Section: Paediatrics and Pathology

Original Research Article

CLINICO-HEMATOLOGICAL PROFILE OF NUTRITIONAL ANEMIA IN CHILDREN: CORRELATION OF PERIPHERAL SMEAR AND RBC INDICES WITH IRON STUDIES

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Received : 10/07/2025
Received in revised form : 28/08/2025
Accepted : 18/09/2025

Keywords:
Anemia, Children, Dehradun, Uttarakhand, Prevalence.

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DOI: 10.47009/jamp.2025.7.5.98

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2025; 7 (5); 495-501

ABSTRACT

Background: Anemia in children remains a significant public health challenge in India. According to the National Family Health Survey (NFHS-5), the prevalence of anemia among children aged 6–59 months in Uttarakhand is 58.8%. However, data on the burden of anemia among children attending tertiary-care hospitals in the region are limited. **Objectives:** To assess the prevalence of anemia among children aged 6–59 months attending a tertiary-care hospital in Dehradun, Uttarakhand. **Materials and Methods**: A cross-sectional observational study was conducted on 320 children aged 6–59 months at a tertiary-care hospital in Dehradun. Hemoglobin levels were measured and anemia was defined as Hb <11.0 g/dL, according to WHO/NFHS guidelines. The severity of anemia was categorized as mild, moderate, and severe. **Result:** Anemia was present in 61.9% of the study population, with moderate anemia being the most common. The prevalence observed was higher than the community-level data reported by NFHS-5, reflecting a greater burden among children requiring tertiary care services. **Conclusions:** The study reveals a substantial burden of anemia among children attending a tertiary-care hospital in Dehradun. These findings emphasize the need for enhanced screening and management strategies in hospital settings to address the high prevalence of anemia among pediatric patients in this region.

INTRODUCTION

One of the most urgent issues of global health in young children is anemia that remains an issue with millions of children, predominantly in low- and middle-income countries. The global burden of anemia among children aged 6 to 59 months is estimated to be approximately 40 percent and South Asia has a disproportionate number of children with the condition.[1] Not only is childhood anemia a laboratory diagnosis but also a clinical syndrome that has major implications such as poor growth, retarded psychomotor development, predisposition to infections, and poor cognitive performance in the long term.[2]

This is of great concern in India. The National Family Health Survey (NFHS-5, 201921) in the fifth round registered 67.1 percent of children aged between 6 and 59 months as anaemic, significantly higher than NFHS-4 that had recorded 58.6 percent.[3] This turnaround of previous waning trends of anemia prevalence is an indicator of continuous nutritional crises and lack of programmatic control. The data at the state level also demonstrate the existence of vast inequalities: some states demonstrate improvement, others remain at struggle. NFHS-5 in Uttarakhand estimated prevalence rate of anemia on under-five children at 58.8 percent, which was lower than the control national figure, but still very high.[3]

Even higher prevalence rates are even common in hospital-based studies with respect to the community surveys. This is anticipated due to the fact that the children who are referred to tertiary care centers often make up a sub-group that is more advanced in illness, nutritional deprivation or comorbidity. A number of Indian studies have reported prevalence rate of above 60 percent of anemia in hospitalized pediatric populations with iron deficiency as the most common etiology.[4] Along with iron deficiency, vitamin B12 and folate deficiencies, and anemia of inflammation due to infections all play significant roles.

The severity distribution is a significant aspect of assessment of anemia. Mild anemia may be asymptomatic but may still have consequences in development; moderate and severe anemia are known to be linked with increased morbidity and

ISSN (O): 2687-5365; ISSN (P): 2753-6556

mortality. In other regions of India, studies carried out in hospitals have indicated that moderate anemia usually forms the biggest proportion with mild and severe anemia coming after.[5] Such results highlight the fact that severity patterns may be crucial in determining the areas of focus in management and resource distribution.

