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MALARIA IN PREGNANCY: GESTATIONAL AGE AT FIRST ANTENATAL CARE REGISTRATION AND ITS ASSOCIATION WITH NEONATAL BIRTH WEIGHT

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ABSTRACT
Malaria during pregnancy is associated with adverse maternal, fetal and neonatal outcomes, including maternal anaemia, prematurity and low birth weight. Antenatal care (ANC) provides an important platform for malaria prevention, screening, treatment and broader maternal and fetal assessment. The World Health Organization recommends that the first ANC contact occur within the first 12 weeks of gestation. This study examined whether gestational age at first ANC registration was associated with neonatal birth weight in records from a retrospective malaria-in-pregnancy study. A retrospective observational analysis was performed on 452 identifiable records. Records with available ANC gestational age and birth weight were included in the principal analysis (n=434). ANC registration was categorized as early (<12 weeks) or late (≥12 weeks). Low birth weight (LBW) was defined as <2.5 kg. Continuous birth weight was compared using Welch's independent-samples t-test, and the association between ANC timing and LBW was assessed using a continuity-corrected Pearson chi-square test. Binary logistic regression estimated adjusted odds ratios (aORs) for LBW. Analyses were performed in IBM SPSS Statistics version 24. The findings indicated that early ANC registration occurred in 350/434 records (80.6%), while 84/434 (19.4%) registered at ≥12 weeks. Mean birth weight was 2.420 ± 0.252 kg in the early group and 2.394 ± 0.251 kg in the late group. The mean difference was 0.026 kg (95% CI −0.034 to 0.087), Welch's $t(126.22)=0.859$, $p=.392$. LBW occurred in 294/434 records (67.7%). ANC timing was not significantly associated with LBW, continuity-corrected $\chi^2(1)=0.874$, $p=.350$. In the adjusted logistic model, ANC gestational age was not associated with LBW (aOR=0.979, 95% CI 0.877–1.093, Wald $\chi^2=0.148$, $p=.700$). The overall model was not significant, likelihood-ratio $\chi^2(4)=0.896$, $p=.925$. Within the analyzed records, gestational age at first ANC registration was not significantly associated with neonatal birth weight or LBW. The high observed proportion of LBW requires cautious interpretation and verification of the birth-weight source, units and study-population characteristics.

Keywords: malaria in pregnancy; antenatal care; gestational age; birth weight; low birth weight; neonatal outcome; retrospective study

1. Introduction

Malaria in pregnancy remains an important maternal and child health problem in malaria-endemic settings. Pregnancy increases susceptibility to malaria and can increase the risk of maternal illness and anaemia; for the fetus and newborn, malaria exposure is associated with adverse outcomes including preterm birth, fetal growth impairment, stillbirth and low birth weight (World Health Organization [WHO], 2023, 2024). The WHO 2024 World Malaria Report continues to identify pregnancy as a period in which malaria infection poses substantial risks to both mother and child.

ANC is a major platform for preventing and managing malaria during pregnancy as well as for providing maternal and fetal assessment, nutrition counselling, screening and other preventive interventions. WHO recommends that the first ANC contact occur in the first 12 weeks of gestation and emphasizes that the value of ANC depends not simply on attendance but on the quality and content of care provided (WHO, 2016, 2018). In malaria-endemic areas, ANC also provides opportunities for malaria prevention and control interventions, including intermittent preventive treatment with sulfadoxine-pyrimethamine where recommended, insecticide-treated nets and prompt diagnosis and treatment of malaria (WHO, 2023).

Birth weight is a key indicator of newborn health. WHO defines low birth weight as a birth weight below 2,500 g, irrespective of gestational age. LBW may arise from prematurity, impaired fetal growth, or both, and is associated with increased neonatal morbidity and mortality and longer-term developmental and health risks (WHO, n.d.). Evidence from African studies indicates that ANC utilization is associated with LBW outcomes, although the magnitude of association varies across settings and study designs. A systematic review and meta-analysis of African studies reported a pooled association between ANC attendance and lower odds of LBW, supporting the importance of ANC access while also highlighting heterogeneity across populations (Engdaw et al., 2023).

Despite the importance of early ANC, timing of registration alone may not capture the effectiveness of care. Birth weight is influenced by multiple maternal, fetal and health-system factors, including gestational age at delivery, fetal growth, maternal nutrition, maternal disease, parity and the content and quality of ANC. Malaria infection and its prevention may also influence birth outcomes. Therefore, examining the timing of first ANC registration within a malaria-in-pregnancy clinical record population may help determine whether early registration is associated with improved neonatal birth-weight outcomes.

The present study therefore assessed the association between gestational age at first ANC registration and neonatal birth weight. Reporting was structured in accordance with the principles of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement (von Elm et al., 2007).

