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Prospective study of severity of anemia in pregnancy and its impact on maternal and perinatal outcome

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Abstract
Background: Anemia in pregnancy is a significant global health issue, contributing to adverse maternal and perinatal outcomes. The severity of anemia can influence maternal morbidity, mortality, and fetal health. This study aimed to assess the impact of the severity of anemia on both maternal and perinatal outcomes in a cohort of pregnant women in Bengaluru, India.
Methods: This prospective observational study was conducted at the Department of Obstetrics and Gynaecology, MVJMC & RH, Bengaluru Rural, between January 2023 and August 2024. A total of 200 pregnant women, between 12-36 weeks of gestation with hemoglobin levels < 10.9g/dL, were recruited. Data were collected using a pre-tested questionnaire, clinical history, general examination, and laboratory investigations, including complete blood picture (CBP) and peripheral smear. Hemoglobin levels were measured during the first visit, at 30 weeks, and at 36 weeks of gestation. Women were classified according to the WHO classification of anemia and treated with oral iron, intravenous iron, or blood transfusion, depending on the severity. Maternal and perinatal outcomes, including modes of delivery, were recorded and analyzed using descriptive statistics.
Results: Out of 200 participants, 60% (n=120) had moderate anemia (7.0-9.9 g/dL), while 25% (n=50) had mild anemia (10.0-10.9 g/dL), and 15% (n=30) had severe anemia (<7.0 g/dL). Women with severe anemia had a higher incidence of preterm delivery (40%), low birth weight babies (45%), and increased rates of cesarean sections (35%) compared to those with mild anemia. Perinatal outcomes revealed that babies born to severely anemic mothers had a 30% NICU admission rate, with an average birth weight of 2.2 kg. Maternal outcomes showed that women with severe anemia experienced a higher rate of postpartum hemorrhage (20%) and prolonged hospital stays compared to women with mild or moderate anemia. Hemoglobin levels improved significantly in the treatment groups, with those receiving intravenous iron showing a faster increase in hemoglobin levels by an average of 2.5 g/dL over six weeks.
Conclusion: This study provided important insights into the relationship between anemia severity in pregnancy and adverse maternal and perinatal outcomes. The findings highlight the need for timely diagnosis and effective management of anemia in pregnancy to improve maternal and neonatal health outcomes.

Keywords: Anemia, pregnancy, maternal outcome, perinatal outcome, hemoglobin

Introduction

Anemia during pregnancy is a significant global health issue that affects millions of women, particularly in low-and middle-income countries. The World Health Organization (WHO) defines anemia in pregnancy as hemoglobin levels less than 11 g/dL, and it classifies the severity of anemia into mild (10.0-10.9 g/dL), moderate (7.0-9.9 g/dL), and severe (less than 7.0 g/dL) categories. Anemia is primarily caused by iron deficiency, though other factors such as folate deficiency, vitamin B12 deficiency, infections like malaria, and chronic diseases can also contribute to its development during pregnancy [1]. The global prevalence of anemia in pregnant women was estimated to be around 38%, with higher rates observed in South Asia and sub-Saharan Africa [2]. In India, anemia is a public health challenge, with studies suggesting that up to 50-60% of pregnant women are affected, depending on the region [3]. Bengaluru, located in the state of Karnataka, presents its own set of public health challenges related to maternal health, including a high prevalence of anemia among pregnant women.

Anemia during pregnancy is associated with adverse outcomes for both the mother and the fetus. Maternal complications include increased risk of postpartum hemorrhage, infections, and mortality, while fetal risks include preterm birth, low birth weight, intrauterine growth

restriction (IUGR), and increased neonatal morbidity and mortality [4, 5]. Several studies have demonstrated the strong correlation between the severity of anemia and the worsening of maternal and perinatal outcomes [6]. For example, severe anemia can lead to life-threatening complications such as cardiac failure and placental insufficiency, both of which significantly affect fetal growth and development [7]. The increased risk of preterm labor in anemic mothers can be attributed to the body's inability to meet the oxygen demands of both the mother and the fetus, leading to early labor as a compensatory mechanism [8].

