

The Impact of Malaria Severity, BMI, and Hemoglobin Levels on Cervical Length and Miscarriage Risk in First-Trimester Pregnancies

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ABSTRACT

Introduction: Malaria in pregnancy is a significant public health issue in endemic regions, with implications for maternal and fetal health. This study examines the relationship between malaria severity, systemic health markers, and cervical length in first-trimester pregnancies, providing insights into their combined impact on miscarriage risk.

Method: A cross-sectional study was conducted at KAIFA Ultrasound Center, involving 200 first-trimester pregnant women with laboratory-confirmed malaria. Data on maternal age, BMI, hemoglobin levels, and malaria severity were collected. Cervical length was measured via transabdominal ultrasound. Statistical analyses included Pearson and Spearman correlations, one-way ANOVA, post-hoc tests, and logistic regression.

Results: Higher malaria parasitemia levels were significantly associated with shorter cervical lengths (ANOVA $F = 9.4$, $p < 0.001$). Post-hoc analyses revealed significant differences between all parasitemia groups. BMI and hemoglobin levels were also associated with cervical length; obese women and those with hemoglobin < 10 g/dL exhibited significantly shorter cervical lengths (ANOVA $F = 6.8$, $p = 0.002$ and $F = 4.3$, $p = 0.01$, respectively). Logistic regression identified cervical shortening (≤ 25 mm), BMI ≥ 25 kg/m², and low hemoglobin as predictors of miscarriage.

Conclusion: Malaria severity, high BMI, and anemia contribute to cervical shortening, increasing miscarriage risk. Integrating cervical length assessments, nutritional interventions, and malaria prevention into antenatal care can improve outcomes in malaria-endemic regions.

Keywords: BMI, cervical length, hemoglobin, malaria.

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1. INTRODUCTION

Malaria remains one of the most pressing public health challenges in endemic regions, particularly among vulnerable populations such as pregnant women [1]. In these areas, the intersection of malaria and pregnancy results in significant maternal and fetal health risks, including anemia, low birth weight, preterm delivery, and miscarriage [2]. The first trimester of pregnancy represents a particularly critical period, as it involves the foundational stages of placental development and maternal-fetal interaction [3]. Malaria infections during this period can disrupt these processes, with potentially severe consequences for pregnancy outcomes [4]. Despite global efforts to combat malaria, its burden on maternal health remains substantial in sub-Saharan Africa, where it accounts for a

significant proportion of pregnancy-related complications [5]. Notably, interventions such as intermittent preventive treatment in pregnancy (IPTp) and insecticide-treated bed nets (ITNs) are typically implemented from the second trimester onward, leaving women in early pregnancy vulnerable to infection and its associated complications [6]. Cervical length, a key indicator of pregnancy viability, has been widely recognized as a predictor of miscarriage and preterm birth [7]. Shortened cervical length in early pregnancy has been associated with increased risks of adverse outcomes, as it reflects changes in cervical integrity often mediated by inflammatory processes [8]. While extensive research has explored cervical changes in various contexts, the relationship between malaria-induced inflammation and cervical shortening during the first trimester remains underexplored [9].



This gap is particularly pertinent in malaria-endemic regions where systemic inflammation due to high parasitemia levels may compromise cervical integrity [10]. Studies suggest that malaria parasites provoke immune responses characterized by elevated pro-inflammatory cytokines, which can alter the structural and functional stability of the cervix [11]. Furthermore, maternal factors such as body mass index (BMI), hemoglobin levels, and parity may exacerbate these effects, compounding risks for adverse pregnancy outcomes [12]. Given the dearth of research linking malaria and cervical shortening in early pregnancy, this study aims to provide critical insights into this relationship [13]. By investigating the prevalence of shortened cervical length among first-trimester pregnant women with malaria and analyzing its associations with systemic health markers, this research seeks to inform clinical practices in antenatal care.

The specific objectives of this study are:

1. To evaluate the prevalence of decreased cervical length in first-trimester pregnant women with malaria.
2. To analyze the relationships between BMI, hemoglobin levels, parity, and malaria severity with cervical length.
3. To assess the implications of these findings for antenatal care practices in malaria-endemic regions.

This investigation builds upon existing evidence and aims to bridge the gap in knowledge regarding malaria's impact on cervical integrity. The findings will serve as a foundation for designing targeted interventions to improve maternal and fetal outcomes in high-risk populations.

