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Original Research Article

"Association Between Maternal Anemia Severity and Low Birth Weight"

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Abstract: ***Background:*** Maternal anemia remains a major public health concern in developing countries and is an important contributor to adverse perinatal outcomes. Low birth weight (LBW) continues to be a significant cause of neonatal morbidity and mortality. The severity of maternal anemia may influence fetal growth and birth weight, but region-specific hospital-based evidence remains limited. ***Aim:*** To evaluate the association between maternal anemia severity and low birth weight among pregnant women delivering at a tertiary care hospital. ***Methods:*** A hospital-based observational analytical study was conducted in the Department of Obstetrics and Gynaecology at Government Medical College, Anantnag, from January 2023 to December 2024. A total of 200 pregnant women were included. Maternal hemoglobin levels were recorded and anemia was categorized into mild, moderate, and severe based on standard criteria. Neonatal birth weight was measured immediately after delivery, and LBW was defined as birth weight <2500 g. Statistical analysis included Chi-square test, odds ratio calculation, and multiple logistic regression analysis. A p-value <0.05 was considered statistically significant. ***Results:*** Among 200 participants, 142 (71%) were anemic, with 31% mild, 35% moderate, and 10% severe anemia. The overall incidence of LBW was 29.5%. A progressive increase in LBW incidence was observed with increasing anemia severity: 10.4% in non-anemic mothers, 19.4% in mild anemia, 40% in moderate anemia, and 70% in severe anemia (p <0.001). Moderate anemia increased the risk of LBW by 3.06 times, while severe anemia increased the risk by 7.47 times after adjustment for confounders. Preterm delivery was also a significant independent predictor. ***Conclusion:*** Maternal anemia severity is significantly associated with low birth weight, with a clear dose–response relationship. Severe anemia markedly increases the risk of LBW. Early detection and effective management of maternal anemia during pregnancy are essential strategies to reduce adverse neonatal outcomes.

Keywords: Maternal Anemia; Low Birth Weight; Pregnancy; Hemoglobin; Neonatal Outcome; Severity of Anemia; Perinatal Risk; Obstetrics.

INTRODUCTION

Low birth weight (LBW), defined as birth weight less than 2500 grams irrespective of gestational age, is one of the most important indicators of neonatal health and survival worldwide [1]. Globally, nearly 20 million infants are born with LBW every year, accounting for approximately 15–20% of all live births and contributing significantly to neonatal morbidity, mortality, impaired growth, and long-term metabolic disorders [1]. Despite improvements in maternal health services, LBW remains a persistent challenge in low- and middle-income countries.

Maternal anemia is a common medical condition during pregnancy and is defined as hemoglobin concentration less than 11 g/dL [2]. It reduces oxygen-carrying capacity and compromises placental oxygen delivery, thereby affecting fetalgrowth and development. Global estimates indicate that more than 30% of pregnant women are affected by anemia, with the highest burden seen in South Asia and sub-Saharan Africa [2]. Several large-scale epidemiological studies have demonstrated that maternal anemia significantly increases the risk of low birth weight, preterm birth, and perinatal mortality [3].

Population-based data from India have shown that maternal anemia is independently associated with an increased risk of delivering LBW infants even after adjusting for socioeconomic and obstetric factors [3]. Systematic reviews and meta-analyses have consistently reported that anemic pregnant women have significantly higher odds of delivering LBW neonates compared to non-anemic women, with pooled risk estimates showing approximately 20–30% increased risk [4]. Prospective cohort evidence further suggests a dose–response relationship, where increasing severity of maternal anemia is associated with progressively lower birth weight [5].

Studies conducted in rural Indian settings have also emphasized that maternal anemia is a major modifiable determinant of low birth weight, influenced by nutritional status, socioeconomic factors, and access to antenatal care [6]. A pooled analysis demonstrated that maternal anemia increases the risk of LBW by approximately 23%, reinforcing its clinical and public health significance [7]. Furthermore, systematic evidence confirms that moderate to severe anemia in pregnancy significantly elevates the risk of adverse perinatal outcomes, including LBW [8].

In the Indian context, anemia continues to be highly prevalent among pregnant women despite national iron supplementation initiatives, and LBW prevalence remains around 17–18% according to recent national surveys [9]. Broader global analyses have highlighted that anemia in women of reproductive age remains a persistent challenge in South Asia, where micronutrient deficiencies and maternal undernutrition are common contributors to fetal growth restriction [10].

