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Prevalence of Iron Deficiency Anaemia and Biochemical Markers of Iron Status Among Pregnant Women Attending Specialist Hospital, Sokoto

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Abstract

Background: Iron-deficiency anaemia (IDA) remains a major nutritional disorder among pregnant women in low- and middle-income countries. Accurate assessment of iron status using reliable biochemical markers is essential for effective antenatal care. This study determined the prevalence of iron-deficiency anaemia and evaluated haematological and biochemical markers of iron status among pregnant women attending a specialist hospital in Sokoto, Nigeria.

Materials and Methods: A descriptive cross-sectional study was conducted among 270 pregnant women aged 18 - 44 years attending antenatal clinics at the Specialist Hospital, Sokoto. Data collected included socio-demographic and obstetric characteristics, haematological indices, and iron status parameters — serum ferritin, serum iron, and total iron-binding capacity.

Results: The prevalence of IDA among participants was 65.9% (178/270). Iron-deficiency anaemia was significantly more common in women of low socio-economic status than in those of middle or high status (80.5% vs. 49.1%; $p < 0.001$). Women with high parity (≥4 deliveries) had a higher prevalence of IDA than those with ≤3 deliveries (75.6% vs. 57.4%; $p = 0.028$). Similarly, IDA was more prevalent among women not receiving iron supplementation than among those who were (78.1% vs 59.3%; $p = 0.031$).

Women with IDA had significantly lower mean haemoglobin, haematocrit, serum iron, serum ferritin, transferrin saturation, mean corpuscular volume, and mean corpuscular haemoglobin than non-IDA women (all $p < 0.001$).

On multivariable logistic regression, low socio-economic status (adjusted odds ratio [aOR] = 3.15, 95% CI: 1.90–5.22), high parity (aOR = 2.08, 95% CI: 1.08–3.99), and lack of iron supplementation (aOR = 1.92, 95% CI: 1.05–3.50) were identified as independent predictors of IDA.

Conclusion: Iron-deficiency anaemia is highly prevalent among the studied pregnant women in Sokoto. Low socio-economic status, high parity, and inadequate iron supplementation are significant predictors of IDA. Incorporating biochemical markers such as serum ferritin into routine antenatal screening, alongside strengthened nutritional interventions, may improve early detection and maternal outcomes.

Key words: Prevalence, Iron Deficiency Anaemia, Pregnant Women, Serum Ferritin

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Introduction

Anaemia during pregnancy continues to be a major public health concern, particularly in low- and middle-income countries (LMICs) (1). According to the World Health Organisation, approximately 41.8% of pregnant women globally are affected by anaemia, with iron deficiency accounting for most of these cases (2). During pregnancy, physiological changes such as increased plasma volume, increased iron requirements for fetal growth, placental development, and red cell mass production all contribute to the risk of iron deficiency and, consequently, iron deficiency anaemia (IDA) (3). In sub-Saharan Africa, this problem is further exacerbated by malaria, helminth infections, poor nutrition, and limited access to quality antenatal care (4).

In Nigeria, the situation is particularly critical. National surveys report anaemia in pregnancy prevalence rates of up to 50–60% (4). However, these numbers often refer broadly to anaemia (haemoglobin < 11 g/dL) rather than specifically to iron-deficiency anaemia. More focused studies show that the prevalence of IDA among pregnant women ranges from about 25% to 45.6% in Nigeria (2). For example, a recent study in Lagos and Kano found that 41% of pregnant women with moderate or severe anaemia had serum ferritin levels <30 ng/mL, i.e., iron deficiency (5). Another rural Nigerian study reported a prevalence of iron deficiency (ferritin < 15 µg/L) at 40.8% and IDA at 23.6% (6). These findings highlight the high burden of iron deficiency among pregnant Nigerian women.

Serum ferritin is widely regarded as a sensitive and specific marker of body iron stores and, when reduced, serves as a reliable indicator of iron deficiency. It remains the most commonly used non-invasive test for assessing iron deficiency during pregnancy (7). However, determining appropriate cut-off values in pregnant women is complicated by physiological changes and the influence of inflammation on ferritin concentrations. Studies vary in their choice of the 3 serum ferritin thresholds: <12 ng/mL, <15 ng/mL, and <30 ng/mL (7). However, the serum ferritin level of <15 ng/mL is considered the long-standing consensus threshold, which balances high specificity with moderate sensitivity, and is recommended in WHO guidelines for adults (8).