2. MATERIALS AND METHODS

2.1. Study Design

This was a cross-sectional study conducted at KAIFA Ultrasound Center, a maternal imaging facility in Damaturu, Yobe State, Nigeria. The study spanned from January 2024 to December 2024 and involved pregnant women in their first trimester.

2.2. Study Population

A total of 200 first-trimester pregnant women diagnosed with malaria were recruited based on the following criteria:

2.2.1. Inclusion Criteria

1. Gestational age ≤ 12 weeks confirmed via ultrasound.
2. Positive laboratory-confirmed malaria diagnosis.
3. Informed consent provided by participants.

2.2.2. Exclusion Criteria

1. Known cervical or uterine anomalies.
2. Chronic medical conditions (e.g., diabetes, hypertension).
3. Multiple gestations.

2.3. Data Collection

Clinical and Demographic Data: Maternal age, BMI, parity, and hemoglobin levels were recorded. Malaria severity was assessed based on parasitemia levels categorized as low, moderate, or high.

Ultrasound Measurements: Cervical length was measured using transabdominal ultrasound with a standardized protocol to ensure accuracy. Measurements were recorded in millimeters (mm).

2.4. Statistical Analysis

1. Descriptive Statistics: Demographic and clinical characteristics were summarized using means, standard deviations, and proportions.
2. Correlation Analysis: Pearson and Spearman correlation coefficients were used to evaluate the relationships between cervical length and independent variables, including BMI, hemoglobin levels, and malaria severity.
3. ANOVA: One-way ANOVA was performed to analyze differences in cervical length across categorical groups:
 - BMI categories: underweight, normal, overweight, and obese.
 - Parasitemia levels: low, moderate, and high.
 - Hemoglobin levels: normal (≥ 10 g/dL) and low (< 10 g/dL).
4. Post-Hoc Testing: Tukey's Honest Significant Difference (HSD) test was conducted to identify pairwise differences between groups when ANOVA indicated significant results.
5. Logistic Regression: Predictors of miscarriage were analyzed using logistic regression models, considering cervical length (≤ 25 mm), BMI (≥ 25 kg/m²), and hemoglobin levels (< 10 g/dL).

3. RESULTS

Table I highlights the distribution of participants by age and BMI. Normal BMI was the most prevalent category (60%), while obesity was the least (5%). These distributions provide a baseline for analyzing the relationship between BMI and cervical length.

Correlation analysis reveals significant inverse relationships between BMI, hemoglobin, parasitemia levels, and

TABLE I: SOCIODEMOGRAPHIC AND CLINICAL CHARACTERISTICS

Variable	Frequency (n = 200)	Percentage (%)
Maternal age (years)		
<20	40	20
20–29	110	55
30–39	45	22.5
>40	5	2.5
BMI (kg/m ²)		
<18.5 (Underweight)	20	10
18.5–24.9 (Normal)	120	60
25–29.9 (Overweight)	50	25
≥ 30 (Obese)	10	5

TABLE II: ASSOCIATIONS BETWEEN MALARIA SEVERITY, BMI, HEMOGLOBIN, AND CERVICAL LENGTH

Variable	Mean cervical length (mm)	Correlation coefficient (r)	p-value
BMI	30.2 ± 5.4	-0.42	<0.001
Hemoglobin (g/dL)	30.2 ± 5.4	0.38	0.002
Parasitemia level			
High	25.6 ± 4.8	-0.50	<0.001
Moderate	28.1 ± 5.2	-	
Low	32.5 ± 6.1	-	

TABLE III: PREDICTORS OF MISCARRIAGE (LOGISTIC REGRESSION)

Predictor	Odds ratio	95% CI	p-value
Cervical length (≤25 mm)	3.5	2.1–5.9	<0.001
BMI (≥25 kg/m ²)	1.8	1.1–3.0	0.02
Hemoglobin <10 g/dL	2.2	1.3–3.7	0.01

TABLE IV: ANOVA RESULTS FOR DIFFERENCES IN CERVICAL LENGTH BY INDEPENDENT VARIABLES

Variable	Groups	Mean cervical length (mm)	F-statistic	p-value
BMI	Underweight	33.1 ± 4.2	6.8	0.002
	Normal	31.5 ± 5.0		
	Overweight	28.7 ± 4.8		
	Obese	26.4 ± 5.5		
Parasitemia level	Low	32.5 ± 6.1	9.4	<0.001
	Moderate	28.1 ± 5.2		
	High	25.6 ± 4.8		
Hemoglobin level	Normal (≥10 g/dL)	30.8 ± 5.4	4.3	0.010
	Low (<10 g/dL)	28.2 ± 4.9		

cervical length (Table II). High parasitemia correlates with the shortest cervical lengths, underscoring its impact.

