Original Article
DOI: https://doi.org/10.70749/ijbr.v3i5.2244

INDUS JOURNAL OF BIOSCIENCE RESEARCH
https://ijbr.com.pk
ISSN: 2960-2793/ 2960-2807

Fetal Outcomes in Maternal Iron Deficiency Anemia

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ARTICLE INFO

Keywords: Iron Deficiency Anemia, Pregnancy, Fetal Outcomes, Low Birth Weight, Preterm Birth, Small for Gestational Age.

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Declaration
Authors' Contribution
All authors equally contributed to the study and approved the final manuscript

Conflict of Interest: No conflict of interest.

Funding: No funding received by the authors.

Article History
Received: 09-03-2025 Revised: 15-05-2025
Accepted: 21-05-2025 Published: 30-05-2025

ABSTRACT

Background: Maternal anemia caused by iron deficiency is a widespread condition in pregnant females and is a significant risk to fetal and birth development. Despite its proven impact, the association between anemia in the mother and adverse neonatal consequences such as low birth weight, prematurity, and small for gestational age is an area of research. **Objective:** To assess the frequency of fetal outcomes in patients with maternal iron deficiency anemia. **Study Design:** Cross-sectional analytical study. **Duration and Place of Study:** This study was conducted from September 2024 to February 2025 at the Department of Obstetrics and Gynecology, Pakistan Aeronautical Complex (PAC) Kamra. **Methodology:** A total of 130 pregnant women aged 18–40 years in their third trimester with singleton pregnancies and diagnosed with iron deficiency anemia (hemoglobin <11 g/dL, serum ferritin <15 µg/L, and MCV <82 fL) were enrolled. Patients with conditions such as preeclampsia, diabetes, fetal anomalies, or a history of blood transfusion during pregnancy were excluded. **Results:** The mean maternal age was 29.1 ± 7.03 years, with a mean gestational age of 38.6 ± 1.48 weeks and a mean BMI of 27.49 ± 3.67 kg/m^2. Among the participants, 24.6% of infants were small for gestational age, 16.9% were born preterm, and 18.5% had low birth weight. These adverse outcomes were significantly associated with younger maternal age (≤30 years), lower parity (0–3), and lower BMI (≤25 kg/m^2). **Conclusion:** Maternal iron deficiency anemia is a significant risk factor for adverse fetal outcomes, particularly among younger, low-parity mothers with lower BMI.

INTRODUCTION

Pregnancy anemia is a common condition characterized mainly by decreased number of red blood cells and low concentration of hemoglobin in blood. Without it, hemoglobin is unable to carry oxygen to tissues and organs, and during pregnancy, significant amounts of iron are needed to support the growing fetus as well as the increased pregnant woman's blood volume.[2] Iron deficiency anemia is common among pregnant women because it faces the increased iron requirements for pregnancy, which can exceed the amount available from dietary intake or absorption. This may result in fatigue, weakness, dizziness or pallor and without treatment become a complication in both the mother and the fetus.[3] Blood tests that measure the level of hemoglobin are usually used to identify if a woman has anemia, and anemia is an important indicator of a woman's health during prenatal care.[4]

Iron deficiency anemia in the mother can have an effect on fetal development.[5] The fetus needs iron to grow, and in fact brain growth and hence overall organ function depends on iron. Iron deficiency in pregnancy can cause low oxygen carrying capacity of maternal blood and it may be associated with an inadequate oxygen and nutrient supply to the fetus. Therefore, this may impair normal development or cause cognitive deficits later in life. It may also lead to stillbirth or neonatal death in some.[6] The risk of infant anemia after birth can also deplete the baby's iron reserves, and also deplete iron during pregnancy, potentially compromising the child's growth and early childhood cognitive development.[7]

Maternal iron deficiency anemia is a strong risk factor for small-for-gestational age (SGA) baby.[8] Those who are smaller than the 10th percentile for their gestational age are called SGA, which could happen when the placenta does not provide sufficient nutrients or oxygen to the fetus.[9] Red blood cells and proper placental function are both essential and depend on iron. Iron deficiency can make placenta development and blood flow inadequate that oxygen and nutrients supply to the fetus is reduced.[10] Because of this, babies born to mothers with iron deficiency anemia may be at higher risk for the condition of intrauterine growth restriction (IUGR) and have lower birth weights, which can cause complications at birth.

