Bloodlines and Trimesters: Morphological Anemia Patterns among Tribal Mothers in Ranchi, Jharkhand

[1] Anup Kumar Dhanvijay; [2, 3] Kumar Vivek; [2,4] Anjali Sinha;
[1] Mohammed Jaffer Pinjar; [5] Nikhil Kumar

Corresponding Author: Dr. Anup kumar Dhanvijay

Abstract:

Background: Anemia during pregnancy is a significant public health issue, especially among tribal populations in India, due to poor nutrition, limited healthcare access, and a high prevalence of hemoglobinopathies. Morphological classification aids in understanding etiology and guiding interventions. **Objective:** To assess morphological patterns of anemia among tribal pregnant women in Ranchi, Jharkhand, across trimesters. **Methods:** A cross-sectional study was conducted on 406 anemic tribal pregnant women attending the Obstetrics and Gynaecology Department at a tertiary care centre in Ranchi, Jharkhand (January–December 2017). Hemoglobin estimation, peripheral smear examination, and sickle cell screening were performed. Anemia was classified as mild (10.0–10.9 g/dl), moderate (7.0–9.9 g/dl), and severe (<7.0 g/dl). Trimester-wise distribution of morphological anemia types was analyzed using chi-square tests, followed by pairwise Fisher's exact tests with Bonferroni correction. **Results:** Microcytic hypochromic anemia was most common (51.0%), followed by dimorphic (26.8%), normocytic normochromic (11.6%), macrocytic (6.2%), sickle cell anemia (4.2%), and pancytopenia (0.2%). Most women had mild (52.0%), moderate (39.2%), and severe (8.8%) anemia. Significant differences in anemia distribution were observed across trimesters ($p < 0.001$). Microcytic anemia predominated in all trimesters, with dimorphic anemia more common in later trimesters. **Conclusion:** Microcytic hypochromic anemia predominates among tribal pregnant women in Ranchi, with dimorphic anemia also prevalent. The findings indicate combined iron, folate, and vitamin B12 deficiencies, alongside hemoglobinopathies, emphasizing the need for early screening, nutritional interventions, and routine sickle cell testing in antenatal programs for tribal populations.

Keywords: Anemia, Pregnant Women, Trimesters, Morphology, Hemoglobin, Erythrocyte Indices, Tribal Health

Introduction

Anemia during pregnancy remains a critical public health issue worldwide, with a disproportionately high burden in low- and middle-income countries. (1) In India, the situation is particularly severe among tribal populations, who often face compounded vulnerabilities due to geographic isolation, limited access to healthcare, poor nutrition,

and socioeconomic marginalization. (2) According to the World Health Organization (WHO), the prevalence of anemia among pregnant women in developing regions is alarmingly highreaching up to 56%and tribal communities are among the most affected subgroups. (1)

Pregnancy induces significant physiological changes, including increased plasma volume and heightened nutritional demands, which render women more susceptible to developing anemia. (3) This condition, if left unaddressed, can lead to serious maternal and fetal complications such as preterm labour, low birth weight, increased perinatal and maternal mortality, and long-term developmental impairments in the child. (4) The effects are often magnified in tribal populations due to persistent nutritional deficiencies, parasitic infections, and limited utilization of antenatal care services. (5) Anemia in pregnancy can be classified as relativedue to hemodilutionor absolute, stemming from actual reductions in red cell mass caused by factors such as nutritional deficiencies (especially iron, folate, and vitamin B12), chronic infections, hemoglobinopathies, or blood loss. (3, 6) Understanding the morphological patterns of anemiawhether microcytic, normocytic, or macrocyticprovides crucial insights into its underlying etiology and guides appropriate clinical management. (7)

In India, tribal communities represent a vulnerable segment with distinct socio-cultural and health challenges. In the state of Jharkhand, which has a significant tribal population, maternal anemia is a major contributor to adverse pregnancy outcomes. (5) However, region-specific data, particularly on the morphological types of anemia across different trimesters of pregnancy, remain limited. (8)

This study was therefore undertaken to assess the morphological patterns of anemia among tribal pregnant women in various trimesters in Ranchi, Jharkhand. By identifying the hematological characteristics and trimester-wise trends, the findings aim to support the development of targeted, culturally appropriate interventions to reduce anemia-related morbidity and improve maternal and neonatal health in tribal communities.

