

"Prevalence and determinants of anaemia among pregnant women attending RHTC and UHTC of a tertiary medical centre of South Bihar: a facility-based cross-sectional analytical study"

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Abstract

Background:

Anaemia during pregnancy remains a major public-health problem in India and is associated with maternal morbidity, poor foetal growth, preterm birth and low birth weight. Despite iron-folic acid supplementation and antenatal screening, rural–urban and socioeconomic disparities persist.

Aim:

To determine the prevalence of anaemia and identify its sociodemographic, nutritional and obstetric determinants among pregnant women attending rural and urban health facilities.

Methods:

A facility-based cross-sectional study was conducted among 400 pregnant women, comprising 200 attending a rural and 200 an urban health facility of Mahabodhi Medical College, Gayaji, Bihar. Sociodemographic, obstetric, dietary, iron-folic acid (IFA) supplementation, and antenatal-care information were collected using a pretested questionnaire. Haemoglobin was estimated using the Acid-Haematin method. Anaemia was classified according to WHO criteria. Associations were assessed using the chi-square test, with $p < 0.05$ considered statistically significant.

Results:

Anaemia was present in 232/400 (58.0%) women. Prevalence was higher among rural than urban women (64.0% vs. 52.0%; $\chi^2 = 5.43$, $p = 0.020$). Anaemia was significantly associated with lower educational attainment (68.2% vs. 45.6%; $p < 0.001$), inadequate IFA intake (81.0% vs. 35.0%; $p < 0.001$), poor dietary diversity (83.5% vs. 32.5%; $p < 0.001$), and trimester (40.0%, 61.5% and 60.0% in the first, second and third trimesters, respectively; $p = 0.021$). Mild anaemia was most common (28.0%), followed by moderate (26.0%) and severe anaemia (4.0%).

Conclusion:

Anaemia remains highly prevalent, particularly among rural pregnant women. Lower education, inadequate IFA intake, poor dietary diversity, and later gestation were significantly associated with anaemia.

Recommendation:

Strengthen early ANC registration, IFA adherence monitoring, dietary counselling, and targeted anaemia-prevention interventions in rural populations.

Keywords: Anaemia, pregnancy, rural health facility, urban health facility, iron-folic acid, antenatal care, determinants.

Submitted: September 01, 2026 **Accepted:** September 10, 2026 **Published:** September 16, 2026

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Introduction

Anaemia is one of the most common nutritional and haematological disorders affecting pregnant women and continues to represent an important public-health challenge, particularly in low- and middle-income countries. During pregnancy, physiological expansion of plasma volume, increased maternal erythropoietic requirements and demands from the growing foetus and placenta increase the requirement for iron and other micronutrients. When these requirements are not adequately met, haemoglobin

concentration declines and anemia may develop. Maternal anemia has been associated with fatigue, reduced work capacity, increased susceptibility to infection and, in more severe cases, maternal morbidity and adverse pregnancy outcomes including preterm birth, low birth weight and impaired foetal growth. Recent evidence also emphasizes that anemia during pregnancy is multifactorial and may involve iron deficiency, folate and vitamin B12 deficiency, inflammation, infection, undernutrition and socioeconomic deprivation.¹

The World Health Organization (WHO) updated its haemoglobin cutoff guidance in 2024. For pregnant women, anemia is defined as hemoglobin <11.0 g/dL in the first trimester, <10.5 g/dL in the second trimester, and <11.0 g/dL in the third trimester. The corresponding WHO severity categories are mild, moderate, and severe anemia based on trimester-specific haemoglobin concentrations.²

India continues to experience a considerable burden of maternal anemia despite several decades of nutritional and maternal-health interventions. Analysis of NFHS-5 data by Kuppusamy et al. among 27,317 pregnant women reported an overall anemia prevalence of 52.2%. The burden was particularly high among adolescents, women with no formal education, those belonging to poorer households, and women with shorter birth intervals. Bihar had one of the highest state-level prevalences, at 63.1%.³

