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Pregnancy-Related Hematocrit Changes and Malaria-Associated Anemia with ABO/Rh Blood Group Distribution in Nigerian Women

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Abstract

Objective: Pregnancy is associated with physiological hematologic changes that may be exacerbated by endemic infections such as malaria in sub-Saharan Africa. This study evaluated hematocrit levels, malaria history, and ABO/Rh blood group distribution among Nigerian women.

Materials and Methods: A cross-sectional study was conducted among 45 pregnant women, stratified by trimester, and 45 age-matched nonpregnant controls attending a tertiary hospital in North-Central Nigeria. Hematocrit was measured using an automated hematology analyzer, while ABO and Rh blood groups were determined using standard serological techniques. Malaria exposure within the preceding 12 months was assessed using a structured questionnaire; among pregnant women, malaria infection within the preceding 12 months was additionally confirmed by microscopy or hospital records. Associations were examined using independent t-tests, one-way analysis of variance (ANOVA), and chi-square tests, with statistical significance set at $p<0.05$.

Results: Mean hematocrit was significantly lower among pregnant women compared with nonpregnant controls (33.14% ± 2.86% vs 34.36% ± 2.99%; $p=0.020$). Hematocrit values did not differ significantly across pregnancy trimesters ($p=0.742$). A history of confirmed malaria infection within the preceding 12 months was associated with a reduction in hematocrit among pregnant women (32.26% ± 2.85% vs 34.22% ± 2.49%; $p=0.020$). Blood group O positive was the most prevalent phenotype (33.3%), and ABO/Rh distribution did not differ significantly between pregnant and nonpregnant women.

Conclusion: Pregnancy in this Nigerian population was associated with a modest but physiologically appropriate reduction in hematocrit, while recent malaria infection produced an additional, clinically important decline. The observed ABO/Rh distribution follows expected regional patterns.

Keywords: Hematocrit, pregnancy, anemia, ABO blood group, Rh blood group, malaria, Nigeria

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INTRODUCTION

Pregnancy induces substantial hematological and hemodynamic adaptations required to support maternal and fetal oxygen demands (1). An expansion of plasma volume greater than the increase in red blood cell mass results in dilutional reductions in hematocrit and hemoglobin concentrations, commonly referred to as the "physiological anemia of pregnancy" (2,3). Although adaptive, this process may be exacerbated by nutritional deficiencies and infections, leading to clinically significant anemia.

Anemia in pregnancy remains a major public health concern in sub-Saharan Africa and is associated with adverse outcomes including preterm birth, low birth weight, small-for-gestational-age infants, and increased maternal mortality (4,5). In Nigeria, malaria continues to be a major contributor to anemia during pregnancy through mechanisms such as hemolysis and suppression of erythropoiesis (6,7).

In addition to hematological indices, the distribution of ABO and Rh blood groups has important clinical implications in obstetric practice (8). Understanding population-specific blood group patterns is essential for effective blood donor recruitment, transfusion preparedness, and prevention of hemolytic disease of the newborn (9). Despite these implications, data from North-Central Nigeria remain limited, particularly regarding the interaction between pregnancy-related hematocrit changes, malaria exposure, and ABO/Rh blood group distribution.

Therefore, this study aimed to compare hematocrit levels between pregnant women and age-matched nonpregnant controls, evaluate the effect of recent confirmed malaria infection on hematocrit in both pregnant and nonpregnant women, and describe the ABO and Rh blood group distribution in this population to support antenatal transfusion preparedness and local blood stock planning.

MATERIALS AND METHODS

Study Design and Setting

This cross-sectional analytical study was carried out at the antenatal clinic of the University of Ilorin Teaching Hospital (UITH) in Ilorin, Kwara State, North-Central Nigeria.

Ethical approval was obtained from the Institutional Review Board of the University of Ilorin Teaching Hospital (approval no.: UITH/CAT/189/VOL.17A/537). Written informed consent was obtained from all participants, and confidentiality was maintained using unique study identifiers.

Study Population and Sample Size

The study population comprised 45 pregnant women, stratified equally by gestational age into three trimester-based groups (15 women per trimester), and 45 age-matched nonpregnant women recruited from the community and hospital staff as controls. Pregnant participants were enrolled consecutively during routine antenatal clinic visits using a convenience sampling method, based on eligibility and willingness to participate within the study period. The final sample size was determined by feasibility within the study period, with equal trimester allocation to ensure internal comparability. Similar sample sizes have been employed in hospital-based hematological studies in comparable settings and have been shown to be sufficient for detecting clinically meaningful differences in hematocrit levels (10,11).

