SJ Pediatrics and Child Health Africa
Vol. 3 No. 2 (2026): February 2026 Issue
https://doi.org/10.51168/j2bvy688
Original Article

A Cross-Sectional Study of Anemia among Children Aged 1–12 Years Attending a Tertiary Care Hospital.

Dr. Chidura Naveen[1], Dr. Kairamkonda Rajashekar[2], Dr. Kuturu Sharanya[1]
[1]Assistant Professor, Department of Paediatrics, Government Medical College, Nizamabad, Telangana, India
[2]Associate Professor, Department of Paediatrics, Government Medical College, Nizamabad, Telangana, India

Abstract
Background:
Anemia in childhood remains a major public health concern in India because it influences growth, immunity, school performance, and neurocognitive development. Hospital-based data are useful for understanding the clinical burden and the distribution of anemia severity and morphology among children presenting for care.

Objectives:
To determine the prevalence, severity, and morphological pattern of anemia among children aged 1–12 years attending a tertiary care hospital and to describe its distribution across age, sex, socioeconomic status, and dietary iron intake groups.

Methods:
This cross-sectional study included 200 children aged 1–12 years. Demographic, socioeconomic, and dietary information was collected using a structured proforma. Hemoglobin estimation and peripheral smear examination were carried out for all participants. Anemia was classified according to age-specific hemoglobin cutoffs and further graded as mild, moderate, or severe.

Results:
Among 200 children, 118 were anemic, giving an overall prevalence of 59.0%. Moderate anemia was the commonest grade, followed by mild and severe anemia. Anemia was more frequent in younger children, especially those aged 1–3 years, and was slightly higher among females than males. Children from lower socioeconomic strata and those with inadequate dietary iron intake showed a substantially higher burden. Microcytic hypochromic anemia was the predominant peripheral smear pattern, followed by normocytic normochromic anemia.

Conclusion:
Anemia constituted a substantial burden among children attending this tertiary care center, with the highest vulnerability seen in younger age groups and socioeconomically disadvantaged children. The predominance of microcytic hypochromic smears supports a strong contribution of nutritional iron deficiency to the observed burden.

Recommendations:
Routine screening of high-risk children, nutrition-focused counselling for caregivers, timely iron supplementation, and strengthened follow-up within pediatric services should be integrated into hospital practice to improve early detection and management.

Keywords: *Anemia; children; hemoglobin; iron deficiency; nutritional anemia; peripheral smear; tertiary care hospital.*
Submitted: *January 01, 2026* ***Accepted:*** *February 01, 2026* ***Published:*** *February 28, 2026*

***Corresponding author**: Dr. Chidura Naveen*
Email: ***naveenchidura645@gmail.com***
Assistant Professor, Department of Paediatrics, Government Medical College, Nizamabad, Telangana, India

Introduction
Anemia in children is one of the most persistent public health problems in low- and middle-income countries, and India continues to contribute a large share of this burden [1-3]. It is not merely a laboratory abnormality; it reflects nutritional deprivation, repeated infections, inflammation, parasitic infestation, and broader socioeconomic disadvantage [5,6]. When anemia develops early in life, it can adversely affect physical growth, psychomotor development, immunity, exercise tolerance, learning capacity, and later productivity [2-5]. Because these effects extend beyond the individual child to family well-being and educational attainment, childhood anemia remains an important clinical and public health priority.

The etiological spectrum of childhood anemia is broad. Iron deficiency is the commonest cause, but folate deficiency,

https://doi.org/10.51168/j2bvy688

vitamin B12 deficiency, chronic inflammatory states, hemoglobinopathies, and other less frequent hematological disorders also contribute to the clinical picture [4,5]. Morphological assessment on peripheral smear remains a practical tool in routine pediatric care because it helps identify broad etiologic patterns, particularly the distinction between microcytic hypochromic, normocytic normochromic, macrocytic, and dimorphic anemia [4,10]. In resource-constrained settings, such initial classification can guide early therapeutic decisions, further laboratory evaluation, and referral planning.

