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Original Research Article

# CLINICO-HEMATOLOGICAL PROFILE OF NUTRITIONAL ANEMIA AMONG ADOLESCENT GIRLS ATTENDING A TERTIARY CARE CENTRE

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## ABSTRACT

**Background:** Adolescence is a critical phase of rapid growth and development requiring adequate nutrition. In India, nearly 59% of adolescent girls are anemic due to poor dietary habits, menstrual blood loss, and socioeconomic deprivation. Nutritional anemia, mainly caused by iron, vitamin $B_{12}$, and folate deficiencies, severely affects physical growth, cognition, and future maternal health. **Aim and Objective:** To assess the clinico-hematological and socio-demographic profiles of adolescent girls with nutritional anemia. **Materials and Methods:** A cross-sectional observational study was conducted on 100 adolescent girls (10–19 years) attending a tertiary care hospital. Clinical history, examination, hematological parameters (Hb, MCV, MCH, MCHC, RDW, PBS), and biochemical indices (serum ferritin, iron, TIBC, vitamin $B_{12}$, folate) were analyzed. Socioeconomic status, BMI, dietary habits, and maternal education were recorded. Statistical analysis was done using SPSS with $p < 0.05$ considered significant. **Result:** The majority (55%) were aged 14–16 years; 62% resided in rural areas and 48% belonged to lower-middle socioeconomic class. Severe anemia (< 8 g/dL) was seen in 71% of cases, with fatigue (96%) and pallor (88%) as predominant manifestations. Microcytic hypochromic anemia was most common (57%), followed by megaloblastic (29%) and dimorphic (14%). Iron deficiency (57%) was the leading cause, while vitamin $B_{12}$ and folate deficiencies accounted for 20% and 9%, respectively. **Conclusion:** Nutritional anemia remains highly prevalent among adolescent girls, predominantly due to iron deficiency and aggravated by low BMI, vegetarian diet, and poor maternal literacy. Early screening, dietary education, and supplementation programs are essential to break this intergenerational cycle of malnutrition.

## INTRODUCTION

Adolescence is a period of rapid growth and physiological transition associated with increased nutritional demands for iron, folate, and vitamin $B_{12}$ to support hematopoiesis and hormonal changes. Inadequate dietary intake during this stage, especially among girls, predisposes to nutritional anemia, a major public health concern that affects physical growth, cognitive performance, and future maternal health.[1] In India, nearly 59% of adolescent girls are anemic, one of the highest rates globally.[2]

The etiology of nutritional anemia is multifactorial. Iron deficiency arises from menstrual blood loss and poor dietary iron intake,[3] vitamin $B_{12}$ deficiency occurs in predominantly vegetarian populations,[4] and folate deficiency results from low consumption of green leafy vegetables or chronic illnesses.[5] Socioeconomic deprivation, low parental literacy, and rural residence aggravate poor nutrition and healthcare access, perpetuating an intergenerational cycle of malnutrition.[6]

Clinically, adolescent anemia presents with fatigue, pallor, and reduced exercise tolerance.[7] Hematologically, microcytic hypochromic and megaloblastic patterns are common, reflecting iron and vitamin deficiencies.[8,9] Previous Indian studies have consistently demonstrated that iron deficiency remains the predominant cause of anemia among adolescent girls, often linked to poor diet, menstrual blood loss, and low socioeconomic status.[10] Kumar Vijayant et al. reported iron deficiency in more than half of adolescents studied, with additional cases showing combined nutritional deficits.[10] Shuchismita et al. observed overlapping vitamin $B_{12}$ and folate deficiencies contributing to megaloblastic and dimorphic anemia patterns.[11] Joag et al. found microcytic hypochromic anemia to be the most frequent morphological type in rural adolescents, reinforcing the dominance of iron deficiency while acknowledging the coexistence of other micronutrient shortages.[12] Moreover, Louwman et al. documented that even marginal vitamin $B_{12}$ deficiency can impair cognitive function in adolescents, underscoring its clinical relevance despite lower prevalence compared to iron deficiency.[13]

Given the high prevalence and multifactorial nature of anemia in this group, it is crucial to understand the clinico-hematological and sociodemographic profile of affected adolescents. The present study therefore aimed to assess the clinical features, hematological indices, and biochemical parameters—serum iron, ferritin, vitamin $B_{12}$, and folate—and to identify associated sociodemographic and dietary factors contributing to nutritional anemia among adolescent girls attending a tertiary care centre.