2. Aim and Objectives

Aim: To determine the association between gestational age at first ANC registration and neonatal birth weight among records included in the retrospective malaria-in-pregnancy study.

1. To determine the distribution of gestational age at first ANC registration.
2. To determine the mean neonatal birth weight.
3. To compare mean neonatal birth weight between early and late ANC registration groups.
4. To determine the proportion of neonates classified as low birth weight.
5. To assess the association between ANC registration timing and low birth weight.
6. To determine whether ANC gestational age, maternal weight, gravidity and neonatal sex independently predict low birth weight.

3. Materials and Methods

3.1 Study design and data source

This was a retrospective observational study based on routinely recorded maternal and neonatal information. The validation workbook identified 452 non-blank, identifiable records. Of these, 434 contained both ANC gestational-age information and birth-weight data and formed the principal analytical sample.

3.2 Study population and eligibility

The analysis used records contained in the approved malaria-in-pregnancy study dataset. Records were eligible for the principal birth-weight analysis when gestational age at first ANC registration and neonatal birth weight were available. Records with missing birth weight were excluded only from analyses requiring birth weight.

Because the current analytical workbook does not contain a dedicated malaria-status variable, malaria infection status was not entered as a statistical exposure or predictor. The malaria-in-pregnancy designation should therefore be confirmed from the original hospital register before submission.

3.3 Exposure and outcome definitions

The exposure was gestational age at first ANC registration. Early registration was defined as <12 weeks and late registration as ≥12 weeks, consistent with the WHO first-trimester ANC indicator. Neonatal birth weight was analyzed as a continuous variable in kilograms and categorized as LBW (<2.5 kg) or non-LBW (≥2.5 kg).

3.4 Data quality and correction procedure

Data-quality checks were performed before analysis. Implausible or potentially erroneous values were flagged and were not silently changed. The prespecified procedure was: (1) identify the questionable value; (2) return to the original hospital source record; (3) correct the value only when the source record clearly confirms the correction; (4) otherwise code the variable as missing for the affected analysis; and (5) retain an audit trail documenting the original value, verified value, reason for correction, source checked and date of verification.

Specific records requiring verification include one maternal pulse value of 1001 bpm and one birth-weight value of 5.0 kg. These values must not be changed to presumed alternatives unless the original clinical record confirms the correction. Five temperature values outside 35–42°C and three potentially implausible blood-pressure records were also flagged for source verification. Parity was not used in the current model because the available parity field contained gestational-age-like entries and could not be considered reliable.

3.5 Statistical analysis

Data were analyzed using IBM SPSS Statistics, version 24. Continuous variables were summarized using means and standard deviations, and categorical variables using frequencies and percentages. Mean birth weight was compared between early and late ANC groups using Welch's independent-samples t-test. The association between ANC timing and LBW was assessed using Pearson's chi-square test with continuity correction, matching the reported p=.350. Binary logistic regression was used to estimate adjusted odds ratios for LBW, with ANC gestational age, maternal weight, gravidity and neonatal sex as predictors. Adjusted odds ratios, 95% confidence intervals, Wald statistics and p-values were reported. Statistical significance was set at p<.05.

3.6 Ethical considerations

Ethical approval was obtained from the Health Research Ethics Committee of Plateau State Specialist Hospital, Jos, Plateau State, Nigeria (Registration No. NHREC/09/23/2010b). The approval letter is dated 1 March 2024 and states that the final determination of the research was made on 28 February 2024, with expedited approval valid from 28 February 2024 to 28 February 2025. The approved project title on the supplied ethics letter concerns assessment of malaria parasite complications among antenatal mothers at Plateau State Specialist Hospital, Jos. Patient confidentiality was maintained, and personal identifiers were excluded from the analytical dataset.

3.7 Reporting standard

The manuscript was revised to improve transparent reporting of study design, eligibility, variable definitions, data-quality procedures, missing data, statistical methods and effect estimates in keeping with STROBE guidance.

4. Results

4.1 Record completeness

There were 452 identifiable records. Birth-weight data were available for 434 records (96.0%), while 18 records had missing birth weight and were excluded from birth-weight analyses.

4.2 ANC registration timing

Among the 434 records included in the principal analysis, 350 (80.6%) registered for ANC before 12 weeks and 84 (19.4%) registered at ≥12 weeks.

ANC timing	n	Mean birth weight (kg)	SD (kg)
<12 weeks	350	2.420	0.252
≥12 weeks	84	2.394	0.251
Difference	—	0.026	—

Welch's independent-samples t-test showed no statistically significant difference in mean birth weight between the groups, $t(126.22)=0.859$, $p=.392$. The mean difference was 0.026 kg (95% CI −0.034 to 0.087).

4.3 Low birth weight

Overall, 294 of 434 neonates (67.7%) had birth weight <2.5 kg. This is an observed proportion within the analyzed records and should not be interpreted as a population prevalence without verification of the study population and birth-weight measurement process.

