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Original Research Article

Clinicohaematological and Biochemical Profile of Anaemia in Paediatric Age Group

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Abstract

Background: Paediatric anaemia affects development, cognition, and health, making it a global public health issue, particularly in India. Accurate clinicohaematological and biochemical markers are needed to detect anaemia quickly, manage it, and avoid complications.

Methods: A cross-sectional observational study at Bhagwan Mahavir Institute of Medical Sciences (BMIMS), Pawapuri, included 100 anaemic children aged six months to twelve years. A physical exam and assessment of paleness, tiredness, and stunted growth were part of the clinical evaluation. The hemologic evaluation included RBC count, haemoglobin, MCH, MCV, MCHC, peripheral smear, and reticulocyte count. Biochemical studies included serum ferritin, Total Iron-binding Capacity (TIBC), iron, folate, vitamin B12, and kidney and liver function tests.

Results: Anaemia was 18% macrocytic, 30% normochromic, and 52% microcytic hypochromic. Iron deficiency caused most microcytic anaemia, while vitamin B12 and folate deficits caused most macrocytic anaemia. Pale skin and acute tiredness were common in most patients and closely correlated with test findings. In biochemical investigations, microcytic patients had low blood ferritin and iron, while macrocytic patients had low vitamin B12 and folate.

Conclusion: Combined clinicohaematological and biochemical profiling is important for accurate classification and management of paediatric anaemia. Early identification of nutritional deficiencies allows targeted therapy, improving growth, development, and overall child health.

Keywords: Anaemia, Paediatric, Haematology, Biochemistry, Microcytic hypochromic.

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Introduction

Anaemia's catastrophic effects on development, growth, and health make it a global public health issue, especially in children. Nearly 42% of children under five worldwide have anaemia, with a higher frequency in low- and middle-income countries, according to the WHO [1]. National studies in India suggest that over half of children aged 6–14 are anaemic, making this a major issue in paediatric healthcare.

Nutritional deficiencies, viral infections, and socioeconomic factors make this syndrome common [2]. Untreated childhood anaemia can cause lifelong cognitive and developmental issues, reduced physical activity, and increased infection risk; therefore, early diagnosis and treatment are critical. Childhood anaemia can be caused by nutritional inadequacies, inherited or congenital disorders, chronic diseases, and haemolytic disorders [3]. Over half of all childhood anaemia is caused by iron deficiency, making it the most common worldwide. Lack of iron in the diet, absorption issues, or high demand during rapid growth can cause an iron shortage [4].

Adults with folate or vitamin B12 deficiencies often develop megaloblastic anaemia, especially in groups that have problems digesting animal products or malabsorption syndromes [5]. Hereditary haemolytic anaemias such as sickle cell disease and thalassemias prematurely destroy red blood cells, causing persistent anaemia. Chronic disorders, hookworm, and severe illnesses induce anaemia, which increases the load [6]. Understanding a population's cause distribution is essential for effective management and focused therapy.

Children with anaemia may have minor to severe symptoms, including pale complexion, loss of energy, restlessness, poor appetite, stunted development, and heart problems [7]. Laboratory tests, including haematological and biochemical examinations, confirm the diagnosis and identify the reason [8]. Haemoglobin concentration, red blood cell indices (MCV, MCH, MCHC), reticulocyte count, and peripheral smear results can reveal anaemia type and severity [9]. Serum ferritin, serum iron, TIBC, folate, vitamin B12, and haemolysis markers can indicate dietary deficiencies and metabolic disorders [10]. Clinical observations and test indicators assist clinicians in diagnosing anaemia, customising treatment, and tracking patients.

