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ORIGINAL ARTICLE

Prospective Study on the Effect of Iron Supplementation During Pregnancy on Maternal Anemia

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ABSTRACT:
Background: Anemia during pregnancy is a prevalent global health problem, particularly in developing countries, and is most commonly caused by iron deficiency. Physiological changes during gestation increase maternal iron requirements to support fetal growth and placental development. Inadequate dietary intake, poor absorption, and increased iron demand lead to a high burden of iron-deficiency anemia (IDA), which contributes to maternal morbidity, preterm labor, and low birth weight. Iron supplementation remains a cornerstone of antenatal care, aiming to replenish iron stores and prevent the progression of anemia. However, adherence, tolerance, and the magnitude of hematologic improvement vary with population characteristics and healthcare delivery settings. **Aim:** The present study was conducted to evaluate the effect of iron supplementation on maternal anemia and hematological indices among pregnant women attending a tertiary care hospital. **Material and Methods:** This prospective observational study was conducted on 106 pregnant women attending the antenatal clinic of a tertiary care hospital. Women aged 18–40 years with singleton pregnancies and without chronic illnesses were included. Detailed demographic data were recorded, and baseline investigations such as hemoglobin, serum ferritin, serum iron, total iron-binding capacity (TIBC), and red cell indices were obtained. Participants received oral ferrous sulfate tablets containing 100 mg elemental iron as per institutional protocol. Follow-up assessments were done after supplementation to evaluate hematological improvements. Data were analyzed using SPSS version 16.0, applying paired *t*-tests and Chi-square tests where appropriate, with $p < 0.05$ considered statistically significant. **Results:** The mean hemoglobin level increased significantly from 9.64 ± 1.21 g/dL to 11.38 ± 1.07 g/dL ($p < 0.001$). Serum ferritin improved from 18.32 ± 6.45 ng/mL to 32.48 ± 7.93 ng/mL ($p < 0.001$), while serum iron rose from 42.57 ± 8.62 µg/dL to 67.35 ± 9.14 µg/dL ($p < 0.001$). TIBC decreased significantly from 380.64 ± 44.72 µg/dL to 345.16 ± 38.24 µg/dL ($p = 0.002$). The proportion of non-anemic women increased from 16.98% to 63.21%, while severe anemia reduced from 13.21% to 0.94% ($p < 0.001$). Gastrointestinal side effects were mild, and compliance was high (83.96%). **Conclusion:** Iron supplementation during pregnancy produced a significant improvement in hematological parameters and markedly reduced the prevalence and severity of anemia, with good tolerability and compliance. Routine antenatal iron therapy remains an effective and essential strategy to improve maternal hematologic status and pregnancy outcomes.

Keywords: Iron supplementation, pregnancy, maternal anemia, serum ferritin, hemoglobin improvement