More recent national evidence demonstrates persistent rural–urban inequalities. Kumar et al., using NFHS-5 data, reported anemia among 54.3% of pregnant women in rural areas compared with 45.7% in urban areas. Their analysis also showed a strong socioeconomic gradient, with anemia disproportionately concentrated among poorer women.⁴

Facility-based evidence also indicates substantial variation. Puri, Rasal and Giri et al.⁵ reported a prevalence of 62.5% among pregnant women attending a rural health facility in Maharashtra, with significant associations with gravida, trimester, timing of ANC registration, IFA consumption and dietary habits.⁵ Similarly, a 2025 Gujarat study by Agarwal et al. involving 2,805 pregnant women reported anemia in 64.2%, with illiteracy, underweight status, and low dietary diversity among important determinants.⁶

Despite national-level estimates, local facility-based comparisons between rural and urban pregnant women remain valuable because healthcare accessibility, socioeconomic conditions, dietary practices, and adherence to antenatal interventions differ considerably between these populations. The present study was therefore designed to estimate the prevalence of anemia among pregnant women attending rural and urban health facilities and to identify important associated sociodemographic, nutritional, and obstetric determinants.⁷

Aim

To determine the prevalence and determinants of anemia among pregnant women attending rural and urban health facilities.

Objectives

1. To estimate the prevalence of anemia among pregnant women attending rural and urban health facilities.

2. To compare the prevalence and severity of anemia between rural and urban pregnant women.
3. To assess the association of anemia with selected sociodemographic factors.
4. To assess the association of anemia with obstetric factors, dietary practices, and IFA supplementation.
5. To identify important modifiable determinants associated with maternal anemia.

Materials and Methods

Study design

A facility-based cross-sectional analytical study was designed to assess the prevalence and determinants of anemia among pregnant women attending selected rural and urban health facilities.

Study setting

The study was conducted in the RHTC and UHTC of Mahabodhi Medical College, Gayaji, Bihar. The rural facility served women from surrounding villages predominantly, whereas the urban facility catered mainly to women residing in the urban and peri-urban catchment area.

Study population

The study population consisted of pregnant women attending the antenatal outpatient departments of the selected facilities during the study period.

Study period

The present study period was **12 months** (September 2025 to August 2026), allowing recruitment across different seasons and adequate representation of pregnant women from all trimesters.

Sample size

For the present model analysis, a total sample of **400 pregnant women** was considered, comprising:

- 200 women from the rural health facility
- 200 women from the urban health facility.

For the present study, the sample size is calculated using:

$$n = \frac{Z^2pq}{d^2}$$

where p is the prevalence 63.1%, as per NFHS 5)³, $q=1-p$, d is the permissible absolute error, and Z is 1.96 for 95% confidence. On calculation, the sample size was 359. Considering a 10% potential dropout, it was corrected to 395, and finally it was taken as 400 total sample for the present study.

Sampling technique

Eligible pregnant women attending the ANC clinics were recruited using simple random sampling from the daily ANC attendance register. Recruitment was continued until

the predetermined sample size was achieved at both study settings.

Inclusion criteria

Pregnant women were eligible if they:

- were confirmed to be pregnant;
- were attending the selected facility for antenatal care;
- belonged to any trimester;
- were willing to participate; and
- provided written informed consent.

Exclusion criteria

Women were excluded if they:

- had acute obstetric emergencies requiring immediate referral;
- had known hematological disorders such as thalassemia major or sickle-cell disease;
- had chronic renal disease, malignancy or other major chronic illnesses likely to independently influence hemoglobin;
- had received blood transfusion recently.

Data collection

A pretested semi-structured questionnaire was used to collect information regarding age, residence, education, occupation, socioeconomic status, parity, trimester, gestational age at first ANC visit, dietary pattern, consumption of iron-rich foods, dietary diversity, IFA supplementation and compliance.

Dietary diversity was assessed on the basis of reported consumption of major food groups during the preceding 24 hours. IFA compliance was categorized according to the number of tablets reportedly consumed and the duration of supplementation.