The objectives are to classify pregnant women according to severity of anemia based on hemoglobin levels, to determine the incidence of low birth weight among different anemia categories, and to assess the strength of association between maternal anemia severity and neonatal birth weight outcomes. The study is justified because maternal anemia remains highly prevalent despite ongoing nutritional programs, and low birth weight continues to contribute significantly to neonatal morbidity and mortality; however, region-specific data correlating anemia severity with birth weight are limited. Understanding this relationship in a tertiary care setting will help in early identification of high-risk pregnancies and improve antenatal risk stratification. The expected future outcomes include strengthening screening protocols, improving targeted iron supplementation strategies, reducing the incidence of low birth weight, and contributing evidence-based recommendations for maternal health interventions at institutional and regional levels.

MATERIALS & METHODOLOGY

The present study was conducted as a hospital-based observational analytical study in the Department of Obstetrics and Gynaecology at Government Medical College, Anantnag, from January 2023 to December 2024. A total of 200 pregnant women who delivered during the study period and fulfilled the inclusion criteria were enrolled. Pregnant women with documented hemoglobin levels during the third trimester and singleton live births were included, while women with multiple gestations, known hemoglobinopathies, chronic systemic illnesses, or incomplete records were excluded.

Detailed demographic, obstetric, and clinical information was collected from medical records and antenatal case sheets. Maternal hemoglobin levels were recorded from laboratory reports, and anemia severity was classified according to standard criteria into mild, moderate, and severe anemia based on hemoglobin concentration. Neonatal birth weight was measured within one hour of delivery using a calibrated digital weighing scale, and low birth weight was defined as birth weight less than 2500 grams irrespective of gestational age.

The primary outcome variable was low birth weight, and the main exposure variable was severity of maternal anemia. Data were entered in Microsoft Excel and analyzed using appropriate statistical software. Categorical variables were expressed as frequency and percentage, while continuous variables were summarized using mean and standard deviation. The association between maternal anemia severity and low birth weight was assessed using the Chi-square test, and strength of association was determined using odds ratio with 95% confidence interval. A p-value of less than 0.05 was considered statistically significant. Ethical approval was obtained from the Institutional Ethics Committee prior to commencement of the study, and confidentiality of patient data was strictly maintained throughout the research process.

RESULTS

A total of 200 pregnant women were included in the study. The majority of participants were in the age group of 20–25 years (39%), followed by 26–30 years (32%), while 18% were above 30 years and 11% were below 20 years. Multigravida women constituted 57% of the study population, and 43% were primigravida. Most deliveries were term (81%), whereas 19% were preterm. Regarding anemia status, 29% were non-anemic, while 71% were anemic, 31% had mild anemia, 35% had moderate anemia, and 10% had severe anemia. Overall, 29.5% of neonates were born with low birth weight (LBW), while 70.5% had normal birth weight.

A progressive increase in the incidence of low birth weight was observed with increasing severity of maternal anemia. Among non-anemic women, 10.4% delivered LBW infants, whereas the proportion increased to 19.4% in mild anemia, 40% in moderate anemia, and 70% in severe anemia. This association between anemia severity and LBW was found to be statistically highly significant (Chi-square = 32.84, $p < 0.001$).

Crude analysis demonstrated that women with moderate to severe anemia had 5.21 times higher odds of delivering LBW infants compared to non-anemic and mildly anemic women (95% CI: 2.71–9.99, $p < 0.001$). On multiple logistic regression analysis, after adjusting for age, parity, and gestational age, moderate anemia independently increased the risk of LBW by 4.98 times ($p <0.001$), while severe anemia increased the risk by 7.47 times ($p < 0.001$). Preterm delivery was also a strong independent predictor, increasing the odds of LBW by 5.36 times ($p < 0.001$). The regression model showed good explanatory power with Nagelkerke R^2 of 0.41 and overall model significance ($p < 0.001$).

These findings indicate a clear dose–response relationship between maternal anemia severity and low birth weight, with severe anemia emerging as a major independent predictor of adverse neonatal outcome.