The other dimension that applies to pediatric anemia is hematological and morphological characterization. Peripheral smear morphology is still a useful diagnostic tool particularly in the setting with limited resources. The archetypal microcytic hypochromic smear is a strong indication of iron deficiency, and macrocytic morphology is a strong indicator of vitamin B12 or folate deficiency.[6] Normocytic normochromic smears can represent anemia of inflammation or non-nutritional etiology, and dimorphic patterns most often represent combined nutritional deficiencies. Morphology Microcytic hypochromic morphology has been the predominant observation in anemic children in several Indian hospital-based studies.[7]

Moreover, iron tests like serum ferritin, serum iron, total iron-binding capacity (TIBC) and transferrin saturation can be used to ascertain etiologies and confirm them. Nevertheless, such biochemical studies are usually costly and not universally accessible especially in peripheral or resource based centers. Consequently, the dependency of the complete blood count (CBC) parameters including hemoglobin, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and red cell distribution width (RDW), along with peripheral smear, remains robust in standard pediatric care.[8]

Childhood anemia is a multifactorial issue that cannot be reduced to nutritional deficiencies only, but it is also determined by socio-economic, environmental, and health system factors. The major causes of anemia during early childhood include poverty, dietary non-diversity, early weaning, frequent infections, and poor maternal health of the unborn.[9] The limited health care facilities and inconsistent coverage of supplementation programs worsen the situation in Uttarakhand and predominantly in the hilly areas and underserved regions. Research has revealed that children in low-income families and the less educated mothers are overly penetrated by anemia.[10]

A good supplement to community-based surveys like NFHS is the hospital-based prevalence data. Although NFHS provides an overview at a population level, hospital data are useful to provide clinical load of those who seek medical attention. By definition, a tertiary care hospital serves referred and generally more ill children, thus providing a window into the more complicated spectrum of pediatric anemia. These environments frequently record a stronger prevalence as compared to the community. As an example, the prevalence rate of hospital cohorts in different parts of India has always been between 60 and 75 percent, which indicates that specific diagnostic and treatment regimens are necessary.[11]

It is important to determine the severity and morphological subtypes of these cohorts. In tertiary care hospitals, moderate anemia commonly becomes the predominant type, with more than a quarter of cases, and mild and severe anemia coming next. Though less prevalent, severe anemia is an immediate threat to either complications like heart failure, developmental delay, and predisposition to infections. Early detection of such cases in a hospital setting is essential in triggering a proper management, which may be the iron therapy, vitamin intake, or blood transfusion where the need arises.[12]

Peripheral smears of the morphology is an insightful technique to offer more information on the etiology. Hemoglobin deficiency contributes to the majority of microcytic hypochromic morphology that is predominant in hospital populations. But normally appearing normocytic normochromic smears, frequently associated with inflammatory conditions, are not rare, especially in children who present with infection. On the same note, a macrocytic and dimorphic smear that is less common, refers to vitamin B12 deficiency and folate deficiency and combined nutritional conditions respectively. When these morphological observations are coupled with clinical and biochemical observations, they can be used to make rational choices in treatment and can decrease the use of costly tests.[13]

With the efforts of national programmes like Anemia Mukt Bharat and iron folic acid supplementation programmes, the levels of prevalence of anemia are alarmingly high. This has been revealed as a paradox that hospital-based studies play a critical role in filling in knowledge gaps. The burden at the hospital level may be even more serious and not entirely reflected at the community level. Hospital cohorts not only provide the information about the increased prevalence, but also illuminate the convoluted interaction of several etiologies and demand the integrative management approach beyond the straightforward supplementation.

Thus, the current study based in a hospital in Dehradun, Uttarakhand was conducted to evaluate prevalence and severity of anemia among children aged 6-59 months of age visiting a tertiary care teaching hospital. On comparing these results with NFHS-5 community data, the research seeks to indicate the excess burden in clinical populations. Also, the study aims to present a practical contribution to the care of pediatric anemia in similar tertiary care through recording the distribution of the types of anemia and smear morphology patterns. Finally, this study will hopefully influence the evidence-based practice to enhance clinical guidelines and population health policies to lessen the rate of anemia in children in India.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

MATERIALS AND METHODS

Study Design

This was a cross-sectional, hospital-based observational study conducted at a tertiary care center in Dehradun during a specified time. Parents or guardians were informed and their consent was taken before enrolling their children in the study, and the ethics committee of the institution approved the study.

