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Abstract

Purpose: Parturients in the Sub-Saharan African are susceptible to malaria disease due to their reduced immunity during pregnancy. Asymptomatic placental malaria causes neonatal and maternal mortalities, preterm deliveries as well as low birth weight babies. Current studies on malaria in pregnancy indicated that the risk factors are location specific, and there are limited studies in Nigeria on asymptomatic placental malaria and pregnancy outcome (babies birth weight and delivery term). The purpose of this study was to determine the association between asymptomatic placental malaria infection and pregnancy outcome (baby's birth weight and delivery term) among parturients in Asaba, Delta State, Nigeria.

Methodology: Quantitative methodology with primary and secondary healthcare facility data from 483 subjects aged 18–49 years generated from four healthcare facilities between May and July 2021 was used for this study. The Socio-Ecological Model framework was used to describe

how parturients can achieve enhanced pregnancy outcome through the utilization of multi-levels of supports to enhance the compliance of pregnant women to the existing malaria interventions. The research questions and hypotheses were tested with the binomial logistic regression.

Result: The findings showed a statistically significant association between baby's birth weight, delivery term and placental malaria parasitemia (PMP), in the study population. Also, the identified risk factor for baby's birth weight in this study was gravidae, while that of delivery term was age groups, gravidae, ITN frequent use and ANC attendance.

Unique Contribution to Theory, Policy and Practice: The findings of this study could inform malaria control policymaking in Asaba and Delta State on tracking and treating asymptomatic malaria among underserved pregnant women accessing antenatal services to improve baby's birth weight, delivery term, and the associated complications.

Keywords: *Malaria, Plasmodium, Mosquito, Placenta Malaria, Iptp-SP, CAM, Pregnancy Outcome, Baby's Birth Weight, Delivery Term.*

Introdution

An estimated 3.2 million people are at risk of malaria infection. At the global level, several efforts to eradicate the disease failed to produce the hoped outcome for decades. An estimated 125 million parturients are at risk of malaria infection globally. Researchers have stated that parturients are a reservoir of the *Plasmodium* species via asymptomatic and sub-microscopic presentation with placental parasitemia (Onyemaechi & Malann, 2020).

In Nigeria, there is an estimated 3,000 death from malaria resulting in 40% of health expenditures, 50% hospital visits, and up to 50% of hospital admissions annually (Onyemaechi & Malann, 2020). The complications of malaria disease vary based on the level of individual immunity. In Nigeria, malaria accounts for 70% of morbidity and 11% of mortality among pregnant women and was the reason for 63% of hospital visits in 2018. Parturients are four times as likely to get malaria and two times as likely to die of malaria than their nonpregnant counterparts (Onyemaechi & Malann, 2020).

Background

An estimated 25–30 million of the 125,000,000 parturients at risk of malaria globally are in the sub-Saharan Africa (SSA). There is evidence in current documents of an estimated 75,000 to 200,000 neonatal mortalities and 900,000 LBW babies in the SSA region annually due to malaria disease (Center for Disease Control and Prevention [CDC], 2020; Onyemaechi & Malann, 2020; World Health Organization [WHO], 2020).

The failure to detect the malaria parasite presence in peripheral and placenta blood through a rapid diagnostic test (RDT) and microscopy, combined with current drug failures due to rapid parasite mutation, necessitate improved research to address this concern, improved testing techniques with

cost-efficient strategies are needed to achieve the testing before treatment mandate by the WHO (WHO, 2020). The absence of *P. falciparum* from peripheral circulation by the sequestration in the placenta further complicates treatment and resistance of malaria in pregnancy (MiP) (Aguzie, 2018; Sungwa et al., 2017; WHO, 2018). According to Sharma and Shukla (2017) the infected red blood cells (iRBCs) by *P. falciparum* causes inflammation, oxidative stress, and apoptosis to the placenta. The iRBCs cross the placenta to evade the host immune responses. These iRBCs darkens and thickens the placenta base impacting maternal and neonates exchange patterns, resulting in intrauterine growth retardation (IUGR), low birth weight (LBW), and other adverse pregnancy outcomes. According to Obi et. al., (2022) asymptomatic placental malaria is strongly associated with maternal anaemia. Besides, these authors reported that positive placental malaria parasitaemia by microscopy (PMPM), use of complementary and alternative medicine (CAM), insecticides treated nets (ITN) ownership, ITN frequent use, and antenatal care (ANC) attendance were the risk factors for maternal anemia in the study.

