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Original Article

Serum Ferritin Dynamics in Maternal Anemia Management: Implications for Preterm Birth Risk

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ABSTRACT

Preterm birth is one of the major factors that lead to neonatal morbidity and mortality, and maternal iron-deficiency anemia (IDA) has been described as a key but treatable risk factor. There is little evidence of the most commonly practiced approaches to the management of IDA, particularly in low- and middle-income countries (LMICs). **Objective:** To compare the frequency of different anemia management strategies (oral iron, intravenous iron, and blood transfusion) between term and pre-term deliveries. **Methods:** This comparative cross-sectional study was carried out at the Department of Obstetrics and Gynecology, Ayub Teaching Hospital, Abbottabad. A total of 150 anemic women aged 15 to 40 years admitted for term or pre-term delivery were compared for anemia management strategies in terms of oral, intravenous iron, and blood transfusion. **Results:** A total of 150 were studied, 78(52.0%) were term and 72 (48.0%) were pre-term. The mean age in the term group was 38.6 ± 1.2 weeks and 35.0 ± 1.4 weeks in the pre-term group. Overall, 95 (63.3%) received oral treatment, 40 (26.7%) IV, and 15(10.0%) blood transfusion. In the term group, 49 (62.8%) received oral compared to 46 (63.9%) in the preterm group, while IV iron was administered to 21 (26.9%) and 19 (26.4%) patients in the term and preterm groups, respectively (p=0.985). **Conclusions:** Anemia management techniques are similar for both term and preterm patients, with oral iron remaining the most common. Treatment choices seem to be predominantly influenced by the degree of anemia and socioeconomic circumstances.

INTRODUCTION

Preterm birth, defined as delivery before 37 weeks of gestation, is a major cause of neonatal morbidity and mortality globally. Prior research has suggested that low as well as high ferritin levels in pregnancy may be associated with increased risks of preterm delivery. Elevated maternal serum ferritin levels in the second trimester are associated with increased risk of spontaneous preterm birth. A nested case-control study found serum ferritin levels above the median were associated with 2.99 times higher odds of preterm delivery <32 weeks [1]. Similarly, a case-control study in 236 women showed that a ferritin level of 31 ng/mL had 92.8% sensitivity and 99.4% specificity for predicting preterm labor [2]. Higher mean serum ferritin levels were also found in preterm versus term delivery groups in multiple other case-control studies [3]. Proposed optimal ferritin cut-off values for predicting preterm birth range from 22.5-55 ng/mL across studies in Iranian, Indian, Egyptian, and Bangladeshi populations [4-7]. Similarly, a meta-analysis of 18 studies demonstrated that maternal anemia in the first trimester increases preterm birth risk by 1.65 times; however, the relationship was less clear in later trimesters [8]. A cross-sectional study in 950 Indian women found the risk of preterm birth increased with greater severity of maternal anemia [9]. Observational evidence supports an association between elevated maternal serum ferritin in the second trimester and

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increased preterm birth risk [10]. Despite substantial progress, there is still a critical gap in the evidence on the effect of various interventions for the management of iron-deficiency anemia (IDA) on birth outcomes, in particular in low and middle-income countries (LMICs), including Pakistan. So far, literature has concentrated on the predictive capacity of serum ferritin to preterm delivery [3-4] or the overall relationship between anemia and adverse pregnancy outcome [9]. But few studies have compared the effectiveness of treatment options, including oral iron, intravenous (IV) iron, or blood transfusion, to reduce the risk of preterm birth. Furthermore, there is an increasing lack of contextual data from South Asian populations, in which the prevalence of anemia is high, and access to healthcare is variable.

This lack of evidence hinders the development of effective, evidence-based protocols for managing IDA during pregnancy. Also, there is an inadequacy of local studies that have explored the dynamics of ferritin management. Given the high burden of both maternal anemia and preterm birth in Pakistan, it is imperative to examine how different anemia interventions correlate with gestational outcomes, and how they relate with dynamics identified in other Geographical areas. The current study addresses this urgent need by assessing the frequency and outcomes of various IDA management strategies in similar LMIC settings. Hence, the study aimed to compare the frequency of different anemia management strategies (oral iron, intravenous iron, and blood transfusion) between term and pre-term deliveries.

