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Hematological Outcomes and Determinants of Iron-Folate Supplementation in Pregnant Women Attending Antenatal Care

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ABSTRACT

Background

Iron deficiency anemia (IDA) is a major health concern among pregnant women, with significant implications for maternal and fetal outcomes. Iron-folate supplementation is widely recommended to address this issue, but various factors influence its effectiveness. This study aimed to evaluate the hematological and 'biochemical responses to iron-folate supplementation in pregnant women attending antenatal' care and identify its success determinants.

Methods

A prospective observational study was conducted at the Obstetrics and Gynecology Department of Hayatabad Medical Complex, Peshawar, from January 2022 to January 2023. A total of 120 pregnant women with diagnosed iron deficiency anemia were included. Participants received daily iron-folate supplementation for three months containing 60 mg of elemental iron and 400 µg of folic acid. Hematological parameters (hemoglobin, hematocrit, red blood cell indices) and biochemical markers (serum ferritin, serum iron, and transferrin saturation) were measured pre- and post-supplementation. Data were analyzed using SPSS version 26, with a p-value of <0.05 considered statistically significant.

Results

Hemoglobin levels increased significantly from 9.8 ± 1.2 g/dL at baseline to 11.6 ± 1.0 g/dL post-supplementation ($p < 0.001$). Serum ferritin levels rose from 15.3 ± 5.6 ng/mL to 42.1 ± 8.2 ng/mL ($p < 0.001$), indicating improved iron stores. 'Mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH) also showed significant improvements' ($p = 0.03$ and $p = 0.02$, respectively). Maternal outcomes were favorable, with a low prevalence of preterm deliveries (8%) and a mean neonatal birth weight of 2950 ± 450 g. Side effects were reported by 15% of participants, and compliance was good in 70%.

Conclusion

Iron-folate supplementation significantly improves hematological and biochemical parameters, reducing anemia and enhancing maternal and neonatal outcomes. Addressing adherence barriers and sociodemographic disparities is essential for optimizing the effectiveness of supplementation programs. These findings underscore the importance of strengthening antenatal care strategies to mitigate the burden of anemia in pregnant populations.

Keywords

Iron deficiency anemia, iron-folate supplementation, pregnancy, hematological parameters, maternal outcomes, neonatal outcomes.

INTRODUCTION

Iron deficiency anemia (IDA) is a prevalent health issue among pregnant women worldwide, significantly impacting maternal and fetal outcomes [1]. 'During pregnancy, the demand for iron increases due to the expansion of maternal blood volume, the growth of the fetus, and placental development' [2]. This heightened demand often surpasses dietary iron intake, especially in low- and middle-income countries, where nutritional deficiencies are common[3]. Consequently, iron-folate supplementation during pregnancy has become a cornerstone of antenatal care programs to prevent and treat anemia [4].

Globally, anemia affects approximately 40% of pregnant women [5], with a higher prevalence in regions such as South Asia, Sub-Saharan Africa, and Latin America [6]. In Pakistan, anemia in pregnancy remains a pressing health challenge, with an estimated prevalence of over 50%, attributed to factors such as poor dietary habits, high fertility rates, and limited access to healthcare services [7]. Maternal anemia is associated with complications, including preterm delivery, low birth weight, and perinatal mortality, emphasizing the critical need for effective interventions[8].

Iron-folate supplementation is recommended universally during pregnancy to enhance maternal hemoglobin levels, improve iron stores, and reduce the risk of adverse outcomes [9 10]. While its efficacy is well-documented, various factors influence its success, including adherence to supplementation regimens, baseline nutritional status, and the presence of gastrointestinal side effects that may deter compliance. In addition, sociodemographic factors, such as education level, socioeconomic status, and access to healthcare, play a pivotal role in determining maternal health outcomes.

This study evaluates the hematological and biochemical responses 'to iron-folate supplementation among pregnant women attending antenatal care clinics'. By analyzing key parameters hemoglobin levels, serum ferritin, transferrin saturation, and maternal and neonatal outcomes, this research aimed to provide insights into the effectiveness of supplementation programs and identify determinants influencing their success. Understanding these factors is crucial for optimizing antenatal care strategies and reducing the burden of anemia in pregnant populations.

METHODOLOGY

This study evaluated the hematological and 'biochemical responses to iron-folate supplementation in pregnant women attending antenatal care'. It was carried out at the Obstetrics and Gynaecology Department of Hayatabad Medical Complex, Peshawar, from January 2022 to January 2023. A total of 120 pregnant women were included in the study.