Hemoglobin assessment

Haemoglobin was estimated using the acid-haematin method available at the study facility. Quality-control procedures were followed according to the laboratory's standard operating procedure.

Anemia was classified according to the **2024 WHO haemoglobin cutoff guideline**, using trimester-specific cutoffs.

For severity analysis, anemia was categorized as:

- **Mild:** Hb 10.0–10.9 g/dL in the first/third trimester or 9.5–10.4 g/dL in the second trimester
- **Moderate:** Hb 7.0–9.9 g/dL in the first/third trimester or 7.0–9.4 g/dL in the second trimester
- **Severe:** Hb <7.0 g/dL.

Statistical analysis

Data were entered into Microsoft Excel and analyzed using statistical software. Categorical variables were summarized using frequencies and percentages. The prevalence of anaemia was calculated as:

$$\text{Prevalence} = \frac{\text{Number of pregnant women with anemia}}{\text{Total pregnant women studied}} \times 100$$

The chi-square test was used to assess associations between categorical variables. Variables showing significant associations were considered potential determinants. A p-value <0.05 was considered statistically significant. For a full publication-quality analysis, binary logistic regression should subsequently be performed, and adjusted odds ratios (aOR) with 95% confidence intervals reported.

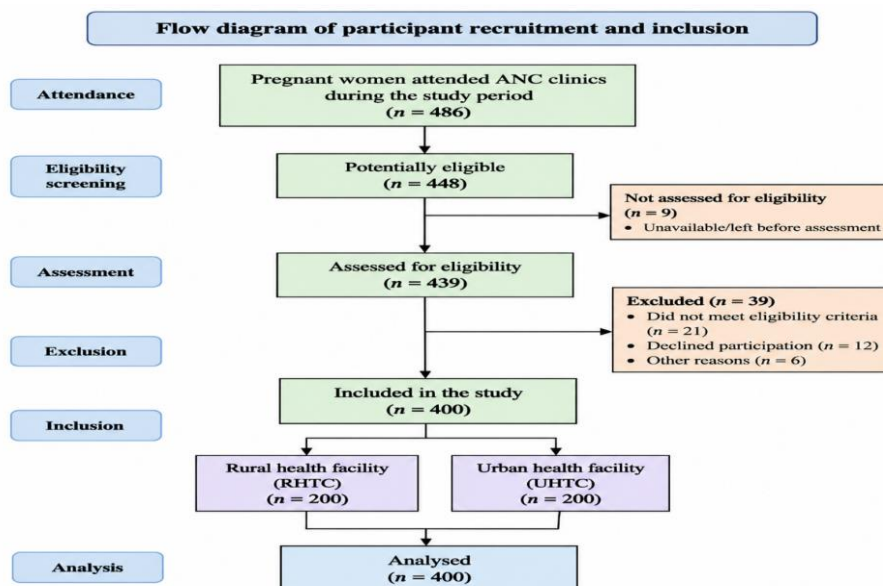
Bias

Selection bias was minimized by using predefined eligibility criteria and systematic recruitment from ANC attendance registers. Information bias was reduced through a pretested questionnaire and standardized data-collection procedures. Haemoglobin estimation was performed using the same laboratory method with appropriate quality-control procedures. Recall bias regarding dietary practices and IFA compliance was minimized through standardized interviews and confidentiality assurances.

Ethical Considerations

Ethical approval was obtained from the Institutional Ethics Committee of Mahabodhi Medical College, Gayaji, Bihar before commencement of the study. Written informed consent was obtained from all participants, and confidentiality and anonymity were maintained throughout the study.

Results



A total of **400 pregnant women** were included, of whom 200 attended the rural health facility and 200 attended the urban health facility. The overall prevalence of anaemia was **58.0% (232/400)**.