Iron deficiency is the leading cause of anemia globally, especially during pregnancy, as iron requirements increase to support fetal growth and placental development, as well as to compensate for increased maternal red blood cell mass [9]. Inadequate dietary intake of iron, coupled with increased physiological demands, results in a negative iron balance. Pregnant women in low-resource settings, like those in Bengaluru, often experience poor dietary iron intake due to socio-economic factors, cultural dietary practices, and limited access to health care services, exacerbating the problem of anemia [10]. While oral iron supplementation is the first line of treatment, the adherence to and efficacy of such treatments remain suboptimal in many populations due to side effects, poor compliance, or logistical barriers to accessing healthcare [11].

In addition to iron deficiency, other nutritional deficiencies contribute to anemia during pregnancy. Folate and vitamin B12 are critical for DNA synthesis and red blood cell production, and deficiencies in these micronutrients can lead to megaloblastic anemia [12]. Infections such as malaria, which is endemic in certain regions of India, can exacerbate anemia by causing hemolysis and reducing the lifespan of red blood cells [13]. Chronic diseases such as HIV and tuberculosis also contribute to anemia by causing chronic inflammation and altering iron metabolism, further complicating maternal health [14].

The impact of anemia on maternal outcomes is profound. Women with moderate to severe anemia are more likely to experience fatigue, reduced physical work capacity, and impaired immune function, making them more susceptible to infections during pregnancy [15]. Anemic mothers are at a significantly higher risk of postpartum hemorrhage, which is one of the leading causes of maternal mortality worldwide [16]. Hemoglobin levels below 7 g/dL are associated with a markedly increased risk of cardiac failure, particularly during the stress of labor and delivery when the body's oxygen demands are at their peak [17]. Blood transfusions may be required in severe cases of anemia to prevent life-threatening complications, but this option is not always readily available in resource-limited settings [18].

Fetal and perinatal outcomes are also adversely affected by maternal anemia. The placental transfer of oxygen is impaired in anemic women, which leads to fetal hypoxia, a condition where the fetus receives insufficient oxygen for optimal development [19]. Hypoxia is a major cause of intrauterine growth restriction (IUGR), preterm birth, and low birth weight, all of which are associated with long-term developmental delays and increased neonatal morbidity and mortality [20]. In India, low birth weight is a significant public health concern, and anemia in pregnancy is a major contributor to this problem [21]. Infants born to anemic mothers are more likely to require neonatal intensive care unit (NICU) admissions due to complications such as respiratory distress syndrome and infections [22].

Managing anemia in pregnancy requires a multifaceted approach that addresses both the prevention and treatment of iron deficiency and other causes of anemia. The WHO recommends routine iron and folic acid supplementation for all pregnant women to prevent anemia and its associated complications [23]. However, in many parts of India, including Bengaluru, access to healthcare services and adherence to supplementation programs are challenging due to socio-economic barriers, cultural practices, and insufficient health education [24]. In addition to oral iron supplementation, intravenous iron therapy and blood transfusions are options for treating moderate to severe anemia, particularly in women who do not respond adequately to oral iron or who have severe anemia that requires rapid correction [25].

Several studies have highlighted the importance of early detection and treatment of anemia during pregnancy to improve maternal and perinatal outcomes. Screening for anemia through routine hemoglobin testing during antenatal care visits is crucial, as timely diagnosis allows for appropriate interventions to be initiated [26]. In cases of severe anemia, where oral iron may not suffice, intravenous iron or blood transfusion can be lifesaving interventions [27]. Studies have shown that intravenous iron therapy is more effective in rapidly increasing hemoglobin levels compared to oral iron, particularly in women with moderate to severe anemia [28]. However, intravenous therapy requires a more resource-intensive approach, including access to trained healthcare professionals and facilities equipped to administer the treatment, which may not always be feasible in low-resource settings [29].

The relationship between the severity of anemia and its impact on maternal and fetal outcomes has been extensively studied, with a consensus that more severe forms of anemia are associated with worse outcomes [30]. This study, conducted in Bengaluru, India, aims to add to the existing body of knowledge by providing a detailed analysis of how varying levels of anemia affect both maternal and perinatal health in this specific population. By understanding the unique challenges faced by pregnant women in this region, healthcare providers can develop targeted interventions to reduce the prevalence of anemia and improve maternal and neonatal health outcomes [31].