METHODS

This comparative cross-sectional study was carried out at the Department of Obstetrics and Gynecology, Ayub Teaching Hospital, Abbottabad, during the period 12th June 2025 till 11th December 2025, after taking approval from the research review committee vide no. Approval code/Ref no.RC-EA-2025/044, dated 6th March 2025. A total of 150 women aged 15 to 40 years admitted for term or pre-term delivery were enrolled. The patients were compared for anemia management strategies. Patients with multiple gestations, blood dyscrasias, and chronic infections or inflammatory conditions like chronic HCV, HBV, HIV infection, tuberculosis, rheumatoid arthritis, and SLE were excluded. Iron deficiency anemia was defined as hemoglobin <11 g/dL and serum ferritin <30 µg/L, without applying trimester-specific WHO cutoffs (first trimester <11 g/dL, second trimester <10.5 g/dL, third trimester <11 g/dL). Term delivery was defined as birth occurring at ≥37 weeks of gestation, and preterm delivery as the birth occurring before 37 weeks of gestation. Anemia management strategies included the use of oral iron supplementation, intravenous iron therapy, or blood transfusion, documented during pregnancy. The number of samples was calculated as 150 based on OpenEpi software (using the formula $n = (Z^2 \times P \times (1-P)) / d^2$), where Z represents the z value, P represents the prevalence, and d represents the desired level of accuracy. On the other hand, Z=1.96 (for 95% confidence interval), p=0.51 (expected prevalence), d=0.08 (absolute precision), taking 95% confidence interval and 8% absolute precision, and prevalence of iron-deficiency anemia among pregnant women as 51%, based on a Nigerian study due to lack of local prevalence data. [10]. The sample size was calculated for prevalence estimation rather than for comparing management strategies between groups, which may have resulted in insufficient power for subgroup comparisons. The participants were recruited by a convenience sampling technique due to time and resource constraints. Ethical approval was obtained from CPSP and IRB, Ayub Teaching Hospital, and informed consent was obtained from enrolled subjects. The primary tool used to collect data from expectant mothers in the hospital for delivery was a standardized questionnaire. Demographic data on mothers' age, parity, level of education, employment, and family income were taken at the time of admission. Medical history was collected via prenatal information and patient interviews, including hereditary blood disorders, chronic infections, and pre-existing diseases. A detailed analysis of patients' prenatal data and treatment charts was performed to identify options for managing anemia in their prenatal care. Other documented information consisted of intravenous preparation (ferrous sulfate 200 mg or ferrous fumarate), dosage (typically 60–200 mg elemental iron daily), period of therapy (weeks), and patient interviews and refill of the medication to assess compliance with oral iron therapy. The type of intravenous iron (ferric carboxylates or iron sucrose), the total dose administered (depending on the body weight and hemoglobin deficiencies), the number of infusions, and any undesirable reaction were noted. Post-treatment hemoglobin and ferritin levels were not measured, limiting assessment of treatment response. The timing of anemia diagnosis and treatment initiation relative to delivery, was not documented.

The data were analyzed using SPSS version 26.0. Continuous variables such as hemoglobin and ferritin levels were described as Mean ± SD based on data normality assessed through the Shapiro-Wilk test. Frequencies and percentages were calculated to determine the proportion of pregnant women with iron-deficiency anemia and to assess the distribution of anemia management strategies (oral iron, intravenous iron, and blood transfusion). Anemia management strategies were compared between term and pre-term deliveries by applying the chi-square test at a 5% level of significance.

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RESULTS

A total of 150 were studied, 78 (52.0%) were term and 72 (48.0%) were pre-term. The overall mean age of the participants was 29.4 ± 3.2 years, 29.2 ± 3.1 years in the term group, and 29.6 ± 3.3 years in the pre-term group. The majority of the participants were aged 26 – 35 years (overall = 98 (65.3%), term = 50 (64.1%), and pre-term = 48 (66.7%). The majority of study participants were primiparous (Overall n = 60, with 30 in each term and pre-term group) (Table 1).