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INTRODUCTION

Anemia in pregnancy remains a major global public health concern, disproportionately affecting women in low- and middle-income countries and contributing to substantial maternal and perinatal morbidity. The most common etiology is iron deficiency, driven by inadequate dietary intake, low iron bioavailability from predominantly plant-based diets, infection-related losses, and increased physiological requirements during gestation. Global estimates from large pooled surveillance datasets consistently show a high prevalence of anemia among pregnant women, underscoring the scale of the problem and its resistance to routine programmatic efforts.[1] The clinical consequences of maternal iron deficiency and anemia are broad, encompassing maternal fatigue, reduced work capacity, heightened susceptibility to infection, and increased risk of peripartum transfusion. For the fetus and newborn, iron deficiency during gestation has been linked to impaired growth, preterm birth, and suboptimal neonatal iron endowment with potential implications for neurodevelopment. Foundational syntheses have argued that iron supplementation during pregnancy can mitigate many of these risks by restoring hemoglobin and iron stores, though the magnitude of benefit may vary by timing, baseline status, and adherence to therapy.[2] Physiologically, the pregnancy trajectory is characterized by expanding plasma volume, increased red-cell mass, and iron demands that escalate across trimesters to support fetoplacental growth. Dietary iron alone often cannot meet these needs, particularly where staple diets are high in phytates and polyphenols that inhibit absorption. Authoritative reviews of nutritional iron deficiency highlight both the biological mechanisms (including regulation of absorption and mobilization) and the population-level determinants that sustain high anemia burdens, emphasizing that preventive strategies must overcome low bioavailability and competing morbidities to succeed.[3] Evidence from quantitative syntheses indicates that prenatal iron supplementation improves hematologic status and reduces the risk of maternal anemia at term. A comprehensive meta-analysis reported dose–response relations for hemoglobin and ferritin improvements and demonstrated that consistent antenatal iron use lowers the odds of anemia and iron deficiency by delivery. Such findings reinforce the biological rationale for supplementation while also highlighting key programmatic levers—initiation early enough in pregnancy, sufficient elemental iron dose, and sustained adherence—to realize clinically meaningful gains.[4] At the population level, maternal anemia intersects with broader nutrition and development agendas. The Lancet's series on maternal and child undernutrition positioned micronutrient deficiencies—including iron deficiency—as central drivers of adverse outcomes across the life course, particularly in South Asia and sub-Saharan Africa. Within that framework, antenatal iron supplementation is a core, scalable intervention to improve maternal nutritional status and to contribute indirectly to better fetal growth and survival. Framing iron deficiency in pregnancy within this global context underscores why rigorous prospective evaluations in real-world antenatal services are essential to inform policy and practice in high-burden settings.[5] Translating this evidence into clinical guidance depends on understanding recommended intakes and how they relate to physiological demands. Dietary Reference Intakes delineate average requirements and upper limits, but in pregnancy, needs rise beyond what is typically achieved through diet alone, justifying prophylactic supplementation strategies. Such standards also inform the elemental iron content of commonly prescribed preparations and the duration of therapy needed to replenish stores while balancing tolerability.[6] Even as consensus has grown around the preventive value of iron, epidemiologic analyses stress that baseline status and timing strongly influence observed benefits. Reviews focused on iron status in pregnancy show that anemia or iron deficiency identified early in gestation is associated with higher risks of adverse outcomes such as preterm birth, whereas later-detected anemia may reflect hemodilution rather than true iron deficit. These insights highlight why prospective studies that measure hematological indices before and after supplementation—alongside acceptability and adherence—are critical. They help disentangle physiologic dilution from deficiency, quantify clinically relevant improvements in hemoglobin and iron stores, and characterize program performance (side-effects, compliance) under routine antenatal care conditions.[7]

MATERIALS AND METHODS

This was a prospective observational study conducted at a tertiary care hospital to evaluate the effect of iron supplementation during pregnancy on maternal anemia. A total of 106 pregnant women attending the antenatal outpatient department were enrolled in the study after obtaining informed written consent. Ethical approval was obtained from the Institutional Ethics Committee prior to commencement of the study.The study included 106 antenatal women in various trimesters of pregnancy who met the inclusion criteria. Inclusion criteria were pregnant women aged 18–40 years with singleton pregnancy and no significant comorbidities such as chronic renal disease, hemoglobinopathies, or pre-existing anemia of non-pregnancy causes. Exclusion criteria included multiple pregnancies, patients with pre-eclampsia, gestational diabetes mellitus, or those on concurrent hematinic or vitamin supplementation other than the prescribed study regimen.

Methodology

Detailed demographic and obstetric data including age, parity, gestational age, dietary habits, and socioeconomic status were recorded. Baseline investigations were performed at enrollment, including complete blood count, peripheral smear, serum ferritin, serum iron, total iron-binding capacity (TIBC), and transferrin saturation. The hemoglobin concentration was estimated using the cyanmethemoglobin method. Mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) were also assessed using an automated hematologyanalyzer.

All enrolled participants received routine antenatal care and were administered oral iron supplementation in the form of ferrous sulfate tablets (each containing 100 mg elemental iron) as per institutional guidelines. Compliance with supplementation was ensured through regular follow-up visits and pill counts. Participants were counseled regarding dietary sources of iron and measures to improve absorption, such as concurrent intake of vitamin C and avoidance of tea or coffee near medication time.