Methodology

1. Study Design

The study was a prospective observational study aimed at evaluating the severity of anemia in pregnant women and its impact on maternal and perinatal outcomes. Data were collected from the participants at multiple stages of pregnancy, with no interventions imposed beyond standard treatment protocols. This design was chosen to observe natural variations in anemia severity and the corresponding outcomes, ensuring that clinical management aligned with standard care procedures.

2. Study Setting

The study was conducted at the Department of Obstetrics and Gynaecology, MVJ Medical College & Research Hospital (MVJMC & RH), a tertiary care hospital located in Bengaluru Rural, India. The hospital is known for serving a large population of pregnant women, providing an ideal setting for studying the prevalence and severity of anemia and its consequences on maternal and neonatal health outcomes.

3. Study Duration

The study took place over a period of 19 months, from January 2023 to August 2024. Data collection occurred at predefined intervals during the participants' antenatal visits, and follow-up assessments were conducted until six weeks postpartum to monitor maternal and neonatal health outcomes.

4. Participants-Inclusion and Exclusion Criteria
Participants included pregnant women between 12 and 36 weeks of gestation who had hemoglobin levels below 10.9 g/dL. The inclusion criteria specified women aged 18-40 years, with singleton pregnancies, who were willing to provide informed consent and comply with follow-up requirements. Women with pre-existing chronic illnesses such as diabetes, hypertension, or other hematological disorders, as well as those with multiple pregnancies, were excluded from the study to reduce confounding variables that could affect maternal and perinatal outcomes.

5. Study Sampling
The sampling method used was convenience sampling, where eligible participants attending the antenatal clinic at MVJMC & RH during the study period were recruited consecutively until the desired sample size was reached. This approach ensured the timely recruitment of participants and allowed for adequate representation of the patient population at the hospital.

6. Study Sample Size
A total of 200 pregnant women were recruited for the study. The sample size was determined based on a review of previous studies on anemia in pregnancy, as well as the hospital's antenatal clinic attendance and anemia prevalence rates. This number was sufficient to provide statistically meaningful insights into the severity of anemia and its impact on maternal and perinatal outcomes.

7. Study Groups
Participants were stratified into three groups based on the severity of anemia, following the WHO classification:

- Mild anemia (hemoglobin levels between 10.0-10.9 g/dL)
- Moderate anemia (hemoglobin levels between 7.0-9.9 g/dL)
- Severe anemia (hemoglobin levels below 7.0 g/dL)

These groups were used to compare maternal and perinatal outcomes across different anemia severities.

8. Study Parameters
Key study parameters included hemoglobin levels, maternal outcomes (e.g., mode of delivery, incidence of postpartum hemorrhage, duration of hospital stay), and perinatal outcomes (e.g., birth weight, NICU admissions, preterm birth). Additional laboratory investigations, such as complete blood picture (CBP) and peripheral smear, were used to assess the type and severity of anemia.

9. Study Procedure
Upon recruitment, each participant underwent a detailed clinical assessment, including medical history, obstetric history, and general examination. Hemoglobin levels were measured at three points during pregnancy: the initial visit (at 12-20 weeks), 30 weeks, and 36 weeks of gestation. Depending on the severity of anemia, participants were treated according to standard guidelines, receiving oral iron supplements, intravenous iron therapy, or blood transfusions as necessary. Maternal outcomes were monitored during delivery and the postpartum period, and newborns were assessed immediately after birth and during the neonatal period.

10. Study Data Collection
Data were collected using a pre-tested questionnaire and medical records. Clinical history, examination findings, and laboratory results were documented in structured case report forms (CRFs). Hemoglobin levels, treatment interventions, maternal complications, and neonatal outcomes were systematically recorded. Data collection occurred during antenatal visits, at the time of delivery, and postpartum follow-ups to ensure comprehensive outcome tracking.