Eligibility Criteria

Eligible participants were pregnant women aged 18–45 years with confirmed viable singleton pregnancies. Controls were nonpregnant women aged 18–45 years with no pregnancy in the preceding 12 months. Participants with active systemic infection, known hemoglobinopathies, chronic medical conditions affecting hematological parameters, recent blood transfusion (within three months), hematological malignancy, or current use of antiretroviral or immunosuppressive therapy were excluded.

Data Collection

Trained research assistants administered a structured questionnaire to obtain sociodemographic characteristics, obstetric history, current pregnancy details, iron supplementation, bed net use, and self-reported malaria history within the preceding 12 months. Among pregnant women, recent malaria infection was further ascertained by review of hospital records and peripheral blood smear microscopy performed at or around the time of recruitment. For nonpregnant controls, malaria exposure within the past 12 months was based on self-reported episodes that had been previously confirmed by microscopy or hospital diagnosis; no additional parasitological testing was performed at enrollment.

Laboratory Procedures

Venous blood samples (5 mL) were collected aseptically from the antecubital vein into EDTA K_3 tube (3 mL) for hematocrit measurement and plain tube (2 mL) for blood grouping. Hematocrit was measured using an automated hematology analyzer (Sysmex XN-350; Sysmex Corporation, Kobe, Japan). ABO and Rh blood groups were determined using standard tube and tile agglutination methods with commercially prepared antisera. All samples were processed within 4 hours of collection and stored at room temperature (20–25°C) prior to analysis.

Statistical Analysis

Data were analyzed using SPSS version 22.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as means ± standard deviation (SD) and compared between groups using independent t-tests. Categorical variables were summarized as frequencies and percentages and compared using chi-square tests. All statistical tests were two-tailed, and $p<0.05$ was considered statistically significant.

RESULTS

Sociodemographic Characteristics

A total of 45 pregnant women were enrolled. The majority were aged 26–35 years (80.0%), and most had at least secondary education, with 60.0% having completed university education (Table 1). Mean hematocrit values did not differ significantly across age groups, occupational categories, or educational levels (all $p>0.05$; Table 1).

Hematocrit Levels by Pregnancy Status

Mean hematocrit was significantly lower among pregnant women compared with nonpregnant controls (33.14% ± 2.86% vs. 34.36% ± 2.99%; mean difference, 1.22%; 95% confidence interval [CI], 0.08–2.36; $p=0.020$) (Table 2). This finding indicates a modest but statistically significant reduction in hematocrit associated with pregnancy.

Obstetric, Nutritional, and Clinical Variables in Pregnant Women

Obstetric assessment showed that 44.4% of pregnant participants were *primigravida*, 35.6% *multigravida*, and 20.0% grand *multigravida* (Table 3). A history of miscarriage or abortion was reported by 22.2% and 84.4% reported iron supplementation, while 57.8% reported insecticide-treated bed net use (Table 3).

Mean hematocrit did not differ significantly by gestational trimester, gravidity status, history of miscarriage, iron supplementation, or bed net use (all $p>0.05$). In contrast, a history of malaria infection within the preceding 12 months was associated with significantly lower hematocrit: women with malaria history had a mean hematocrit of 32.26% ± 2.85%, compared with 34.22% ± 2.49% among those without such history (mean difference 1.96%; 95% CI, 0.29–3.63; $p=0.020$), corresponding to an approximately 5.7% relative reduction (Table 3).

Hematocrit Levels by Malaria History in Pregnant and

Table 1. Sociodemographic characteristics and hematocrit levels among pregnant women (n=45).

Characteristics	Category	n (%)	Mean hematocrit ± SD (%)	*p*-value*
Age (years)	18–25	7 (15.6)	31.96 ± 3.79	0.284
	26–35	36 (80.0)	33.46 ± 2.53	
	36–45	2 (4.4)	31.25 ± 2.84	
Occupation	Employed	20 (44.4)	32.80 ± 2.44	0.552
	Unemployed	7 (15.6)	34.50 ± 2.15	
	Self-employed	13 (28.9)	33.15 ± 2.48	
	Student	5 (11.1)	32.48 ± 5.53	
Educational level	Primary	2 (4.4)	29.60 ± 0.42	0.301
	Secondary	13 (28.9)	33.04 ± 2.18	
	Graduate	27 (60.0)	33.25 ± 2.99	
	Postgraduate	3 (6,7)	34.08 ± 3.31	

SD: Standard deviation.
**p*-values from one-way ANOVA.

Table 2. Comparison of hematocrit levels between pregnant and non-pregnant women.

Group	Mean hematocrit (%) ± SD	Mean difference (95% CI)	*p*-value*
Pregnant (n=45)	33.14 ± 2.86	1.22 (0.08–2.36)	0.020
Non-pregnant (n=45)	34.36 ± 2.99	–	–

SD: Standard deviation, **CI:** Confidence interval.
*Independent samples t-test.