Determining the prevalence of iron deficiency anaemia (IDA) among pregnant women in specific settings is essential for guiding local maternal health initiatives (9). Furthermore, assessing the usefulness of serum ferritin as a diagnostic marker in antenatal care could enhance screening practices, especially in resource-limited environments (10). Evidence from Nigeria indicates that up to 41% of pregnant women with moderate to severe anaemia have iron deficiency, as shown by low serum ferritin levels (5). In another study involving rural pregnant women in Nigeria, 40.8% had serum ferritin concentrations below 15 µg/L, and 23.6% were identified as having IDA despite iron supplementation, indicating persistent iron depletion (6). These findings highlight the substantial burden of IDA and emphasise the importance of early detection.

Although several studies have assessed iron deficiency and iron deficiency anaemia among pregnant women in Nigeria and other African countries, most of them have focused on haemoglobin concentration or a limited set of biochemical markers rather than a comprehensive panel of iron status indicators. For example, Ajepe and colleagues reported a 12.3% prevalence of iron deficiency anaemia in Lagos using haemoglobin and serum ferritin measurements. They recommended additional markers, such as transferrin saturation, to improve sensitivity (11). Systematic evidence from sub-Saharan Africa also highlights the high anaemia burden, while studies using multiple biochemical iron indices remain scarce (12). To the best of our knowledge, no prior study from Sokoto, Nigeria, has evaluated iron deficiency anaemia using a comprehensive panel of iron biomarkers such as serum ferritin, serum iron, total iron-binding capacity, and transferrin saturation in the same cohort, thereby justifying the current investigation.

Against this background, the present study was aimed to determine the prevalence of iron deficiency anaemia among pregnant women attending Specialist Hospital, a tertiary health centre in Sokoto, using serum ferritin as a diagnostic indicator. The study also explored the relationship between selected socio-demographic and obstetric factors and iron deficiency anaemia in this population.

Materials and Methods

Study Design and Population

This descriptive cross-sectional study was conducted at the Specialist Hospital, Sokoto, Nigeria, a major referral centre that provides antenatal care services to women from Sokoto metropolis and its surrounding rural communities.

Sample Size Determination

The study population comprised 270 pregnant women aged 18-44 years attending the antenatal clinic. The minimum sample size was calculated using the formula for an infinite population (13): $n = Z^2pq / d^2$

Where n is the minimum required sample size, Z is the standard normal deviate at 95% confidence level (1.96), p is the estimated prevalence of pregnant women with inadequate iron status (0.20) (14), q = 1 - p = 0.80, and d is the desired precision (0.05). Substituting the values: n = (1.96)2 · 0.2 · 0.8 (0.05)2 = 245.

In order to control for a potential 10% rate of attrition, 25 participants were added to the sample size, giving a total of 270 pregnant women who were ultimately recruited for the study. Participants were selected through systematic random sampling, and informed written consent was obtained from each participant after the study objectives were explained in English or Hausa.

Ethical Consideration

Ethical approval for the study was obtained from the Ethics Committee of the Specialist Hospital, Sokoto. No formal approval number was issued; the approval letter is available upon request. To avoid confounding effects, women with known chronic illnesses, haemoglobinopathies, or recent blood transfusions were excluded. Informed written consent was obtained from all participants before data and sample collection began.

Study Participants

Participants were categorised into the second (14-27 weeks) and third (≥28 weeks) trimesters based on gestational age calculated from the last menstrual period or ultrasound records. Socio-economic status was determined using a composite score of education, occupation, and monthly income, and categorised as high, middle, or low according to a standardised scoring system. Data on socio-demographic and obstetric characteristics were collected using a structured, interviewer-administered questionnaire.

Sample Collection and Processing

Five millilitres of venous blood were collected from each participant, using aseptic techniques, into plain and Ethylenediaminetetraacetic acid (EDTA) tubes. The EDTA sample was used for haematological analysis. At the same time, the blood in the plain tubes was allowed to clot for about 10 minutes and then centrifuged at 5000 rpm for 10 minutes to obtain serum, which was used for biochemical analysis.