Methodology

Type and place of study: Cross-sectional done in department of Physiology, Rajendra Institute of Medical Sciences, Ranchi

Sample size and Sampling method:

Cochrane's formula was used to calculate the sample size for this cross-sectional study. Accordingly, sample size was calculated as 384. Consecutive sampling (a type of non-probability purposive sampling) technique was used as the sampling method for selection of participants.]

Study Population:
The study population consisted of 406 pregnant anemic women aged 18 to 40 years in various trimesters. The study was carried out from Jan 2017–December 2017 at a tertiary care hospital in Ranchi, Jharkhand. Participants were recruited from both outpatient and inpatient settings of the Obstetrics and Gynaecology Department.

Inclusion and Exclusion Criteria:
Inclusion criteria encompassed all apparently normal anemic tribal pregnant women in different trimesters attending the hospital. Exclusion criteria included non-tribal pregnant females, those who did not provide consent, those who were uncooperative, and non-anemic pregnant tribal females.

Data Collection:
After obtaining necessary approvals from the institutional ethics committee and informed written consent from the participants, detailed history-taking and general, systemic, and obstetrical examinations were conducted. Venous blood samples were collected from each subject for laboratory analysis. The study was conducted on 406 pregnant tribal women whose hemoglobin level was <11 g/dl. (9) Hemoglobin concentration of 10–10.9 g/dl, 7–9.9 g/dl, and <7 g/dl was considered as mild, moderate, and severe anemia, respectively. Hematological parameters like Complete Blood Count (CBC) were measured using an automated hematology analyzer which has been used in our earlier study. (10) Peripheral blood smears were stained with Leishman's stain and examined under a compound microscope to evaluate the morphological characteristics of red blood cells, including their size, shape, and staining properties. Sickle cell screening was performed using a freshly prepared 2% sodium metabisulphite solution, and cases testing positive were further confirmed by hemoglobin electrophoresis. A detailed clinical and obstetric history was documented for each participant, along with an assessment of their socioeconomic status.

Statistical Analysis:
Descriptive statistics were employed to summarize the data: Frequencies and percentages were calculated for categorical variables such as morphological type of anemia, severity, trimester distribution, gravida status, and age groups. All data collected were recorded and analysed using the Statistical Package for Social Sciences (SPSS) version 20.0. For each trimester, the distribution of anemia types was tested using the Chi-square goodness-of-fit test followed by pairwise Fisher's exact tests with Bonferroni correction for multiple comparisons. A p-value <0.05 (after correction) was considered significant.

Observations

Table I: Demographic and Clinical Characteristics of Study Participants (N = 406)

Characteristic	Category	Frequency (n)	Percentage (%)
Age Group (Years)	18–20	32	7.9%
	21–25	176	43.4%
	26–30	161	39.7%
	31–35	29	7.1%
	>35	8	2.0%
Trimester	First	43	10.6%
	Second	86	21.2%
	Third	277	68.2%
Gravida Status	Primigravida	112	27.6%
	Multigravida	249	61.3%
	Grand multipara	45	11.1%
Severity of Anemia	Mild (10–10.9 g/dl)	211	52.0%
	Moderate (7–9.9 g/dl)	159	39.2%
	Severe (<7 g/dl)	36	8.8%

Table II: Morphological Patterns of Anemia

Morphological Pattern	1st Trimester (n=43)	2nd Trimester (n=86)	3rd Trimester (n=277)	Total (n=406)
Microcytic hypochromic	18 (41.9%)	34 (39.5%)	155 (55.9%)	207 (51.0%)
Dimorphic anemia	13 (30.2%)	26 (30.2%)	70 (25.3%)	109 (26.8%)
Normocytic normochromic	6 (14.0%)	10 (11.6%)	31 (11.2%)	47 (11.6%)
Macrocytic anemia	3 (7.0%)	7 (8.1%)	15 (5.4%)	25 (6.2%)
Sickle cell anemia	2 (4.6%)	8 (9.3%)	7 (2.5%)	17 (4.2%)
Pancytopenia	1 (2.3%)	0 (0 %)	0 (0 %)	1 (0.2%)

