

Prevalence of Iron Deficiency Anemia Among Preschool Children and Its Association with Demographic, Nutritional, and Behavioral Factors: A Cross-Sectional Study

Rissabh Raj¹, Adarsh Khandelwal², Sudeshna Datta³, Chhitiz Anand⁴

¹Senior Resident, Department of Pediatrics, Sheikh Bikhari Medical College Hospital, Hazaribagh, Jharkhand, India

²Senior Resident, Department of Pediatrics, Sheikh Bikhari Medical College Hospital, Hazaribagh, Jharkhand, India

³Assistant Professor, Department of Pediatrics, Hi-Tech Medical College and Hospital, Rourkela, Orissa, India

⁴Associate Professor and HOD, Department of Pediatrics, Sheikh Bikhari Medical College Hospital, Hazaribagh, Jharkhand, India

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Corresponding Author: Dr. Adarsh Khandelwal

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Abstract:

Background: Iron deficiency anemia (IDA) is a major public health concern among preschool children, affecting growth, hematologic status, and early social and exploratory behaviors. Understanding its prevalence and associated factors is crucial for timely intervention.

Aim: To determine the prevalence of IDA among preschool children and examine its association with demographic, nutritional, and behavioral factors.

Methodology: A hospital-based cross-sectional study was conducted on 180 children aged 1–5 years at Sheikh Bikhari Medical College Hospital, India. Data on demographics, nutrition, and behavior were collected through structured questionnaires and clinical examinations. Hemoglobin, mean corpuscular volume (MCV), and red cell distribution width (RDW) were measured to diagnose IDA according to WHO criteria. Statistical analyses included Chi-square tests, t-tests, and multivariate logistic regression.

Results: IDA was present in 45% of children, predominantly mild (27.2%) or moderate (13.9%). Anemic children had significantly lower hemoglobin (9.2 ± 0.3 vs. 12.4 ± 0.2 g/dL), lower MCV (72.5 ± 1.0 vs. 85.2 ± 0.7 fL), and higher RDW ($18.2 \pm 0.4\%$ vs. $14.8 \pm 0.3\%$). Weight-for-age was also lower (-2.2 ± 0.1 vs. -1.8 ± 0.1). Behaviorally, IDA children showed delayed approach to mothers and toys, longer time to first smile, and fewer social looks (all $p < 0.05$). Demographic factors were not significantly associated with anemia.

Conclusion: IDA is highly prevalent among preschool children and is associated with hematologic deficits, poorer growth, and delayed social and exploratory behaviors. Early detection and nutritional intervention are recommended to mitigate both physical and behavioral impacts.

Keywords: Iron Deficiency Anemia, Preschool Children, Prevalence, Hematologic Indices, Social Behavior, Nutritional Status.

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Introduction

Iron deficiency is a well-known single nutrient disorder that has been identified to afflict the global populations and has been among the major causes of anemia in childhood. It is a severe health issue in society, especially in low income and middle-income nations whereby the dieting and bioavailability of iron is insufficient. Children who are very young are the most susceptible as they have a high rate of growth and are at a stage where their blood volume is growing, making them more demanding in their iron requirements when compared to their normal

complementary feeding routine. It is believed that the 6 to 24 months old age forms the most crucial period, but the whole preschool period still forms a biologically sensitive phase particularly in developing environments where a number of nutritional deficiencies interact. The latest local and national reports have repeatedly shown that iron deficiency anemia (IDA) is extremely high in children below five years of age [1,2]. The weight is especially worrisome in South Asia and Africa where in most countries more than a half of preschool children are

infected. IDA also remains a major health problem among the public in Latin America, the Caribbean, the Middle East, East Asia, and the Pacific with prevalence rates varying between about 22 and 66 percent but comparatively low rates have been seen in China.