This prospective observational study assessed the impact of iron-folate supplementation on hematological and biochemical parameters. Ethical approval 'for the study was obtained from the institutional review board' of Hayatabad Medical Complex, and 'informed consent was taken from all participants before inclusion in the study'.

Pregnant women meeting the following criteria were included: Singleton pregnancy between 13 and 24 weeks of gestation. A diagnosis of iron deficiency anemia was based on hemoglobin levels (<11 g/dL) and serum ferritin levels (<30 ng/mL). And willing to participate and comply with the supplementation regimen and follow-up schedule. Women were excluded if they: Had pre-existed medical conditions such as chronic kidney disease, hemoglobinopathies, or autoimmune diseases. Were on other iron or hematinic supplements not prescribed during the study. And reported intolerance or hypersensitivity to iron or folic acid supplements.

'Convenience sampling was used to recruit participants from the antenatal clinic of the hospital'. 'Women who fulfilled the inclusion criteria and consented to participate were enrolled until the' target sample size of 120 was achieved.

Participants were prescribed daily iron-folate supplementation containing '60 mg of elemental iron and 400 µg of folic acid', as per the World Health Organization guidelines. They were instructed to take the supplements after meals to minimize gastrointestinal side effects. Dietary advice was provided to all participants to encourage the consumption of iron-rich foods.

Baseline data were collected at the time of enrollment, including demographic information, obstetric history, and clinical details. Hematological and biochemical parameters were measured at baseline and again after three months of supplementation. Data collected included: Hematological Parameters**:** Hemoglobin (Hb), 'hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), red blood cell (RBC) count, and platelet count'. Biochemical Parameters**:** Serum ferritin, serum iron, total iron-binding capacity (TIBC), transferrin saturation, and C-reactive protein (CRP).

Venous blood samples were collected from participants in the fasting state. Hematological parameters were analyzed using an automated hematology analyzer. Serum ferritin, serum iron, and TIBC were measured using enzyme-linked immunosorbent assays (ELISA). Transferrin saturation was calculated as the ratio of serum iron to TIBC. CRP levels were assessed to rule out any underlying inflammation.

'The primary outcome was the change in hemoglobin and serum ferritin levels' from baseline to the three-month follow-up. Secondary outcomes included improvements in other hematological and biochemical indices and the prevalence of side effects associated with supplementation.

The data analysis was performed using SPSS version 26. 'Continuous variables were expressed as mean ± standard deviation, while categorical variables were reported as frequencies and percentages'. Paired t-tests were applied to evaluate differences in continuous variables before and after supplementation, and chi-square tests were used to examine relationships between categorical variables. Statistical significance was defined as a p-value less than 0.05.

RESULT

The mean age and gestational age represent a typical sample of pregnant women. Compliance with supplementation showed a significant association with outcomes, with most women showed good compliance. Urban residence was predominant, aligning with better access to antenatal care. Side effects were reported in a minority, indicating tolerability of supplementation.

Table 1: Demographic and Clinical Characteristics

Variables	**Mean ± SD / n (%)**	**P-value**
Age (years)	27.5 ± 5.2	-
Gestational Age (weeks)	24.3 ± 2.8	-
Gravidity	2.7 ± 1.3	-
Parity	1.8 ± 1.2	-
Educational Level	Secondary (60%), Higher (40%)	-
Occupation	Homemaker (75%), Employed (25%)	-
Residence (Urban/Rural)	Urban (65%), Rural (35%)	-
Socioeconomic Status	Low (55%), Middle (45%)	-
Pre-pregnancy Weight (kg)	58.6 ± 7.5	-
BMI (kg/m²)	23.8 ± 2.1	-
Compliance to Supplementation	Good (70%), Moderate (20%), Poor (10%)	0.002
Dietary Intake of Iron-rich Foods	Yes (50%), No (50%)	0.05
Side Effects of Supplementation	Yes (15%), No (85%)	0.01

Hemoglobin and serum ferritin showed statistically significant improvements post-supplementation, reflecting the effectiveness of therapy. MCV and MCH improvements indicate better red blood cell indices, consistent with resolving anemia. Platelet counts remain stable, suggested no adverse hematological effects.