Table III: Trimester wise comparison of morphological patterns of anemia

Trimester	Chi-square (df=5)	P-value	Main interpretation
1st (n=43)	32.77	4.2×10^{-6}	Microcytic anemia significantly higher than macrocytic, sickle cell, and pancytopenia. No significant difference between microcytic and dimorphic anemia.
2nd (n=86)	59.35	1.65×10^{-11}	Microcytic anemia significantly higher than normocytic, macrocytic, sickle cell, and pancytopenia. Dimorphic anemia also significantly higher than macrocytic, sickle cell, and pancytopenia.
3rd (n=277)	372.94	$< 2.2 \times 10^{-16}$	Very strong differences observed. Microcytic anemia significantly higher than all other forms. Dimorphic anemia also significantly higher than macrocytic, sickle cell, and pancytopenia. Normocytic anemia significantly higher than sickle cell and pancytopenia, but not macrocytic

Results:
Among the 406 tribal pregnant women studied, anemia was most common in women of early reproductive age. The majority were in the third trimester and had a history of previous pregnancies. In terms of severity, mild anemia was observed most frequently, followed by moderate anemia, while severe cases were relatively uncommon. (Table I) The morphological distribution of anemia showed distinct trimester-wise patterns. Microcytic hypochromic anemia emerged as the predominant type in all trimesters, with its frequency rising sharply in the third trimester. Dimorphic anemia was the second most frequent pattern, while normocytic, macrocytic, and sickle cell anemia occurred less often, and pancytopenia was rare. (Table II) Chi-square analysis confirmed significant differences in the distribution of morphological types across trimesters: microcytic anemia consistently outnumbered the rarer forms; in the second trimester, dimorphic anemia also showed significant predominance; and by the third trimester, microcytic anemia overwhelmingly surpassed all other patterns. (Table III)

Discussion:
This cross-sectional study explored the morphological patterns of anemia among 406 tribal pregnant women attending RIMS, Ranchi, across different trimesters. The

findings highlight a high burden of anemia in this population, with varied severity and morphological types.

Most women were aged 18–25 years (51.3%) and 26–30 years (39.7%), indicating that anemia predominantly affects women in their prime reproductive age group. The small percentage of women above 35 years (2.0%) is reflective of early marriage and childbearing practices in tribal communities. These younger womenare vulnerable due to nutritional inadequacies and physiological immaturity, compounding the risk of anemia. (11)

The trimester-wise distribution revealed that 68.2% of anemic women were in the third trimester, followed by 21.2% in the second and only 10.6% in the first trimester. This trend indicates a progressive increase in anemia prevalence with advancing gestation, consistent with the physiological hemodilution of pregnancy and increased fetal nutritional demands in later trimesters. (12) The third trimester is critical for fetal growth and iron transfer; hence, early detection and correction of anemia in the first and second trimesters is crucial to avoid complications later in pregnancy.

In terms of parity, multigravida women (61.3%) represented the largest group, followed by primigravida (27.6%) and grand multipara (11.1%). Multigravida and grand multiparous women are at increased risk due to cumulative nutritional depletion from previous pregnancies, especially in the absence of adequate inter-pregnancy intervals and supplementation. (13) This highlights the importance of interconception care and family planning counselling in tribal health programs.

More than half the participants (52.0%) had mild anemia, followed by moderate (39.2%), and severe anemia (8.8%). This distribution which is similar to findings of previous studyreflects a spectrum of severity in the study group, with a significant proportion at risk of worsening clinical outcomes if left unaddressed. While mild anemia may initially be asymptomatic, progression to moderate or severe forms increases the risks of maternal fatigue, infections, preterm labour, and intrauterine growth restriction. (14) The notable proportion of severe anemia cases emphasizes the need for aggressive monitoring and supplementation, especially in under-resourced tribal populations.