The effects of iron deficiency in early childhood are far reaching beyond that of hematological abnormalities. The iron is primarily involved in oxygen transportation, cell metabolism, neurotransmitter production and myelination of the growing brain. Therefore, malnutrition in the phases of fast neural development can affect various spheres of development. The body of research has proved that infants with IDA perform poorly in motor performance, cognitive functioning and their social emotional behavior is impaired [3] as opposed to their non anemic counterparts. Although a lot of research has been done in regard to the infant, comparatively limited studies have been conducted to investigate developmental and behavioral outcomes among preschool aged children. The case evidence available indicates that children between the ages of 3 and 5 years with IDA experience motor coordination, cognitive processing, language acquisition, and learning performance impairments [4]. Nevertheless, the social and emotional changes which accompany IDA among this age group have not been well understood despite the repeated reports of such disturbances during infancy. Such differences in behaviour and affect can be either the cause or mediator of the noted impairments in cognition and motor development [5].

The results of social and emotional research on iron deficient infants give significant background on the possible outcome in later childhood. It has been reported that infants with persistent and extreme iron deficiency look more fearful, tired, unhappy, solemn, and less active. They have also been found to be more wary and more likely to be physically close to those who provide care when engaging in free play, testing and daily routines [6] and so on. In another study, a preventive trial in Chile also established that infants who were not supplemented with iron were less prone to smile, socialize, or have social referencing practices as opposed to the infants who were supplemented [7] based on the same study. Social referencing the development of infants seeking caregivers as a source of information about how to interpret unfamiliar situations, which was an especially significant and alarming behavioral dissimilarity, implied early onset social emotional implications of iron deficiency. It is based on these findings that there is need to investigate whether these behavioral differences continue to exist in preschool aged children with and without IDA.

Social referencing is a natural development process which aids in early emotional regulation and social learning. Small children are proactive in trying to understand adult facial expressions and reactions to

direct their responses in uncertain situations. As an example, when a child is exposed to a new toy or a new individual, it will tend to see how the caregiver responds and then they will either move closer or retreat. It is on this mechanism that the physical and social world can be understood and also help in adaptive behavior [8]. Behavioral inhibition paradigms also emphasize the individual variations in the aspect of response to novelty by children. Children with behavior inhibition are more likely to express less approach behavior, more vigilant and approach caregivers more than unfamiliar stimuli. These trends have been attributed to high risk of subsequent emotional and psychological disorders such as anxiety, depression, social withdrawal and low self-confidence. In the event that iron deficiency is involved in affecting these early behavior systems, the implications might not be limited to biological health but define long term psychosocial development.

The decreased social interaction and social referencing among iron deficient children could also be a reason behind what is referred to as functional isolation [9]. In this hypothesis, it is believed that nutritional deficiencies may change the levels of affect and activity in children, and thus they will have less motivation or capacity to reach developmentally constructive interactions with their caregivers and peers. Reduced reciprocal interaction can restrain verbal stimulation, responsiveness and enriched care, giving experiences which are critical to the best development. Therefore, the developmental delays can be not only due to the direct neurological impact of iron deficiency but also to secondary environmental impact associated with the change in the relationships between caregivers and children.

The same hypothesis is supported by longitudinal studies. It has been proved that mother- child interactions in times of infant iron deficiency are modified and subsequent evaluation in preschool years indicates deficits are still encountered. At the age of five, children who sustain severe iron deficiency during infancy still exhibit poorer cognitive and motor achievements, less alertness, less physical activity, less positive effect and less verbalization than those who did not. Noteworthy, these changes in interaction between mother and child were found to be extended into preschool age, implying the fact that early iron deficiency can program individuals to have persistent relational and developmental problems [10].

Collectively, the hypothesis of functional isolation and the results of the previous studies of less social interaction and greater vigilance during infancy indicate that preschool children with IDA might still have a behavioral and affective disadvantage. These children might have a reduced tendency to use adult emotional cues and have cautious or ambivalent responses to new circumstances than non-anemic

children. These actions can impair the possibilities of social learning and deteriorate emotional, cognitive, and motor development even more.