Table 3. Hematocrit levels in relation to obstetric, nutritional, and clinical variables (n=45).

Characteristics	Category	n (%)	Mean hematocrit ± SD (%)	*p*-value*
Gestational trimester	1st trimester	15 (33.3)	33.17 ± 2.59	0.742
	2nd trimester	15 (33.3)	33.51 ± 2.88	
	3rd trimester	15 (33.3)	32.70 ± 3.15	
Gravidity	*Primigravida*	20 (44.4)	33.17 ± 2.59	0.170
	Multigravida	16 (35.6)	33.51 ± 2.88	
	Grand multigravida	9 (20.0)	32.72 ± 3.11	
History of miscarriage	Yes	10 (22.2)	32.79 ± 2.59	0.674
	No	35 (77.8)	33.23 ± 2.93	
Iron supplementation	Yes	38 (84.4)	33.13 ± 2.91	0.988
	No	7 (15.6)	33.11 ± 2.64	
Bed-net use	Yes	26 (57.8)	33.06 ± 2.72	0.855
	No	19 (42.2)	33.22 ± 3.06	
Malaria history (past 12 months)	Yes	25 (55.6)	32.26 ± 2.85	0.020*
	No	20 (44.4)	34.22 ± 2.49	

SD: Standard deviation.
*p=0.020 indicates statistical significance; *p*-values from independent t-tests or one-way ANOVA as appropriate.

Nonpregnant Controls

Among pregnant women, 25 (55.6%) reported at least one microscopy- or hospital-confirmed malaria episode within the preceding 12 months, whereas 20 (44.4%) reported no malaria episode in that period (Table 4). Among nonpregnant controls, 9 (20.0%) reported at least one confirmed malaria episode in the past 12 months, while 36 (80.0%) reported no malaria episode.

Pregnant women with recent malaria had lower mean hematocrit than those without such history (32.26% ± 2.85% vs. 34.22% ± 2.49%), consistent with the pattern observed in Table 3. In nonpregnant controls, mean hematocrit was slightly lower in women with prior malaria compared with those without (33.9% ± 3.1% vs. 34.6% ± 2.9%), but this difference was small and not statistically significant (Table 4).

ABO and Rh Blood Group Distribution

Blood group O positive (O+) was the most prevalent phenotype among pregnant women (33.3%), followed by B positive (24.4%) and AB positive (24.4%), whereas A positive was less common (15.6%) and O negative was rare (2.2%) (Table 5). ABO and Rh distributions were similar between pregnant and nonpregnant women, with no statistically significant difference observed (χ^2=2.14; p=0.143) (Table 5). The observed distribution is consistent with reported frequencies in Nigerian and West African populations. It is noted, however, that in this cohort AB positive (24.4%) was more prevalent than A positive (15.6%), which diverges from the typical West African ranking where group A (20–27%) exceeds group AB (1–5%) (12–14). This observed pattern is retained as reported from the data and is discussed in context.

DISCUSSION

This study demonstrates a modest but statistically significant reduction in hematocrit among pregnant women compared with age-matched nonpregnant controls, consistent with physiological hemodilution during pregnancy (1,15). The magnitude of this difference aligns with the expected dilutional fall in hematocrit that accompanies plasma volume expansion in normal gestation (3,11,16). The absence of significant variation in hematocrit across trimesters suggests that hematological adaptations occur relatively early and then stabilize in the absence of additional pathological stressors.

Table 4. Hematocrit levels by malaria history in pregnant women (n=45) and non-pregnant controls (n=45).

Group	Malaria history (past 12 months) *	n	Mean hematocrit ± SD (%)
Pregnant women	Yes	25	32.26 ± 2.85
Pregnant women	No	20	34.22 ± 2.49
Non-pregnant controls	Yes	9	33.9 ± 3.1
Non-pregnant controls	No	36	34.6 ± 2.9

SD: Standard deviation.
*Malaria history based on microscopy- or hospital-confirmed episodes.

Table 5. ABO and Rh blood group distribution in pregnant women (n=45) and non-pregnant controls (n=45).

Blood group	Pregnant (n=45) n (%)	Control (n=45) n (%)	Total (n=90) n (%)	*p*-value
A+	7 (15.6)	9 (20.0)	16 (17.8)	χ^2=2.14; p=0.143
B+	11 (24.4)	12 (26.7)	23 (25.6)	
AB+	11 (24.4)	5 (11.1)	16 (17.8)	
O+	15 (33.3)	18 (40.0)	33 (36.7)	
O−	1 (2.2)	1 (2.2)	2 (2.2)	
Total	**45 (100)**	**45 (100)**	**90 (100)**	

The mean hematocrit of 33.14% observed in this cohort is slightly higher than values reported in some Nigerian studies, where anemia prevalence among pregnant women ranges from 35% to 76.5% (17,18). This comparatively better profile may reflect the urban tertiary-care setting, greater uptake of iron supplementation, relatively better nutrition, and the exclusion of women with significant chronic comorbidities. Nonetheless, the observed reduction in hematocrit relative to nonpregnant controls underscores the continuing burden of pregnancy-related anemia in this context and its potential contribution to adverse obstetric outcomes described previously.