Indian literature consistently shows that the burden of anemia is not evenly distributed. Younger children, those from poorer households, and children exposed to food insecurity or suboptimal dietary practices are disproportionately affected [5,6]. Maternal anemia, lower parental education, recurrent illness, and inadequate intake of iron-rich foods have been identified as important determinants in previous Indian studies [10]. National analyses also suggest that despite longstanding supplementation and food-based programs, the decline in childhood anemia has been inconsistent, and recent surveys have highlighted continuing concern regarding moderate and severe anemia in vulnerable groups.

Hospital-based studies remain relevant because they capture children who are already interacting with the health system and therefore represent an opportunity for diagnosis, counselling, treatment, and follow-up. Earlier studies from India have shown high prevalence of anemia among hospitalized or teaching-hospital pediatric populations, with moderate anemia frequently predominating and microcytic hypochromic smears being the most common morphology [7,9]. However, local data from different regions remain important because anemia patterns vary with dietary habits, socioeconomic conditions, referral profiles, and healthcare access. Region-specific evidence can strengthen screening strategies, nutritional counselling, and institution-level pediatric protocols.

Against this background, the present study was undertaken to estimate the burden of anemia among children aged 1–12 years attending a tertiary care hospital. The objectives of the study were to determine the prevalence of anemia, describe its severity and peripheral smear morphology, and assess its distribution according to age group, sex, socioeconomic status, and dietary iron intake.

Methodology

Study design and setting

This was a hospital-based cross-sectional study conducted in the Department of Pediatrics, Government Medical College, Nizamabad, Telangana, India, over a period of one year from January 2025 to December 2025. The study was undertaken to describe the burden and profile of anemia among children aged 1–12 years attending this tertiary care teaching hospital. The institution caters to a mixed population drawn from urban, peri-urban, and surrounding rural areas, thereby providing a representative clinical setting for the assessment of pediatric anemia. Prior approval was obtained from the Institutional Ethics Committee before initiation of the study. Written informed consent was obtained from the parent or legal guardian of each participant before enrollment.

Study population and eligibility

Children aged 1–12 years presenting to the pediatric services during the study period were considered eligible. Both male and female children were included. Children whose caregivers did not consent, those who had received a recent blood transfusion, and those with incomplete clinical or laboratory records were excluded from the final analysis. A total sample size of 200 children was achieved using consecutive sampling of eligible participants. Each enrolled child underwent structured clinical evaluation and laboratory assessment on the same visit or admission episode to ensure uniform data capture.

Sample size determination

The sample size was calculated using the standard formula for estimation of a single proportion in a cross-sectional study:

$n = Z^2pq / d^2$

where n = required sample size, Z = standard normal deviate at 95% confidence level [1.96], p = anticipated prevalence of anemia, q = 1 − p, and d = absolute precision. Assuming an expected prevalence of anemia of 59% based on previous hospital-based evidence, p was taken as 0.59 and q as 0.41. With an absolute precision of 7%, the minimum sample size was 189.65, which was rounded to 190. After adding 5% to compensate for possible incomplete records or non-response, the final required sample size was 199.13, which was rounded to 200 participants. Eligible children were thereafter enrolled by consecutive sampling until the final sample size was achieved.

Data collection

Data were collected using a predesigned and pretested proforma. Information on age, sex, and relevant clinical details was recorded at enrollment. Socioeconomic status was categorized into lower, middle, and upper classes using a standard household socioeconomic classification appropriate to the local setting. Dietary iron intake was assessed through caregiver interviews based on routine consumption of iron-rich foods and was grouped as adequate or inadequate for analytic purposes. For presentation of age-related distribution, participants were classified into four groups: 1–3 years, 4–6 years, 7–9 years, and 10–12 years.