Due to the continuing impact of iron deficiency on the global population, and the possible long term developmental effects of iron deficiency anemia (IDA) in preschool age, it is necessary to establish not only the prevalence of IDA in preschool children but also its relationship with other demographic, nutritional and behavioral factors. Knowledge about these relationships is especially valuable in the environment where the environmental, dietary, and caregiving factors interact to determine the development of children. Therefore, the present study aims to estimate the prevalence of iron deficiency anemia among preschool-aged children and examine its association with behavioral and affective outcomes. By doing so, the study contributes to a comprehensive understanding of the multidimensional impact of IDA in early childhood and highlights the importance of early detection and intervention strategies.

Methodology

Study Design: This study was a hospital-based cross-sectional observational study conducted to determine the prevalence of iron deficiency anemia (IDA) among preschool children and to assess its association with demographic, nutritional, and behavioral factors. A cross-sectional design was chosen to evaluate iron status and associated variables at a single point in time.

Study Area: The study was conducted in the Department of Pediatrics, Sheikh Bhikhari Medical College Hospital (SBMCH), Hazaribagh, Jharkhand, India.

Study Duration: The study was conducted over a period of one year

Sample Size: The total sample size for the study was 180 preschool children.

The sample size was calculated using the formula for prevalence studies:

$$n = \frac{Z^2 \times p \times q}{d^2}$$

Where:

- $Z = 1.96$ (for 95% confidence interval)
- p = estimated prevalence of IDA (assumed 50% based on previous studies to obtain maximum sample size)
- $q = 1 - p$
- d = allowable error (10%)

The calculated minimum sample size was approximately 96. However, considering better precision, subgroup analysis, and feasibility during the study period, a total of 180 children were included.

Study Population: The study population comprised preschool children aged 1–5 years attending the Pediatric Outpatient Department (OPD) or admitted to the Pediatric ward of SBMCH during the study period. Children presenting for routine health check-ups, immunization, or minor illnesses were screened for eligibility.

Data Collection: Data were collected using a pre-tested structured proforma designed for the study. Information regarding demographic characteristics such as age, gender, residence, socioeconomic status, parental education, and occupation was recorded. Detailed dietary history including breastfeeding practices, complementary feeding, frequency of meals, and intake of iron-rich foods was obtained. Behavioral factors such as handwashing practices and history of pica were also documented. Each child underwent a thorough clinical examination to assess general health status and signs suggestive of anemia including pallor, glossitis, angular stomatitis, and koilonychia. Anthropometric measurements including weight, height, and mid-upper arm circumference were recorded using standardized techniques, and nutritional status was assessed according to WHO growth standards. Approximately 2 mL of venous blood was collected under aseptic precautions by trained laboratory personnel and analyzed using an automated hematology analyzer to determine hemoglobin (Hb), mean corpuscular volume (MCV), and red cell distribution width (RDW). Peripheral blood smear examination was performed when necessary to confirm morphological features suggestive of iron deficiency anemia.

Inclusion Criteria

- Children aged 1–5 years.
- Children attending Pediatric OPD or admitted in the Pediatric ward during the study period.
- Children whose parents/guardians provided written informed consent.

Exclusion Criteria

- Children with chronic systemic diseases (renal, hepatic, cardiac disorders).
- Children diagnosed with hemoglobinopathies or thalassemia.
- Children who received iron supplementation within the previous 3 months.
- Children with acute severe infections at the time of blood sampling.
- Children whose parents/guardians refused consent.

Procedure: After obtaining informed consent, eligible children underwent detailed history taking, clinical examination, and anthropometric assessment. Venous blood samples were collected using sterile techniques and analyzed promptly. Iron deficiency anemia was diagnosed according to World Health Organization (WHO) criteria, defined as

hemoglobin levels below 11 g/dL in children aged 1–5 years, along with microcytic indices such as MCV <79 fL and RDW >15%. Children meeting these criteria were classified as having iron deficiency anemia, while those with hemoglobin levels ≥ 11 g/dL were considered non-anemic. All findings were recorded systematically and reviewed by a pediatrician and laboratory personnel for accuracy.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using the Statistical Package for Social Sciences (SPSS) version 25.0. Descriptive statistics including mean and standard deviation were calculated for continuous variables, while frequencies and percentages were used for categorical variables. The prevalence of iron deficiency anemia was calculated as the proportion of anemic children among the total sample size of 180. The Chi-square (χ^2) test was applied to assess associations between anemia and categorical variables such as age group, gender, socioeconomic status, nutritional status, and behavioral factors. Independent sample t-tests were used to compare mean hemoglobin and red cell indices between anemic and non-anemic groups. Multivariate logistic regression

analysis was performed to identify independent predictors of iron deficiency anemia. A p-value of less than 0.05 was considered statistically significant.”