Haematological analysis

Haemoglobin concentration, haematocrit, and red cell indices were determined using an automated haematology analyser (Sysmex KX-21N).

Biochemical analysis

Serum was separated and used to measure ferritin, iron, and total iron-binding capacity (TIBC) using enzyme-linked immunosorbent assay (ELISA) kits from Randox, UK. Transferrin saturation (TS) was calculated as serum iron divided by TIBC, multiplied by 100. Anaemia in pregnancy was defined as a haemoglobin concentration below 11.0 g/dL in accordance with the WHO (2021) criteria. Iron deficiency was defined as a serum ferritin concentration less than 15 µg/L. Participants with both low haemoglobin and low ferritin levels were classified as having iron deficiency anaemia (IDA).

Statistical analysis

Data were entered and analysed using IBM SPSS version 25. Descriptive statistics were expressed as means ± standard deviation (SD) for continuous variables and percentages for categorical variables. Associations between categorical variables were assessed using the Chi-square test. Multivariable logistic regression analysis was performed to identify independent predictors of IDA among the study participants. Statistical significance was set at $p < 0.05$. Data completeness was assessed before analysis, and complete-case analysis was used for variables with missing values. The proportion of missing data was minimal and did not materially affect the results.

Results

A total of 270 pregnant women aged 18-44 years participated in the study. Of these, 129 (47.8%) were in their second trimester, while 141 (52.2%) were in the third trimester of gestation. Participants belonged to varying socio-economic classes, ranging from high to low.

Association between Socio-economic Status and Serum Ferritin Level

Using a serum ferritin cut-off value of <15 µg/L to define iron deficiency, a statistically significant association was observed between socio-economic status and serum ferritin levels across both trimesters ($p < 0.001$).

In the second trimester, 50 (38.8%) of the 129 women were iron-deficient, while 79 (61.2%) had normal ferritin levels. Among iron-deficient women, the majority belonged to the low socio-economic class (54.0%), followed by the middle (24.0%) and high classes (22.0%). In contrast, most non-iron-deficient women were from the high socio-economic class (84.8%).

Similarly, in the third trimester, iron deficiency was observed in 128 (90.8%) women, while only 13 (9.2%) were non-iron deficient. Nearly half of the iron-deficient women in the third trimester belonged to the low socio-economic class (49.2%). In contrast, non-iron-deficient women were predominantly from the high socio-economic class (61.5%). Overall, iron deficiency was more prevalent among women of low socio-economic status across all trimesters.

Table 1: Association between socio-economic status and serum ferritin levels among pregnant women by trimester (n = 270)

Socio-economic Class	**ST (n = 129)**			**TT(n = 141)**			**Total (n = 270)**	**p-value**
	Anaemic (n, %)	**Non-anaemic (n, %)**	**Total (n, %)**	**Anaemic (n, %)**	**Non-anaemic (n, %)**	**Total (n, %)**		
High	11 (22.0)	67 (84.8)	78 (60.5)	31 (24.2)	8 (61.5)	39 (27.7)	117 (43.3)	<0.001
Middle	12 (24.0)	9 (11.4)	21 (16.3)	34 (26.6)	4 (30.8)	38 (27.0)	59 (21.9)	
Low	27 (54.0)	3 (3.8)	30 (23.3)	63 (49.2)	1 (7.7)	64 (45.3)	94 (34.8)	
Total	50 (38.8)	79 (61.2)	129 (100)	128 (90.8)	13 (9.2)	141 (100)	270 (100)	

Iron deficiency was defined as serum ferritin < 15 µg/L. Values are presented as frequencies and percentages. Associations between socio-economic status and ferritin status were assessed using the Chi-square test. $P < 0.001$ indicates a significant association between socio-economic status and serum ferritin levels in both trimesters. Statistical significance was set at $p < 0.05$. ST = Second trimester; TT = Third trimester.