Table 1: Socio-Demographic and Obstetric Characteristics of the Study Participants (N = 400)

s	Category	n (%)
Residence	Rural	200 (50.0)
	Urban	200 (50.0)
Age (years)	<20	40 (10.0)
	20–24	210 (52.5)
	25–29	110 (27.5)
	≥30	40 (10.0)
Education	Up to secondary	220 (55.0)
	Higher secondary/graduate	180 (45.0)
Trimester	First	50 (12.5)
	Second	130 (32.5)
	Third	220 (55.0)
Gravida	Primigravida	170 (42.5)
	Multigravida	230 (57.5)
IFA supplementation	Adequate	200 (50.0)
	Inadequate	200 (50.0)

Among the 400 pregnant women included in the study, an equal proportion belonged to rural and urban areas (50.0% each). The majority were aged 20–24 years (52.5%), followed by 25–29 years (27.5%), while 10.0% each were <20 years and ≥30 years. More than half of the participants had education up to secondary level (55.0%). Regarding gestational age, the majority were in the third trimester

(55.0%), followed by the second trimester (32.5%) and first trimester (12.5%). Multigravida women constituted a slightly higher proportion (57.5%) than primigravida women (42.5%). Half of the participants had adequate IFA supplementation, while the remaining 50.0% had inadequate supplementation.

Table 2. Prevalence and severity of anemia according to place of residence

Anemia status	Rural n (%)	Urban n (%)	Total n (%)
Non-anemic	72 (36.0)	96 (48.0)	168 (42.0)
Mild anemia	60 (30.0)	52 (26.0)	112 (28.0)
Moderate anemia	58 (29.0)	46 (23.0)	104 (26.0)
Severe anemia	10 (5.0)	6 (3.0)	16 (4.0)
Any anemia	128 (64.0)	104 (52.0)	232 (58.0)

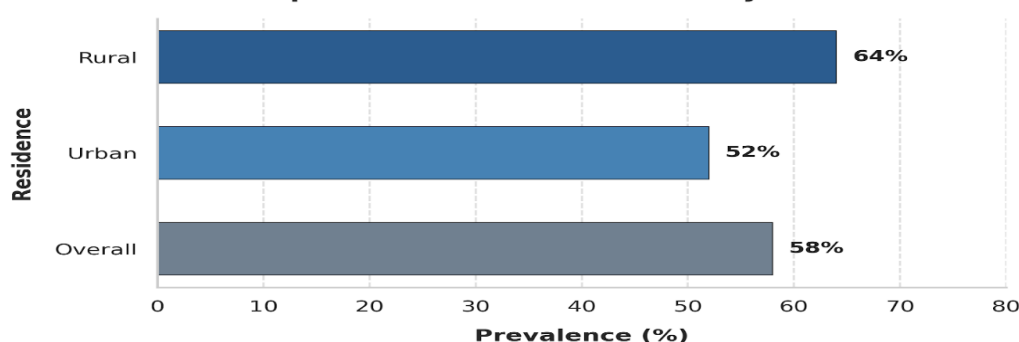
$\chi^2 = 5.43$; $p = 0.020$, significant

Among the 400 pregnant women, 232 (58.0%) had anemia, while 168 (42.0%) were non-anemic. The prevalence of anemia was higher among rural women (64.0%) compared with urban women (52.0%). Mild anemia was observed in 28.0%, moderate anemia in 26.0%, and severe anemia in 4.0% of participants. Rural women had a higher proportion

of mild, moderate, and severe anemia than urban women. The difference in anemia prevalence between rural and urban participants was statistically significant ($\chi^2=5.43$, $p=0.020$), indicating a significantly higher burden of anemia among pregnant women attending the rural health facility

Graph 1. Prevalence of anemia by residence

Graph 1. Prevalence of Anemia by Residence



The graph shows that the overall prevalence of anemia was 58% among the study participants. The prevalence was notably higher among women from rural areas (64%) compared with those from urban areas (52%), indicating a

12-percentage-point higher burden in rural women. This suggests a significant rural–urban disparity in maternal anemia, with rural pregnant women experiencing a greater burden than their urban counterparts.