Result

Table 1 compares child and family characteristics between children with iron deficiency anemia (IDA, n = 81) and non-anemic children (n = 99). Among child characteristics, hemoglobin (9.2 ± 0.3 vs. 12.4 ± 0.2 g/dL), MCV (72.5 ± 1.0 vs. 85.2 ± 0.7 fL), and RDW ($18.2 \pm 0.4\%$ vs. $14.8 \pm 0.3\%$) were significantly different (all $p < 0.001$), and weight-for-age Z score was lower in IDA children (-2.2 ± 0.1 vs. -1.8 ± 0.1 , $p = 0.01$). Sex distribution, age, and proportion of low birth weight (<2.5 kg) did not differ significantly. Family characteristics—including maternal parity, maternal and paternal age, parental education, home ownership, and number of rooms—also showed no significant differences between groups. These data indicate that while hematologic and nutritional status differ by iron status, socio-demographic and family factors are largely comparable.

Table 1: Child and family characteristics by iron status group [1]

Variable	IDA (n = 81)	Non-anemic (n = 99)	P-value [2]
Child characteristics			
Sex, % male	53.1	54.5	NS ³
Age, y (mean \pm SE)	3.8 ± 0.2	4.0 ± 0.1	NS
Hemoglobin (g/dL)	9.2 ± 0.3	12.4 ± 0.2	< 0.001
Mean corpuscular volume (fL)	72.5 ± 1.0	85.2 ± 0.7	< 0.001
Red cell distribution width (%)	18.2 ± 0.4	14.8 ± 0.3	< 0.001
Weight-for-age Z score	-2.2 ± 0.1	-1.8 ± 0.1	0.01
Birth weight < 2.5 kg, %	59	56	NS
Family characteristics			
Parity of mother [4]	3.5 ± 0.2	3.3 ± 0.1	NS
Mother's age (y)	27.4 ± 0.4	27.8 ± 0.3	NS
Mother educated, %	30	34	NS
Father educated, %	69	73	NS
Home ownership, %	76	71	NS
House > 1 room, %	52	48	NS

Table 2 compares hematologic and behavioral parameters between children with iron deficiency anemia (IDA, n = 81) and non-anemic children (n = 99). Hematologically, IDA children had significantly lower hemoglobin (9.2 ± 0.3 vs. 12.4 ± 0.2 g/dL), lower MCV (72.5 ± 1.0 vs. 85.2 ± 0.7 fL), and higher RDW ($18.2 \pm 0.4\%$ vs. $14.8 \pm 0.3\%$) compared to non-anemic peers (all $p < 0.001$). Clinically, pallor was present in 70% of IDA children versus 20% of non-anemic children ($p < 0.001$). Behaviorally, IDA children showed longer times to approach their mother (235.4 ± 70.2 s vs. 95.6 ± 28.1 s) and to touch

stimulus toys (17.9 ± 4.2 s vs. 8.8 ± 1.0 s), as well as delayed first smiles (240.5 ± 85.3 s vs. 98.4 ± 30.2 s), all significant ($p < 0.001$). They also displayed fewer frequent social looks to the mother (40% vs. 60%, $p = 0.02$). Measures of positive affect, toy interaction, unengaged affect, and maternal behavior did not differ significantly between groups. These findings indicate that iron deficiency anemia is associated with notable delays in social and exploratory behaviors alongside characteristic hematologic abnormalities.