In fact, iron deficiency anemia in pregnancy has been linked to preterm birth (birth before 37 weeks of

gestation) and low birth weight.[11] But these outcomes are multifactorial mechanisms that are thought to be due to reduced placental function, impaired fetal blood flow and inadequate fetal nutrient delivery. Preterm birth and low birth weight contribute significantly to the neonatal morbidity and mortality, and preterm or low birth weight babies are at increased risk of respiratory disease, infection, developmental delay, and long-term health complications.[12] Early intervention in iron deficiency in pregnancy through supplementation and proper prenatal care can reduce these risks and produce better maternal and neonatal outcomes.[13]

Study conducted by Chen, et al. demonstrated that among women suffering from iron deficiency anemia during pregnancy, 20.2% delivered babies who were small for gestational age. Additionally, 15.7% of these pregnancies resulted in preterm deliveries, while 13.7% of babies had low birth weight.[14]

Despite being highly preventable, anemia caused by a lack of iron affects numerous pregnant women worldwide and potentially could have a significant impact on fetal development and delivery. Through a critical appraisal of the correlation of anemia in the mother with fetal consequences such as low birth weight, prematurity, and restriction of intrauterine growth, health workers will be better placed to detect vulnerable pregnancies and institute proper intervention in a timely manner. Such research is critical in the development of evidence-based guidelines to promote the health of mothers and newborns in anemic environments with limited resources.

METHODOLOGY

This cross-sectional study was conducted between September 2024 and February 2025 at the Department of Obstetrics and Gynecology, Pakistan Aeronautical Complex (PAC) Kamra. A total of 130 women, aged 18 to 40 years, were selected for the study, with all participants being in their third trimester, having a singleton pregnancy, and meeting the criteria for maternal iron deficiency anemia as defined by hemoglobin levels below 11 g/dL, serum ferritin levels below 15 µg/L, and Mean Corpuscular Volume (MCV) below 82 fL. The sample size was determined using a 95% confidence level, 6% margin of error, and an anticipated frequency of low birth weight of 13.7% in women with maternal iron deficiency anemia.[14]

Exclusion criteria consisted of a history of sickle cell disease, preeclampsia, placental abruption, diabetes, hypertension, previous blood transfusions during pregnancy, or fetal anomalies detected via ultrasound.

Upon obtaining ethical approval and informed consent from all participants, demographic information was gathered, including age, gestational age, body mass index (BMI), parity, socioeconomic status, education, occupation, and residential status. Laboratory data for hemoglobin levels, serum ferritin, and MCV were recorded as part of the inclusion process. Participants were then monitored throughout their pregnancy until delivery, with fetal outcomes, including small for gestational age, preterm birth, and low birth weight, noted according to the operational definitions provided.

Babies were classified as small for gestational age when their weight fell below the tenth percentile for their developmental stage. Deliveries occurring before the 37-week mark were categorized as premature, while newborns weighing under 2,500 grams were documented as having low birth weight.

For data processing, IBM SPSS software (version 26) was utilized. For category-based information, calculations included frequency counts and percentage distributions. For numerical measurements, results were presented as either means with standard deviations or medians with interquartile ranges, based on distribution patterns. The Shapiro-Wilk method determined data normality. The analysis incorporated grouping based on factors including maternal age, pregnancy duration, body mass index, and number of previous pregnancies. After this classification, comparative assessments employed chi-square testing or Fisher's exact method when appropriate, with statistical significance established at p-values of 0.05 or less.

RESULTS

Demographic data (Table-I) revealed patients had a mean age of 29.107±7.03 years, mean gestational age of 38.639±1.48 weeks, and mean BMI of 27.493±3.67 kg/m^2. The patients' average parity was 2.292±1.86. Laboratory values showed mean hemoglobin of 9.020±1.10 g/dL, serum ferritin of 9.981±3.33 µg/L, and MCV of 77.103±4.16 fL, confirming iron deficiency anemia. Regarding socioeconomic status, 58 patients (44.6%) were from low socioeconomic status, 52 (40%) from middle, and 20 (15.4%) from high status. Most patients (96, 73.8%) resided in rural areas compared to 34 (26.2%) in urban settings. Occupationally, the vast majority (122, 93.8%) were housewives with only 8 (6.2%) employed. Education levels varied with 20 (15.4%) uneducated, 60 (46.2%) having primary education, 34 (26.2%) with secondary education, and 16 (12.3%) with higher education.