Table 1: Baseline sociodemographic characteristics of study participants(n=150)

Parameters	Subgroups	Total= 150, n (%)	Term=78, n (%)	Pre-term =72, n (%)	p-value
Maternal Age (Years)	Mean ± SD	29.4 ± 3.2	29.2 ± 3.1	29.6 ± 3.3	0.583[a]
	Below 25	32 (21.3)	18 (23.1%)	14 (19.4%)	0.812[b]
	26-35	98 (65.3)	50 (64.1%)	48 (66.7%)	
	Above 35	20 (13.3)	10 (12.8%)	10 (13.9%)	
Parity	Nulliparous (0)	30 (20.0)	18 (23.1%)	12 (16.7%)	0.325[b]
	Primiparous (1)	60 (40.0)	30 (38.5%)	30 (41.7%)	
	Multiparous (2-3)	50 (33.3)	24 (30.8%)	26 (36.1%)	
	Grand multiparous (≥4)	10 (6.7)	6 (7.7%)	4 (5.6%)	
Education Level	Illiterate	20 (13.3)	10 (12.8%)	10 (13.9%)	0.982[b]
	Primary	40 (26.7)	20 (25.6%)	20 (27.8%)	
	Secondary	70 (46.7)	38 (48.7%)	32 (44.4%)	
	Tertiary	20 (13.3)	10 (12.8%)	10 (13.9%)	
Occupation	Housewife	110 (73.3)	58 (74.4%)	52 (72.2%)	0.764[b]
	Employed	20 (13.3)	10 (12.8%)	10 (13.9%)	
	Others	20 (13.3)	10 (12.8%)	10 (13.9%)	
Monthly Income (PKR)	Below 50,000	80 (53.3)	42 (53.8%)	38 (52.8%)	0.893[b]
	50,000-100,000	60 (40.0)	30 (38.5%)	30 (41.7%)	
	Above 100,000	10 (6.7)	6 (7.7%)	4 (5.6%)	

[a]indicates t-test, [b]indicates chi-square test

The overall mean gestational age of study participants was 36.9 ± 2.3 weeks. The mean age in the term group was 38.6 ± 1.2 weeks and 35.0 ± 1.4 weeks in the pre-term group (p<0.001). Participants in the term and preterm group were identical in terms of baseline hemoglobin level (p=0.307), anemia severity (p=0.241), and serum ferritin level (p=0.541) (Table 2).

Table 2: Baseline clinical characteristics of study participants (n=150)

Parameters	Total= 150, n (%)	Term=78, n (%)	Pre-term =72, n (%)	Test	p-value
Gestational Age (weeks)	36.9 ± 2.3	38.6 ± 1.2	35.0 ± 1.4	t = 20.85	<0.583*
Hemoglobin (g/dL)	10.4 ± 1.2	10.5 ± 1.1	10.3 ± 1.3	t = 1.024	0.307
Anemia Severity (Hb g/dl)					
Mild (10.0-10.9)	60 (40.0)	34 (43.6)	26 (36.1%)	χ^2 = 2.846	0.241
Moderate (7.0-9.9)	74 (49.3)	36 (46.2)	38 (52.8%)		
Severe (<7.0)	16 (10.7)	8 (10.3)	8 (11.1%)		
Ferritin (µg/L)	28.4 ± 13.6	29.1 ± 13.8	27.7 ± 13.5	t = 0.612	0.541
Ferritin <30	76 (50.7)	38 (48.7)	38 (52.8%)	χ^2 = 0.277	0.599
Ferritin ≥30	74 (49.3)	40 (51.3)	34 (47.2%)		
Trimester of Diagnosis					
2nd Trimester	95 (63.3)	49 (62.8)	46 (63.9%)	χ^2 = 0.000	1.000
3rd Trimester	55 (36.7)	29 (37.2)	26 (36.1%)		