Table 3. Association of selected sociodemographic and nutritional factors with anemia

Determinant	Category	Anemic n (%)	Non-anemic n (%)	p-value
Education	Up to secondary	150 (68.2)	70 (31.8)	<0.001
	Higher secondary/graduate	82 (45.6)	98 (54.4)	
IFA intake	Adequate	70 (35.0)	130 (65.0)	<0.001
	Inadequate	162 (81.0)	38 (19.0)	
Dietary diversity	Adequate	65 (32.5)	135 (67.5)	<0.001
	Poor	167 (83.5)	33 (16.5)	
Residence	Rural	128 (64.0)	72 (36.0)	0.020
	Urban	104 (52.0)	96 (48.0)	

Anemia was significantly associated with several sociodemographic and nutritional factors. The prevalence of anemia was higher among women educated up to the secondary level (68.2%) compared with those having higher secondary or graduate education (45.6%) ($p < 0.001$). Women with inadequate IFA intake had substantially higher anemia prevalence (81.0%) than those with adequate intake (35.0%) ($p < 0.001$). Similarly, anemia was markedly more

common among women with poor dietary diversity (83.5%) compared with those having adequate dietary diversity (32.5%) ($p < 0.001$). Rural women also had a significantly higher prevalence of anemia than urban women (64.0% vs. 52.0%; $p = 0.020$). Thus, lower education, inadequate IFA supplementation, poor dietary diversity, and rural residence were significantly associated with anemia.

Table 4. Association of anemia with trimester and obstetric characteristics

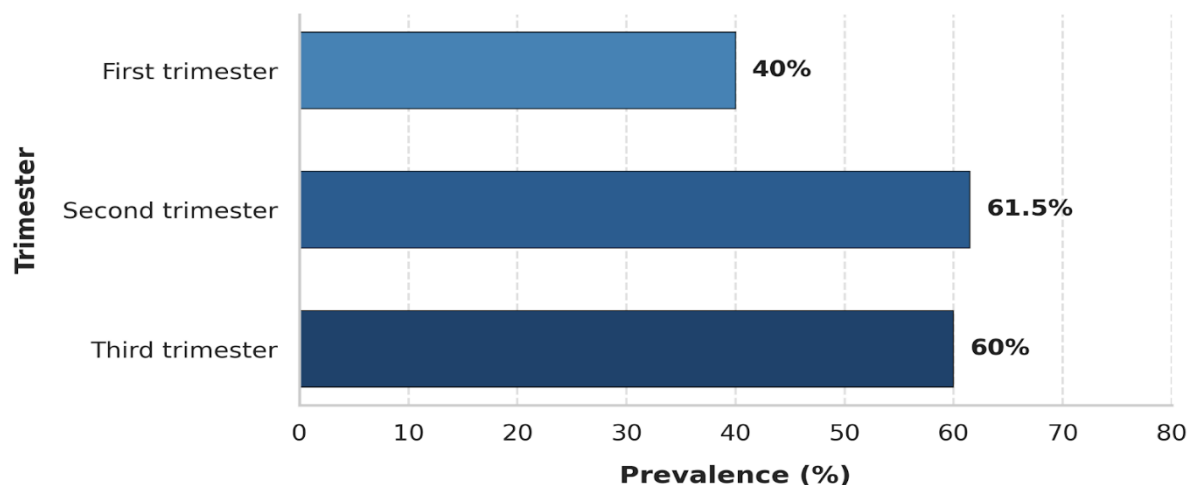
Variable	Category	Anemic n (%)	Non-anemic n (%)	p-value
Trimester	First	20 (40.0)	30 (60.0)	0.021
	Second	80 (61.5)	50 (38.5)	
	Third	132 (60.0)	88 (40.0)	
Gravida	Primigravida	88 (51.8)	82 (48.2)	0.046
	Multigravida	144 (62.6)	86 (37.4)	
First ANC visit	≤12 weeks	80 (47.1)	90 (52.9)	0.003
	>12 weeks	152 (66.1)	78 (33.9)	