Follow-Up and Outcome Measures

Follow-up assessments were conducted periodically during antenatal visits. Hemoglobin and serum ferritin levels were re-evaluated to assess changes in hematological indices. The primary outcome measure was the improvement in hemoglobin concentration following iron supplementation. Secondary parameters included changes in serum ferritin, MCV, MCH, MCHC, and clinical symptoms of anemia such as fatigue, pallor, and dyspnea. Compliance and side effects related to iron therapy were also recorded.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics such as mean, standard deviation, and percentage were used for baseline characteristics. Paired *t*-tests were applied to compare pre- and post-supplementation values of hematological parameters. Chi-square tests were used for categorical variables. A *p*-value of <0.05 was considered statistically significant.

RESULTS

Demographic and Baseline Characteristics

Table 1 illustrates the demographic and baseline characteristics of the 106 pregnant women enrolled in the study. The majority of participants (43.40%) belonged to the age group of 25–30 years, followed by 35.85% in the 18–24 years group, while 20.75% were above 30 years. This indicates that most women were in their prime reproductive age. Regarding parity, 46.23% were primigravidas, and 53.77% were multigravidas, suggesting a relatively balanced distribution.Socioeconomic analysis revealed that more than half of the women (54.72%) belonged to the middle socioeconomic class, 29.25% were from the lower class, and 16.04% from the upper class. Dietary assessment showed that vegetarian women constituted a higher proportion (60.38%) compared to those following a mixed diet (39.62%), which may influence iron intake and absorption. Most participants were enrolled during the second trimester (51.89%), followed by 28.30% in the third trimester and 19.81% in the first trimester.

Baseline Hematological Parameters

Table 2 presents the baseline hematological profile of the participants prior to iron supplementation. The mean hemoglobin level was 9.64 ± 1.21 g/dL, which is below the normal range (11–14 g/dL), indicating that most of the women were anemic at baseline. The mean serum ferritin level was 18.32 ± 6.45 ng/mL, reflecting depleted iron stores, while the mean serum iron level was 42.57 ± 8.62 µg/dL, also below the normal reference range.The total iron-binding capacity (TIBC) was elevated (380.64 ± 44.72 µg/dL), suggesting increased binding sites due to iron deficiency. Similarly, the mean transferrin saturation was low (12.54 ± 3.18%), confirming iron deficiency anemia. Red cell indices such as MCV (75.22 ± 5.38 fL), MCH (24.13 ± 2.67 pg), and MCHC (31.46 ± 1.92 g/dL) were all lower than normal, indicating microcytic hypochromic anemia.

Effect of Iron Supplementation on Hematological Parameters

Table 3 compares the hematological parameters before and after iron supplementation. The mean hemoglobin level increased significantly from 9.64 ± 1.21 g/dL to 11.38 ± 1.07 g/dL (*p*< 0.001), indicating substantial improvement in anemia status. Serum ferritin, an indicator of iron stores, showed a significant rise from 18.32 ± 6.45 ng/mL to 32.48 ± 7.93 ng/mL (*p*< 0.001), demonstrating improved iron reserves following supplementation.Similarly, serum iron levels increased from 42.57 ± 8.62 µg/dL to 67.35 ± 9.14 µg/dL (*p*< 0.001), while TIBC decreased from 380.64 ± 44.72 µg/dL to 345.16 ± 38.24 µg/dL (*p* = 0.002), reflecting enhanced iron availability. The transferrin saturation improved significantly from 12.54 ± 3.18% to 19.52 ± 3.89% (*p*< 0.001). Red cell indices also showed marked improvement; MCV increased from 75.22 ± 5.38 fL to 82.74 ± 4.91 fL, MCH from 24.13 ± 2.67 pg to 27.58 ± 2.19 pg, and MCHC from 31.46 ± 1.92 g/dL to 33.12 ± 1.43 g/dL, all showing statistically significant changes (*p*< 0.05).

Changes in Severity of Anemia Following Supplementation

The distribution of anemia severity before and after iron therapy is summarized in Table 4. Initially, 46.23% of women had moderate anemia and 13.21% had severe anemia, while only 16.98% were non-anemic. After iron supplementation, the proportion of non-anemic women increased remarkably to 63.21% (*p*< 0.001). The percentage of moderately anemic women reduced from 46.23% to 13.21% (*p*< 0.001), and severe anemia cases decreased drastically from 13.21% to 0.94% (*p*< 0.001).The mild anemia group showed minimal change (23.58% before vs. 22.64% after, *p* = 0.812), suggesting that some participants remained mildly anemic despite therapy.