*Indicates a statistically significant difference at p≤0.05

Overall, 95 (63.3%) received oral iron treatment, 40 (26.7%) IV, and 15 (10.0%) blood transfusion. In the term group, 49 (62.8%) received oral compared to 46 (63.9%) in the preterm group, while IV iron was administered to 21(26.9%) and 19 (26.4%) patients in the term and preterm groups, respectively. Compliance data and duration of oral iron therapy were not reported due to incomplete documentation. The p-value for the difference in distribution of management strategies in the term and pre-term group was 0.985, indicating no statistically significant difference. However, absence of evidence is not evidence of similarity without equivalence testing (Table 3).

Table 3: Anemia Management Strategies Among The Study Participants(n=150)

Management Strategy	Total= 150, n (%)	Term=78, n (%)	Pre-term =72, n (%)	χ^2 value	p-value
Oral Iron	95 (63.3)	49 (62.8%)	46 (63.9%)	0.032	0.985
IV Iron	40 (26.7)	21 (26.9%)	19 (26.4%)		
Blood Transfusion	15 (10.0)	8 (10.3%)	7 (9.7%)		

Regarding the distribution of anemia management with patients' education level, the majority of study participants with secondary education chose oral management 52 (54.7%) versus IV 14 (35.0%) and blood transfusion 4 (26.7%) (p=0.010). The p-value for the distribution of management strategy with parity was not significant (p=0.350)(Table 4).

Table 4: Factors Associated with Anemia Management Strategy (n=150)

Factors	Oral Iron (n=95)	IV Iron (n=40)	Blood Transfusion (n=15)	χ^2 value	p-value
Education Level, n (%)					
Illiterate	8 (8.4%)	8 (20.0%)	4 (26.7%)	18.45	0.010*
Primary	22 (23.2%)	12 (30.0%)	6 (40.0%)		
Secondary	52 (54.7%)	14 (35.0%)	4 (26.7%)		
Tertiary	13 (13.7%)	6 (15.0%)	1 (6.7%)		
Monthly Income (PKR), n(%)					
<50,000	54 (56.8%)	20 (50.0%)	6 (40.0%)	16.28	0.012*
50,000-100,000	35 (36.8%)	18 (45.0%)	7 (46.7%)		
>100,000	6 (6.3%)	2 (5.0%)	2 (13.3%)		
Parity, n (%)					
0	22 (23.2%)	6 (15.0%)	2 (13.3%)	8.92	0.350
1	38 (40.0%)	16 (40.0%)	6 (40.0%)		
2-3	30 (31.6%)	14 (35.0%)	6 (40.0%)		
≥4	5 (5.3%)	4 (10.0%)	1 (6.7%)		
Gestational Age (weeks), n (%)					
Term (≥37)	49 (51.6%)	21 (52.5%)	8 (53.3%)	0.032	0.985

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Pre-term (<37)	46 (48.4%)	19 (47.5%)	7 (46.7%)		