## MATERIALS AND METHODS

This cross-sectional observational study was conducted in the Department of Pediatrics, GSVM Medical College, Kanpur, after approval from the Institutional Ethics Committee. The study was carried out from January 2021 to October 2022 among adolescent girls (10–19 years) attending outpatient and inpatient services.

A total of 100 participants meeting the WHO definition of anemia (Hb < 12 g/dL) were included. Exclusion criteria comprised chronic illness, acute blood loss, haemolytic anaemia, bone marrow suppression, and who are not willing to give consent. Data on age, dietary habits, menstrual history, socioeconomic status, and maternal education were collected using a structured proforma. Body mass index (BMI) was calculated to assess nutritional status. Clinical examination focused on signs of anemia and nutritional deficiency. Hematological tests included Hb, MCV, MCH, MCHC, and RDW measured by an automated analyzer; peripheral smear determined morphological type. Biochemical parameters—serum iron, TIBC, ferritin, vitamin $B_{12}$, and folate—were analyzed using standard methods.

Data were processed in SPSS v22.0. Descriptive statistics summarized findings, and Chi-square or Student's t-test/ANOVA assessed associations; $p < 0.05$ was considered statistically significant.

## RESULTS

Most patients (55%) were aged 14–16 years, indicating mid-adolescence as the most affected group, while 10–13 years accounted for one-third and 17–19 years only 12%. Nearly half (48%) belonged to the lower-middle socioeconomic class, followed by 32% in the upper-lower group. This pattern highlights that nutritional anemia peaks during puberty's rapid growth phase and is more prevalent among economically weaker adolescents due to poor nutrition, limited healthcare access, and low awareness of dietary requirements.

The table reveals that a vast majority of patients (71%) suffered from severe anemia, indicating a significantly high disease burden in the study population. Moderate anemia was observed in 24% of cases, while only 5% had mild anemia. This distribution suggests delayed diagnosis and poor nutritional or healthcare access among patients, highlighting the need for early screening and effective preventive interventions to reduce severe anemia prevalence. [Table 1]

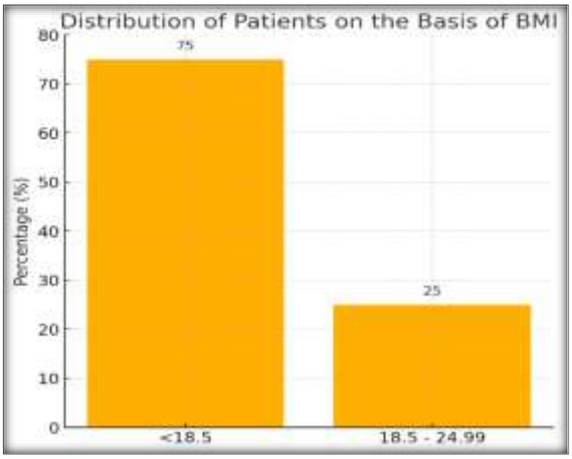


**Figure 1: The distribution of patients on the basis of BMI**

The figure shows that 75% of patients had a BMI below 18.5, indicating that undernutrition was predominant in the study population, while only 25% had a normal BMI range of 18.5–24.99. This high prevalence of low BMI suggests chronic nutritional deficiency and poor dietary intake, which


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may contribute significantly to the development and severity of anemia observed among these patients. [Figure 1]

The table shows that nearly half of the patients (48%) had mothers educated only up to the 5th class, while 28% had education between the 6th and 8th classes, and only 24% studied beyond the 9th standard. This indicates a strong link between low maternal education and the prevalence of anemia, as limited literacy often correlates with poor nutritional awareness, inadequate dietary practices, and reduced healthcare utilization among families. [Table 2]