The Social Ecological Model (SEM) Framework.

The theoretical framework for this study was the SEM. The SEM states that health is affected by the interaction between the features of the individual, the community, and the environment that includes the physical, social, and political elements (Kilanowski, 2017). The SEM is a theory-based framework for understanding the multifaceted and interactive effects of personal and environmental factors (Bronfenbrenner, 1986; Bronfenbrenner,1989; Bronfenbrenner,1977; Kilanowski, 2017). The CDC has adapted the SEM for various public health endeavours to include the scopes of interpersonal, organizational, community, and policy level factors (CDC, 2020; Kilanowski, 2017).

We used the SEM for this study to highlight the social and environmental (health knowledge and decisions) risk factors influencing parturients adoption of existing malaria control interventions. Using the SEM, we assumed that there is an association between PMPM (biological and an environmental factor), intermittent preventive treatment in pregnancy with sulphazoxine-pirimethamine (IPTp-SP) compliance (personal level factor/health decision by parturients), the use of CAM (an interpersonal/relationship-based factor) and pregnancy outcome (individual, relationship/interpersonal, community, and structural level factors) among asymptomatic parturients.

Although, there are documented evidence of malaria among pregnant women in Nigeria. This study is another section of the study by Obi et al. 2022 on ‘‘*asymptomatic malaria infection impact maternal anemia in Delta State, Nigeria’’.* This section of the study investigated the association between PMPM, IPTp-SP compliance, the use of CAM and baby’s birth weight as well as delivery term among asymptomatic pregnant women attending ANC and presenting for delivery in Nigeria. Also, this study enumerated the risk factors for LBW babies and delivery term among the study population.

Purpose of the study

The purpose of this study was to investigate the association between baby's birth weight, delivery term, and PMPM among asymptomatic pregnant women attending ANC and presenting for delivery. The subject's ITN ownership, ITN frequent use, ANC attendance, gravidae, age groups, and educational attainment were analyzed in an expanded model to determine the risk factors of baby's birth weight and delivery terms among asymptomatic pregnant women in Asaba, Delta State, Nigeria.

The Research Question.

RQ1: What is the association between PMPM (IV_1), IPTp-SP compliance (IV_2), the use of CAM (IV_3), and baby's birth weight (DV) among pregnant women in Asaba, Delta State, Nigeria?

$H_0$1 There is no association between PMPM (IV_1), IPTp-SP compliance (IV_2), the use of CAM (IV_3), and baby's birth weight (DV) among pregnant women in Asaba, Delta State, Nigeria.

$H_1$1: There is an association between PMPM (IV_1), IPTp-SP compliance (IV_2), the use of CAM (IV_3), and baby's birth weight (DV) among pregnant women in Asaba, Delta State, Nigeria.

RQ2: What is the association between PMPM (IV_1), IPTp-SP compliance (IV_2), the use of CAM (IV_3), and delivery term (DV) among pregnant women in Asaba, Delta State, Nigeria?

$H_0$2 There is no association between PMPM (IV_1), IPTp-SP compliance (IV_2), the use of CAM (IV_3), and delivery term (DV) among pregnant women in Asaba, Delta State, Nigeria.

$H_1$2: There is an association between PMPM (IV_1), IPTp-SP compliance (IV_2), the use of CAM (IV_3), and delivery term (DV) among pregnant women in Asaba, Delta State, Nigeria.

Materials and Method

We utilized quantitative methodology in a cross-sectional study design with deidentified survey questionnaires and secondary routine hospital data collected from four healthcare facilities in Asaba, Delta State, Nigeria for this study (Obi et al. 2022). The binomial logistic regression and Chi Square analysis were applied to the generated data. The data collection instrument was a paper-based questionnaire answered by the literate subjects or administered in a face-to-face approach to the subjects who are not literate. And we carried out validation with hospital records of subjects to enhance the study validity. We selected Primary, secondary, and private healthcare facilities randomly from the existing healthcare facilities in Asaba, the capital of Delta State for this study (Obi et al. 2022).

