild (+) parasitaemia in this study aligns with the report by Quakyi et al. (2019) that low density parasitaemia is common in high burden malaria regions. The high prevalence of placental malaria parasitaemia in this study could be explained by the report by Kapisi et al. (2017) that high burden malaria relates to placental malaria parasitaemia. Furthermore, Anorue et al. (2020) reported a higher prevalence (65.8%) by microscopy from their study in a tertiary healthcare facility in Asaba, Delta State, Nigeria, while Omer et al. (2017) reported 58.9% of placental malaria by microscopy in Uganda.

Maternal Anemia Among the Study Population.

The prevalence of maternal anemia in this study was 41.6%. Rouamba et al. (2021) reported similar prevalence of anemia (35.9% and 46.6%) with data collected in 2013/2014 and 2017 in Burkina Faso. Although Olukosi and Afolabi (2018) in their study in Lagos, Nigeria had higher results of 81.4% prevalence of anemia. According to Desai et al. (2007), malaria infection is highly associated with anemia and poor pregnancy outcome at all levels of pregnancy, while White, (2018) reiterated that malaria infection is associated with maternal anemia. These authors stated that *P. falciparum* is directly linked with maternal death in a low transmission setting while in a high transmission setting, it is an indirect cause of mortality via maternal anemia. The present study also revealed a strong association between placental malaria and maternal anemia. Omer et al. (2021) reported that placental malaria impacted the immune response that may change the haemoglobin level of the parturients. Therefore, a successful pregnancy outcome is dependent on the placental. The analysis of the data in this study showed a strong association between maternal anemia and placental malaria. The prevalence of maternal anemia in this study is higher among subjects with positive PMPM than in the subjects with negative PMPM as shown in the results. There is a statistically significant association between malaria infection and maternal anemia in pregnancy by various authors across different locations in the SSA (Olukosi & Afolabi, 2018; Rouamba et al. 2021; White, 2018). Nevertheless, several studies reiterated that the cause of anemia is multifactorial (Rouamba et al., 2021; Renzo et al., 2015; Tabrizi & Barjasteh, 2015); worm infestation, nutritional deficiency, poverty, low SES, and poor nutrition have been widely reported in connection with anaemia (Ononga et al., 2014; Haider et al., 2013).

The reported prevalence of 17.6% of the use of CAM aligns with the report by Ogbonnaya et al. (2019) that there is widespread belief among parturients in Nigeria that the use of CAM is safe. Nergard et al. (2015) also reported on the increasing use of CAM by parturients in Mali and other African countries.

The low IPTp-SP compliance has been reported in the SSA (Amoakoh-Coleman et al., 2020; Roman et al., 2019).

Limitation of the Study

The limitation of the study is the absence of a molecular testing/analysis (via the PCR or histology) of the placental parasitaemia of the malaria parasite, which is attributable to financial constrain. These techniques have improved sensitivity, specificity, and can quantify parasitaemia (with respect to the PCR) (Mfuh et al., 2019). In addition, the use of hospital routine data of placental malaria by RDTs and microscopy, implies that misdiagnosis cannot be ruled out, errors in reading by the microscopist, accurate staining of slides, or misidentification of the parasite species. Therefore, the researchers were not in control of the quality of these secondary data. Furthermore, the survey questionnaires were based on self-reporting, hence, re-call and information bias could not be ruled out and the quality of the collected data may not be in the required standard. In addition, we observed about 2.6% of missing and incomplete data and after all efforts to complete them were explored without success, they were removed from the data used in the final analysis and this could impact the internal validity of the study. Also, the result of this study was limited to the Asaba city in Delta State, Nigeria. Hence, it cannot be generalized to Delta State or Nigeria.

Conclusion.

The high prevalence of placental malaria in this study could be attributed to the low utilization of the existing interventions (ITNs, IPTp-SP compliance) and it resulted in adverse maternal anemia. Incorporating the findings of this study to the existing body of evidence could guide the malaria control stakeholders to expand interventions to track and treat asymptomatic malaria infection in pregnancy.

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Declaration

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Ethical approval: this study was approved by the Ethical Review Committee (ERC) of the Delta State Ministry of Health (MOH/GEN/6679/1) and Walden University (05-04-21-0997016). The procedures used for this study adheres to study concerning human subjects.

Availability of data and materials: The datasets analysed in this study are not publicly available because the primary data are owned by the researchers while the secondary data are owned by the four healthcare facilities used for this study.

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