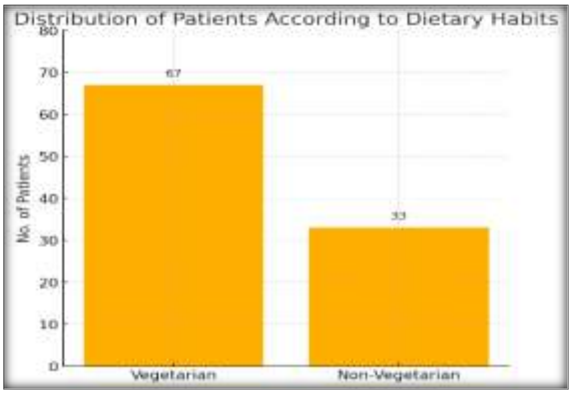


**Figure 2: Distribution of patients according to dietary habits**

The table indicates that 62% of patients belonged to rural areas, while only 38% were from urban regions. This rural predominance highlights disparities in nutrition, education, and healthcare accessibility, which may contribute to higher anemia prevalence. Limited awareness, inadequate dietary diversity, and poor socioeconomic conditions in rural settings likely play a major role in the observed trend. [Table 3]

The table demonstrates that fatigue (96%), shortness of breath (76%), and anorexia (70%) were the most frequent symptoms among anemic adolescents, followed by palpitations (62%), fever (18%), and limb swelling (10%). These findings reflect the systemic impact of anemia on oxygen transport and tissue perfusion. The predominance of fatigue and breathlessness underscores the physiological strain imposed by reduced hemoglobin levels on overall metabolic function. [Table 4]

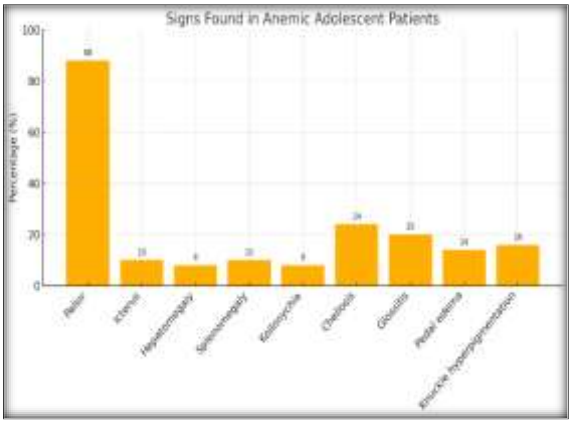


**Figure 3: Signs Found in Anemic Adolescent Patients**

The figure shows that pallor was the most common sign, seen in 88% of anemic adolescents, followed by cheilosis (24%) and glossitis (20%), indicating nutritional deficiencies such as iron, folate, or vitamin $B_{12}$ deficiency. Other findings like pedal edema, knuckle hyperpigmentation, and hepatosplenomegaly occurred less frequently. These signs collectively reflect the chronicity and systemic effects of anemia on tissue oxygenation and nutritional status. [Figure 3]

**Table 1: Distribution of Patients According to Severity of Anemia**

| Grading of Anemia (WHO Classification) | No. of Patients | Percentage (%) |
|---|---|---|
| Mild (11–11.9 g/dL) | 5 | 5% |
| Moderate (8–10.9 g/dL) | 24 | 24% |
| Severe (<8 g/dL) | 71 | 71% |

**Table 2: Distribution of Patients According to Maternal Education Status**

| Mother's Education | No. of Patients | Percentage (%) |
|---|---|---|
| 0 to 5th class | 48 | 48% |
| 6th to 8th class | 28 | 28% |
| ≥ 9th standard | 24 | 24% |

**Table 3: Distribution of Patients on the Basis of Residence**

| Residence | No. of Patients | Percentage (%) |
|---|---|---|
| Urban | 38 | 38% |
| Rural | 62 | 62% |

**Table 4: Symptoms Found in Anemic Adolescent Patients**

| Symptoms | No. of Patients | Percentage (%) |
|---|---|---|
| Fatigue | 96 | 96% |
| Anorexia | 70 | 70% |
| Shortness of breath | 76 | 76% |
| Palpitations | 62 | 62% |
| Swelling of limbs | 10 | 10% |
| Fever | 18 | 18% |

Table 5: Patients Classification on the Basis of Peripheral Blood Smear

| Peripheral Blood Smear (PBS) | No. of Patients | Percentage (%) |
|---|---|---|
| Dimorphic anemia | **14** | **14%** |
| Megaloblastic anemia | **29** | **29%** |
| Microcytic hypochromic anemia | **57** | **57%** |

The table shows that microcytic hypochromic anemia was the most prevalent type (57%), followed by megaloblastic anemia (29%) and dimorphic anemia (14%). This predominance indicates iron deficiency as the leading cause of anemia among the study group. The presence of megaloblastic and dimorphic patterns further suggests concurrent deficiencies of vitamin $B_{12}$ and folate, reflecting multiple nutritional insufficiencies in the adolescent population.