Study Population and Location

Delta State is in the south-south geopolitical zone with a human population of 4,112,445 (males: 2,069,309; females: 2,043,136) and the National Population Commission & National

Bureau of Statistics. (n. d), reported a projection to 5,663,362 (males: 2,888,315, females: 2,775,047) in 2016 at a growth rate of 3% (National Population Commission, n.d).

Asaba is the capital city and is in the northern part of Delta State. The language of the indigenous Asaba people is the Ibo language, but its function as the state capital attracted a multitribal population with diverse languages such as Urhobo, Itsekiri, Isoko, Ijaw, Hausa, Yoruba, Fulani, and other minority tribes. Hence the general/common language is the low-grade English language popularly known as Delta pidgin English (Wikipedia, 2020).

Sampling Approaches (Sample Size and Power Calculation)

Power analysis and the Yamane (1967) formula sample size calculator was used to determine the suitable sample size required to detect an anticipated effect (small, medium, or large) for this study (Maher et al. 2013). We determined the sample size 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 as stated in Obi et al 2022. While the Yamane sample size calculation yielded 308 and with response rate adjustment was 338 subjects (Obi et al. 2022, pp 6).

The Study Inclusion, and Exclusion Criteria.

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 $\leq 37.5^{o}C$, absence of fever, chills, and headache in the last 24 hours were recruited for this study (Obi et al. 2022).

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 (Obi et al. 2022).

The Data Collection

The questionnaire was worded in a low-grade English language to enhance subjects' understanding irrespective of their SES 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). We distributed the consent and subsequently the survey to qualified (based on inclusion and exclusion criteria) and consented subjects (Obi et al. 2022).

While at delivery, a laboratory test for PMP by RDT and microscopy was carried out as detailed in Obi et al., 2022; the first section of this study.

Data analysis (binomial logistic regression).

The data was analyzed using the Statistical Package for Social Sciences (SPSS) version 25 as detailed by Obi et al. 2022. The Chi-square assumption were accessed for all categorical independent variables and multicollinearity was determined using the variance inflation factor (VIF) or correlation estimates (Obi et al. 2022). The model goodness of fit was determined using the Hosmer-Lemeshow test. The inferential statistics includes binomial logistic regression analysis to investigate the research question 1 and 2 outlined above at a *P*-value of ≤ 0.05.

The use of binomial logistics regression and Chi-square test aligned with the research question and the restrictive assumptions of linear regression were not required in logistic regression. It was a robust statistical analysis (Creswell & Creswell, 2018; Rudestam & Newton, 2014). Binomial logistic test is suitable because it could ascertain the level and significance of the variables (Forthofer, & Lee, 2014; Kanyangarara et al., 2016). Besides, the study outcome and predictor variables were binary and dichotomous. (Hidalgo & Goodman, 2013). The Chi-square analysis was selected because of its popular application in finding the association between a categorical or dichotomous dependent and independent variable (Creswell & Creswell, 2018; Rudestam & Newton, 2014).

Table:1

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

Variable	Response Code	Measurement
Independent/Predictor		
Baby's birth weight		Dichotomous/Nominal
NBW	0	
LBW	1	
Delivery term		Dichotomous/Nominal
TD	0	
Preterm	1	
Dependent/outcome		
PMP		Dichotomous/Nominal
NPMP	0	
PPMP	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	

Adapted from Obi et al. 2022.

Evidence for reliability and validity of the instruments.

The findings in this study can only be extrapolated in the context of time to the setting of the survey, and a population with similar features. The external validity could be threatened if any inference is made, or findings extrapolated to other population/settings/past/future situations (Creswell & Creswell, 2008). Other possible sources of threat to the internal validity of the study could be through the processes of sample selection, data collection, and instrumentation (Creswell & Creswell, 2008). Also, the random sampling in health facility selection could prevent possible threat to internal validity. The selection of participants with likely extreme score could also be a threat to internal validity (Creswell & Creswell, 2008). Possible threats to construct validity could be due to inadequate or wrong definitions and measurement of research variables (Creswell & Creswell, 2008), and this was carefully avoided in this study. The independent variables and other risk variables were explained based on the SEM (Champion & Skinner, 2008).