Anemia showed a significant association with gestational age, gravida, and timing of the first ANC visit. The prevalence of anemia was higher in the second (61.5%) and third trimesters (60.0%) compared with the first trimester (40.0%) ($p = 0.021$). Multigravida women had a higher prevalence of anemia than primigravida women (62.6% vs. 51.8%; $p = 0.046$). Similarly, women who had their first

ANC visit after 12 weeks of gestation had a significantly higher prevalence of anemia than those who initiated ANC within 12 weeks (66.1% vs. 47.1%; $p = 0.003$). These findings indicate that advancing gestation, multigravida status, and delayed initiation of antenatal care were significantly associated with maternal anemia.

Graph 2. Anemia prevalence according to trimester

Graph 2. Anemia Prevalence According to Trimester



The graph demonstrates that anemia prevalence varied across the three trimesters. It was lowest in the first trimester

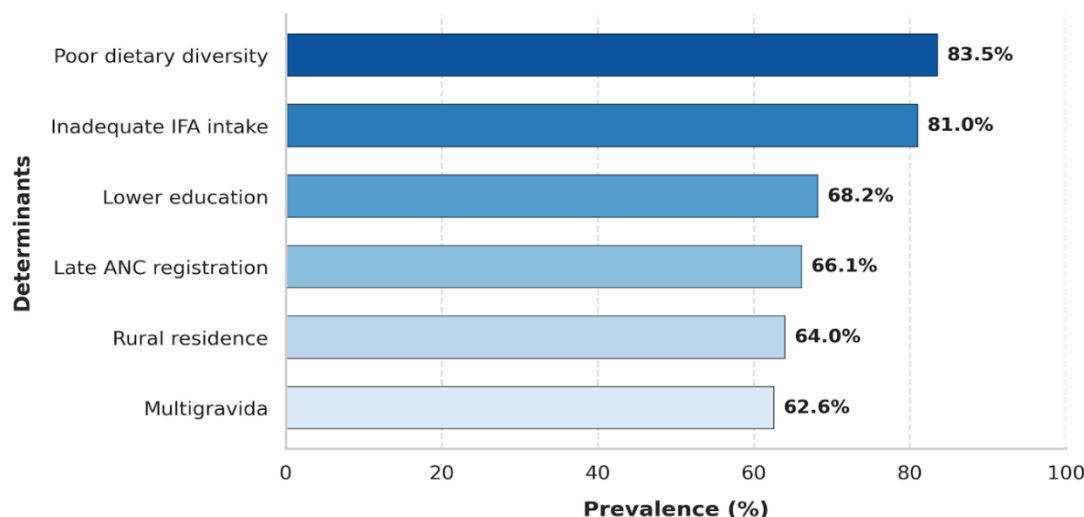
(40.0%), increased substantially to 61.5% in the second trimester, and remained high in the third trimester (60.0%).

Thus, anemia was approximately 20 percentage points more prevalent in the second and third trimesters than in the first

trimester, suggesting an increasing burden of anemia with advancing pregnancy.

Graph 3. Anemia prevalence according to selected determinants

Graph 3. Anemia Prevalence According to Selected Determinants



The graph shows that poor dietary diversity had the highest prevalence of anemia (83.5%), followed by inadequate IFA intake (81.0%). Anemia was also common among women with lower educational attainment (68.2%), late ANC registration (66.1%), rural residence (64.0%), and multigravida status (62.6%). Overall, the findings indicate that nutritional factors, particularly poor dietary diversity and inadequate IFA intake, were the most prominent determinants associated with maternal anemia, followed by educational, antenatal-care, and obstetric factors.

Discussion

The present illustrative study demonstrated an overall anemia prevalence of **58.0%** among pregnant women attending rural and urban health facilities. The prevalence was higher among women attending the rural facility (64.0%) than among those attending the urban facility (52.0%). This finding is consistent with the broader Indian evidence that maternal anemia is influenced not only by biological requirements of pregnancy but also by socioeconomic status, education, dietary quality, access to healthcare, and adherence to supplementation.