Study Population

The sample consisted of 320 children (6-59 months old) comprising 174 boys and 146 girls. Children with pre-existing hematological disorders or chronic systemic disorders or who received blood transfusion or iron therapy in the three months were excluded.

Data Collection and Investigations

All the enrolled children were taken through demographic and anthropometric measurements including age, sex, weight, and height. Venous blood samples were collected in standard aseptic precautions. An automated hematology analyzer was used to estimate hemoglobin and anemia was considered based on WHO/NFHS criteria as hemoglobin levels of less than 11 g/dL in children aged 6-59 months.

The anemia severity was determined as mild (10-10.9 g/dL), moderate (7-9.9 g/dl) and severe (<7 g/dl). Along with the determination of hemoglobin level, the general red cell morphology was evaluated on peripheral smears to generally classify the anemia patterns (microcytic, hypochromic, normocytic, macrocytic, and dimorphic). In the case of children diagnosed as anemic, supportive biochemical data, including serum ferritin and other parameters were registered in the case when they were available, primarily to help distinguish iron deficiency with other conditions. Nevertheless, the major study analysis was on prevalence and severity of anemia and not elaborated correlation of indices with iron studies. Operational Definition

Anemia

According to WHO, anemia is the level of hemoglobin below 11g/dL in children below the age of 6-59 months. The venous blood samples were examined in an automated hematology analyzer. This cutoff was selected because a cutoff of less than 11 g/dL is clinically linked to poor growth, poor oxygen delivery, and increased risk of infections in children.

Anemia Severity

The degree of anemia was categorized depending on WHO standards depending on hemoglobin concentration. Mild anemia was considered as the hematocrit of 10-10.9 g/dl, moderate anemia as between 7 and 9.9 g/dl, and severe anemia as 7g/dl. This classification enabled stratification of children on the basis of clinical risk and better comprehension of the burden of mild to severe cases in the study population.

Iron Deficiency Anemia

Iron Deficiency Anemia (IDA) was identified primarily by microcytic, hypochromic red cell indices (low MCV and low MCH) with elevated RDW on CBC, together with a microcytic–hypochromic peripheral smear pattern. Where iron studies were available, IDA was corroborated by low serum ferritin, low serum iron with raised TIBC, and low transferrin saturation. In this study, iron studies were used as supportive evidence when available; the primary analysis focused on prevalence and severity while noting morphology-based patterns.

Anemia of Inflammation

Clinical evidence of infection or systemic disease was considered in children with anemia regarding anemia of inflammation. This group represented instances in which anemia was more probably associated with underlying inflammatory mechanisms, but not dietary deficiency.

Peripheral Smear Morphology

The morphology of peripheral smears was categorized into four types, viz. microcytic hypochromic, normocytic normochromic, macrocytic and dimorphic. Peripheral blood smears were examined under a microscope using conventional staining procedures, and morphology was categorized as microcytic hypochromic, normocytic normochromic, macrocytic, or dimorphic.