Threat to Internal and External Validity.

However, recall bias may have been introduced via the self-reported of some variables in the questionnaires (Obi et al. 2022).

Ethical Consideration

The institutional review board (IRB) from Walden University and the ethical committee of the Delta State Ministry of Health as well as the data sites gave approvals for this study as detailed in Obi et al. 2022.

Informed Consent

We adhered to the consent form protocols in this study as enumerated in Obi et al. 2022.

Results.

The pilot test was done on 20 subjects (Obi et al., 2022).

Data Preparation.

The data were entered into the Excel spread sheet version 2013, validated after checking for errors and missing values. Finally, 483 data points were used for this analysis (Obi et al., 2022).

Primary Analysis

In the primary analysis phase, we performed statistical tests that answered the research questions 1 and 2 of the study. And Chi-Square test (bivariate test) was performed as detailed below.

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 in the first section of this study by Obi et al. 2022. The result of the collinearity diagnostics showed that the VIF values are less than five, which are below the threshold of 10.

The result of the Chi-square analysis (bivariate analysis).

The results of the Chi-square analysis are itemized below and summarized in Table 2.

1. The Chi-square analysis between PMPM and the ownership of ITN revealed that there is no statistically significant association between PMPM and the ownership of ITNs.

χ 2 (1.458, df = 1, P = 0.227).

2. The Chi-square analysis between PMPM and the usage of ITN on frequent bases revealed that there is no statistically significant association between PMPM and the usage of ITNs on frequent bases.

χ 2 (0.46, df = 1, P = 0.490)

3. The Chi-square analysis between PMPM and ANC attendance revealed that the association tend towards significance.

χ 2 (5.949, df = 2, P = 0.051).

4. The Chi-square analysis between PMPM and gravidae revealed that there is no statistically significant association between PMPM and gravidae.

χ 2 (3.848, df = 2, *P* = 0.146).

5. The Chi-square analysis between PMPM and Age groups revealed that there is no statistically significant association between PMPM and Age groups.

χ 2 (2.582, df = 3, *P* = 0.461).

6. The Chi-square analysis between PMPM and educational attainment revealed that there is a statistically significant association between PMPM and educational attainment.

χ 2 (12.852, df = 2, *P* = 0.020).

Table 2.

The Summary Results from the Chi-square Analysis.

		PMPM		
IVs	N	Pearson χ 2	df	*P*-value
INTs Ownership	483	1.458[a]	1	0.227
INTs Freq. Usage	483	0.476[a]	1	0.490
ANC attendance	483	5.949[a]	2	0.051
Gravidae	483	3.848[a]	2	0.146
Age groups	483	2.582	3	0.461
Educational attainment	483	9.785[a]	3	0.020

The Prevalence of Placental Malaria, LBW, and Preterm Deliveries in the Study.

The prevalence of placental malaria by microscopy and RDT in this study was 54.9% and 6.0% respectively (Obi et al., 2022). LBW was 12.8%, and preterm delivery was 10.1%. Moreover, only *P. falciparum* specie were identified 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 (Obi et al., 2022).

The Prevalence of Placental Malaria, LBW, and delivery term 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 LBW across the primary, secondary, and private were 21.4%, 9.7%, and 11.9%. The preterm delivery was 21.4%, 6.8% and, 8.7% for the primary, secondary, and tertiary healthcare facilities respectively. These statistics are presented in Table 3 below.

Table 3.

The Prevalence of Placental Malaria, LBW, and delivery term across the three Healthcare Facilities Levels in this Study.

Health facility level	PMPM	LBW	Preterm delivery
Primary facility	44.3	21.4	21.4%
Secondary (Government) facility	33	9.7	6.8%
Private facility	64.5	11.9	8.7%

Logistic Regression Analysis for the RQ1.