Table I

Patient Demographics

Demographics		Mean ± SD / n (%)
Age (years)		29.107±7.03
Gestational age (weeks)		38.639±1.48
BMI (kg/m^2)		27.493±3.67
Parity		2.292±1.86
Hemoglobin (g/dL)		9.020±1.10
Serum Ferritin (µg/L)		9.981±3.33
MCV (fL)		77.103±4.16
Socioeconomic Status	Low	58 (44.6%)
	Middle	52 (40%)
	High	20 (15.4%)
Residential Status	Rural	96 (73.8%)
	Urban	34 (26.2%)
Occupation	Job	8 (6.2%)
	Housewife	122 (93.8%)
Education	Uneducated	20 (15.4%)
	Primary	60 (46.2%)
	Secondary	34 (26.2%)
	Higher	16 (12.3%)

Table-II documented specific fetal outcomes, with 32 (24.6%) infants being small for gestational age (SGA), 22 (16.9%) experiencing preterm birth, and 24 (18.5%) having low birth weight.

Table II

Fetal outcomes in patients with maternal iron deficiency anemia

Fetal outcomes	Frequency	%age
Small for Gestational Age	32	24.6%
Preterm Birth	22	16.9%
Low Birth Weight	24	18.5%

Table-III presented detailed stratification of these outcomes by demographic factors. For SGA, younger mothers (≤30 years) had significantly higher rates (45.7% vs. 0%, p<0.001), as did those with lower parity (0-3) (33.3% vs. 0%, p<0.001) and lower BMI (≤25 kg/m^2) (80% vs. 0%, p<0.001). Similar patterns were observed for preterm birth, with higher rates in younger mothers (31.4% vs. 0%, p<0.001), lower parity (22.9% vs. 0%, p=0.002), and lower BMI (55% vs. 0%, p<0.001). Low birth weight followed the same trend, occurring more frequently in younger mothers (34.3% vs. 0%, p<0.001), those with lower parity (25% vs. 0%, p=0.001), and lower BMI (60% vs. 0%, p<0.001). Notably, socioeconomic status showed no significant association with any of the adverse fetal outcomes (p=0.406 for SGA, p=0.292 for preterm birth, and p=0.401 for low birth weight), despite varying frequencies across socioeconomic groups.

Table III

Association of Fetal outcomes with Demographic Factors

Demographic Factors		Small for Gestational Age		p-value
		Yes n(%)	No n(%)	
Age	≤30	32 (45.7%)	38 (54.3%)	<0.001*
	>30	0 (0%)	60 (100%)	
Parity	0-3	32 (33.3%)	64 (66.7%)	<0.001*
	>3	0 (0%)	34 (100%)	
BMI (kg/m^2)	≤25	32 (80%)	8 (20%)	<0.001*
	>25	0 (0%)	90 (100%)	
Socioeconomic Status	Low	12 (20.7%)	46 (79.3%)	0.406*
	Middle	16 (30.8%)	36 (69.2%)	
	High	4 (20%)	16 (80%)	
Demographic Factors		**Preterm Birth**		**p-value**
		Yes n(%)	**No n(%)**	
Age	≤30	22 (31.4%)	48 (68.6%)	<0.001*
	>30	0 (0%)	60 (100%)	
Parity	0-3	22 (22.9%)	74 (77.1%)	0.002*
	>3	0 (0%)	34 (100%)	
BMI (kg/m^2)	≤25	22 (55%)	18 (45%)	<0.001*
	>25	0 (0%)	90 (100%)	
Socioeconomic Status	Low	8 (13.8%)	50 (86.2%)	0.292*
	Middle	12 (23.1%)	40 (76.9%)	
	High	2 (10%)	18 (90%)	
Demographic Factors		**Low Birth Weight**		**p-value**
		Yes n(%)	**No n(%)**	
Age	≤30	24 (34.3%)	46 (65.7%)	<0.001*
	>30	0 (0%)	60 (100%)	
Parity	0-3	24 (25%)	72 (75%)	0.001*
	>3	0 (0%)	34 (100%)	
BMI (kg/m^2)	≤25	24 (60%)	16 (40%)	<0.001*
	>25	0 (0%)	90 (100%)	
Socioeconomic Status	Low	10 (17.2%)	48 (82.8%)	0.401*
	Middle	12 (23.1%)	40 (76.9%)	
	High	2 (10%)	18 (90%)	

Fisher Exact Test*

DISCUSSION

Our findings show that 24.6% of infants were classified as small for gestational age, 16.9% were born prematurely, and 18.5% had low birth weight. These conditions were significantly associated with younger maternal age (≤30 years), low parity (0-3), and low BMI (≤25 kg/m^2). These associations are due to a variety of physiological mechanisms. Maternal iron deficiency reduces oxygen delivery to the fetus by decreasing hemoglobin concentration, leading to chronic fetal hypoxia and consequent fetal growth restriction. Iron-deficient younger mothers have potentially compromised physiological reserves and stores to support fetal growth. The striking association with low maternal BMI suggests that such mothers have more than one nutritional issue, with caloric as well as micronutrient deficiencies compromising the development and function of the placenta. The association with low parity is likely due to the failure to adapt to pregnancy since multiparity is generally associated with augmented uteroplacental circulation in the second and later pregnancies. The failure to demonstrate an association with socio-economic status, despite its known association with nutritional status, suggests that anemia due to iron deficiency is the dominant pathophysiological cause of adverse outcomes regardless of socio-economic status.