Age, occupation, and educational level were not significantly associated with hematocrit among pregnant women, in contrast to reports linking older maternal age, low educational attainment, and lower socioeconomic status with increased anemia risk (19,20). The lack of strong sociodemographic gradients may reflect relatively uniform access to antenatal care and supplementation in this population, as well as the limited power to detect modest differences. Variability across studies highlights the need for larger, population-based investigations to better delineate demographic and socioeconomic determinants of hematological status in pregnancy.

Malaria infection emerged as the principal clinical determinant of hematocrit reduction among pregnant women. Those with a recent microscopy- or hospital-confirmed malaria episode within the preceding 12 months had an almost 2% absolute and approximately 5.7% relative reduction in hematocrit compared with women without such history, a difference that is both statistically and clinically important (6,7). This finding is consistent with established mechanisms of malaria-associated anemia, including hemolysis of parasitized and nonparasitized erythrocytes, splenic sequestration, and inflammatory suppression of erythropoiesis (6,7,21,22). Similar patterns reported from other malaria-endemic settings reinforce malaria as a major modifiable contributor to anemia during pregnancy (22,23). The smaller, nonsignificant difference in hematocrit by malaria history among nonpregnant controls suggests that the physiological milieu of pregnancy amplifies the hematological impact of malaria.

Despite high reported uptake of iron supplementation, no significant association was observed between self-reported iron use and hematocrit levels. This may reflect adequate baseline iron status in some women, variable adherence to prescribed supplements, and the counteracting effects of concurrent infection and inflammation, particularly malaria (24). Evidence from other settings indicates that hematological responses to iron-folate supplementation can be delayed or blunted in the presence of infection and may require prolonged, well-supervised therapy to produce measurable improvements (2,24). The absence of direct measurements of iron indices, vitamin B12 and folate concentrations, inflammatory markers, and renal and hepatic function parameters in the present study limits more detailed mechanistic interpretation.

The ABO and Rh blood group distribution in this cohort closely mirrors previously described Nigerian and West African patterns, with a predominance of blood group O and low prevalence of Rh-negative phenotypes, and no meaningful differences between pregnant and nonpregnant women (12–14,25). These findings have practical implications for obstetric transfusion services, supporting planning for adequate stocks of group O blood and reinforcing the need for systematic antenatal Rh typing and targeted anti-D immunoprophylaxis to prevent alloimmunization and hemolytic disease of the fetus and newborn (12,25,26).

This study has limitations. Its cross-sectional design precludes causal inference regarding temporal relationships among pregnancy, malaria infection, and changes in hematocrit. Malaria in pregnant women was confirmed by microscopy at or around recruitment, whereas malaria status in nonpregnant controls was based on recalled, previously confirmed episodes without contemporaneous testing, which may have introduced misclassification and residual confounding. Iron indices, vitamin B12 and folate levels, inflammatory markers, and renal and hepatic function tests were not measured, as these investigations were not included in the original study protocol; therefore, baseline profiles for these parameters could not be generated for either group, which limits the ability to distinguish physiological hemodilution from anemia driven by nutritional deficiencies or chronic inflammation. The modest sample size, particularly within malaria-exposed subgroups, may also have reduced power to detect smaller differences and constrained multivariable modelling.

CONCLUSION

Pregnancy in this Nigerian cohort was associated with a modest, physiologically appropriate reduction in hematocrit, which was further worsened by malaria infection within the preceding 12 months. ABO and Rh distributions mirrored regional patterns, supporting antenatal transfusion planning and targeted Rh prophylaxis in malaria-endemic settings. These findings underscore the need to strengthen integrated malaria prevention strategies during antenatal care, alongside routine hematological monitoring. Health facilities should apply locally generated blood group distribution data to optimize obstetric transfusion preparedness. Future multicenter studies with standardized parasitological confirmation and comprehensive nutritional indices are warranted to better distinguish physiological hemodilution from pathology-driven anemia.

Ethical Approval: This study was approved by the Institutional Review Board of the University of Ilorin Teaching Hospital on February 5, 2025, with decision no. UITH/CAT/189/VOL.17A/537.

Informed Consent: Written informed consent was obtained from all participants.

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