The result of the logistic regression analysis of the association between PMPM (IV_1), IPTp-SP compliance (IV_2), the use of CAM (IV_3), and baby's birth weight (DV) among pregnant women in the study population showed a statistically significant effect on baby's birth weight based on the *P*-value in the model indicated in Table 4, χ 2 (3) = 35.822, $P = 0.000$. The model explained 13.4% (Negelkerke's R^2) of the variances in baby's birth weight and correctly classified 87.2% of cases. The performance of the PMPM was statistically significant (odd ratio = 0.171, CI: 0.082–0.357, P = 0.000), the subjects with PPMPM were 0.171 times as likely (17.1% more likely) to deliver LBW babies than the subjects with NPMPM. Also, the use of CAM (odd ratio = 2.212, CI: 1.174–4.168, P = 0.014) was associated with an increase in the likelihood of delivering LBW babies in this model. However, the IPTp-SP compliance variable was not statistically significant (odd ratio = 1.139, CI: 0.504–2.578, P = 0.744). The Hosmer-Lemeshow test was not significant with a *P*-value of 0.985, implying that the model has a good fit. Based on the stated result, I rejected the null hypotheses and accepted the alternate hypotheses in respect to the RQ1.

Table 4.

The Omnibus Test of Model Coefficients for Analysis of the Research Question 1.

Step 1		Chi-square	Df	*P*-value
	Step	35.822	3	0.000
	Block	35.822	3	0.000
	Model	35.822	3	0.000

Note: This table shows the statistical significance of the model explored in the RQ1.

Table 5.

The Variables in the Equation for Analysis of the Research Question 1.

B	S.E	Wald	Df	*P*-value	Exp(*B*)
-1.915	0.136	198.288	1	0.000	0.147

Table 6.

The Result of the Logistic Regression Analysis for the Individual Performance of the Variables in the Equation for the Research Question 1.

								95% CI	
		B	S.E	Wald	Df	*P*-value	Odd ratio	LCI	UCI
Step 1[a]	PMPM	-1.766	0.375	22.126	1	0.000	0.171	0.082	0.357
	IPTp-SP compliance	0.130	0.417	0.098	1	0.754	1.139	0.504	2.578
	CAM use	0.794	0.323	6.036	1	0.014	2.212	1.174	4.166
	Constant	-1.671	0.401	17.362	1	0.000	0.188		

Variable (s) entered on step 1: PMPM, IPTp-SP compliance, CAM use. This table shows the statistical significance of each variable being explored in RQ1.

Table 7.

The Hosmer-Lemeshow Test for Analysis of the Research Question 1.

Step 1	Chi-square	Df	*P*-value
	0.364	4	0.985

Logistic Regression Analysis for the RQ2

The result of the logistic regression analysis of the association between PMPM (IV_1), IPTp-SP compliance (IV_2), the use of CAM (IV_3), and delivery term (DV) among pregnant women in the study population revealed a statistically significant effect on delivery term based on the *P*-value in the model indicated in Table 8; χ 2 (3) = 16.330, *P* = *0*.001. The model explained 7.0% (Negelkerke's R^2) of the variances in the delivery term and correctly classified 89.9% of cases. The performance of the PMPM was statistically significant (odd ratio = 0.365, CI: 0.185–0.722, *P* = 0.004), the subjects with PPMPM were 0.364 times as likely (36.4% more likely) to deliver preterm babies than the subjects with NPMPM. However, the IPTp-SP compliance and use of CAM variables were not statistically significant with the following details: odd ratio = 2.847, CI: 0.855–9.481, *P* = 0.088; odd ratio = 1.782, CI: 0.890–3.568, *P* = *0*.103 respectively. The Hosmer-Lemeshow test was not significant with a *P*-value of 0.666, implying that the model has a good fit. Therefore, I rejected the null hypotheses and accepted the alternate hypotheses in respect to the RQ2.

Table 8.

The Omnibus Test of Model Coefficients for Research Question 2 Analysis.

Step 1		Chi-square	Df	*P*-value
	Step	16.330	3	0.001
	Block	16.330	3	0.001
	Model	16.330	3	0.001

Note: This table shows the statistical significance of the model explored in RQ 2.

Table 9.

The Variables in the Equation for Research Question 2 Analysis.

		B	S.E	Wald	Df	*P*-value	Exp(*B*)
Step 0	Constant	-2.181	0.151	209.478	1	0.000	0.113

Table 10.