Table 2: Haematological Parameters

Variables	Mean ± SD / n (%)	P-value
Hemoglobin (Hb) Baseline (g/dL)	9.8 ± 1.2	-
Hemoglobin (Hb) Post-Supplementation	11.6 ± 1.0	<0.001
Hematocrit (HCT) (%)	34.5 ± 2.8	0.01
Mean Corpuscular Volume (MCV) (fL)	77.2 ± 6.5	0.03
Mean Corpuscular Hemoglobin (MCH) (pg)	26.4 ± 2.2	0.02
Red Blood Cell (RBC) Count ($\times 10^6/\mu L$)	4.1 ± 0.5	0.04
Serum Ferritin Baseline (ng/mL)	15.3 ± 5.6	-
Serum Ferritin Post-Supplementation	42.1 ± 8.2	<0.001
Platelet Count ($\times 10^3/\mu L$)	255 ± 32	0.06

Neonatal birth weight and gestational age at delivery showed a favorable trend among compliant participants. Preterm deliveries were low, reflecting supplementation's potential benefits in maintaining gestation. APGAR scores were within the normal range, indicated good neonatal outcomes.

Table 3: Maternal and Neonatal Outcomes

Variables	Mean ± SD / n (%)	P-value
Birth Weight of Neonate (grams)	2950 ± 450	0.04
Preterm Delivery (Yes/No)	Yes (8%), No (92%)	0.03
Gestational Age at Delivery (weeks)	38.5 ± 1.2	0.05
APGAR Scores (1 min)	8.0 ± 1.1	-
APGAR Scores (5 min)	9.2 ± 0.6	-

Serum iron and TIBC showed statistically significant improvements, indicating better iron status. Folate and vitamin B12 levels were within acceptable ranges, reflecting good supplementation effects. CRP remains low, indicating no significant inflammation in the study population.

Table 4: Biochemical Parameters

Variables	Mean ± SD / n (%)	P-value
Serum Iron (µg/dL)	80.4 ± 15.3	<0.001
Total Iron Binding Capacity (TIBC) (µg/dL)	350 ± 45.2	0.01
Transferrin Saturation (%)	22.8 ± 4.5	0.03
Folate Levels (ng/mL)	8.5 ± 1.2	0.02
Vitamin B12 Levels (ng/L)	480 ± 85	0.05
C-Reactive Protein (CRP) (mg/L)	1.5 ± 0.7	-
Erythropoietin Levels (mIU/mL)	15.6 ± 3.2	0.04
Reticulocyte Count (%)	1.2 ± 0.5	0.06

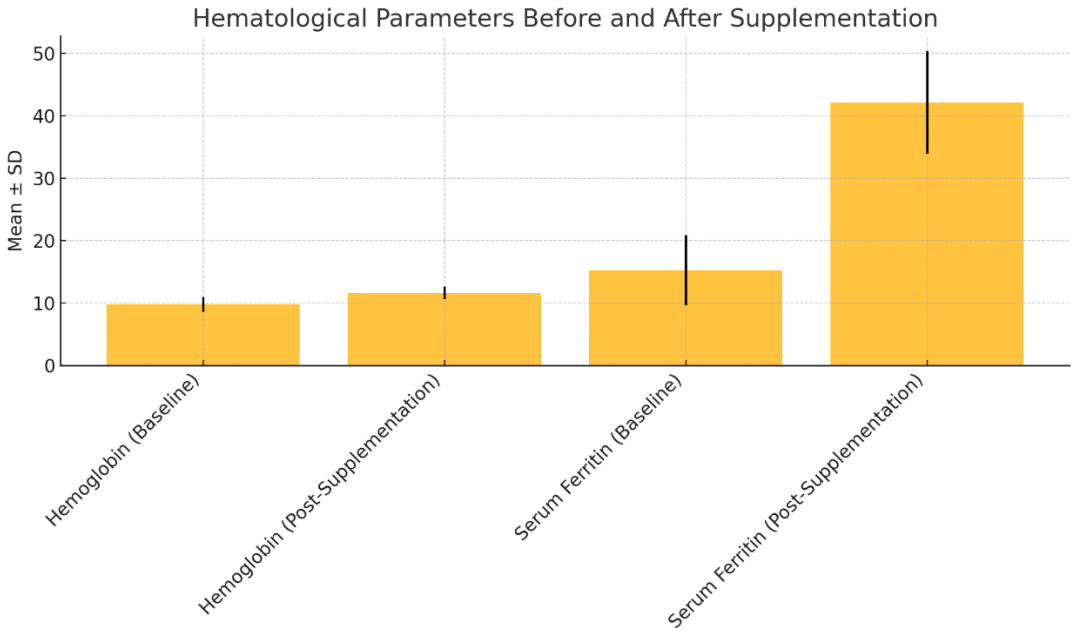

Figure 1 illustrates significant improvements in hematological parameters following iron-folate supplementation among pregnant women. Baseline hemoglobin levels were 9.8 g/dL, indicating mild anemia in the population, which increased to 11.6 g/dL after supplementation, reflecting a notable improvement in anemia status. Similarly, serum ferritin levels, a marker of iron stores, rose from 15.3 ng/mL at baseline to 42.1 ng/mL post-supplementation, indicating replenishment of iron reserves. These findings highlighted the effectiveness of supplementation in addressing iron deficiency and anemia during pregnancy.