Association between Maternal Factors and Iron-Deficiency Anaemia

Significant association was found between iron-deficiency anaemia (IDA) and various maternal factors. Women from low socio-economic backgrounds had a significantly higher prevalence of IDA compared with those from middle or high socio-economic classes ($p < 0.001$).

Also, women who had four or more deliveries were more likely to be anaemic than those with three or fewer deliveries ($p = 0.028$). In addition, women who were not on iron supplementation had a significantly higher prevalence of IDA than those receiving supplements ($p = 0.031$). Maternal age, level of education, and gestational age were not significantly associated with IDA ($p > 0.05$).

Table II. Association between selected maternal factors and iron-deficiency anaemia in pregnancy.

Variable	**Categories**	**IDA Present (%)**	**IDA Absent (%)**	**p-value**
Socio-economic status	Low	80.5	19.5	<0.001
	Middle/High	49.1	50.9	
Parity	≤ 3 deliveries	57.4	42.6	0.028
	≥ 4 deliveries	75.6	24.4	
Iron supplementation	Yes	59.3	40.7	0.031
	No	78.1	21.9	
Gestational age	2nd / 3rd trimester	66.2 / 68.0	33.2 / 32.0	0.537

Iron-deficiency anaemia (IDA) was defined as haemoglobin concentration < 11.0 g/dL in the presence of serum ferritin < 15 µg/L. Values are presented as percentages. Associations between categorical variables and IDA were assessed using the Chi-square test. A p-value < 0.05 was considered statistically significant. IDA = Iron Deficiency Anaemia.

Haematological and Biochemical Markers Stratified by IDA Status

Comparisons of haematological and biochemical parameters between women with IDA and those without IDA are presented in Table 3.3. Overall, women with IDA showed a significantly lower mean haemoglobin, haematocrit, serum iron, serum ferritin, transferrin saturation, mean corpuscular volume (MCV), and mean corpuscular haemoglobin (MCH) values than women without IDA ($p < 0.001$).

Total iron-binding capacity (TIBC) was also significantly higher among women with IDA than those without IDA.

Table III. Distribution of haematological and biochemical markers among pregnant women by iron-deficiency anaemia status.

Variable	IDA (n = 178) Mean ± SD	Non-IDA (n = 92) Mean ± SD	p-value
Haemoglobin (g/dL)	9.8 ± 1.4	11.6 ± 1.2	<0.001
Haematocrit (%)	30.5 ± 3.9	35.1 ± 4.0	<0.001
Serum iron (µg/dL)	48.2 ± 20.1	61.7 ± 23.2	<0.001
TIBC (µg/dL)	365.2 ± 46.3	353.1 ± 50.1	0.045
TSAT (%)	15.0 ± 6.8	19.3 ± 7.1	<0.001
Serum ferritin (µg/L)	11.2 ± 6.3	21.8 ± 8.2	<0.001
MCV (fL)	78.6 ± 7.2	82.5 ± 6.4	<0.001
MCH (pg)	26.1 ± 2.8	28.4 ± 3.0	<0.001

Values are presented as mean ± standard deviation. Comparisons between the IDA and non-IDA groups were performed using an independent-samples t-test. A p-value < 0.05 was considered statistically significant. Hb = Haemoglobin; HCT = Haematocrit; MCV = Mean Corpuscular Volume; MCH = Mean Corpuscular Haemoglobin; SI = Serum Iron; TIBC = Total Iron-Binding Capacity; TS = Transferrin Saturation; IDA = Iron Deficiency Anaemia; SD = Standard Deviation.

Predictors of Iron-Deficiency Anaemia

Low socio-economic status emerged as a strong predictor of IDA after adjusting for potential confounders (adjusted odds ratio [aOR] = 3.15; 95% CI: 1.90 - 5.22; $p < 0.001$).

High parity (≥4 deliveries) was associated with approximately two-fold increased odds of IDA (aOR = 2.08; 95% CI: 1.08 - 3.99; p = 0.028), while lack of iron supplementation was also an independent predictor (aOR = 1.92; 95% CI: 1.05 - 3.50; p = 0.031). Gestational age and maternal age were not significant predictors of IDA after adjustment.

Table IV. Multivariable logistic regression analysis of predictors of iron-deficiency anaemia among pregnant women.