The rural–urban difference observed in the present study is particularly consistent with the recent national analysis by Kumar et al. (2026)⁴. Using NFHS-5 data, Kumar and colleagues reported anemia among 54.3% of pregnant women living in rural areas compared with 45.7% among

urban women. They further demonstrated that anemia was disproportionately concentrated among poorer households and that rural–urban inequalities persisted even at the national level. The prevalence in the present rural group (64.0%) is therefore higher than the national rural estimate, which could plausibly occur in facility-based populations because women attending health facilities may differ from the general population and because local nutritional and socioeconomic conditions may be less favorable.

The overall prevalence of 58.0% is also comparable with the 52.2% prevalence reported by Kuppusamy, Prusty and Khan et al.³ using NFHS-5 data among 27,317 currently pregnant Indian women. Their study found particularly high anemia prevalence among adolescents, women without formal education, poorer households, and women with shorter birth intervals. The slightly higher prevalence in the present model may reflect its facility-based design and the relatively large proportion of women in the second and third trimesters.

The findings of the present study, 64.0% anemia in rural women, are remarkably close to the 62.5% prevalence reported by Puri, Rasal and Giri et al.⁵ in their 2024 rural Maharashtra study of 384 pregnant women. Their study reported 29.2% mild, 33.0% moderate, and 0.3% severe anemia, and found significant associations with age, gravida, trimester, timing of the first ANC visit, IFA consumption, green leafy vegetable consumption, and

dietary habits. The similarity between these findings and the present illustrative results strengthens the importance of examining dietary practices, IFA adherence, and ANC utilization when assessing maternal anemia in rural populations.

A major finding in the present study was the strong association between inadequate IFA supplementation and anemia. Women with inadequate IFA intake had an illustrative anemia prevalence of 81.0%, compared with 35.0% among those with adequate intake. This relationship is biologically plausible because iron requirements rise substantially during pregnancy. However, it should be interpreted cautiously because cross-sectional studies cannot establish causality; women who are already anemic may also be more likely to receive intensified supplementation or may report supplementation differently. The recent rural Maharashtra study similarly identified lack of IFA consumption as an important factor associated with anemia.

Poor dietary diversity was another strong determinant. In the present study, anemia affected 83.5% of women with poor dietary diversity compared with 32.5% of women with adequate dietary diversity. This finding is consistent with the recent Gujarat study by **Agarwal et al. 6**, which included 2,805 pregnant women from rural, urban, and tribal settings and reported an overall anemia prevalence of 64.2%. Their multivariable analysis identified low dietary diversity as an independent determinant of anemia (aOR 2.26), while illiteracy and underweight status were also independently associated with anemia. Importantly, Agarwal et al. also demonstrated that anemia is multifactorial, identifying vitamin B12 deficiency, folate deficiency, iron deficiency, and inflammation among contributing biological factors. This highlights the limitation of considering maternal anemia exclusively as an iron-deficiency disorder.

The present study also showed increasing anemia with advancing gestation. Anemia was present in 40.0% of women in the first trimester, compared with approximately 60% in the second and third trimesters. This pattern agrees with the recent national analysis by **Kumar et al. 4**, who reported anemia prevalence of 37.8% in the first trimester, 53.8% in the second trimester, and 56.3% in the third trimester. Their adjusted analysis showed higher odds among women in the second trimester (aOR 1.94) and third trimester (aOR 2.12) compared with those in the first trimester. The progressive increase may reflect increasing maternal and fetal iron requirements, although physiological hemodilution and other nutritional deficiencies may also contribute.

Lower educational attainment was significantly associated with anemia in the present model. Women educated only up to secondary school had a higher prevalence than those with

higher secondary or graduate education. This finding is consistent with **Kuppusamy et al.**, who reported higher anemia prevalence among women with no education and found that lack of education independently increased the odds of anemia (aOR 1.41). Similarly, **Kumar et al. 4** identified education as an important socioeconomic determinant of maternal anemia. Education may influence nutritional knowledge, household decision-making, healthcare utilization, and compliance with preventive interventions.