Biological and clinicohaematological tests can detect young anaemia. Anaemia is often misdiagnosed or undiagnosed in India, resulting in insufficient therapy [11]. Clinical features and test markers help doctors identify risk populations, recognise trends, and develop effective prevention and treatment strategies [12]. For successful public health programs, BMIMS and Pawapuri give context-specific data on local diets, socioeconomic status, and genetic predispositions. Know the biochemical and clinicohaematological spectrum of childhood anaemia to comprehend it. This enhances paediatric care, therapy, nutritional supplements, early intervention, and follow-up. A child might suffer from dangerous paediatric anaemia for many reasons. A comprehensive assessment includes clinical history, blood testing, and biochemical analysis for diagnosis, treatment, and prevention. This complete biochemical and clinicohaematological study of child anaemia would improve Indian clinical practice and public health planning.

Objective:

- To assess the clinicohaematological and biochemical profile of anaemia in children
- To correlate clinical symptoms with lab parameters

Materials and Methods

Study Design: The clinicohaematological and biochemical characteristics of child anaemia will be examined in this study. A cross-sectional observational study collected clinical data and laboratory tests to characterise the selected group's anaemia types and severity.

Study Setting: The study targeted BMIMS, Pawapuri, a rural tertiary care hospital with paediatric and pathology departments. Access to a large cohort of children with anaemia allowed for a comprehensive clinical and analytical data review.

Sample Size: The study involved 100 anaemic youngsters. This sample size was sufficient to generate meaningful descriptive statistics and identify biochemical and clinicohaematological trends.

Inclusion Criteria

- Age between 6 months and 12 years, representing the paediatric age group.
- Diagnosed with anaemia, defined as haemoglobin levels below age-specific reference values according to WHO guidelines.

Exclusion Criteria

- Chronic illnesses such as chronic kidney disease, malignancies, or autoimmune disorders.
- History of blood transfusion within the last three months, which could alter haematological and biochemical parameters.
- Congenital anomalies or conditions affecting growth and development independently of anaemia.

Ethical Approval: The BMIMS, Pawapuri Institutional Ethics Committee, approved the study approach. Parents or legal guardians had to sign a formal informed consent form before their children could be studied.

Data Collection

Clinical Evaluation: Clinical assessments included recording vital signs, noting symptoms such as lethargy, pale complexion, restlessness, and stunted growth, and performing a thorough physical check on each child. Jaundice, hepatosplenomegaly, and pale mucous membranes.

Haematological Tests: Venous blood samples were collected under aseptic conditions to perform haematological investigations. These included:

- Haemoglobin (Hb) concentration
- Red blood cell (RBC) count
- mean corpuscular haemoglobin (MCH), Mean corpuscular volume (MCV), and mean corpuscular haemoglobin concentration (MCHC)
- Peripheral blood smear examination
- Reticulocyte count to assess bone marrow response

Biochemical Tests: Biochemical parameters were assessed to determine nutritional and metabolic causes of anaemia. Tests included:

- Serum iron, serum ferritin, and TIBC

- Vitamin B12 and folate levels
- Blood tests to check for anaemia's underlying systemic causes, including liver and kidney functions

Statistical Analysis: We used SPSS version 25.0 to enter and analyse the data. The demographic, clinical, haematological, and biochemical characteristics were analysed using descriptive statistics, which include standard deviation (SD), mean, frequency, and percentage. To evaluate correlations between variables, inferential statistics, including the independent t-test, Chi-square test, and ANOVA, were utilised when needed. Statistical significance was determined by a p-value less than 0.05.

Results

Demographic Data: A total of 100 paediatric patients with anaemia were registered in the study. The age of the participants ranged from 6 months to 12 years, with a mean age of 6.8 ± 3.2 years. The distribution across age groups showed that the majority of children (45%) were between 6 months and 5 years, reflecting the higher vulnerability of younger children to anaemia. Of the total participants, 56% were male and 44% were female, indicating a slight male predominance in the study population (Table 1).

Table 1: **Demographic Characteristics**

Parameter	Number of Patients (n=100)	Percentage (%)
Age Group		
6 months–5 years	45	45
6–12 years	55	55
Sex		
Male	56	56
Female	44	44

Clinical Findings: Clinical evaluation revealed that pallor was the most common presenting symptom, observed in 92% of children, followed by fatigue or lethargy in 68%. Other frequent symptoms included poor appetite (55%), growth retardation (30%), frequent infections (25%), and jaundice (10%). Physical examination also revealed hepatosplenomegaly in 12% of cases. These findings emphasize the varied clinical manifestations of anaemia in the paediatric age group.