Variable	Adjusted Odds Ratio (aOR)	95% CI	p-value
Socio-economic status (Low vs Middle/High)	3.15	1.90-5.22	<0.001
Parity (≥4 vs ≤3)	2.08	1.08-3.99	0.028
Iron supplementation (No vs Yes)	1.92	1.05-3.50	0.031
Gestational age (Third vs Second Trimester)	1.12	0.62-2.03	0.710
Maternal age (>30 vs ≤30 years)	1.05	0.60-1.84	0.870

Results are presented as adjusted odds ratios (aOR) with 95% confidence intervals (CI). Variables entered into the model included socio-economic status, parity, iron supplementation status, maternal age, and gestational age. Statistical significance was set at $p < 0.05$.

Discussion

Iron-deficiency anaemia (IDA) represents a clinical condition of major public health concern among pregnant women, particularly in low- and middle-income countries. This study assessed the prevalence of IDA and evaluated biochemical and haematological markers of iron status among pregnant women attending a specialist hospital in Sokoto, Nigeria. The findings demonstrate a high burden of IDA, with significant associations among iron deficiency, socio-economic status, parity, and iron supplementation practices.

The overall prevalence of anaemia in this study was 71.1%, while iron-deficiency anaemia (IDA), defined by serum ferritin levels below 15 µg/L and low haemoglobin, was observed in 65.9% of participants. This finding is consistent with reports from other parts of Nigeria, where IDA prevalence among pregnant women has been reported to range between 25% and 45.6% depending on the population studied and diagnostic criteria used (2,5). The higher prevalence observed in the present study may reflect regional differences in dietary iron intake, socio-economic conditions, and access to quality antenatal care services. These findings align with recent reports from Nigeria indicating that a large proportion of pregnant women have depleted iron stores (5,6). Variations across studies—some showing higher or lower prevalence—are expected and may be attributed to differences in study settings, sampling methods, ferritin cut-off points, seasonal factors, and the proportion of women receiving iron supplementation (5).

Globally, anaemia affects approximately 41.8% of pregnant women, with iron deficiency accounting for the majority of cases (15). In sub-Saharan Africa, the burden is disproportionately higher due to factors such as food insecurity, recurrent infections, and limited healthcare resources (3). The present findings, therefore, align with global and regional trends and reinforce the need for context-specific strategies to improve maternal iron status.

A key finding of this study is the strong association between low socio-economic status and iron deficiency across both second and third trimesters. Women from lower socio-economic backgrounds were significantly more likely to have depleted iron stores, as reflected by low serum ferritin concentrations. This observation is consistent with previous Nigerian and African studies that have shown socio-economic disadvantage to be a major determinant of poor maternal nutritional status (2,4).

Low socio-economic status often limits access to iron-rich foods, dietary diversity, and timely antenatal care, including iron supplementation. Also, women from poor households have a higher likelihood of being exposed to infections and being of higher parity, both of which increase iron requirements during pregnancy. These factors may explain the observed association and highlight the importance of socio-economic considerations in antenatal nutritional interventions. This trend aligns with findings from other studies conducted in Nigeria and across sub-Saharan Africa, which link poverty, limited dietary diversity, and inadequate access to antenatal care to poorer iron status (6,16).

The present study also demonstrated a significant association between high parity (≥4 deliveries) and iron-deficiency anaemia. This finding is probably due to the cumulative depletion of maternal iron stores arising from repeated pregnancies without adequate spacing. Similar associations between high parity and anaemia have been reported in Nigerian and other African populations (2,3).

In the current study, iron supplementation was protective, evidenced by the finding that women not receiving supplements were significantly more likely to have IDA. This finding supports current World Health Organisation recommendations for routine iron supplementation during pregnancy to prevent maternal anaemia and associated adverse outcomes (15). However, the persistence of high IDA prevalence despite supplementation suggests potential issues with late initiation of antenatal care, poor adherence, or inadequate dosing, warranting further investigation.

Comparison of haematological and biochemical indices between IDA and non-IDA participants revealed significant differences in haemoglobin, haematocrit, serum iron, serum ferritin, transferrin saturation, mean corpuscular volume (MCV), and mean corpuscular haemoglobin (MCH). Women with IDA consistently exhibited lower values for these parameters, while total iron-binding capacity (TIBC) was higher, reflecting depleted iron stores and compensatory upregulation of iron-binding proteins.