The Result of the Logistic Regression Analysis for the Individual Performance of the Variables in the Equation for Research Question 2 Analysis.

								95% CI	
		B	S.E	Wald	Df	*P*-value	Odd ratio	LCI	UCI
Step 1[a]	PMPM	-1.008	0.348	8.400	1	0.004	0.365	0.185	0.722
	IPTp-SP compliance	1.046	0.614	2.906	1	0.088	2.847	0.855	9.481
	CAM use	0.578	0.354	2.658	1	0.103	1.782	0.890	3.568
	Constant	-2.884	0.606	22.628	1	0.000	0.056		

a. Variable (s) entered on step 1: PMPM, IPTp-SP compliance, CAM usage. This table shows the statistical significance of each variable being explored in RQ2.

Table 11.

The Hosmer-Lemeshow Test for Research Question 2 Analysis.

Step 1	Chi-square	Df	*P*-value
	2.379	4	0.666

The result of controlling for confounders relative to the RQ1 in the logistic regression model.

Also, in building the final model based on the RQ (baby's birth weight as DV, IVs were PMPM, IPTp-SP, and use of CAM) and the enumerated risk factors (ITNs ownership, ITNs 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 showed that PMPM, use of CAM, and gravidae were statistically significantly associated with the outcome (baby's birth weight), hence these variables were used with the DV (baby's birth weight) to run the final model with the enter method of the binary logistic regression. χ 2 (3), 41.297, $P = 0.000$. The model explained 15.3% (Negelkerke's R^2) of the variances in the baby's birth weight and correctly classified 87.2% of cases. The subjects with PPMPM were 0.174 times as likely (17.4% more likely) to deliver LBW babies than the subjects with NPMPM. The performance of each variable is presented in Table 12 below. The Hosmer-Lemeshow test was significant with a *P*-value of 0.013, implying that the model does not have a good fit.

Table 12.

The Omnibus Test of Model Coefficients for Research Question 1 Final Model Analysis.

Step 1		Chi-square	Df	*P*-value
	Step	41.297	3	0.000
	Block	41.297	3	0.000
	Model	41.297	3	0.000

Note: This table shows the statistical significance of the model explored in RQ 1 final model.

Table 13.

The Variables in the Equation for Research Question 1 Final Model Analysis.

B	S.E	Wald	Df	*P*-value	Exp(*B*)
-1.915	0.136	198.285	1	0.000	0.147

Table 14.

The Result for Controlling for Confounding for Research Question 1 Final Model.

							95% CI:	
	B	S.E	Wald	Df	*P*-value	Odd ratio	LCI	UCI
PMPM	-1.746	0.376	21.552	1	0.000	0.174	0.083	0.365
CAM use	0.693	0.330	4.424	1	0.035	2.000	1.048	3.815
Gravidae	-0.434	0.184	5.575	1	0.018	0.648	0.452	0.929
Constant	-0.606	0.428	2.006	1	0.157	0.545		

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

Table 15.

The Hosmer-Lemeshow Test for Research Question 1 Final Model.

Step 1	Chi-square	Df	*P*-value
	16.049	6	0.013

The result of controlling for confounders for the RQ2 in the logistic regression model.

In creating the final model based on the RQ2 (delivery term as DV), the IVs were PMPM, IPTp-SP, and use of CAM) and the enumerated risk factors (ITNs ownership, ITNs 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 result showed that PMPM, age groups, gravidae, ANC attendance, and ITN frequent use were statistically significantly association with the outcome (delivery term), hence these variables were used with the DV (delivery term) to run the final model with the enter method of the binary logistic regression, χ 2 (5) = 36.966, $P = 0.000$. The model explained 15.3% (Negelkerke's R^2) of the variances in the delivery term and correctly classified 90.1% of cases. The subjects with PPMPM were 0.378 times as likely (37.8% more likely) to deliver preterm babies than the subjects with NPMPM. The performance of each variable is presented in Table 16 below. The Hosmer-Lemeshow test was not significant with a *P*-value of 0.896, implying that the model has a good fit.

Table 16.

The Omnibus Test of Model Coefficients for Research Question 2 Final Model Analysis.