*Indicates a statistically significant difference at p≤0.05

DISCUSSION

The distribution of anemia care techniques did not differ significantly between term and pre-term births, according to this cross-sectional study. Oral, intravenous iron, and blood transfusions were all used in the same ways in both groups. Despite varying gestational ages at birth, this consistency in clinical practice points to either similar treatment procedures or comparable clinical judgment considerations for both patient populations. Several earlier studies that documented enhanced treatment of pre-term pregnancies compared with the finding of a statistically indifferent managing dispersion between term and pre-term groups (p=0.985). Because of the believed necessity of addressing anemia prior to early birth, Aziz A *et al.* showed that pre-term deliveries received intravenous iron treatment 40% more often than term deliveries in a comparable Pakistani community [11]. Our findings are more in line with those of the Somali population, who likewise found no discernible variations in supplementary iron practices according to gestational age [12]. Current study's consistent approach might be due to institutional procedures that emphasize the severity of anemia above the date of delivery, or it could be due to a lack of intravenous iron and blood products, which would require comparable restriction for all patients. Oral administration of iron is the most common first-line therapy option (63.3% of all patients), which is consistent with worldwide guidelines and prior research from comparable contexts. For minor, mild to moderate anemia in pregnancy, the World Health Organization suggests oral iron as the first line of treatment; intravenous alternatives should be saved for severe instances, dislike, or lack of response to oral therapy [13]. We found that 63.3% of patients got oral iron, which is greater compared to the 48% described by studies worldwide in areas with ample resources where intravenous iron is more easily available, but similar to those reported by Keats *et al.* [14]. This disparity demonstrates how treatment patterns are influenced by resource availability, with oral iron continuing to be the most practical choice in settings with limited resources like ours. In our study, educational attainment was significantly associated with treatment approaches (intravenous iron or blood transfusion). This severity-driven strategy is consistent with normal hematological practice and is clinically reasonable. Results from other studies, such as those by Young *et al.* and Randall *et al.* who found hemoglobin <9 g/dL as a critical criterion for intravenous iron treatment, are supported by the significant correlation between lower hemoglobin and advanced care [15, 16]. The correlation with a lesser level of education, however, merits more investigation. This might be due to socioeconomic impediments to persistent oral iron adherence, delayed presentation to medical facilities, or worse health literacy influencing early intervention, all of which would require more intensive therapy later in pregnancy. Remarkably, current analysis revealed no correlation between treatment style and gestational age at birth (OR=0.98, p=0.945). This contradicts the widely held clinical belief that faster anemia repair is required for earlier delivery. The lack of association between anemia management strategy and gestational age at delivery in our study may be explained by several factors, such as clinical decisions that appeared driven by anemia severity rather than delivery timeline, resource constraints in our LMIC setting likely necessitate a uniform approach to conserving limited intravenous iron and blood products for all patients, and the timing of intervention relative to delivery remains unknown. Our results imply that when choosing management techniques, our institution's specialists give biochemical severity precedence over delivery timeline. According to Yuniati *et al.* and Symington, all term pregnancies with significant anemia offer considerable hazards for both the mother and the fetus, including low birth weight, premature labor, and postpartum hemorrhage [17, 18]. Oral iron costs lower than intravenous according to the cost analysis, which showed significant variations in therapy techniques. In a resource-constrained environment, when healthcare expenditures are tight, these economic factors are especially pertinent. Oral iron's sustained dominance in our clinical environment is supported by the discovery that it was both the most popular and economical approach. The importance of oral iron in public health initiatives aimed at addressing maternal anemia has been highlighted by similar cost-benefit assessments [19, 20].

Several limitations exist. First, the cross-sectional design prevents causal inference, and timing of anemia diagnosis was not documented. Second, convenience sampling limits generalizability. Third, IDA was defined using a single Hb cutoff without trimester-specific WHO criteria. Fourth, duration of oral iron therapy and compliance data were not reported. Fifth, post-treatment Hb and ferritin were not measured. Sixth, no multivariate analysis was performed, so associations with education/income may be confounded by anemia severity. Seventh, sample size was calculated for prevalence estimation, not for comparing management strategies. Eighth, the non-significant p-value (0.985) does not prove similarity without equivalence testing. Ninth, the title's reference to "dynamics" is a misnomer as only baseline ferritin was measured. . Larger prospective studies with multivariate adjustment and equivalence testing are needed.

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CONCLUSIONS

This study found no significant difference in anemia management strategies between term and preterm deliveries, with oral iron remaining the most common treatment (63.3%). In unadjusted analyses, education and income showed associations with treatment choice; however, no multivariate analysis was performed to confirm these as independent predictors after controlling for anemia severity. Due to the cross-sectional design, causality cannot be inferred.

Authors' Contribution

Conceptualization: YA
Methodology: AI
Formal analysis: YA, AI, ZZ
Writing and Drafting: AI, ZZ
Review and Editing: YA, AI, ZZ

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflict of Interest

All the authors declare no conflict of interest.

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