Serum ferritin emerged as a particularly valuable marker for assessing iron status, consistent with previous studies that regard ferritin as the most sensitive indicator of body iron stores (7). Although ferritin is influenced by inflammation, its use in combination with other indices, as done in this study, enhances diagnostic reliability. The findings reinforce the limitations of relying solely on haemoglobin concentration for diagnosing iron deficiency in pregnancy, as haemoglobin reduction often occurs later in the course of iron depletion.

Multivariable logistic regression analysis identified low socio-economic status, high parity, and lack of iron supplementation as independent predictors of IDA. These findings highlight the multifactorial nature of iron deficiency in pregnancy and underscore the need for integrated interventions that address both biomedical and social determinants of health.

The persistence of these predictors after adjustment for confounding variables strengthens confidence in the observed associations and supports targeted antenatal strategies focused on high-risk groups. Similar predictors have been reported in previous Nigerian studies, further validating the present findings (5,6).

Conclusion

Iron-deficiency anaemia is a highly prevalent condition among pregnant women attending Specialist Hospital, Sokoto. The study demonstrated that a substantial proportion of participants had depleted iron stores and that iron-deficiency anaemia was significantly associated with low socio-economic status, high parity, and lack of iron supplementation. Women with iron-deficiency anaemia exhibited significantly poorer haematological and biochemical profiles, including lower haemoglobin concentration, serum ferritin, serum iron, transferrin saturation, and red cell indices, alongside elevated total iron-binding capacity. Serum ferritin proved to be a valuable biochemical marker for assessing iron status during pregnancy, offering greater sensitivity for identifying iron deficiency than haemoglobin alone. These findings underscore the limitations of relying solely on conventional haematological indices for diagnosing iron deficiency in pregnancy and the importance of incorporating biochemical assessment into antenatal care where feasible. Despite its cross-sectional and single-centre design, this study provides important evidence on the burden and determinants of iron-deficiency anaemia among pregnant women in Sokoto. It contributes to the growing body of Nigerian data on maternal iron status.

Study Limitations

This study has certain limitations that should be considered when interpreting the findings. Although a formal sample size calculation was performed and adjusted for attrition, the study was primarily powered to estimate the prevalence of iron-deficiency anaemia rather than to detect small differences across all subgroups, which may have affected the precision of some subgroup analyses.

The cross-sectional design of the study limits the ability to infer causal relationships between identified factors and iron-deficiency anaemia. The design does not allow assessment of temporal changes in iron status across pregnancy, including the trimester-specific progression of iron depletion.

Additionally, this was a single-centre study conducted at a specialist hospital in Sokoto, which may limit the generalisability of the findings to pregnant women in other regions of Nigeria or to settings with different socio-economic profiles, health-seeking behaviours, and antenatal care practices.

Despite these limitations, the study provides valuable insight into the burden and determinants of iron-deficiency anaemia among pregnant women in this setting. It highlights the importance of incorporating biochemical markers into antenatal iron assessment.

Recommendations

1. Antenatal care programmes should strengthen routine screening for iron deficiency, including serum ferritin measurement in addition to haemoglobin estimation, particularly for women at higher risk of iron depletion.
2. Pregnant women from low socio-economic backgrounds and those with high parity should be prioritised for the intensification of the nutritional counselling, early initiation of antenatal care, and close monitoring of iron status.
3. Efforts should be made to ensure timely initiation, adequate dosing, and adherence to iron supplementation during pregnancy through improved health education and follow-up.
4. Community-based health education programmes should emphasise the importance of birth spacing and adequate nutrition before and during pregnancy. This is aimed at reducing cumulative depletion of maternal iron stores.
5. Multicentre and longitudinal studies are recommended in the future to assess temporal changes in iron status across different stages of pregnancy, evaluate inflammatory markers alongside ferritin, and improve the generalisability of findings across different regions of Nigeria.

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Conflict of Interest

The authors declare no conflicts of interest regarding the publication of this research.

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