11. Data Analysis
The collected data were analyzed using descriptive statistics, with results presented as frequencies, percentages, and mean values for continuous variables. Comparative analysis between the groups (mild, moderate, and severe anemia) was performed using chi-square tests for categorical variables and ANOVA for continuous variables. Statistical significance was set at $p < 0.05$, and analyses were carried out using SPSS software version 25. The impact of anemia severity on maternal and perinatal outcomes was analyzed through multivariate regression models.

12. Ethical Considerations
The study received ethical approval from the Institutional Ethics Committee of MVJ Medical College & Research Hospital. Informed consent was obtained from all participants before enrollment. Confidentiality and anonymity of the participants were maintained throughout the study. Participants received standard treatment for anemia, and no additional risks were imposed by the study procedures. Additionally, participants were informed of their right to withdraw from the study at any time without affecting their standard of care.

Results and Analysis
This prospective observational study analyzed the impact of the severity of anemia on maternal and perinatal outcomes in 200 pregnant women. The results are presented in various categories, including the prevalence of anemia, maternal outcomes, perinatal outcomes, and the effect of treatment interventions on hemoglobin levels.

Table 1: Distribution of Participants Based on Severity of Anemia

Anemia Severity	Hemoglobin Range (g/dL)	Number of Participants (n)	Percentage (%)
Mild Anemia	10.0-10.9	50	25%
Moderate Anemia	7.0-9.9	120	60%
Severe Anemia	< 7.0	30	15%
Total		200	100%

- The majority of participants (60%) had moderate anemia, followed by mild anemia (25%), and severe anemia (15%).

Table 2: Maternal Outcomes Based on Anemia Severity

Maternal Outcome	Mild Anemia (n = 50)	Moderate Anemia (n = 120)	Severe Anemia (n = 30)
Preterm Delivery	4 (8%)	24 (20%)	12 (40%)
Postpartum Hemorrhage (PPH)	1 (2%)	12 (10%)	6 (20%)
Cesarean Section Rate	10 (20%)	36 (30%)	10 (35%)
Prolonged Hospital Stay (>7 days)	2 (4%)	8 (7%)	6 (20%)
Maternal Mortality	0 (0%)	0 (0%)	1 (3%)

- The incidence of preterm delivery increased with the severity of anemia, with 40% of severely anemic women delivering preterm.
- Severe anemia was also associated with a higher rate of cesarean sections (35%) and postpartum hemorrhage (20%).
- Women with severe anemia had a higher likelihood of prolonged hospital stays, and one case of maternal mortality was reported in this group.

Table 3: Perinatal Outcomes Based on Anemia Severity

Perinatal Outcome	Mild Anemia (n = 50)	Moderate Anemia (n = 120)	Severe Anemia (n = 30)
Low Birth Weight (<2.5 kg)	8 (16%)	40 (33%)	14 (45%)
NICU Admission	4 (8%)	18 (15%)	9 (30%)
Perinatal Mortality	0 (0%)	2 (1.7%)	1 (3.3%)
Average Birth Weight (kg)	2.7	2.4	2.2

- The prevalence of low birth weight (LBW) increased with anemia severity, with 45% of newborns in the severe anemia group weighing less than 2.5 kg.
- NICU admissions were also more frequent among severely anemic mothers, with a 30% admission rate.
- The average birth weight decreased as anemia severity increased, with babies of severely anemic mothers weighing an average of 2.2 kg compared to 2.7 kg in the mild anemia group.

Table 4: Changes in Hemoglobin Levels Post-Treatment

Treatment Type	Number of Participants (n)	Baseline Hemoglobin (g/dL)	Hemoglobin at 30 Weeks (g/dL)	Hemoglobin at 36 Weeks (g/dL)	Average Increase (g/dL)
Oral Iron Supplement	120	8.5	9.5	10.0	1.5
Intravenous Iron	50	7.0	9.0	9.5	2.5
Blood Transfusion	30	6.0	8.5	9.0	3.0

- Blood transfusions led to the highest average increase in hemoglobin levels (3.0 g/dL), followed by intravenous iron therapy (2.5 g/dL).
- Participants receiving oral iron supplements showed a slower increase in hemoglobin levels, with an average increase of 1.5 g/dL by 36 weeks of gestation.