Cervical shortening has been found to be the strongest predictor of miscarriage (Table III). High BMI and low hemoglobin levels are also significant risk factors.

ANOVA analysis demonstrated significant differences in cervical length across BMI categories, parasitemia levels, and hemoglobin groups (Table IV).

Post-hoc analyses highlight significant differences in cervical length across BMI, parasitemia levels, and hemoglobin groups (Table V). These findings reinforce the importance of considering these factors in antenatal care.

4. DISCUSSION

This study provides critical insights into the multifaceted relationship between malaria severity, systemic health markers, and cervical length in early pregnancy. The findings underscore significant associations, as evidenced by correlation analyses and ANOVA results, supporting the hypothesis that systemic inflammation and nutritional deficits contribute to cervical shortening and subsequent

TABLE V: POST-HOC ANALYSIS FOR CERVICAL LENGTH BY BMI, PARASITEMIA LEVEL, AND HEMOGLOBIN LEVEL

Variable	Comparison groups	Mean difference (mm)	p-value
BMI	Underweight vs. normal	1.6	0.045
	Underweight vs. overweight	4.4	<0.001
	Underweight vs. obese	6.7	<0.001
	Normal vs. overweight	2.8	0.010
	Normal vs. obese	5.1	<0.001
	Overweight vs. obese	2.3	0.015
Parasitemia level	Low vs. moderate	4.4	0.008
	Low vs. high	6.9	<0.001
	Moderate vs. high	2.5	0.020
Hemoglobin level	Normal vs. low	2.6	0.030

pregnancy risks. Our results reveal that higher parasitemia levels are significantly associated with shorter cervical lengths (ANOVA $F = 9.4$, $p < 0.001$). Women with high parasitemia had a mean cervical length of 25.6 mm, compared to 28.1 mm and 32.5 mm in moderate and low parasitemia groups, respectively. This observation aligns with the findings by Feng *et al.* (2021), who reported that systemic inflammation induced by infections compromises cervical integrity [13]. Elevated parasitemia likely exacerbates inflammatory responses, triggering cervical remodeling, as previously suggested by van den Broek *et al.* [14]. Significant differences in cervical length were observed across BMI categories (ANOVA $F = 6.8$, $p = 0.002$). Obese women (≥ 30 kg/m²) exhibited the shortest cervical lengths (26.4 mm), while underweight women (< 18.5 kg/m²) had the longest (33.1 mm) [15]. Correlation analysis further indicated a moderate inverse relationship between BMI and cervical length ($r = -0.42$, $p < 0.001$). These findings are consistent with Romero *et al.* [16], who identified obesity as a risk factor for adverse pregnancy outcomes, potentially mediated by systemic inflammation and hormonal imbalances that weaken cervical structures [17]. Low hemoglobin levels (< 10 g/dL) were significantly associated with reduced cervical length (mean = 28.2 mm; ANOVA $F = 4.3$, $p = 0.01$). Spearman correlation analysis demonstrated a positive relationship between hemoglobin levels and cervical length ($r = 0.38$, $p = 0.002$). These results corroborate prior studies [18] linking maternal anemia to increased miscarriage risks. Anemia likely contributes to hypoxia and oxidative stress, which impair cervical integrity [19].

5. CLINICAL IMPLICATIONS

These findings emphasize the need for integrated antenatal care strategies in malaria-endemic regions:

1. Routine Cervical Length Screening: Implementing ultrasound-based cervical length measurements for at-risk populations could facilitate early identification of pregnancies at risk for miscarriage or preterm birth [20].

2. Targeted Nutritional Interventions: Addressing anemia and obesity through tailored nutritional programs may mitigate their impact on cervical integrity.
3. Enhanced Malaria Management: Strengthening malaria prevention and treatment in the first trimester is critical to reducing systemic inflammation and its adverse effects.

6. LIMITATIONS AND FUTURE RESEARCH

While this study provides valuable insights, its single-center design and cross-sectional methodology limit generalizability and causal inferences. Longitudinal studies across diverse populations are necessary to validate these findings and explore underlying mechanisms in greater depth. Additionally, post-hoc analyses could further delineate subgroup differences, enhancing our understanding of interactions between malaria, BMI, and anemia in cervical shortening.

CONFLICT OF INTEREST

The authors declare that they do not have any conflict of interest.

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