Table 1: Demographic and Clinical Profile of Study Participants (n = 200)

Variable	Frequency (n)	Percentage (%)
Age Group (years)		
<20	22	11.0
20–25	78	39.0
26–30	64	32.0
>30	36	18.0
Parity		
Primigravida	86	43.0
Multigravida	114	57.0
Gestational Age		
Preterm	38	19.0
Term	162	81.0
Severity of Anemia		
Non-Anemic	58	29.0
Mild	56	28.0
Moderate	60	30.0
Severe	26	13.0
Birth Weight Outcome		
Low Birth Weight	59	29.5
Normal Birth Weight	141	70.5

Table 2: Distribution of Low Birth Weight According to Severity of Maternal Anemia (n = 200)

Severity of Anemia	Total n (%)	LBW n (%)	Normal BW n (%)
Non-Anemic	58 (24.0%)	6 (10.3%)	43 (89.6%)
Mild	56 (31.0%)	11 (19.6%)	50 (80.6%)
Moderate	60 (35.0%)	24 (40.0%)	42 (60.0%)
Severe	26 (10.0%)	18 (69.2%)	6 (30.0%)
Total	200 (100%)	59 (29.5%)	141 (70.5%)

Chi-square = 44.80
p-value < 0.001 (Highly Significant)

Table 3: Association Between Maternal Anemia and Low Birth Weight (Crude Analysis)

Variable	LBW n (%)	Normal BW n (%)	Odds Ratio (OR)	95% CI	p-value
Non-Anemic + Mild (n=110)	17 (15.5%)	93 (84.5%)	Reference	—	—
Moderate + Severe (n=90)	42 (46.7%)	48 (53.3%)	4.98	2.71–9.99	<0.001*

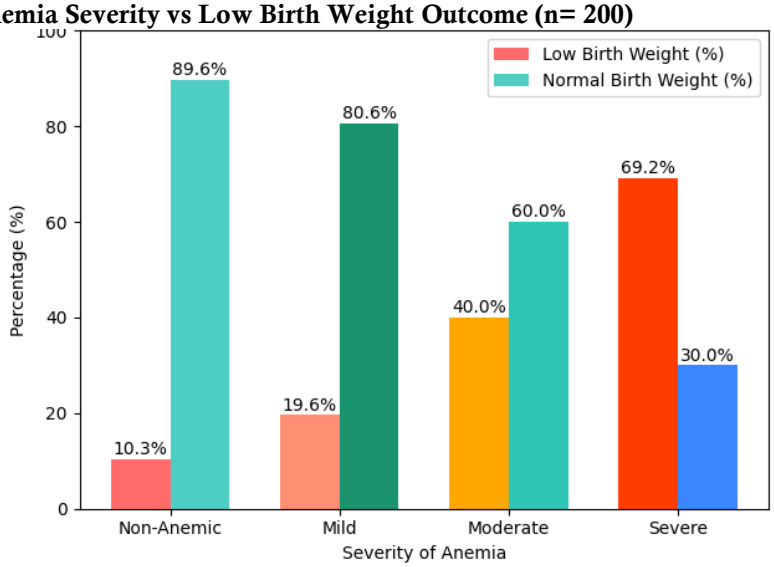
Table 4: Multiple Logistic Regression Analysis for Predictors of Low Birth Weight

Variable	β Coefficient	Standard Error	Adjusted OR	95% CI	p-value
Moderate Anemia	1.12	0.38	4.98	1.45–6.42	<0.001*
Severe Anemia	2.01	0.52	7.47	2.68–20.84	<0.001*
Age >30 years	0.44	0.29	1.55	0.87–2.74	0.13
Multigravida	0.28	0.27	1.32	0.78–2.25	0.29
Preterm Delivery	1.68	0.41	5.36	2.41–11.92	<0.001*
Constant	-2.76	0.62	—	—	0.001

Model Summary:

- Nagelkerke $R^2 = 0.41$
- Overall Model Significance: $p < 0.001$

Figure 1: Maternal Anemia Severity vs Low Birth Weight Outcome (n= 200)



DISCUSSION

In this study (n = 200), low birth weight (LBW) showed a clear relationship with maternal anemia severity, with a stepwise rise in LBW proportion as anemia moved from mild to moderate and severe categories. This "dose–response" pattern is clinically meaningful because it supports the concept that worsening maternal iron deficiency (and reduced oxygen-carrying capacity) can progressively impair placental oxygen/nutrient delivery and fetal growth, thereby increasing the probability of LBW rather than producing only a binary effect (anemia vs non-anemia). Similar population-level observations in India show that LBW remains a substantial public-health burden (around ~17% nationally in large representative datasets), but the burden tends to rise in high-risk groups—especially where maternal undernutrition and anemia are common—making anemia-severity analysis important for targeted antenatal interventions. [11]

When this study's severity-wise findings are compared with international prospective evidence, the direction and gradient are strongly supported. A large cohort from Central China demonstrated that LBW risk increased with anemia severity, reporting adjusted odds that rose from mild (aOR ~1.6) to moderate (aOR ~2.0) and markedly for severe anemia (aOR ~6.1), with a significant trend across categories. [12] The pattern aligns well with this study's inference that severe anemia contributes the highest LBW risk, while moderate anemia still carries a clinically important excess risk over mild anemia.