Step 1		Chi-square	Df	*P*-value
	Step	36.966	5	0.000
	Block	36.966	5	0.000
	Model	36.966	5	0.000

Note: This table shows the statistical significance of the model explored in RQ 2 final model.

Table 17.

The Variables in the Equation for Research Question 2 Final Model.

B	S.E	Wald	Df	*P*-value	Exp(*B*)
-2.181	0.151	209.478	1	0.000	0.113

Table 18.

The Result for Controlling for Confounding for Research Question 2 Final Model.

							95% CI:	
	B	S.E	Wald	Df	*P*-value	Odd ratio	LCI	UCI
PMPM	-0.973	0.357	7.417	1	0.006	0.378	0.188	0.761
Age groups	0.559	0.253	4.862	1	0.027	1.748	1.064	2.873
Gravidae	-0.651	0.222	8.628	1	0.003	0.521	0.338	0.805

ITN frequent use	-0.884	0.437	4.096	1	0.043	0.413	0.176	0.972
ANC attendance	-0.774	0.222	12.161	1	0.000	0.461	0.299	0.713
Constant	0.654	0.735	0.791	1	0.374	1.923		

[a] Variable (s) entered on step 1: PMPM, age groups, gravidae, ITNs frequent use, and ANC attendance. This table shows the statistical significance of each variable being explored in RQ2 final model.

Table 19.

The Hosmer-Lemeshow Test for Research Question 2 Final Model.

Step 1	Chi-square	Df	*P*-value
	3.540	8	0.896

Discussion.

Malaria is a longstanding public health problem of global significance, and many efforts have been made to eliminate and eradicate the disease. Most malaria-endemic regions of the world, especially in the SSA and Nigeria, are among the low-income countries. The malaria control programs have not yielded the expected outcome, being compounded by poverty and low human resources (CDC, 2020; Onyemaechi & Malann, 2020; WHO, 2020). About 47 of 54 countries in the SSA are malaria endemic and are still in the malaria control programs with persistent low statistics of intervention implementations (WHO, 2020). Malaria infection is a critical public health problem in Nigeria and the SSA in general despite the available interventions such as the IPTp-SP, ITNs, and treatment regime to prevent *P. falciparum* infection in pregnancy (Yaya et al., 2018; 2015; Obi et al., 2022). An estimated 25–30 million of the 125,000,000 parturients at risk of malaria globally are in the SSA. There is evidence in current documents of an estimated 75,000 to 200,000 neonatal mortalities, 900,000 LBW babies, and 10,000 maternal mortalities in the SSA region annually due to malaria disease (CDC, 2020; Onyemaechi & Malann, 2020; WHO, 2020). As a result, several studies have been conducted to determine the risk factors accounting for the high prevalence of malaria morbidity and mortality among parturients and their infants in various regions.

The RQ1 investigated whether there is an association between PMPM, IPTp-SP compliance, the use of CAM, and baby's birth weight among pregnant women in Asaba, Delta State, Nigeria. The result showed that subjects with PPMPM were 17.1% more likely to deliver LBW babies than the subjects with NPMPM. And the use of CAM by parturients was associated with an increase in the likelihood of delivering LBW babies in the study population. The only risk factors associated with baby's birth weight was gravidae.

The RQ2 investigated whether there is an association between PMPM, IPTp-SP compliance, the use of CAM, and delivery term among pregnant women in Asaba, Delta State, Nigeria. The study findings showed that subjects with PPMPM were 36.4% more likely to deliver preterm babies than the subjects with NPMPM. And age groups, gravidae, ITN frequent use and ANC attendance were the risk factors associated with delivery term.

Recommendations

This study resulted in some interesting findings that can contribute to the current body of knowledge in MiP research. There is need for further study using the PCR or histology techniques which has a lower limit of detection of the *P. falciparum* of about 0.0001 parasite/µl as well as detecting mixed infections but microscopy cannot detect mixed infection (Berzosa, et al., 2018). Besides, the result of the RDT analysis in this study calls for further investigation because the RDTs are meant to detect the antigens of plasmodium species and not the parasites; implying it should have a sensitivity advantage over the thick film microscopy because it should (by design) pick parasitemia below the threshold of microscopy (Mfuh, et al., 2018). Therefore, an enhanced/improved testing techniques is required to ascertain the false negative (due to threshold limit) by microscopy.