Table 6: Distribution of Patients on the Basis of Deficiencies of Vitamin $B_{12}$, Folic Acid, and Iron Deficiency

| Type of Anemia | Deficiency Type | No. of Patients | Percentage (%) |
|---|---|---|---|
| Microcytic Hypochromic Anemia | Iron deficiency | 57 | 57% |
| Megaloblastic Anemia | Folic acid deficiency | 9 | 9% |
| | Vitamin $B_{12}$ deficiency | 20 | 20% |
| Dimorphic Anemia | Iron and folic acid deficiency | 2 | 2% |
| | Iron and Vitamin $B_{12}$ deficiency | 8 | 8% |
| | Both Vitamin $B_{12}$, folic acid and iron deficiency | 4 | 4% |

The table reveals that iron deficiency was the predominant cause of anemia (57%), followed by vitamin $B_{12}$ deficiency (20%) and folic acid deficiency (9%). Mixed deficiencies involving iron with folate or vitamin $B_{12}$ accounted for smaller proportions. These findings highlight that iron deficiency remains the primary etiological factor in adolescent anemia, though concurrent vitamin deficiencies further aggravate hematological impairment and complicate recovery.

Table 7: Mean Values of Hematological Parameters in Various Types of Anemia

| Hematological Parameters | Dimorphic Anemia (n=14) | Megaloblastic Anemia (n=29) | Microcytic Hypochromic Anemia (n=57) |
|---|---|---|---|
| Hb (g/dL) | 7.043 ± 1.464 | 6.797 ± 1.669 | 6.684 ± 1.703 |
| TLC (cells/cumm) | 7810.714 ± 2033.96 | 6161.724 ± 1340.863 | 9336.842 ± 2085.449 |
| RBC (million/cumm) | 2.318 ± 0.702 | 2.522 ± 0.662 | 1.997 ± 0.536 |
| Platelets (lac/mm³) | 2.13 ± 0.681 | 1.637 ± 0.452 | 2.456 ± 0.417 |
| MCV (fL) | 89.879 ± 9.036 | 116.138 ± 10.72 | 68.77 ± 4.473 |
| MCH (pg) | 33.793 ± 4.422 | 37.562 ± 4.31 | 23.491 ± 2.107 |
| MCHC (g/dL) | 32.471 ± 1.984 | 32.021 ± 2.753 | 26.739 ± 1.476 |
| RDW (%) | 21.821 ± 4.03 | 26.841 ± 3.885 | 19.447 ± 3.01 |
| Serum Iron (µg/dL) | 44.236 ± 11.964 | 109.721 ± 34.097 | 34.063 ± 13.355 |
| TIBC (µg/dL) | 466.357 ± 47.675 | 317.724 ± 73.318 | 549.877 ± 41.469 |
| Serum Ferritin (µg/L) | 13.293 ± 1.618 | 103.859 ± 55.458 | 11.244 ± 1.848 |
| Serum Vitamin $B_{12}$ (ng/L) | 168.214 ± 13.463 | 167.598 ± 65.299 | 365.368 ± 74.561 |
| Serum Folate (ng/L) | 3.164 ± 0.652 | 4.521 ± 1.89 | 11.512 ± 3.003 |

The table demonstrates distinct hematological patterns across different anemia types. Microcytic hypochromic anemia showed low Hb, RBC, serum iron, and ferritin with high TIBC, consistent with iron deficiency, whereas megaloblastic anemia exhibited markedly elevated MCV and MCH due to defective DNA synthesis from vitamin $B_{12}$ or folate deficiency. Dimorphic anemia presented intermediate values, reflecting combined nutritional deficits. These findings emphasize the role of specific biochemical parameters in differentiating anemia types and guiding targeted therapy.

## DISCUSSION

The present study aimed to evaluate the clinico-hematological and socio-demographic profile of anemia among adolescent girls attending a tertiary care center. A total of 100 newly diagnosed anemic adolescents aged 10–19 years with hemoglobin < 12 g/dl were included. The maximum number of patients (55%) belonged to the mid-adolescent age group (14–16 years), followed by 33% in early adolescence (10–13 years) and 12% in late adolescence (17–19 years). This indicates that anemia peaks during mid-adolescence, when rapid growth and menstrual onset increase iron demands. Sharma MK et al,[7] reported a similar trend, with the highest prevalence between 15–19 years, while Kumar Vijayant et al,[10] observed comparable findings with 50% in the 14–16-year group and only 10% in 17–19 years.