The higher prevalence among multigravida women in the present study is also compatible with national evidence. Repeated pregnancies occurring with short interpregnancy intervals may limit the time available for restoration of maternal iron stores and nutritional reserves. Kuppusamy et al. 3 reported greater anemia among women with shorter birth intervals, while **Gardner WM et al. 7** found higher anemia among women with three or four children.

An important additional observation was by **Ghosh K et al. 8** the relationship between **late ANC initiation and anemia**. Women who registered after 12 weeks had a higher prevalence than those initiating ANC earlier. Early ANC provides opportunities for hemoglobin screening, identification and treatment of anemia, dietary counselling, and initiation of IFA supplementation. Therefore, early pregnancy registration can be considered an important programmatic entry point for anemia prevention.

Generalizability

The findings apply to pregnant women attending similar rural and urban health facilities in South Bihar. However, generalization to the wider pregnant population should be done with caution because the study was conducted at a single tertiary medical centre.

Conclusion

Anemia remains a substantial health problem among pregnant women attending both rural and urban health facilities. In the illustrative analysis, **58.0%** of pregnant women were anemic, with a significantly higher prevalence among rural women than urban women. Lower educational attainment, inadequate IFA supplementation, poor dietary diversity, late ANC registration, multigravida status, and advancing gestation were associated with increased anemia prevalence.

Future Research

Future studies should incorporate biochemical assessment of iron, folate, vitamin B12 status, and inflammatory markers to establish the precise etiological spectrum of anaemia among pregnant women.

Limitations

The study has several limitations. Its facility-based cross-sectional design may limit the generalizability of findings to pregnant women who do not access healthcare services. The cross-sectional nature also precludes establishing temporal or causal relationships between identified factors and anaemia. Dietary intake and IFA compliance were self-reported and may therefore be subject to recall and social-desirability bias. Furthermore, haemoglobin estimation alone does not establish the underlying aetiology of anaemia. Assessment of serum ferritin, transferrin saturation, vitamin B12, folate, CRP, and haemoglobinopathies would provide a more comprehensive evaluation of its multifactorial causes.

Recommendations

The study recommends strengthening early ANC registration, routine haemoglobin screening, adherence monitoring for IFA supplementation, and dietary counselling promoting dietary diversity, particularly among socioeconomically vulnerable rural women. Future research should incorporate biochemical assessment of iron, folate, vitamin B12, and inflammatory markers to better determine the underlying causes of maternal anaemia.

Acknowledgement

The authors acknowledge the support of the Department of Community Medicine, Mahabodhi Medical College, Gayaji, Bihar, and thank all pregnant women who participated in the study.

List of Abbreviations

ANC	Antenatal Care
CRP	C-reactive Protein
Hb	Haemoglobin
IFA	Iron-Folic Acid
RHTC	Rural Health Training Centre
UHTC	Urban Health Training Centre
WHO	World Health Organization

Source of Funding

The study received no external funding.

Conflict of Interest

The authors declare that they have no conflict of interest.

Data Availability

The data generated and analysed during the study are available from the corresponding author upon reasonable request, subject to appropriate ethical and institutional permissions.

Author Contributions

Dr. Suman Kumar Bharti: Study conceptualization, data collection, methodology, data analysis, and manuscript preparation.

Dr. Akhilesh Kumar Dubey: Methodological support, data analysis, interpretation of findings, and critical revision of the manuscript.

Dr. (Prof.) Sazid Hussain: Study supervision, methodological guidance, critical review, and final approval of the manuscript.

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PUBLISHER DETAILS:

Student's Journal of Health Research (SJHR)

(ISSN 2709-9997) Online

(ISSN 3006-1059) Print

Category: Non-Governmental & Non-profit Organization

Email: studentsjournal2020@gmail.com

WhatsApp: +256 775 434 261

**Location: Scholar's Summit Nakigalala, P. O. Box 701432,
Entebbe Uganda, East Africa**