In this study, microcytic hypochromic anemia emerged as the most prevalent morphological pattern among tribal pregnant women, accounting for 51.0% of cases. This was followed by dimorphic anemia (26.8%), normocytic normochromic anemia (11.6%), macrocytic anemia (6.2%), sickle cell anemia (4.2%), and a rare case of pancytopenia (0.2%). These diverse morphological profiles reflect the multifactorial etiology of anemia in pregnancy, especially in nutritionally vulnerable and genetically predisposed tribal populations.

Microcytic hypochromic anemia, is classically associated with iron deficiency, the most common nutritional deficiency globally and a major contributor to maternal morbidity. (15) In tribal and rural communities, low iron intake, coupled with high phytate content in staple cereals, frequent gastrointestinal infections, and inadequate supplementation programs contribute to iron deficiency (16, 17).Additionally, blood loss from parasitic infections such as hookworm or malaria, which are prevalent in forested tribal regions, further depletes iron stores. (18) The relatively high proportion of microcytic anemia in this study underscores the need for deworming, malaria control, and iron-fortified food interventions.

Presence of dimorphic anemia being second most common morphological type, points toward coexisting iron and vitamin B12 or folate deficiencies, which are common in pregnant women with inadequate or unbalanced dietary intake. (19)One study done in Sudan among non-tribal pregnant females found the dimorphic anemia as the most common morphological pattern pointing towards the similar pathology. (20)It is well-established that many women in rural India receive intermittent or unsupervised iron-folic acid (IFA) supplementation, leading to incomplete correction of micronutrient deficits and resulting in mixed morphological features. Moreover, repeated pregnancies without adequate nutritional replenishment may aggravate this combined deficiency. (21)Dimorphic anemia has been increasingly reported in Indian studies, especially among low-income and tribal populations, where poor dietary diversity and low intake of animal-source foods contribute to vitamin B12 deficiency.(8)

Normocytic normochromic anemia, observed in 11.6% of participants, often represents anemia of chronic disease (ACD) or early-stage nutritional deficiency anemia, where red cell indices remain within normal limits before becoming microcytic or macrocytic.Chronic low-grade inflammation, common in malnourished or infected individuals, may suppress erythropoiesis and iron utilization, resulting in normocytic anemia. (22)

Macrocytic anemia (6.2%) is typically caused by folate or vitamin B12 deficiency, both of which are prevalent in tribal populations due to diets low in green leafy vegetables, fruits, and animal-source foods. Alcohol use and gastrointestinal malabsorptionoften unrecognized in rural health settingscan also contribute. Folate deficiency, in particular, is dangerous during pregnancy as it increases the risk of neural tube defects in the foetus. (23)

Sickle cell anemia was detected in 4.2% of the cases, aligning with previous studies indicating a high prevalence of hemoglobinopathies among tribal groups in India.(24) Sickle cell disease increases the risk of hemolysis, vaso-occlusive crises, and pregnancy complications, including miscarriage, preeclampsia, and intrauterine growth restriction. Early screening and prenatal counselling are essential in such cases. (25)

Pancytopenia was a rare finding (0.2%) but may indicate bone marrow suppression, aplastic anemia, or nutritional deficiency-induced megaloblastic changes, warranting further diagnostic workup. (26)

Limitations:
The cross-sectional nature of the study limits causal interpretation and tracking of anemia progression across trimesters. As it was hospital-based, findings may not reflect the broader tribal population, especially in remote areas. Absence of biochemical tests (e.g., serum ferritin, folate, B12) restricted etiological confirmation. Self-reported data on diet and obstetric history may have introduced recall bias.

Conclusion
The morphological diversity of anemia observed in this study reflects the complex interplay of nutritional deficiencies, genetic disorders, and inadequate antenatal care in tribal populations. The predominance of dimorphic and microcytic hypochromic anemia highlights the urgent need for comprehensive screening, dietary interventions, and supervised iron-folic acid supplementation. Concurrently, the identification of sickle cell cases underlines the importance of hemoglobinopathy screening programs in antenatal services. A morphologic approach to anemia in pregnancy offers valuable insights into its etiology and guides targeted treatment strategies, particularly in underserved communities.

Acknowledgement
The authors would like to thank department of Obstetrics and Gynaecology and Department of Pathology, RIMS, Ranchi for their support.

Conflict of interest
Authors declared no conflict of interest.

Funding
This research has not received any funding from any public, private or other organization.