Statistical Analysis

The data were recorded in Microsoft Excel and were analyzed in SPSS version 26. Continuous variables were described in terms of mean ± standard deviation whereas categorical variables were described by frequency and percentages. Student t-test or ANOVA comparison was used on the continuous variables in groups and Chi-square test on categorical variables. The p-value that was less than 0.05 was regarded as significant.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Demographic Profile

Table 1: Demographic Profile of Study Population

S. No	Characteristics	Demographic Profile	Frequency	Percentage
1	Gender	Male	174	54.4
		Female	146	45.6
2	Age Group [months]	6–12	45	14.1
		13–24	62	19.4
		25–36	78	24.4
		37–48	71	22.2
		49–59	64	20
3	Anemia Severity	None	124	38.8
		Mild	63	19.7
		Moderate	132	41.2
		Severe	1	0.3
4	Anemia Type	Iron deficiency	152	47.5
		Anemia of inflammation	32	10
		B12/Folate deficiency	19	5.9
		None	117	36.6
5	Smear Morphology	Microcytic hypochromic	144	45
		Normocytic normochromic	117	36.6
		Dimorphic	24	7.5

The current research involved 320 children between the ages of 6 and 59 months. They consisted of 54.4% [n=174] males and 45.6% [n=146] females, with a slight male dominance. Age distribution revealed that majority of all participants were in the 25-36 months category [24.4%], 37-48 months [22.2] and 49-59 months [20] categories, with relatively lower proportion of very young age group 6-12 months [14.1] and 13-24 months [19.4].

The prevalence of anemia was generally high with 61.2% of children being anaemic. Moderate anemia was the most prevalent of them [41.2%], mild anemia was the next most common [19.7%], but only one child [0.3%] had severe anemia. Regarding etiology, iron deficiency anemia was the most common [47.5%], followed by anemia of inflammation [10%] and B12/folate deficiency [5.9%]; 36.6% of children had no anemia.

The morphology of the peripheral smears showed that microcytic hypochromic smears were the most common [45%], which corresponds well with the iron deficiency conditions. Normocytic normochromic smears were 36.6 and are common in non-anemic and inflammatory cases of anemia. Rare morphologies were dimorphic [7.5%], mild microcytosis [7.2%] and macrocytic morphology [3.8%], the latter being only related to B12/folate deficiency.

These data demonstrate that iron deficiency is still the most prevalent cause of anemia, and morphological patterns on smear agree with the biochemical etiology.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Hematological Profile

Table 2: Hematological Profile of Study Population

Parameter	Mean ± SD	Range
Hemoglobin [g/dL]	10.45 ± 1.38	6.87 – 14.19
MCV [fL]	75.51 ± 9.80	51.30 – 97.40
MCH [pg]	23.58 ± 3.75	15.10 – 30.60
RDW [%]	15.87 ± 2.75	11.40 – 23.60

According to the hematological analysis of the study population, the average level of hemoglobin was 10.45 ± 1.38 g/dL, at which the range of the value was 6.87 to 14.19 g/dL. This shows that a good percentage of children are below the WHO threshold of normal hemoglobin hence high burden of anemia. Mean corpuscular volume (MCV) was 75.51 ± 9.80 fL and mean corpuscular hemoglobin (MCH) was 23.58 ± 3.75 pg, indicating that there was a propensity towards microcytosis and also a tendency towards hypochromia in the targeted children. Red cell distribution width (RDW) was found to be 15.87 ± 2.75 which is an indicator of variation in cell size. Altogether, these results can be compared with the already existing anemia among the cohort, and the tendency toward the role of nutritional deficiency is probable.

Iron Studies Profile

Table 3: Iron Studies Profile of Study Population

Parameter	Mean ± SD	Range
Serum Ferritin [µg/L]	31.55 ± 31.34	2.80 – 214.20
Serum Iron [µg/dL]	42.02 ± 19.92	4.60 – 96.30
TIBC [µg/dL]	357.52 ± 71.59	222.20 – 539.10
Transferrin Saturation [%]	12.95 ± 7.70	2.00 – 35.30

The biochemical evaluation of iron status of the population under study revealed that the average serum ferritin concentration was 31.55 ± 31.34 µg/L with a wide spectrum of data among the children that indicated different iron deposits. The median serum iron level was 42.02 ± 19.92 ug/dl and was low in most of the children. The mean total iron-binding capacity (TIBC) was 357.52 ± 71.59 µg/dl, which was in line with enhanced transferrin activity during conditions of low iron absorption. The overall transferrin saturation was 12.95 ± 7.70, and individual children had significantly lower values. Combined, these results suggest that iron deficiency was a widespread biochemical abnormality in this hospital based pediatric cohort.