Socio-economic status plays a pivotal role in nutritional health. In our study, 48% of patients belonged to the lower-middle class and 32% to the upper-lower class. Sharma MK et al,[7] also found that 52% of subjects were from the upper-lower class, while Shuchismita et al,[11] reported anemia predominating among low-income groups (41.2%) compared with medium socioeconomic groups (18.2%). Rahman S et al,[6] similarly demonstrated the highest prevalence (21.5%) among the lower-


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middle class, emphasizing poverty, poor diet, and limited health access as major contributors.

Regarding severity, 5% of our patients had mild anemia, 24% moderate, and 71% severe anemia. The high proportion of severe cases reflects hospital-based selection bias toward symptomatic admissions. In contrast, Joag GG et al,[12] reported 52.9% mild, 40.1% moderate, and 7% severe anemia, a difference likely due to their outpatient setting. The common symptoms in our study were fatigue (96%), shortness of breath (76%), anorexia (70%), and palpitations (62%). Sharma MK et al,[7] observed fatigue in 82% and anorexia in 64% of patients, while Kumar Vijayant et al,[10] similarly highlighted fatigue as the predominant complaint.

The most frequent clinical sign was pallor (88%), followed by pedal edema (14%), icterus (10%), hepatomegaly (8%), and splenomegaly (10%). Comparable findings were reported by Sharma MK et al,[7] where pallor was seen in 66% of cases, with cheilosis and pedal edema in 14% and 10%, respectively. Morphological classification based on MCV and MCH showed microcytic hypochromic anemia as the most common (57%), followed by megaloblastic (29%) and dimorphic anemia (14%). Similar results were documented by Sharma MK et al,[7] and Chaudhary et al,[3] indicating iron deficiency as the leading cause.

Etiological analysis revealed that all microcytic hypochromic cases were due to iron deficiency. Among megaloblastic anemia, 20 patients had vitamin $B_{12}$ deficiency and nine had folic acid deficiency, while dimorphic cases showed combined deficiencies of iron, vitamin $B_{12}$, or folate. Kumar Vijayant et al,[10] also reported low vitamin $B_{12}$ in 45% and folic acid deficiency in 20% of adolescents. Dietary analysis in our study showed 67% vegetarians and 33% non-vegetarians, consistent with Sharma MK et al,[7] who observed 74% vegetarians among anemic girls.

Most participants (62%) were from rural areas, and 75% had BMI < 18.5, showing a three-fold higher risk of anemia in undernourished individuals. Tesfaye M et al,[1] found that adolescents with BMI < 18.5 were 2.54 times more likely to develop anemia. Maternal education also influenced anemia prevalence; 48% of mothers were educated up to the fifth standard, while 24% had higher education. Rahman S et al,[6] reported significantly higher anemia rates among adolescents whose mothers had only primary education, our findings emphasize that adolescent anemia is multifactorial—driven by poor nutrition, low socioeconomic status, vegetarian diet, and maternal illiteracy. The predominance of microcytic hypochromic pattern highlights iron deficiency as the principal etiology, reinforcing the need for early screening, nutritional supplementation, and community-based preventive programs targeting adolescent girls.

## CONCLUSION

Nutritional anemia remains a major health problem among adolescent girls, particularly in mid-adolescence and among those from rural, low-socioeconomic backgrounds. Most cases were severe and primarily microcytic hypochromic, indicating iron deficiency as the principal cause, followed by vitamin $B_{12}$ and folate deficiencies. Low BMI, vegetarian diet, and poor maternal literacy emerged as significant determinants, reflecting persistent nutritional deprivation and intergenerational effects.

Early screening, dietary counseling, and iron-folate supplementation should be prioritized to prevent severe anemia and its long-term consequences. Community-based nutrition education, improved maternal literacy, and strengthened school health programs can help reduce the burden. Integrating adolescent anemia control into national nutrition and reproductive health initiatives is essential to break the cycle of malnutrition and improve future maternal and child health outcomes.

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