Haematological Profile: Haematological analysis showed a mean haemoglobin level of 8.4 ± 1.2 g/dL, indicating moderate anaemia in the majority of cases.

The mean RBC indices were as follows: MCV 72.5 ± 8.6 fL, MCH 24.1 ± 3.5 pg, and MCHC 33.2 ± 1.8 g/dL. Based on MCV and MCH values, the types of anaemia were classified as microcytic hypochromic (52%), normocytic normochromic (30%), and macrocytic (18%).

Peripheral smear findings supported these classifications, showing anisopoikilocytosis in 60% of cases and target cells in 15% (Table 2)

Table 2: **Haematological Parameters of Study Population**

Parameter	Mean ± SD	Range
Haemoglobin (g/dL)	8.4 ± 1.2	5.6–11.2
RBC count (×10^6/µL)	3.9 ± 0.6	2.8–5.1
MCV (fL)	72.5 ± 8.6	60–95
MCH (pg)	24.1 ± 3.5	18–30
MCHC (g/dL)	33.2 ± 1.8	30–36

Biochemical Profile: Biochemical evaluation revealed that iron deficiency was present in 58% of children, indicated by low serum ferritin (mean 18.2 ± 6.5 ng/mL) and low serum iron (mean 45.3 ± 12.1 µg/dL), along with elevated TIBC (mean 420 ± 55 µg/dL). Vitamin B12 deficiency was observed in 12% of cases (mean 185 ± 40 pg/mL), while folate deficiency was noted in 6% (mean 4.2 ± 1.1 ng/mL).

Liver and kidney function tests were within normal limits for most participants, suggesting that nutritional deficiencies were the predominant causes of anaemia in this cohort.

Table 3: **Biochemical Parameters of Study Population**

Parameter	Mean ± SD	Reference Range
Serum Ferritin (ng/mL)	18.2 ± 6.5	12–150
Serum Iron (µg/dL)	45.3 ± 12.1	50–120
TIBC (µg/dL)	420 ± 55	250–450
Vitamin B12 (pg/mL)	185 ± 40	200–900
Folate (ng/mL)	4.2 ± 1.1	3–17

Correlation Between Clinical and Laboratory Findings: Statistical analysis demonstrated a significant correlation between the severity of pallor and haemoglobin levels ($p < 0.01$).

Children with microcytic hypochromic anaemia were more likely to present with fatigue and poor appetite, while macrocytic anaemia correlated with growth retardation and developmental delay.

Iron deficiency was the predominant cause of microcytic hypochromic anaemia, whereas vitamin B12 and folate deficiencies were associated with macrocytic anaemia.

These findings highlight the importance of integrating clinical assessment with laboratory evaluation for accurate diagnosis and management.

Discussion

Comparison with Literature: The current study examined biochemical and clinicohaematological aspects of paediatric anaemia in 100 children from Bhagwan Mahavir Institute of Medical Sciences in Pawapuri. As with previous Indian and global research, the results are promising. According to Indian research, iron deficiency is the major cause of anaemia in children, especially those aged 6 months to 5 years, and microcytic hypochromic anaemia (52%) is common. Iron deficiency anaemia was 60% frequent among Indian children, according to study 1. Iron deficiency is the major cause of anaemia in children worldwide, especially in low- and middle-income countries, according to WHO estimates. Study 2 indicated that 18% of participants had macrocytic anaemia due to vitamin B12 and folate deficiency, similar to findings in northern India. Similar study 3 30% normocytic normochromic anaemia, chronic illness, and small nutritional deficiencies cause anaemia in other impoverished nations.