Laboratory assessment and case definition

Venous blood samples were collected under aseptic precautions and analyzed using a standard automated hematology analyzer for hemoglobin estimation and red cell indices. Anemia was defined using age-appropriate hemoglobin thresholds recommended for children and adolescents, in line with current pediatric guidance based on World Health Organization criteria [4,10]. Cases were further graded as mild, moderate, or severe according to the respective age-specific hemoglobin cutoff ranges [10]. Peripheral smear examination was performed for all anemic children to classify the morphological pattern as microcytic hypochromic, normocytic normochromic, macrocytic, or dimorphic anemia. This morphological approach is widely used in routine pediatric hematology evaluation and remains clinically valuable in resource-constrained settings [4,10].

Bias

Several steps were taken to reduce potential sources of bias. Selection bias was minimized by enrolling consecutive eligible children attending pediatric services during the study period according to predefined inclusion and exclusion criteria. Information bias was reduced by using a predesigned and pretested proforma for uniform collection of demographic, socioeconomic, dietary, clinical, and laboratory data. To limit interviewer-related variation, data were collected in a standardized manner from caregivers at the time of enrollment. Measurement bias was addressed by obtaining venous blood samples under aseptic precautions and processing them using a standard automated hematology analyzer following routine laboratory protocols. Peripheral smear interpretation was performed using uniform morphological criteria. Misclassification bias was further minimized by defining anemia and grading its severity according to age-specific hemoglobin cutoffs based on accepted pediatric guidance. Although dietary iron intake was assessed through caregiver report and therefore remained susceptible to recall bias, the use of simple predefined categories helped improve consistency of classification.

Statistical analysis

Data were entered into Microsoft Excel and analyzed using the Statistical Package for the Social Sciences (SPSS) software, version 25.0. Continuous variables were summarized as mean ± standard deviation, whereas categorical variables were expressed as frequencies and percentages. The prevalence of anemia was calculated as the proportion of children whose hemoglobin values were below the age-specific cutoff. Distribution of anemia across age groups, sex, socioeconomic status, and dietary iron intake categories was presented descriptively. The findings were organized into tables to facilitate interpretation of baseline characteristics, anemia burden, associated distributional patterns, and morphological classification.

Ethical approval

The study protocol was reviewed and approved by the Institutional Ethics Committee of Government Medical College, Nizamabad, Telangana, India, prior to commencement of the study. Written informed consent was obtained from the parent or legal guardian of each child before enrollment, and confidentiality of participant information was maintained throughout the study.

Results

Participant flow

During the study period, children aged 1–12 years attending the pediatric services were assessed for eligibility and enrolled by consecutive sampling. A total of 200 children who fulfilled the inclusion criteria and whose parents or legal guardians provided written informed consent were included in the study. All enrolled participants underwent structured clinical evaluation and laboratory assessment, including hemoglobin estimation, and all 200 children were included in the final analysis. Among these, 118 children were found to have anemia. Peripheral smear examination for morphological classification was performed in all 118 anemic children. As this was a cross-sectional study, no follow-up period was involved. Children were not included in the study if consent was not provided by the caregiver, if the child had received a recent blood transfusion, or if the clinical or laboratory records were incomplete.