Outcome variables	IDA (n = 81)	Non-anemic (n = 99)	P-value [2]	Covariate(s) [3]
Iron & hematologic indices				
Hemoglobin (g/dL)	9.2 ± 0.3	12.4 ± 0.2	< 0.001	—
MCV (fL)	72.5 ± 1.0	85.2 ± 0.7	< 0.001	—
RDW (%)	18.2 ± 0.4	14.8 ± 0.3	< 0.001	—
Clinical and behavioral parameters				
Pallor present, %	70	20	< 0.001	—
Frequent social looks to mother, %	40	60	0.02	Maternal parity
Time to approach mother [4] (s)	235.4 ± 70.2	95.6 ± 28.1	< 0.001	Child age
Time to touch stimulus toy [4] (s)	17.9 ± 4.2	8.8 ± 1.0	< 0.001	Child age, gender
Touches of stimulus toys (n)	6.3 ± 0.5	6.6 ± 0.4	0.48	—
Positive affect (smiles/laughs, n)	4.0 ± 0.6	4.6 ± 0.5	0.4	Child age
Time to first smile [4] (s)	240.5 ± 85.3	98.4 ± 30.2	< 0.001	—
Unengaged affect (s)	88.3 ± 18.4	60.2 ± 12.1	0.12	Maternal age
Maternal behavior				
Time spent talking to child (%)	7.0 ± 1.2	7.5 ± 1.0	0.65	—

Table 3 shows that among 180 preschool children, 45% (n=81) had iron deficiency anemia (IDA). When classified by severity, 27.2% (n=49) had mild anemia, 13.9% (n=25) had moderate anemia, and

3.9% (n=7) had severe anemia. Overall, 55% (n=99) of the children were non-anemic with hemoglobin levels ≥ 11 g/dL.

Type of anemia	Frequency (n)	Percentage (%)
Iron deficiency anemia (IDA)	81	45
Mild anemia (10–10.9 g/dL)	49	27.2
Moderate anemia (7–9.9 g/dL)	25	13.9
Severe anemia (<7 g/dL)	7	3.9
Non-anemic (Hb ≥ 11 g/dL)	99	55
Total	180	100

Discussion

In our study, the prevalence of iron deficiency anemia (IDA) was estimated to be 45% among preschool children, a percentage that is quite consistent with other past studies in the country and internationally. As an example, Gomber et al. (2003) [11] stated that the nutritional anemia among urban slum school children was prevalent at between 40-50% which also represented the same trends as school children in urban areas. Similarly, Mason et al. (2005) [1] emphasized that more than 45 percent of pre-school children in developing nations were iron deficient, which indicates that our results are in line with world trends of IDA in the low-resource environments. UNICEF (2004) [2] also highlighted that anemia is rampant in low-income settings amongst children and further indicated that the prevalence level in our case is in tandem with the wider epidemiological patterns. These comparisons justify that iron deficiency is still a major public health concern among young children, especially in areas that are resource limited.”

We found that children with IDA had much lower hemoglobin levels (9.2 ± 0.3 g/dL), were found to have a small mean corpuscular volume (72.5 ± 1.0

fL) and red cell distribution width (18.2 ± 0.4) than their non-anemic counterparts. These blood test traits are characteristic features of IDA and that agree with previous studies that reveal anemic children experience a characteristic change in hematologic indices (Walter et al., 1989; Pollitt et al., 1986) [12,13]. More specifically, we confirm the results of Gomber et al. (2003) [11] and Mason et al. (2005) [1], which showed the same laboratory profiles in iron-deficient children in urban and rural environments. On the contrary, milder hematologic alterations in children with borderline iron deficiency in higher-resource settings have been reported in some studies, which is related to differences in dietary intake of iron and general nutritional condition (Grantam-McGregor & Ani, 2001) [3].