Ethical considerations
The study protocol was approved by the Institutional Ethics Committee of RIMS, Ranchi.

Code of Ethics
All subjects gave their informed consent for inclusion before they participated in the study. We confirm that the clinical research was done in accordance of the Ethical Principles for Medical Research Involving Human Subjects, outlined in the Helsinki Declaration of 1975.

Running Title: Morphological patterns of Anemia among Tribal Pregnant Women in Different Trimesters

Author Address:
[1] Associate Professor, Department of Physiology, All India Institute of Medical Sciences (AIIMS), Deoghar, Jharkhand, India
[2] Academic Junior Resident, Department of Physiology, Rajendra Institute of Medical Sciences (RIMS), Ranchi, Jharkhand, India
[3] Associate Professor, Department of Physiology, Radha Devi Jageshwari Memorial Medical College, Turki, Muzaffarpur, Bihar, India
[4] Senior Resident, Department of Physiology, All India Institute of Medical Sciences (AIIMS), Deoghar, Jharkhand, India
[5] Additional Professor, Department of Pathology & Lab Medicine, All India Institute of Medical Sciences (AIIMS), Deoghar, Jharkhand, India

ORCID ID:
Anup kumar Dhanvijay: ORCID: 0000-0002-2426-8066
Kumar Vivek: ORCID: 0009-0006-8071-7643
Anjali Sinha: ORCID: 0009-0004-7981-1478
Mohammed Jaffer Pinjar: ORCID: 0000-0002-8130-3999
Nikhil Kumar: ORCID: 0000-0002-0676-4189

Work attributed to: Rajendra Institute of Medical Sciences (RIMS), Ranchi, Jharkhand

Author's Contribution:
AD, KV- Definition of intellectual content, Literature survey, Prepared first draft of manuscript, implementation of study protocol, data collection, data analysis, manuscript preparation and submission of article; **AD, KV**- Concept, design, clinical protocol, manuscript preparation, editing, and manuscript revision; **AD**- Design of study, statistical Analysis and Interpretation; **MJP**- Review Manuscript; **NK**- Review Manuscript; **AS**- Literature survey and preparation of Figures; **AD**- Coordination and Manuscript revision

Conflict of interest: Authors declared no conflict of interest
Source of Funding: There was no financial support concerning this work.

References:

1. Araujo Costa E, de Paula Ayres-Silva J (2023). Global profile of anemia during pregnancy versus country income overview: 19 years estimative (2000–2019). Ann Hematol 102: 2025–2031.
2. Madankar M, Kakade N, Basa L, Sabri B (2024). Exploring maternal and child health among tribal communities in India: A life course perspective. Glob J Health Sci 16: 31–47.
3. Obeagu GU, Obeagu EI (2025). Complications of anemia in pregnancy: An updated overview for healthcare professionals. Medicine (Baltimore) 104: e44246.
4. Edelson PK, Cao D, James KE, Ngonzi J, Roberts DJ, Bebell LM, Boatin AA (2023). Maternal anemia is associated with adverse maternal and neonatal outcomes in Mbarara, Uganda. J Matern Fetal Neonatal Med 36: 2190834.
5. Let S, Tiwari S, Singh A, Chakrabarty M (2024). Prevalence and determinants of anaemia among women of reproductive age in aspirational districts of India: An analysis of NFHS 4 and NFHS 5 data. BMC Public Health 24: 437.
6. Bansal A, Suri V, Sikka P, Attri SV, Varma N, Saini SS, Goyal A, Malhotra P (2024). B12 deficiency is the commonest cause of anaemia during pregnancy in Northern India: Study from a tertiary care institute. Indian J Hematol Blood Transfus 40: 78–82.
7. Freeman AM, Zubair M (2025). Anemia Screening. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing.
8. Krishnan G, Shah PH (2025). Study of morphological types of anemia in antenatal patients at a tertiary care hospital. Ann Pathol Lab Med 12: A226–A231.
9. Kassie GA, Hailegebireal AH, Gebrekidan AY, Woldegeorgis BZ, Adella GA, Haile KE, Asgedom YS (2024). Anemia status and its determinants among reproductive-age women in Tanzania: A multi-level analysis of demographic and health survey data. PLoS One 19: e0311105.
10. Kumari R, Vivek K, Dhanvijay A, Gathe B (2021). Evaluation of hemostatic parameters of apparently normal pregnant Indian females in different trimesters. Natl J Physiol Pharm Pharmacol 11: (page numbers not provided).
11. Madankar M, Kakade N, Basa L, Sabri B (2024). Exploring maternal and child health among tribal communities in India: A life course perspective. Glob J Health Sci 16: 31–47.
12. Locks LM, Bhaise S, Dhurde V, Gugel A, Lauer J, Shah M, Goghari A, Hibberd PL, Patel A (2024). The prevalence of anemia during pregnancy and its correlates vary by trimester and hemoglobin assessment method in Eastern Maharashtra, India. Matern Child Nutr 20: e13684.
13. Dasa TT, Okunlola MA, Dessie Y (2022). Effect of grand multiparity on adverse maternal outcomes: A prospective cohort study. Front Public Health 10: 959633.
14. Shi H, Chen L, Wang Y, Sun M, Guo Y, Ma S, Wang X, Jiang H, Wang X, Lu J, Ge L, Dong S, Zhuang Y, Zhao Y, Wei Y, Ma X, Qiao J (2022). Severity of anemia during