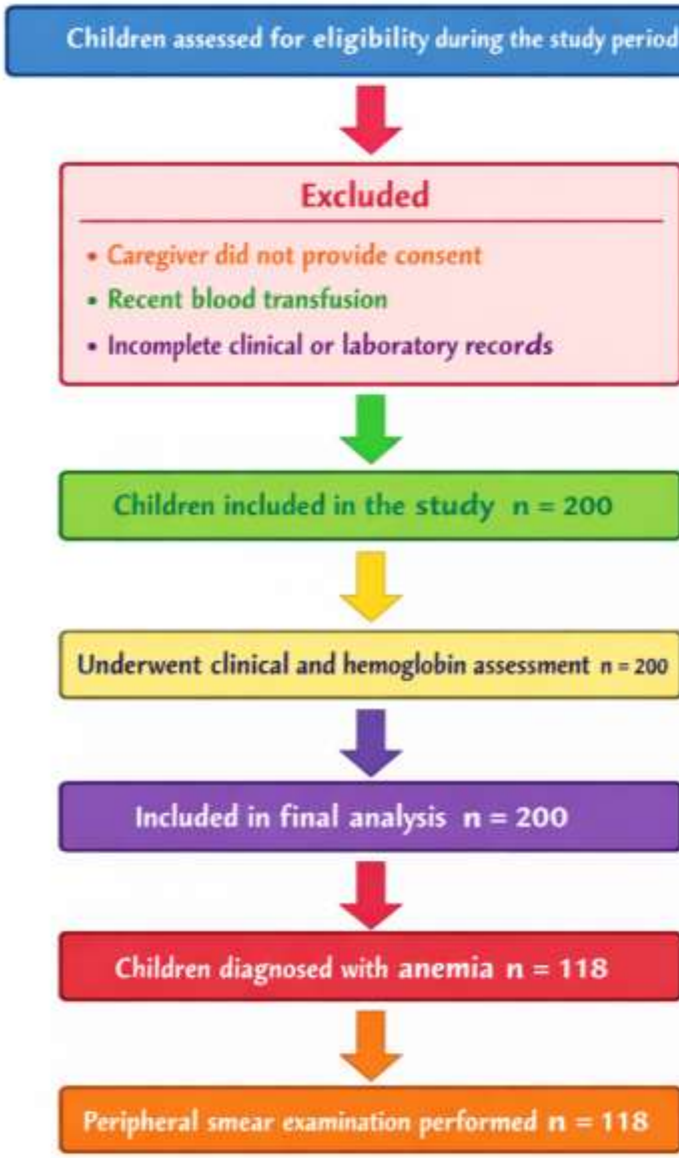

Figure 1. Participant Flow Diagram

A total of 200 children aged 1–12 years attending the tertiary care hospital were included in the study. The mean age of the participants was 6.2 ± 3.1 years. Among them, 108 [54.0%] were males, and 92 [46.0%] were females. The highest proportion of children belonged to the 4–6 years age group [29.0%], followed by 1–3 years [26.0%], 7–9 years [23.0%], and 10–12 years [22.0%] (Table 1).

Table 1. Baseline demographic characteristics of study participants [n = 200]

Variable	Number	Percentage [%]
Age group [years]		
1–3	52	26.0
4–6	58	29.0
7–9	46	23.0
10–12	44	22.0
Sex		
Male	108	54.0
Female	92	46.0

Out of 200 children, 118 were found to have anemia, giving an overall prevalence of 59.0%, while 82 [41.0%] were non-anemic. Among the anemic children, moderate anemia was the most common type, accounting for 54 [45.8%], followed by mild anemia in 46 [39.0%] and severe anemia in 18 [15.2%]. The mean hemoglobin level in the overall study population was 10.4 ± 1.8 g/dL. Among anemic children, the mean hemoglobin level was 8.9 ± 1.3 g/dL, whereas in non-anemic children it was 12.5 ± 0.7 g/dL (Table 2).

Table 2. Prevalence, severity, and hemoglobin profile of anemia among study participants [n = 200]

Variable	Number / Value	Percentage [%] / Mean ± SD
Anemia status		
Anemic	118	59.0
Non-anemic	82	41.0
Severity of anemia among anemic children [n = 118]		
Mild	46	39.0
Moderate	54	45.8
Severe	18	15.2
Hemoglobin profile		
Overall hemoglobin [g/dL]	10.4 ± 1.8	
Hemoglobin in anemic children [g/dL]	8.9 ± 1.3	
Hemoglobin in non-anemic children [g/dL]	12.5 ± 0.7	

Age-wise distribution showed that anemia was more prevalent in younger children. The prevalence was highest in the 1–3 years age group [71.2%], followed by 4–6 years [63.8%], 7–9 years [52.2%], and 10–12 years [45.5%]. Female children had a slightly higher prevalence of anemia [63.0%] compared with males [55.6%]. Anemia was also more common among children from lower socioeconomic status families [75.0%] and among those with inadequate dietary iron intake [75.0%] (Table 3).