Systematic synthesis also supports the association. A meta-analysis reported that maternal anemia is significantly associated with LBW, indicating that—even across varied settings and methodologies—anemia consistently shifts birth weight outcomes toward LBW. [13] This strengthens the interpretability of this study's results, because the observed association is not isolated and remains directionally stable across different regions and study designs.

Evidence from resource-limited settings also echoes the same theme with strong effect sizes. In Northwest Ethiopia, maternal anemia showed a substantial association with LBW, with anemia remaining an independent predictor after multivariable adjustment (AOR reported around 3.5). [14] Such findings reinforce the real-world relevance of anemia correction as a potentially modifiable pathway for reducing LBW, particularly in settings with overlapping nutritional deficiencies.

Indian regional evidence similarly shows elevated LBW burden in settings with very high anemia prevalence. A study from Jharkhand observed high anemiaprevalence (~78%) and LBW prevalence (~33%), and emphasized that adverse outcomes increase with worsening anemia severity (even though the adjusted LBW effect estimate reported in that analysis was comparatively modest). [15] Differences in effect size across Indian studies can plausibly occur due to variations in anemia definition timing (antenatal vs delivery), confounder adjustment, comorbidity profiles, and LBW measurement reliability; however, the overall narrative remains consistent—higher anemia burden tends to accompany higher LBW, and severity tracking provides a better risk signal than a binary definition. [15]

Finally, hemoglobin–birth weight relationships are not always strictly linear. Prospective work from China has shown non-linear patterns (e.g., an "optimal" hemoglobin window with increased risk at both low and very high hemoglobin values), suggesting that while low hemoglobin is clearly harmful, extremely high values may reflect hemoconcentration and placental insufficiency pathways in some populations. [16] While this study focuses on anemia severity, such evidence is useful when interpreting outliers and reinforces why antenatal care should include both screening and context-aware correction of anemia rather than assuming "higher is always better." [16]

Overall, when taken together with large national Indian data and global evidence, this study supports a practical message: as maternal anemia severity increases, LBW risk increases, and therefore severity-based anemia management (especially preventing progression to moderate/severe anemia) should be prioritized to improve birth outcomes. [11–16]

CONCLUSION

The present study demonstrated a significant association between maternal anemia severity and low birth weight. A clear dose–response relationship was observed, with the proportion of low birth weight increasing progressively from non-anemic to mild, moderate, and severe anemia categories. Severe anemia emerged as the strongest independent predictor of low birth weight even after adjusting for maternal age, parity, and gestational age. These findings indicate that worsening maternal hemoglobin levels substantially increase the risk of adverse neonatal outcomes. Early identification and timely management of anemia during pregnancy are therefore crucial in reducing the burden of low birth weight and improving perinatal outcomes in tertiary care settings.

LIMITATIONS

This study was conducted in a single tertiary care institution, which may limit generalizability to community settings. The cross-sectional nature of outcome assessment does not establish causality. Nutritional status, dietary intake, socioeconomic variables, and compliance with iron supplementation were not quantitatively assessed, which may act as confounding factors. Additionally, hemoglobin estimation was based on third-trimester values and did not account for dynamic changes throughout pregnancy. Long-term neonatal follow-up outcomes were also not evaluated.

RECOMMENDATIONS

Routine early antenatal screening for anemia severity should be strengthened, with emphasis on preventing progression from mild to moderate and severe anemia. Targeted iron supplementation, nutritional counseling, and close monitoring of high-risk pregnancies should be implemented to reduce low birth weight incidence. Public health programs should prioritize early detection and treatment of anemia at primary healthcare levels to prevent adverse neonatal outcomes. Future multicentric prospective studies incorporating socioeconomic, nutritional, and longitudinal neonatal outcome data are recommended to further clarify the causal pathway and strengthen policy-level interventions.

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