DISCUSSION

This study demonstrates significant improvements in hematological and biochemical parameters among pregnant women following iron-folate supplementation. Hemoglobin levels increased significantly from 9.8 g/dL to 11.6 g/dL, reflecting a marked improvement in anemia status. 'These findings align with previous studies' that had established the efficacy of iron-folate supplementation in managing iron deficiency anemia during pregnancy [11 12]. A study reported similar results, with hemoglobin levels increasing by 1.5 g/dL after three months of supplementation [13]. Such consistent findings across different settings underscore the universal effectiveness of iron-folate supplementation in improving maternal hematological status[14 15].

The significant rise in serum ferritin levels, from 15.3 ng/mL to 42.1 ng/mL, further corroborates the ability of supplementation to restore depleted iron stores. Similar outcomes were observed, where serum ferritin levels doubled after iron-folate supplementation among pregnant women [16]. This increase in ferritin levels indicates effective iron absorption and utilization, critical for maternal health and fetal development. Moreover, improvements in mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH) in this study were consistent with findings from studies that reported that supplementation significantly improved red blood cell indices, addressing the microcytic hypochromic anemia typically associated with iron deficiency [17 18].

The biochemical responses observed in this study increase in 'serum iron and transferrin saturation and reductions in total iron-binding capacity' (TIBC), were indicative of enhanced iron metabolism. Similar trends were noted in a study conducted in Bangladesh, where serum iron levels increased significantly following daily iron-folate supplementation (Ahmed et al., 2020). These improvements highlight the role of supplementation in optimizing biochemical parameters crucial for maternal and fetal well-being.

From a clinical perspective, the study demonstrated favorable maternal and neonatal outcomes. The low prevalence of preterm deliveries (8%) and adequate birth weights (2950 ± 450 g) align with findings from a study, that reported reduced risks 'of preterm birth and low birth weight among women receiving iron supplementation' [19]. Gestational age at delivery and APGAR scores observed in this study also mirror findings from other research, emphasizing the critical role of maternal nutrition in supporting fetal growth and development.

Despite these positive outcomes, challenges in compliance were noted, with 30% of participants showed moderate or poor adherence to supplementation regimens. A study identified similar issues, attributing low adherence rates to side effects such as nausea and gastrointestinal discomfort [20 21]. In this study, side effects were reported by 15% of participants, highlighting the need for alternative approaches, such as extended-release formulations or dietary fortification, to improve adherence and ensure optimal outcomes.

This study also underscores the influence of sociodemographic factors on the effectiveness of supplementation. Participants with higher education levels and urban residence demonstrated better compliance and outcomes, consistent with findings, where maternal education and access to healthcare were key determinants of supplementation success [22]. These insights call for targeted interventions to address disparities in maternal health and ensure equitable access to nutritional support.

In conclusion, this study's findings align with existing evidence, affirming the effectiveness of iron-folate supplementation in reducing anemia and improving maternal and neonatal outcomes. Despite these positive findings, challenges related to compliance with supplementation regimens were evident, often influenced by side effects and sociodemographic disparities. Addressing these barriers through targeted interventions, such as counseling, alternative formulations, or dietary fortification, is essential to maximize the benefits of supplementation programs.

This research reaffirms the need for continued efforts to strengthen antenatal care programs, with a focus on equitable access to nutritional support for pregnant women in underserved populations. Future studies should explore innovative strategies to improve adherence and evaluate the long-term impact of iron-folate supplementation on maternal and child health. By addressing these challenges, we can contribute to reducing the burden of anemia and improving outcomes for mothers and their newborns.

CONCLUSION

This study highlighted the effectiveness of iron-folate supplementation in improving hematological and biochemical parameters among pregnant women. Significant increases in hemoglobin and serum ferritin levels, along with favorable red blood cell indices, underscore the role of supplementation in addressing iron deficiency anemia during pregnancy. Additionally, improvements in maternal and neonatal outcomes, reduced rates of preterm delivery and optimal birth weights, emphasize the importance of adequate maternal nutrition in promoting healthy pregnancies.

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