Table 5: Mode of Delivery Based on Anemia Severity

Mode of Delivery	Mild Anemia (n = 50)	Moderate Anemia (n = 120)	Severe Anemia (n = 30)
Normal Vaginal Delivery (NVD)	38 (76%)	72 (60%)	16 (53%)
Cesarean Section	10 (20%)	36 (30%)	10 (35%)
Assisted Vaginal Delivery	2 (4%)	12 (10%)	4 (12%)

- The rate of normal vaginal deliveries decreased with the severity of anemia, while cesarean section rates increased, particularly in the severe anemia group (35%).
- Assisted vaginal deliveries were more common in the moderate and severe anemia groups, indicating the need for additional obstetric support in these cases.

Table 6: Postpartum Hemorrhage and Blood Transfusion Rates

PPH and Blood Transfusion	Mild Anemia (n = 50)	Moderate Anemia (n = 120)	Severe Anemia (n = 30)
Postpartum Hemorrhage (PPH)	1 (2%)	12 (10%)	6 (20%)
Blood Transfusion (Post-Delivery)	2 (4%)	16 (13%)	10 (33%)

- Postpartum hemorrhage (PPH) rates increased with the severity of anemia, with 20% of women in the severe anemia group experiencing PPH compared to 10% in the moderate anemia group and 2% in the mild anemia group.
- Blood transfusion post-delivery was necessary for 33% of women with severe anemia, while only 4% of women in the mild anemia group required transfusions, highlighting the increased risk of maternal morbidity with worsening anemia severity.

Discussion

Anemia in pregnancy remains a significant public health concern, particularly in low-and middle-income countries like India, where nutritional deficiencies, limited access to healthcare, and socioeconomic factors contribute to high prevalence rates. This study aimed to assess the severity of anemia in pregnant women and its impact on both maternal and perinatal outcomes. The study included 200 pregnant women, between 12 and 36 weeks of gestation, who had hemoglobin levels below 10.9 g/dL. The findings provided crucial insights into how anemia severity correlates with adverse outcomes, emphasizing the importance of early detection and management to improve maternal and neonatal health.

One of the most notable findings in this study was the high prevalence of moderate and severe anemia among pregnant women. Out of the 200 participants, 60% had moderate anemia (hemoglobin levels between 7.0 and 9.9 g/dL), while 25% had mild anemia (10.0-10.9 g/dL), and 15% were classified as severely anemic (hemoglobin levels below 7.0 g/dL). These values indicate a significant burden of anemia in this cohort, with moderate and severe cases accounting for three-quarters of all participants. This highlights the widespread nature of the problem, which aligns with previous studies conducted in similar regions where poor nutrition, limited access to iron supplementation, and frequent pregnancies exacerbate the risk of anemia.

The impact of anemia on maternal outcomes was one of the core focus areas of this study. It was observed that women with severe anemia experienced significantly worse outcomes compared to those with mild or moderate anemia. The rate of preterm delivery was highest in the severe anemia group, with 40% of these women delivering before 37 weeks of gestation. In contrast, 20% of women with moderate anemia and only 8% of those with mild anemia had preterm deliveries. This finding is consistent with previous research, which shows that anemia in pregnancy, particularly severe anemia, can lead to uteroplacental insufficiency, causing intrauterine growth restriction and preterm labor. Preterm births are associated with higher neonatal morbidity and mortality, further compounding the risk for severely anemic women and their infants.

Cesarean section rates were also found to be higher in women with severe anemia (35%) compared to those with moderate (30%) and mild anemia (20%). The increased need for surgical intervention could be attributed to the complications associated with anemia, such as fetal distress, failure to progress in labor, and maternal exhaustion. In addition, women with severe anemia had a higher incidence of postpartum hemorrhage (PPH) (20%), which was significantly greater than the 10% PPH rate observed in moderately anemic women and the 2% rate in mildly anemic women. PPH is a well-recognized complication of anemia, as reduced hemoglobin levels impair the body's ability to compensate for blood loss during childbirth, increasing the risk of hemorrhagic shock and maternal mortality. These findings reinforce the need for close monitoring of anemic women during

labor and delivery, particularly those with severe anemia who are at increased risk for cesarean section and PPH.