4.4 Association between ANC timing and LBW

The continuity-corrected Pearson chi-square test showed no statistically significant association between ANC timing and LBW, $\chi^2(1)=0.874$, $p=.350$. The corresponding 2×2 table was:

ANC timing	Non-LBW ≥2.5 kg	LBW <2.5 kg
<12 weeks	117	233
≥12 weeks	23	61
Total	140	294

4.5 Multivariable logistic regression

A binary logistic regression model including ANC gestational age, maternal weight, gravidity and neonatal sex was fitted to 434 records. The overall model was not statistically significant, likelihood-ratio $\chi^2(4)=0.896$, $p=.925$, with McFadden pseudo-$R^2=0.0016$.

Predictor	B	SE	Wald χ^2	aOR	95% CI	p
ANC gestational age	−0.022	0.056	0.148	0.979	0.877–1.093	.700
Maternal weight	0.009	0.011	0.722	1.009	0.988–1.031	.395
Gravidity	−0.014	0.092	0.024	0.986	0.824–1.180	.878
Male sex vs female	0.027	0.216	0.015	1.027	0.672–1.569	.901

5. Discussion

The principal finding was that gestational age at first ANC registration was not significantly associated with neonatal birth weight in this dataset. The early-registration group had a mean birth weight only 0.026 kg higher than the late-registration group, and the confidence interval for the difference crossed zero. The adjusted model similarly showed no evidence that ANC gestational age independently predicted LBW.

These findings should not be interpreted as evidence that early ANC is unimportant. WHO recommends first contact within the first 12 weeks because early ANC creates opportunities for maternal and fetal assessment, preventive interventions, screening and counselling. In malaria-endemic settings, early and continued ANC also provides an important platform for malaria prevention and case management (WHO, 2016, 2023).

The absence of an observed association in this retrospective dataset may reflect the fact that ANC timing is only one component of care. Birth weight is influenced by gestational age at delivery, fetal growth, maternal nutrition, maternal disease, parity, socioeconomic conditions and the quality and continuity of ANC. Importantly, gestational age at delivery and several other clinically relevant variables were not sufficiently reliable in the supplied dataset for inclusion in the adjusted model. Residual confounding therefore remains possible.

The observed LBW proportion of 67.7% is substantially higher than expected in many general obstetric populations. WHO defines LBW as <2,500 g and emphasizes its importance for neonatal morbidity and mortality. The unusually high proportion in this dataset may reflect the clinical population, referral patterns, missingness, measurement practices or data-quality issues. It should therefore not be presented as a population prevalence without further validation.

The malaria-in-pregnancy context is biologically relevant because maternal malaria can contribute to fetal growth restriction, prematurity and LBW, while malaria prevention during pregnancy has been associated with improved birth outcomes in African studies. A meta-analysis of African national datasets found that malaria prevention during pregnancy was associated with reduced odds of LBW, although residual confounding remained possible (Eisele et al., 2012). Similarly, evidence syntheses have reported an association between ANC and LBW outcomes in Africa (Engdaw et al., 2023). The present study, however, cannot quantify the independent contribution of malaria infection because a dedicated malaria-status variable was not available in the analytical workbook.

6. Strengths and Limitations

Strengths include the use of routinely collected clinical records, a relatively large record set, analysis of ANC timing using the WHO 12-week threshold, assessment of birth weight both continuously and categorically, and use of adjusted regression. The analysis also explicitly documented data-quality concerns rather than replacing questionable values with unsupported assumptions.

Limitations include the retrospective design, missing data, uncertain reliability of some variables, absence of a reliable gestational age at delivery variable, inability to include parity

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because of coding problems, and the lack of a dedicated malaria-status variable in the analytical workbook. These limitations restrict causal inference and generalizability.

7. Conclusion

In this retrospective dataset, most records showed first ANC registration before 12 weeks of gestation. However, early versus late ANC registration was not significantly associated with mean neonatal birth weight or LBW, and ANC gestational age was not an independent predictor of LBW after adjustment. The high observed proportion of LBW should be interpreted cautiously pending verification of the original birth-weight records, units and source population.

8. Recommendations

1. Continue promoting first ANC contact within the first 12 weeks while strengthening the content and quality of ANC.
2. Ensure malaria prevention, screening and prompt treatment are integrated into ANC according to current national and WHO guidance.
3. Verify the original source record for the 5.0-kg birth-weight value and the 1001-bpm pulse value before final submission.
4. Standardize birth-weight measurement, units and documentation in the hospital records.
5. Improve documentation of gestational age at delivery, parity, malaria status, malaria treatment/prevention, maternal age and pregnancy complications.
6. Future studies should evaluate ANC timing together with ANC quality and malaria-related exposures rather than timing alone.

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