pregnancy and adverse maternal and fetal outcomes. JAMA Netw Open 5: e2147046.
15. Kolarš B, Mijatović Jovin V, Živanović N, Minaković I, Gvozdenović N, Dickov Kokeza I, Lesjak M (2025). Iron deficiency and iron deficiency anemia: A comprehensive overview of established and emerging concepts. Pharmaceuticals (Basel) 18: 1104.
16. Reddy BHR, Thankachan P, Hatakayama M, Hiremath N, Moretti D, Nanjareddy YA, Thumilan MB, Ravikumar RL, Phadnis S, Bose B, Poveda L, Kalaiah G, Zimmermann MB, Shimizu KK, Schlapbach R, Kurpad AV, Sreeman SM (2022). A natural low phytic acid finger millet accession significantly improves iron bioavailability in Indian women. Front Nutr 8: 791392.
17. Bhatnagar RS, Padilla-Zakour OI (2021). Plant-based dietary practices and socioeconomic factors that influence anemia in India. Nutrients 13: 3538.
18. Caldrer S, Ursini T, Santucci B, Motta L, Angheben A (2022). Soil-transmitted helminths and anaemia: A neglected association outside the tropics. Microorganisms 10: 1027.
19. Qasrawi R, Badrasawi M, Al-Halawa DA, Polo SV, Khader RA, Al-Taweel H, Alwafa RA, Zahdeh R, Hahn A, Schuchardt JP (2024). Identification and prediction of association patterns between nutrient intake and anemia using machine learning: A cross-sectional study among university females in Palestine. Eur J Nutr 63: 1635–1649.
20. Abusharib AB (2019). Morphological patterns of anaemia among pregnant women from Sudan. Afr J Lab Med 8: 743.
21. Venkatesh U, Sharma A, Ananthan VA, Subbiah P, Durga R; CSIR Summer Research Training Team (2021). Micronutrient deficiency in India: A systematic review and meta-analysis. J Nutr Sci 10: e110.
22. Ramya G, Vimal M (2016). Analytical study of morphological patterns of anemia and associated illnesses in females. Int J Res Rev 3: 54–57.
23. Singh B, Verma SP, Chauhan AS, Verma DP (2022). Prevalence of anemia among reproductive-age females in the Tharu tribe of the Indo–Nepal border region. J Family Med Prim Care 11: 2961–2964.
24. Rao P, Raj EA, Natesan S, Gudi N (2024). Prevalence of sickle cell disease, sickle cell trait and HbS–β-thalassemia in India: A systematic review and meta-analysis. Clin Epidemiol Glob Health 28: 101678.
25. Habibi A, Benachi A, Lecarpentier E (2023). Managing pregnancy in patients with sickle cell disease from a transfusion perspective. Hematology Am Soc Hematol Educ Program 2023: 640–645.
26. Chiravuri S, De Jesus O (2025). Pancytopenia. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing.