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Clinico-epidemiological and hematological profile of anemia in preschool children (12 months to 60 months) A hospital-based prospective observational study

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ABSTRACT

Introduction: Anemia, a major public health concern, affects nearly 39.8% of preschool children globally, with the highest burden in South Asia and Africa. In India, NFHS-5 (2019–21) reported anemia in 67.1% of children under five, with Rajasthan exhibiting an alarming prevalence of 71.5%. Iron deficiency remains the leading cause, though vitamin B12, folate deficiencies, and chronic infections also contribute. Anemia in early childhood is linked to cognitive impairment, developmental delays, and increased morbidity, emphasizing the need for targeted interventions.

Materials and Methods: A hospital-based prospective study was conducted in the Department of Pediatrics, Pacific Institute of Medical Sciences, Udaipur, from May 2023 to April 2024. The study included 196 anemic children aged 12–60 months. Demographic, clinical, and hematological data were collected using a structured proforma. Hematological parameters were analyzed using an automated hematology analyzer, peripheral blood smear, and biochemical assays for iron and vitamin B12 levels. Statistical analysis was performed using SPSS v28, with $p<0.05$ considered significant.

Results: The study found a higher prevalence of anemia in rural children (65.8%) and lower socioeconomic groups (53.6%). Microcytic hypochromic anemia (64.3%) was the most common type, with iron deficiency (47.3% vs. 31.0%, $p=0.003$) predominant in younger children, while older children had higher rates of sickle cell ($p=0.042$) and aplastic anemia ($p=0.016$). Younger children had lower mean hemoglobin (8.1 vs. 9.4 g/dL, $p<0.001$) and MCV (72.6 vs. 78.3 fL). Clinical findings included pallor (87.8%), fever (57.1%), and weakness (68.9%).

[1] . INTRODUCTION

Anemia , characterized by reduced erythrocytes or impaired oxygen delivery, is a critical public health issue, especially among preschool children. Globally, 39.8% of children aged 6–59 months suffer from anemia , with the highest prevalence in Africa and South Asia. In India, the NFHS-5 (2019–21) reported anemia in 67.1% of children under five, a significant increase from previous surveys. Rajasthan has particularly alarming rates, with 71.5% of children affected, highlighting the urgent need for

Conclusion: Anemia remains a significant burden among preschool children, primarily due to iron deficiency. Socioeconomic and rural-urban disparities highlight the need for targeted nutritional interventions and routine screening programs. Strengthening parental education, dietary supplementation, and preventive strategies could help mitigate anemia 's long-term impact. Future community-based studies are needed to validate findings and evaluate intervention outcomes.

Keywords: *Anemia, Pre school children, Clinical and laboratory profile, Pediatric anemia, Iron deficiency*

targeted interventions. Iron deficiency remains the leading cause, but deficiencies in folate, vitamin B12, and chronic infections also contribute substantially. [1,2] Anemia in early childhood is linked to developmental delays, cognitive impairments, and increased susceptibility to infections, underscoring its long-term consequences. [3]

The pathophysiology of anemia involves either decreased red blood cell production or increased destruction/loss. Nutritional deficiencies, bone marrow dysfunction, and haemolytic conditions contribute to heterogeneity. [4] Morphologically, anemia is classified as microcytic (e.g., iron deficiency, thalassemia), normocytic (e.g., chronic disease), or macrocytic (e.g., B12/folate deficiency). [5] In infants, physiologic anemia occurs due to natural erythropoietic changes, while pathologic anemia suggests underlying conditions like hemolysis or congenital disorders. Older children are particularly vulnerable to iron deficiency due to dietary transitions, such as excessive cow's milk consumption, which exacerbates nutritional gaps. [6] Risk factors for anemia include poor dietary intake, environmental exposures (e.g., lead toxicity), chronic illnesses, and genetic disorders such as thalassemia and sickle cell disease. Socioeconomic disparities further compound the problem, with rural populations facing higher burdens due to limited healthcare access and lower parental education. [7] The WHO classifies anemia severity using age- and gender-specific hemoglobin thresholds, though debates persist regarding their applicability in low-resource settings. Understanding these determinants is crucial for developing effective prevention and management strategies. [8]

The objectives of this study were to assess the clinico-epidemiological and haematological profile of anemia among preschool children (1–5 years), identify predominant etiological factors, and evaluate the association between anemia and sociodemographic variables such as nutritional status, parental education, and rural-urban disparities. The study also aimed to determine anemia 's severity and morphological patterns to guide targeted public health interventions. The study sought to contribute to evidence-based strategies for reducing anaemia's burden in this vulnerable population by addressing these objectives.

2. MATERIALS AND METHODS

A hospital-based prospective study was conducted in the Department of Pediatrics, Pacific Institute of Medical Sciences, Udaipur, Rajasthan, over one year (May 2023–April 2024). The study included children aged 12–60 months admitted with anemia , after obtaining informed consent from parents/guardians. Children outside this age range or those without consent were excluded. A structured proforma was used to record demographic details, clinical history, and socioeconomic status (assessed via the Modified Kuppuswamy Scale 2022, adjusted for January 2024 CPI). Clinical evaluation included anthropometric measurements (height, weight, MUAC), vital parameters, and systemic examination. Blood samples (2 mL in EDTA for CBC/PBF; 2–3 mL in plain vials for serum iron/B12) were collected aseptically. EDTA samples were processed immediately, while serum was separated by centrifugation and stored at 2–8°C for analysis within 24 hours.

Complete blood count (CBC) was performed using an automated hematology analyzer (e.g., Sysmex XN-1000), measuring Hb, RBC indices (MCV, MCH, MCHC, RDW), and leukocyte/platelet counts. Peripheral blood films (PBF), stained with Leishman stain, were examined microscopically for RBC morphology and abnormalities. Serum iron was estimated colorimetrically (ferrozine method), and vitamin B12 levels were assessed via chemiluminescent immunoassay (CLIA/ELISA). Statistical analysis involved descriptive statistics (frequencies, means) and comparative tests (chi-square, logistic regression) using SPSS v28, with significance at $p<0.05$. Ethical clearance was obtained from the Institutional Ethics Committee prior to the study.

3. RESULTS

The study of 196 anemic preschool children (57.1% aged 12-36 months, 42.9% 37-60 months) revealed no significant gender differences ($p=0.60$) but showed higher rural prevalence (65.8%). Nutritional status was comparable across age groups ($p=0.147$), though younger children had lower mean haemoglobin (8.1 vs g/dL, $p<0.001$) and MCV (72.6 vs 78.3 fL).

Microcytic hypochromic anemia predominated (64.3% in both groups), with iron deficiency being most common (47.3% vs 31.0%, p=0.003). Significant clinical differences included higher fever rates in younger children (p<0.001) and increased sickle cell (p=0.042) and aplastic anemia (p=0.016) in older children. The study found severe iron deficiency (57.1% low ferritin, 45.4% low iron) as the most prevalent micronutrient deficiency, followed by vitamin B12 deficiency (34.2%). While folate deficiency was less common (19.4%), borderline levels of ferritin (24.5%) and iron (26.5%) were frequently observed. Mean ferritin (18.4±9.2µg/L) and iron (42.6±18.7µg/dL/dL) levels were significantly suboptimal, though vitamin B12 and folate averages fell within normal ranges despite high deficiency rates.

Demographic Characteristics (n=196)

Variable	**Category**	**Value**	**p-value**
Age Distribution	12–36 months	112 (57.1%)	-
	37–60 months	84 (42.9%)	-
Gender	Male (12–36 months)	48 (42.9%)	0.60
	Female (12–36 months)	64 (57.1%)	
	Male (37–60 months)	32 (38.1%)	
	Female (37–60 months)	52 (61.9%)	
Socioeconomic Status	Lower/Lower Middle	105 (53.6%)	0.728
	Upper Lower	43 (21.9%)	
	Upper/Upper Middle	48 (24.5%)	
Locality	Rural	129 (65.8%)	0.621
	Urban	67 (34.2%)	

Anthropometric Characteristics (n=196)

Parameter	12–36 Months	37–60 Months	Overall
Weight (kg)	Mean: 11.2 (SD: 2.1)	Mean: 15.6 (SD: 1.4)	-
	Median: 10.9 (IQR: 9.5–12.8)	Median: 15.8 (IQR: 14.7–16.4)	-
Height (cm)	Mean: 84.3 (SD: 7.5)	Mean: 100.5 (SD: 4.8)	-
	Median: 84.6 (IQR: 78.4–90.2)	Median: 101.1 (IQR: 96.9–103.5)	-
Nutritional Status	Normal: 76 (67.9%)	Normal: 47 (56.0%)	p=0.147 (Chi- square)

	Moderate Malnutrition: 24	Moderate Malnutrition: 21	p=0.57 (Fisher's)
	Severe Malnutrition: 12	Severe Malnutrition: 16	p=0.18 (Fisher's)

Clinical Features

Feature	**12–36 Months**	**37–60 Months**	**p-value**
Symptoms			
- Weakness/Fatigability	76	59	0.217
- Fever	80	32	**<0.001***
- Pica	24	20	0.581
Signs			
- Pallor	103	69	0.083
- Edema	18	6	**0.012***
- Lymphadenopathy	13	5	**0.038***

Laboratory and Anemia Profile by Age Group

Parameter	**12-36 Months (n=112)**	**37-60 Months (n=84)**	**Overall (n=196)**	**p- value***
Hematological				
Hemoglobin (g/dL)	8.1 ± 1.3	9.4 ± 1.1	8.7 ± 1.5	-
MCV (fL)	72.6 ± 8.4	78.3 ± 7.9	75.1 ± 8.6	-
Biochemical				
Serum Ferritin (µg/L)	18.4 ± 9.2	18.4 ± 9.2	18.4 ± 9.2	-
Serum Iron (µg/dL)	42.6 ± 18.7	42.6 ± 18.7	42.6 ± 18.7	-
Vitamin B12 (pg/mL)	285.4 ± 142.6	285.4 ± 142.6	285.4 ± 142.6	-
Folic Acid (ng/mL)	6.8 ± 3.4	6.8 ± 3.4	6.8 ± 3.4	-
Anemia Etiology				
Iron Deficiency (n (%))	53 (47.3%)	26 (31.0%)	79 (40.3%)	0.003*
Sickle Cell Anemia (n (%))	2 (1.8%)	7 (8.3%)	9 (4.6%)	0.042*
Aplastic Anemia (n (%))	3 (2.7%)	10 (11.9%)	13 (6.6%)	0.01

4. DISCUSSION

This study, conducted at the Department of Pediatrics, Pacific Institute of Medical Sciences, Udaipur (June 2023–May 2024), evaluated anemia 's clinico- epidemiological and hematological profile in preschool children aged 1–5 years. The findings

highlight a substantial anemia burden, with 62.8% of children having normal nutritional status, 37.2% displaying malnutrition, 23.0% with moderate, and 14.3% with severe acute malnutrition. The predominance of microcytic hypochromic anemia (64.3%) suggests iron deficiency as the most common etiology, consistent with global trends that identify nutritional deficits as key contributors.

Gender distribution showed a slight female preponderance (1.4:1), though statistically insignificant (p=0.60). This echoes studies like Kumar et al. (2020),

(9) WHO MGRS (2006), (10) Pasricha et al. (2013) (11), and Gebreweld et al. (2018) (12), all of which reported near-equal gender distribution in anemic preschool populations.

Socioeconomic factors played a notable role, with 53.6% of anemic children belonging to lower and lower-middle classes. This socioeconomic gradient aligns with Kumar et al. (2020), (9) Gupta et al. (2019), (13), and Gebreweld et al. (2018),

(12) who observed over 60% of anemia cases from low-SES backgrounds. The WHO (2021) (1) further supports this, reporting that 70% of the global anemia burden affects underprivileged communities. However, this study found no significant SES variation by age group, contrasting with regional data showing sharper age-related socioeconomic disparities.