Table 3. Distribution of anemia according to selected characteristics [n = 200]

Variable	Total	Anemic	Non-anemic	Prevalence of anemia [%]
Age group [years]				
1–3	52	37	15	71.2
4–6	58	37	21	63.8
7–9	46	24	22	52.2
10–12	44	20	24	45.5
Sex				
Male	108	60	48	55.6
Female	92	58	34	63.0
Socioeconomic status				
Lower	104	78	26	75.0
Middle	70	34	36	48.6
Upper	26	6	20	23.1
Dietary iron intake				
Adequate	88	34	54	38.6
Inadequate	112	84	28	75.0

Peripheral smear examination among the 118 anemic children showed that microcytic hypochromic anemia was the predominant morphological pattern, observed in 68 [57.6%] children. Normocytic normochromic anemia was seen in 34 [28.8%], macrocytic anemia in 10 [8.5%], and dimorphic anemia in 6 [5.1%] (Table 4).

Table 4. Morphological pattern of anemia among anemic children [n = 118]

Morphological type	Number	Percentage [%]
Microcytic hypochromic	68	57.6
Normocytic normochromic	34	28.8
Macrocytic	10	8.5
Dimorphic	6	5.1

Discussion.

The present study demonstrated that anemia affected 59.0% of children aged 1–12 years attending a tertiary care hospital, confirming that childhood anemia remains a substantial clinical burden in this setting. This finding is consistent with the broader Indian evidence showing that anemia continues to affect a large proportion of children despite ongoing policy attention and supplementation

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programs [12-14]. Our estimate is lower than the 72.8% occurrence reported among hospitalized children in Bangalore by Saba et al. [7], yet it remains high enough to indicate that routine pediatric encounters offer an important opportunity for detection and early intervention. The burden observed in the present study also fits within the range described in recent reviews of anemia prevalence across Indian age groups [12,14].

Moderate anemia was the most frequent severity category in our cohort, while severe anemia constituted a smaller but clinically important fraction. This pattern resembles previous hospital-based Indian observations in which moderate anemia predominated over mild and severe forms [8,9]. From a clinical perspective, this is important because moderate anemia can still impair growth, immunity, activity, and cognitive performance even when overt hemodynamic compromise is absent [5]. The mean hemoglobin difference between anemic and non-anemic children in our study further illustrates the substantial hematological gap within this pediatric population. These findings support a strategy of active screening rather than waiting for severe symptomatic disease to declare itself.

A clear age gradient was observed, with the highest prevalence in children aged 1–3 years and a progressive decline in older age groups. This agrees with prior Indian work showing greater vulnerability in younger children, especially during phases of rapid growth, transition to complementary feeding, and increased exposure to nutritionally inadequate diets [10,14]. Female children had a slightly higher prevalence than males in the present study. Although sex differences in preadolescent anemia are not always uniform across studies, Indian datasets have shown that social and dietary disparities can influence this pattern [11]. The markedly greater anemia burden among children from lower socioeconomic strata and among those with inadequate dietary iron intake in our study is also consistent with published evidence linking poverty, dietary insufficiency, maternal disadvantage, and household food insecurity with childhood anemia [13].

Morphologically, microcytic hypochromic anemia was the commonest smear pattern, followed by normocytic normochromic anemia. This predominance strongly suggests that iron deficiency or iron-restricted erythropoiesis contributes substantially to the observed burden, which parallels earlier Indian hospital-based studies where microcytic hypochromic anemia was the leading morphology [7,9]. Nevertheless, the presence of normocytic, macrocytic, and dimorphic patterns indicates that childhood anemia in tertiary care practice is multifactorial rather than exclusively nutritional [10]. This is important because programs focused only on iron delivery will not address all etiologies. Current evidence therefore supports a balanced approach that combines nutritional measures with evaluation for infection, inflammation, and other micronutrient deficiencies when clinically indicated.