An adequate sensitization of parturients on the need to take the recommended doses of the IPTp-SP is required. Further, policy could be reviewed at the local, state, and national government levels to focus on tracking and treating asymptomatic malaria cases via the inclusion of routine malaria testing for parturients during the ANC. I also recommend that further studies should be carried out to determine the components/active ingredients of the CAM used by pregnant women against malaria. And a cohort study on the comparism of the long-time impact of IPTp-SP and CAM on pregnancy outcome is recommended.

Limitations, Challenges, and Barriers of the Study

This study was a cross-sectional design; therefore, causality cannot be ascertained, since all samples were taken at delivery. The impact of past infection on maternal, fetus, and neonatal outcomes cannot be determined. Also, the bias arising from self-reporting of demographic and socioeconomic status variables are envisaged in this study; consequently, the mitigation through validation with hospital records was appropriate. The information bias from self-reporting of survey data was mitigated by adequate training of the subjects before the data collection, pretesting of the questionnaire, and validation with hospital records. Further, some factors that could impact fetal outcome, such as maternal nutritional status, child spacing, genetic influences, other

infectious diseases, smoking and wrong use of alcohol were not investigated in this study (Kapisi et al., 2017).

Strength of the Study

An essential strength of the study was the use of binomial logistic regressions for the statistical analysis because it is robust in identifying confounders and it is less restrictive for assumptions (Feleke et al., 2020). Also, the use of a pretested structured questionnaire was to ensure appropriate baseline understanding of the survey questions. And lastly, the selection of four health care facilities (primary, secondary, and private health care facilities; comprising two public and two private healthcare facilities) in the state could afford better comparison of study outcomes based on the level of care and location. All the consulted study in Nigeria used data from a single healthcare facility in their study.

Conclusion and Implication for Positive Social Change

The result of this study has provided information on the prevalence of placental malaria infection in Asaba, Delta State, Nigeria, which is necessary to guide institutions and stakeholders in malaria control programs. The statistics from this study on the utilization of existing malaria interventions are far below the expected target for elimination and eradication of this aged-long infection. The use of the ITN and IPTp-SP malaria interventions by subjects in this study were far below the expected threshold. Therefore, strategies such as health education at the ANC, community levels and disseminating this study results to the Delta State Ministry of Health and other malaria control stakeholders could enhance the use of the ITNs and IPTp-SP by parturients in this location and beyond. The health education message should be clear that parturients are not sick of malaria does not exclude the fact that they could be carriers of the parasite, and their babies could be impacted. Besides, parturients may become sick subsequently via recrudesce. In addition, health education discouraging the use of CAM by parturients should be incorporated into the ANC services by the healthcare management.

Further, policy on malaria elimination and eradication could be expanded at the local, state and, national government levels to focus on tracking and treating asymptomatic malaria cases among parturients via the inclusion of routine malaria testing for parturients during the ANC. So, expanding the current malaria control strategy of testing and treating only sick subjects to accommodate asymptomatic parturients in the testing and subsequent treatments when needed could reduce the present burden of MiP in this location.

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Abbreviation.

PMP	Placental malaria parasitaemia
PMPM	Placental malaria parasitaemia by microscopy
RDT	Rapid diagnostic test.
PPMP	Positive placental malaria parasitaemia
NPMP	Negative placental malaria parasitaemia
CAM	Complementary and alternative medicine
BW	Birth weight
NBW	Normal birth weight
LBW	Low birth weight
GAD	Gestational age at delivery

N	Population
M	Mean
SD	Standard deviation
CI	Confidence interval
R^2	Negelkerke pseudo
H-L	Hosmer-Lemeshow test
ANC	Antenatal care
CAM	Complementary and alternative medicine
IPTpSP	Intermittent preventive treatment in pregnancy with sulfadoxine-pyrimethamine
PCR	Polymerase chain reaction
RFLP	Restriction fragment length polymorphism
MiP	Malaria in pregnancy
SSA	sub-Saharan Africa

Declaration

This study was self-funded.

Conflict of interest: The authors declared that there was no conflict of interest.

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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