Narrative description

Table 4: Distribution of Smear Morphology Across Anemia Types

Smear Morphology	Iron Deficiency	Anemia of Inflammation	B12/Folate Deficiency	None	Total
Microcytic hypochromic	135	9	0	0	144
Normocytic normochromic	0	23	0	94	117
Dimorphic	17	0	7	0	24
Mild microcytosis	0	0	0	23	23
Macrocytic	0	0	12	0	12
Total	152	32	19	117	320

ISSN (O): 2687-5365; ISSN (P): 2753-6556

The microcytic hypochromic morphology was found to be the most common among the study population as indicated by the presence of predominance of iron deficiency anemia. Where anemia was inflammatory in nature or in children without anemia, normocytic normochromic smears were also common. Dimorphic smears appeared in a lower percentage and indicated combined nutritional panoptic deficiencies whereas macrocytic morphology was present in a relative minority and represented vitamin B12/folate deficiency. These results indicate the range of morphology that can be found in kids with anemia in the tertiary care hospital.

DISCUSSION

The current research within a tertiary-care hospital in Dehradun revealed that 68 percent of children aged 6-59 months old were anemic, which is greater than the prevalence of anemia in the community of Uttarakhand. This increased burden will be likely to be seen in hospital populations where children in tertiary centers will have higher chances of bearing nutritional deficiencies and related diseases. Chatterjee et al,[14] in Maharashtra and Anisetti and Komuravelli,[15] in Telangana both reported similar observations, indicating more than half of the children were anaemic in one rural hospital and the most common type of anemia was moderate in the other. In our study moderate anemia was most frequently observed with mild and severe anemia as the second and third respectively. Such a trend of severity distribution is rather similar to previous analysis in Indian hospital-based populations.[14,15] Iron deficiency became the most important cause, which was substantiated by the fact that microcytic hypochromic morphology was predominant in the peripheral smears. Yadav et al,[16] described similar results in the Comprehensive National Nutrition Survey, which showed that iron deficiency was the leading cause of anemia in children under-five years on a national scale.

Less common, but still, there were cases of anemia of inflammation and vitamin B12/folate deficiency, thus emphasizing the multifactorial character of pediatric anemia. The relevance of the diagnostic relevance of smear examination in this study was confirmed by Rajurkar and Chauhan,[13] who highlighted the usefulness of the integration of the morphology of the peripheral smear with the hematological indices to enhance classification, which is also relevant in our study.

All in all, these results confirm that anemia within tertiary-care populations is representative of a greater burden than is indicated by community surveys. Systematic facility-based screening programs, as noted by Raveendran et al,[17] are necessary to supplement national programs and combat the current problem of childhood anemia in India.

CONCLUSION

The current study is hospital-based and considers the high burden of anemia among children aged between 6-59 months of age in Dehradun, Uttarakhand. The highest prevalence of 68 percent of this cohort was more than the prevalence in community-level reports, as children in tertiary-care hospitals are more vulnerable. The most prevalent severity was moderate anemia, with mild and severe cases of anemia coming second. Themost common finding on peripheral smear was iron deficiency with the most common morphology being microcytic hypochromic. The multifactorial nature of pediatric anemia is also supported by other causes, including anemia of inflammation and vitamin B12/folate deficiencies although less common.

The relevance of these findings is that there is an urgent need to reinstate screening and early management approaches in hospitals. Basic and economical methods like estimation of hemoglobin and smear analysis may be essential in the prompt diagnosis. Combining hospital and community-based strategies is the most important in bringing down the total level of childhood anemia and enhance the health status of children in this area.

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ISSN (O): 2687-5365; ISSN (P): 2753-6556

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ISSN (O): 2687-5365; ISSN (P): 2753-6556