Side Effects and Compliance with Iron Supplementation

Table 5 depicts the reported side effects and compliance among participants. Most women (63.21%) reported no adverse effects during the course of supplementation. The most frequently reported side effects were nausea (13.21%), constipation (10.38%), and epigastric discomfort (8.49%), followed by metallic taste in 4.72% of participants. These side effects were mild and did not necessitate discontinuation of therapy.Compliance with iron supplementation was satisfactory, with 83.96% of participants consuming more than 80% of the prescribed tablets.

Table 1: Demographic and Baseline Characteristics of the Study Participants (n = 106)

Parameter	Categories	Number (n)	Percentage (%)
Age Group (years)	18–24	38	35.85
	25–30	46	43.40
	>30	22	20.75
Parity	Primigravida	49	46.23

	Multigravida	57	53.77
Socioeconomic Status	Lower	31	29.25
	Middle	58	54.72
	Upper	17	16.04
Dietary Habits	Vegetarian	64	60.38
	Mixed Diet	42	39.62
Trimester at Enrollment	First	21	19.81
	Second	55	51.89
	Third	30	28.30

Table 2: Baseline Hematological Parameters Before Iron Supplementation (n = 106)

Parameter	Mean ± SD	Normal Range
Hemoglobin (g/dL)	9.64 ± 1.21	11–14
Serum Ferritin (ng/mL)	18.32 ± 6.45	30–200
Serum Iron (µg/dL)	42.57 ± 8.62	50–150
Total Iron Binding Capacity (µg/dL)	380.64 ± 44.72	250–400
Transferrin Saturation (%)	12.54 ± 3.18	20–50
MCV (fL)	75.22 ± 5.38	80–96
MCH (pg)	24.13 ± 2.67	27–32
MCHC (g/dL)	31.46 ± 1.92	32–36

Table 3: Comparison of Hematological Parameters Before and After Iron Supplementation (n = 106)

Parameter	Before Supplementation (Mean ± SD)	After Supplementation (Mean ± SD)	Mean Difference	*p*-value
Hemoglobin (g/dL)	9.64 ± 1.21	11.38 ± 1.07	+1.74	<0.001*
Serum Ferritin (ng/mL)	18.32 ± 6.45	32.48 ± 7.93	+14.16	<0.001*
Serum Iron (µg/dL)	42.57 ± 8.62	67.35 ± 9.14	+24.78	<0.001*
TIBC (µg/dL)	380.64 ± 44.72	345.16 ± 38.24	–35.48	0.002*
Transferrin Saturation (%)	12.54 ± 3.18	19.52 ± 3.89	+6.98	<0.001*
MCV (fL)	75.22 ± 5.38	82.74 ± 4.91	+7.52	<0.001*
MCH (pg)	24.13 ± 2.67	27.58 ± 2.19	+3.45	<0.001*
MCHC (g/dL)	31.46 ± 1.92	33.12 ± 1.43	+1.66	0.018*

*Statistically significant at $p < 0.05$.

Table 4: Distribution of Participants Based on Severity of Anemia Before and After Iron Supplementation

Severity of Anemia (WHO Criteria)	Hemoglobin (g/dL)	Before Supplementation n (%)	After Supplementation n (%)	*p*-value
No Anemia	≥11.0	18 (16.98%)	67 (63.21%)	<0.001*
Mild (10–10.9)	10–10.9	25 (23.58%)	24 (22.64%)	0.812
Moderate (7–9.9)	7–9.9	49 (46.23%)	14 (13.21%)	<0.001*
Severe (<7.0)	<7.0	14 (13.21%)	1 (0.94%)	<0.001*

*Statistically significant at $p < 0.05$.

Table 5: Reported Side Effects and Compliance with Iron Supplementation

Adverse Effect	Number of Patients (n)	Percentage (%)
Nausea	14	13.21
Constipation	11	10.38
Epigastric discomfort	9	8.49
Metallic taste	5	4.72
No side effects reported	67	63.21
Overall Compliance (>80% tablets taken)	**89**	**83.96**

DISCUSSION

The cohort's baseline pattern—low hemoglobin (9.64 ± 1.21 g/dL), low ferritin (18.32 ± 6.45 ng/mL), low transferrin saturation (12.54%), and high TIBC (380.64 ± 44.72 µg/dL)—is typical of second-trimester iron deficit, when maternal requirements rapidly escalate; Bothwell (2000) detailed the physiologic rise in iron need across gestation and the expected laboratory signature of iron-deficiency anemia, aligning with these baseline indices.[8]