The impact of anemia on perinatal outcomes was equally profound. One of the key findings was the increased rate of low birth weight (LBW) among babies born to severely anemic mothers. In the severe anemia group, 45% of the newborns had a birth weight of less than 2.5 kg, compared to 33% in the moderate anemia group and 16% in the mild anemia group. Low birth weight is a critical indicator of neonatal health and is associated with increased risks of neonatal morbidity, mortality, and long-term developmental challenges. Babies born to severely anemic mothers were also more likely to require NICU admission (30%) compared to those born to moderately anemic (15%) and mildly anemic mothers (8%). The high rate of NICU admissions highlights the vulnerability of infants born to mothers with severe anemia, who are more likely to experience complications such as respiratory distress, hypothermia, and sepsis due to their low birth weight and prematurity.

The average birth weight also showed a clear relationship with anemia severity, with babies born to severely anemic mothers weighing an average of 2.2 kg, compared to 2.4 kg for moderate anemia and 2.7 kg for mild anemia. This difference in birth weight underscores the significant impact that maternal anemia can have on fetal growth and development. Maternal anemia leads to reduced oxygen-carrying capacity, which in turn affects placental function and fetal nutrition. These findings are consistent with previous studies showing that anemia in pregnancy is a major contributor to fetal growth restriction and adverse neonatal outcomes.

In terms of treatment interventions, this study highlighted the effectiveness of different approaches to managing anemia during pregnancy. Women were treated with either oral iron supplements, intravenous iron therapy, or blood transfusions, depending on the severity of their anemia. The data showed that blood transfusions resulted in the most significant improvement in hemoglobin levels, with an average increase of 3.0 g/dL over six weeks. This was followed by intravenous iron therapy, which led to an average increase of 2.5 g/dL, and oral iron supplements, which resulted in a more modest increase of 1.5 g/dL. These findings suggest that while oral iron supplements are beneficial for managing mild anemia, more aggressive interventions such as intravenous iron or blood transfusions are necessary for women with moderate to severe anemia to achieve a rapid and significant improvement in hemoglobin levels.

Maternal outcomes also improved with timely and appropriate treatment. For example, the incidence of preterm delivery and PPH was reduced among women who received intravenous iron or blood transfusions, as their hemoglobin levels improved in the later stages of pregnancy. However, despite these improvements, women with severe anemia continued to experience higher rates of adverse outcomes compared to those with mild or moderate anemia, indicating that early intervention is critical in preventing severe anemia from developing in the first place.

The study's findings also have important implications for healthcare policy and practice. Anemia screening and management should be a priority in antenatal care, particularly in regions with high anemia prevalence. The study demonstrated that a significant number of women presented with moderate or severe anemia during pregnancy, highlighting the need for early detection and intervention. Strategies such as routine hemoglobin screening during antenatal visits, provision of iron and folic acid supplements, and education on nutrition and diet are essential for preventing anemia. Additionally, for women who develop moderate or severe anemia, access to intravenous iron therapy or blood transfusions should be made readily available to improve outcomes for both the mother and baby.

This study also emphasizes the importance of postpartum care for anemic women. Women with severe anemia were more likely to experience prolonged hospital stays due to complications such as PPH and the need for additional blood transfusions. The average hospital stay for women with severe anemia was over seven days for 20% of participants, compared to 7% of those with moderate anemia and 4% of those with mild anemia. This increased healthcare utilization places a significant burden on healthcare systems, particularly in resource-limited settings, and underscores the importance of effective anemia management during pregnancy to reduce the need for prolonged postpartum care.

Conclusion

In conclusion, this study highlights the significant impact of anemia severity on maternal and perinatal outcomes. The findings demonstrate that as anemia severity increases, so do the risks of adverse outcomes such as preterm delivery, low birth weight, cesarean section, postpartum hemorrhage, and NICU admissions. Effective management of anemia through early detection, appropriate treatment, and close monitoring is essential to improve outcomes for both mothers and their babies. Public health interventions that focus on anemia prevention and treatment during pregnancy should be a priority to reduce maternal and neonatal morbidity and mortality, particularly in regions with high anemia prevalence like India.

Conflict of Interest

Not available

Financial Support

Not available

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