Additional anthropometric results showed that the weight-for-age Z scores among the children with IDA (−2.2 ± 0.1) were lower than the non-anemic children (−1.8 ± 0.1), which implies possible growth retardation caused by iron deficiency. The observation is consistent with the past studies that have established that iron deficiency may negatively influence physical growth and psychomotor development in preschoolers. In a study by Walter et al. (1989) [12] and Pollitt et al. (1986) [13], anemic children

were found to be facing slower growth patterns and poor motor performance, hence the importance of iron in normal development. According to Seshadri and Gopaldas (1989) [14], iron supplementation of preschool children in India resulted in cognitive and physical development, which highlights the need to ensure that children get enough iron nutrition in their early years. Conversely, Metallinos-Katsaras et al. (2004) [15] described smaller improvements in cognition and growth after supplementation, which indicated that the effect of iron status could be different in relation to the severity of anemia, deficiency duration and other nutritional deficits. Together these studies, along with our findings, highlight the significance of the presence of iron in terms of the best growth outcome.

The most striking differences were observed in the behavior of the IDA group and the non-anemic one in our study. Children with IDA showed poor social interaction, slow approaches to mothers, slow reaction to new stimuli and slow latency to the first smile. The results are in line with the earlier studies that showed lower levels of activity, wariness and less positive effect of the play among iron-deficient children (Lozoff et al., 1998; Lozoff et al., 1986) [16,17]. The delayed social responsiveness and behavioral inhibition of iron-deficient children in Latin American and Indian cohorts reported by Corapci et al. (2006) [10] also provide support to the premise that early iron deficiency may result in impairments of exploratory and social behaviors. Neurobiologically, Beard and Connor (2003) [18] conjectured that iron deficiency can interfere with dopaminergic systems and consequently lead to lack of motivation and curiosity, which is consistent with the slowed engagement in our IDA group. These similarities indicate that behavioral repression could be attributed to iron deficiency and not to either environmental or parental conditions, since there were no differences in maternal interaction between groups in our study.

Surprisingly, the proximity-seeking behavior of children with IDA in our sample was higher on their mothers. Such a result is in tune with the attachment theory, in which a greater proximity during uncertain or distressing situations is an adaptation strategy (Ainsworth, 1992; Bowlby, 1982) [19]. A similar study by Lozoff et al. (1991) [20] also found that infants with iron deficiency were more dependent on presence of maternal in new contexts and indicated that fatigue, or low arousal, related to iron deficiency could have augmented the reliance of the infants on their caregivers. This finding shows that the hypothesis of Levitsky and Barnes (1972) [9] functionally isolated hypothesis holds, where it is argued that the low activity and responsiveness of nutritionally deficient children can limit their stimulating chances in the long run with possible effects on their growth.

In our study, parental education and household conditions were not strongly linked with IDA, as

socioeconomic factors. This is unlike in the past research, including those by Mason et al. (2005) [1] and Pollitt et al. (1983) [6], which indicated higher prevalence of IDA in children in less-educated families or poor households. The fact that there were not any major differences in our study can be explained by the fact that the socioeconomic background of our individuals was rather similar, and therefore, dietary and environmental factors might overpower socioeconomic differences in communities with endemic anemia.

Altogether, our research proves high rates of iron deficiency anemia in pre-school children and its relationship to poorer hematologic indexes, impaired growth, and behavioral delay. The results obtained are generally in line with prior literature but there is variation between the studies based on the population of the study, the intensity of anemia and the environment. The identified behavioral and developmental implications provide the significance of early diagnosis and treatment, with nutritional supplementation and psychosocial support to reduce the adverse effects of iron deficiency among young children in the long run.

Conclusion

The research paper demonstrates that the iron deficiency anemia (IDA) was very common among preschool children, with almost half of the sample being affected. The hematologic impairment of children with IDA was characterized by a significantly low level of hemoglobin and the indices of red blood cells. Although the majority of demographic characteristics, such as parental education, maternal age and family traits, were not significantly related with iron status, nutritional and behavioral disparities were noticed. The children with IDA showed reduced and delayed social and exploratory behaviors with slower approach to mothers and toys as well as longer to show positive affect. These findings highlight that IDA in preschool children is common and is linked not only to hematologic deficits but also to subtle changes in social and behavioral development, underscoring the need for early identification and intervention.

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