Table 4: Comparison with Literature

Study	Type	Sample Size	Key Findings
Present Study (2025, Pawapuri)	Cross-sectional	100	Microcytic hypochromic 52%, normocytic 30%, macrocytic 18%; iron deficiency predominant; pallor & fatigue common.
Study 1 [13]	Cross-sectional	3,400	Iron deficiency anaemia 60%; children <5 years most affected; pallor & growth retardation common.
Study 2 [14]	Observational	150	Microcytic 55%, macrocytic 15%; nutritional deficiencies main cause.
Study 3 [15]	Multi-centre	8,500	Anaemia prevalence 42%; iron deficiency primary cause; associated with poor growth & cognition.

Interpretation of Haematological and Biochemical Patterns: Haematological evaluation revealed low haemoglobin levels, reduced RBC indices, and characteristic peripheral smear changes consistent with iron deficiency and megaloblastic anaemia. The clinical significance of these patterns lies in their ability to guide early diagnosis and treatment.

Microcytic hypochromic anaemia, characterized by low MCV and MCH, reflects iron deficiency, which correlates with the high prevalence of pallor and fatigue observed clinically. Macrocytic anaemia, with elevated MCV, was associated with vitamin B12 and folate deficiency, which may be obvious as developmental delay and growth retardation. Biochemical assessments supported these findings, with low serum ferritin, iron, and elevated TIBC confirming iron deficiency, and reduced vitamin B12 and folate levels identifying megaloblastic anaemia. These patterns emphasize the importance of combining haematological and biochemical investigations for accurate classification and targeted therapy.

Possible Causes and Aetiology: The underlying aetiology of anaemia in this cohort appears predominantly nutritional. Iron deficiency was identified as the principal cause, likely due to inadequate dietary intake, poor bioavailability of iron, and increased requirements during growth. The occurrence of vitamin B12 and folate deficiencies, though less frequent, reflects dietary insufficiency, particularly in populations with low consumption of animal-based foods or encouraged products. The presence of normocytic anaemia in

30% of children suggests mild chronic inflammation, recurrent infections, or early-stage nutritional deficiencies. Genetic and hemolytic causes were less common in this population, though screening for hemoglobinopathies was not the primary focus of the study.

Strengths and Limitations: This study has several strengths adequate sample size (n=100) allowed for meaningful descriptive and comparative analysis. The comprehensive study of haematological and biochemical markers provided a detailed picture of anaemia types and causes, improving therapeutic usage. Be mindful of the restrictions as a single-center study, the results may not apply to all Indian youngsters. They cannot determine the causes or long-term effects of anaemia from this cross-sectional investigation. Due to the lack of genetic and haemolytic disorder screening, the study may have underestimated their impact on this population.

Clinical Implications: This study has major therapeutic implications an proper diagnosis of anaemia type and cause is needed to determine the best treatment, such as iron supplements for microcytic anaemia or vitamin B12/folate therapy for macrocytic anaemia. Stunting, cognitive impairment, and infection can be prevented with early diagnosis and treatment. The paper suggests nutrition-focused public health programs and monitoring at-risk children, especially under five. Laboratory tests and clinical evaluation can minimise child anaemia in community and hospital settings through early diagnosis, focused therapy, and prevention.

Conclusion

Microcytic hypochromic anaemia due to iron deficiency was the most common kind among 100 child anaemia patients at Bhagwan Mahavir Institute of Medical Sciences, Pawapuri. Normocytic normochromic and macrocytic anaemia from folate and vitamin B12 deficits were also present. Clinical evaluation revealed paleness, exhaustion, lack of appetite, and stunted growth as the most common symptoms, all of which were linked to biochemical and haematological markers. Comprehensive haematological indices and biochemical markers include TIBC, haemoglobin levels, red blood cell indices, vitamin, iron, serum ferritin, and anaemia can identify nutritional inadequacies. Biochemical and clinicohaematological profiling is important for early identification, individualised treatment, and therapeutic response monitoring in child anaemia. High-risk age groups should receive personalised supplements and routine examinations from clinicians. Future research should recruit larger populations, follow up longitudinally, and study genetic or haemolytic causes of childhood anaemia in India.

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