Generalizability

Although the study was hospital-based, the findings remain clinically relevant to similar tertiary care centers serving mixed urban and rural populations in northern Telangana and comparable regions of India. The observed pattern of higher anemia burden in younger children, lower socioeconomic groups, and those with inadequate dietary iron intake is consistent with wider Indian literature, which supports cautious external relevance for screening priorities, counselling strategies, and routine pediatric case-finding in similar care settings.

Conclusion

This cross-sectional study showed that anemia affected more than half of children aged 1–12 years attending a tertiary care hospital in Nizamabad. Moderate anemia formed the largest subgroup, and microcytic hypochromic anemia was the dominant morphological pattern, indicating a strong contribution from nutritional iron deficiency. The burden was greatest among younger children, females, those from lower socioeconomic backgrounds, and children with inadequate dietary iron intake. These findings emphasize that anemia remains an important pediatric health problem in this region. Strengthening hospital-based screening, nutritional assessment, caregiver counselling, and timely treatment can improve early recognition and reduce the immediate and long-term consequences of childhood anemia.

Limitations

The cross-sectional design prevented causal inference. The study was hospital-based and therefore represented children seeking care rather than the entire community. Biochemical markers such as serum ferritin, folate, vitamin B12, C-reactive protein, and stool examination were not included, so etiological classification beyond morphology remained limited. Dietary intake and socioeconomic information depended on caregiver reporting and were vulnerable to recall and reporting bias.

Recommendations

All children attending pediatric services, especially those aged 1–6 years, should undergo routine hemoglobin screening at appropriate intervals. Caregivers should receive focused counselling on age-appropriate iron-rich foods, dietary diversification, and practices that improve iron absorption. Children identified with anemia should be evaluated promptly, treated according to severity, and followed until hematological recovery is documented. The hospital should strengthen linkage with public nutrition and iron-supplementation programs and encourage periodic audits of anemia trends to guide local pediatric care pathways, preventive strategies, and resource allocation.

Acknowledgement

The authors acknowledge the support of the Department of Pediatrics, Government Medical College, Nizamabad, and the participating children and their caregivers. The cooperation of the laboratory personnel and nursing staff in facilitating sample collection, documentation, and processing is gratefully appreciated.

Abbreviations

CBC: complete blood count
Hb: hemoglobin
IDA: iron deficiency anemia
MCV: mean corpuscular volume
SD: standard deviation
SES: socioeconomic status
SPSS: Statistical Package for the Social Sciences
WHO: World Health Organization

Source of Funding

This study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of Interest

The authors declare no conflict of interest.

Author contributions

CN- Concept and design of the study, results interpretation, review of literature, and preparation of the first draft of the manuscript. **KR-** Statistical analysis and interpretation, revision of manuscript. **KS**- QI project administration and data collection.

Data availability

Data is available upon request.

Author Biography

Dr. Chidura Naveen is an Assistant Professor in the Department of Paediatrics at Government Medical College, Nizamabad, Telangana, India. He is actively involved in pediatric clinical care, undergraduate and postgraduate teaching, and academic research. His work focuses on child health, nutritional disorders, and evidence-based pediatric practice. He has contributed to hospital-based clinical studies and remains engaged in improving pediatric health outcomes through patient care, teaching, and research activities.

Dr. Kairamkonda Rajashekar is an Associate Professor in the Department of Paediatrics at Government Medical College, Nizamabad, Telangana, India. He is involved in clinical pediatrics, medical education, and research related to common childhood illnesses and preventive child health. With academic and clinical experience in pediatric practice, he contributes to the training of medical students and supports research initiatives aimed at strengthening the quality of pediatric care and improving child health services.

Dr. Kuturu Sharanya is an Assistant Professor in the Department of Paediatrics at Government Medical College, Nizamabad, Telangana, India. She participates in pediatric patient management, teaching, and research activities within the department. Her academic interests include child nutrition, growth and development, and the clinical evaluation of common pediatric conditions. She is committed to advancing pediatric healthcare through clinical service, medical education, and scholarly work.

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