Anam Ahmed et al. conducted a study to identify the effect of anemia on the outcome of pregnancy and fetal health among mothers visiting GMC Hospital, Ajman, UAE. They found that anemia was more prevalent among young females (≤30 years of age) and among those who were not covered by health insurance, with most of the cases being of mild severity. They found a significantly higher cesarean delivery rate of 39% and a high rate of preterm delivery of 77.8% among anemic mothers. Interestingly, although the birth weight of mothers with moderate to severe anemia

was below the mean, it was within normal limits. They concluded that anemia should be diagnosed and treated early to prevent complications.[15] To the same effect, our study investigated fetal outcomes among pregnant women with anemia caused by iron deficiency. Our population data revealed a mean age of 29.107±7.03 years, with a mean gestational age of 38.639±1.48 weeks and a mean body mass index of 27.493±3.67 kg/m^2. Our average parity among our patients was 2.292±1.86. Our laboratory results corroborated anemia caused by iron deficiency with a mean hemoglobin of 9.020±1.10 g/dL, serum ferritin of 9.981±3.33 µg/L, and MCV of 77.103±4.16 fL. Our results also revealed that younger mothers with an age of ≤30 years had significantly more poor fetal outcomes, including small for gestational age and preterm delivery, as corroborated by the results of Ahmed et al. that anemia prevalence and pregnancy outcome have a negative impact due to the mother's age.

Kharate and Choudhari's narrative review noted that iron deficiency anemia (IDA) affects millions of females across the world, particularly in pregnancy, with resultant fetal and maternal health consequences of low birth weight and developmental impairments.[16] Our results support this, as we also found that 24.6% of the infants were SGA, 16.9% had a preterm birth, and 18.5% had a low birth weight. Similar to Kharate et al., our research also revealed that younger mothers and those of low parity had significantly higher proportions of such adverse consequences.

Noran M. Abu-Ouf and Mohammed M. Jan also referred to anemia among mothers as a significant public health issue and connected it with adverse birth outcomes such as low birth weight and preterm delivery.[17] Our result that low birth weight was more prevalent among younger mothers with low parity and BMI highlights the urgent need to effectively manage anemia among pregnant women to prevent adverse birth outcomes among mothers and neonates.

Qi Zhang et al. also investigated the effects of anemia caused by a lack of iron on pregnancy outcome using a model of rats and determined that supplementation with iron improved the maternal health and the development of the offspring.[18] Our findings also supported the supplementation with iron to correct anemia to improve fetal outcome as we demonstrated that birth weights of mothers with severe to moderate anemia were decreased.

Tejeswini et al. also explained the severity of anemia in mothers and how it affected the outcome of the baby, pointing out the association of anemia with adverse results such as low birth weight and prematurity.[19] Our results confirmed this association as we had notable trends that indicated that younger mothers and those with low parity had more incidences of SGA and low birth weight.

The concordance of our findings with the existing literature underscores the need to address maternal iron-deficiency anemia to promote the health of the mother and the fetus. The overall evidence suggests the need for screening and intervention initiated early to prevent the adverse effects of anemia in pregnancy, which remains a prevalent issue among various populations.

Despite this, the study is subject to certain limitations. As a single-center study, the findings cannot always be generalized to the population as a whole. The sample size was relatively small, and this may diminish the statistical power to detect associations. The use of a retrospective data collection also potentially introduces bias and limits the level of analysis into the effect of anemia by different demographic and clinical factors. Larger multi-center prospective studies in the future would have to corroborate these findings and investigate the mechanisms behind them.

CONCLUSION

Our study revealed that anemia caused by iron deficiency significantly impacts the health of the infant as well as the outcome of the pregnancy. The findings indicate that anemia occurs more frequently in low-parity and young mothers and leads to an increase in the incidence of such adverse events as low birth weight and preterm birth. These findings emphasize the requirement of proper diagnosis and effective management of anemia in pregnancy to prevent the occurrence of such complications and to achieve optimal infant and mother health.

Acknowledgments

We sincerely appreciate the unwavering commitment of the medical team in maintaining precise records and efficiently organizing patient information. Their efforts play a crucial role in upholding the integrity of this study.

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