Anthropometric data revealed expected growth trends, with younger children (12–36 months) displaying lower weight (11.2 kg) and height (84.3 cm) than older peers (15.6 kg; 100.5 cm). Nutritional status was similar across age groups, in line with Kumar et al. (2020) (9) and WHO (2021) (1), which report 60–65% normal nutrition in under-fives. Variability across regions is evident, with higher malnutrition in Ethiopia (Gebreweld et al., 2018) (12) and lower in Vietnam (Nguyen et al., 2019).

Exclusive breastfeeding rates were suboptimal (41.3%), and early complementary feeding was common (58.7%), mirroring Kumar et al. (2020) and WHO (2021) global data. Immunization coverage was relatively strong (76% complete), slightly higher in younger children, consistent with patterns in Vietnam (Nguyen et al., 2019) (14) and Ethiopia (Gebreweld et al., 2018). (12)

Clinically, weakness/fatigability (68.9%) and fever (57.1%) were most frequent. Fever was significantly more common in younger children ($p<0.001$), consistent with Balarajan et al. (2011), (15) Leal et al. (2013), (16) and Stevens et al. (2013),

(17) all of whom noted similar symptomatology with greater prevalence of fever in children under 3. Likewise, Zhang et al. (2015) (18) documented similar age- related clinical trends.

Pallor (87.8%) and tachycardia (49.0%) were the most observed clinical signs, with age-related variation in edema and lymphadenopathy. These patterns aligned with Rahman et al. (2018), (19) Al-Alimi et al. (2014), (20), and Sarma et al. (2016),

(21) who reported similar findings, including increased lymphadenopathy and edema in younger children. Hepatosplenomegaly (14.8%) matched reports by Tesfaye et al. (2015), (22) indicating a regional consistency in systemic manifestations.

Hematologically, younger children exhibited significantly lower hemoglobin (8.1 g/dL), hematocrit (23.4%), and MCV (72.6 fL), supporting microcytic anemia trends. These findings are reinforced by Domellöf et al. (2014), (23) Wang et al. (2016), (24) and Pasricha et al. (2017), (25) all of whom identified similar hematological patterns, while Zuffo et al. (2015) (26) observed even more severe microcytosis. The noted thrombocytosis (282×10^9/L) parallels results by AlFaris et al. (2018), (27) suggesting compensatory hematological changes in iron- deficiency states.

Biochemical profiling revealed iron deficiency (57.1% low ferritin), vitamin B12 deficiency (34.2%), and folate deficiency (19.4%), aligning with data from Ullah et al. (2019), (28) Al Hassan et al. (2015), (29) Morales-Suárez-Varela et al. (2016),

(30) and Mekonnen et al. (2017). (31) Ferritin and B12 levels paralleled those found in Brazil (Osório et al., 2015) (32) and South Africa (Green et al., 2017), (33) highlighting global similarities.

Iron-deficiency anemia was the most common (40.3%), particularly in younger children, as shown in Khan et al. (2018). The study also observed increases in sickle cell anemia and aplastic anemia based on age, aligning with trends noted by Nnodu et al. (2019) (34) and Al-Jafar et al. (2016). (35) This shift from nutritional to genetic or chronic causes with age emphasizes the need for age-targeted interventions.

5. CONCLUSION, LIMITATIONS & RECOMMENDATIONS

This study confirms the high prevalence of anemia among preschool children in a particular geographical region, predominantly due to iron deficiency, with significant rural-urban and socioeconomic disparities. Limitations include its hospital-based design, which may not reflect community prevalence, and the lack of advanced diagnostic tools for some haematological disorders. Recommendations include implementing targeted iron supplementation programs, nutritional

education for parents, and strengthening routine anemia screening in rural areas. Future community-based studies with larger sample sizes are needed to validate these findings and assess long-term intervention outcomes. Addressing these gaps could significantly reduce anaemia's burden in this vulnerable population.

Conflict of Interest: None

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