The rise in hemoglobin from 9.64 to 11.38 g/dL (+1.74 g/dL, $p<0.001$) corresponds well with aggregate effects reported by Peña-Rosas et al. (2012) in the Cochrane review of daily antenatal iron, which demonstrated meaningful reductions in maternal anemia and iron deficiency at term versus no iron—effects most apparent when baseline anemia is prevalent, as in this cohort.[9]

Iron-store repletion was evident with ferritin increasing by +14.16 ng/mL to 32.48 ng/mL ($p<0.001$). Milman et al. (2005) randomized pregnant participants to 20–80 mg ferrous iron daily from 18 weeks and showed dose-responsive preservation/raising of iron stores and less iron-deficiency/IDA at term, mirroring the direction and clinical meaning of the ferritin gain seen here.[10]

Red-cell indices corrected toward normal (MCV +7.52 fL, MCH +3.45 pg, MCHC +1.66 g/dL; all $p<0.05$). By contrast, Bouzari et al. (2011)—randomizing non-anemic women to daily vs. intermittent prophylaxis—reported no significant between-group differences in post-treatment Hb and iron measures, highlighting that the larger index shifts here reflect correction of established deficiency rather than prophylaxis in iron-replete populations.[11]

Severity-class improvement was marked: moderate anemia fell 46.23% → 13.21%, severe 13.21% → 0.94%, and non-anemic rose 16.98% → 63.21% (all $p<0.001$). In a trial where many participants began pregnancy iron-replete, Cogswell et al. (2003) observed limited effects of iron on mid-pregnancy Hb, underscoring that baseline status moderates outcomes and explaining why category shifts were larger in the present cohort.[12]

Biochemical normalization—serum iron +24.78 µg/dL, TSAT +6.98%, and TIBC −35.48 µg/dL—parallels classic supplementation findings in late-pregnancy initiation contexts. In Niamey, Preziosi et al. (1997) provided 100 mg elemental Fe/day from ≈28 weeks and demonstrated improved maternal iron status with benefits extending to infant iron indices, consistent with the store-repletion pattern observed here.[13]

Regarding tolerability, 63.21% reported no adverse effects; the most frequent were nausea (13.21%) and constipation (10.38%). Fewer gastrointestinal complaints with non-daily schedules have been consistently reported; Peña-Rosas et al. (2012) (Cochrane, intermittent dosing) found lower rates of side effects such as constipation and nausea versus daily regimens, which contextualizes the acceptable side-effect rates observed with daily ferrous sulfatehere.[14]

Adherence exceeded expectations (83.96% taking >80% tablets). Programmatic experience synthesized by Galloway & McGuire (1994) showed that adherence hinges on side-effects, counseling, and reliable supply; the high compliance reported here fits with interventions such as anticipatory counseling and pill counts that address these determinants.[15]

Dosing practices were policy-concordant: WHO (2012) recommends daily iron–folic acid (30–60 mg Fe) through pregnancy to reduce maternal anemia and iron deficiency. The hemoglobin increase (+1.74 g/dL) and shift to 63.21% non-anemic are consistent with the prevention-and-treatment intent of those guidelines in moderate-to-high-burden settings.[16]

Finally, adherence and side-effects observed (e.g., mostly mild GI symptoms) resemble pragmatic findings from Brazil: Souza et al. (2009) compared weekly, twice-weekly, and daily ferrous sulfate (60 mg Fe) for 16 weeks in anemic gravidas (n=150; 16–20 weeks), documenting regimen-dependent GI effects and adherence trade-offs—consistent with >80% adherence and acceptable tolerability in the cohort summarized here.[17]

CONCLUSION

Iron supplementation during pregnancy significantly improves hemoglobin concentration, serum ferritin, and other red cell indices, effectively reducing the prevalence and severity of maternal anemia. The regimen was well tolerated, with minimal gastrointestinal side effects and good compliance. These findings affirm that routine antenatal iron supplementation is a safe, effective, and essential strategy to prevent and treat iron-deficiency anemia, ultimately promoting better maternal and fetal health outcomes.

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