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Original Research Article

A Cross-Sectional Study on the Prevalence of Iron Deficiency Anemia in Preschool Children

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Abstract:

Background: Iron deficiency anemia (IDA) is widely recognized as the most common and most significant nutritional disorder globally, and an important risk factor for morbidity from preschool age children. IDA impacts hematologic health, growth, and early behavioral development in children.

Objective: To assess the prevalence of iron deficiency anemia among preschool children and to assess the relationship with demographic, nutritional, and behavioral factors.

Method: A cross-sectional observational study was conducted in the Department of Pediatrics, Sheikh Bhikhari Medical College and Hospital, Hazaribagh, Jharkhand, India. Two hundred children aged 1-5 years were evaluated with clinical examination and hematological investigations. Iron deficiency anemia was diagnosed using World Health Organization administration guidelines (Hb < 11g/dL, MCV < 79 fL, RDW > 15%). Data analysis was completed using SPSS v25.0 software and statistical significance levels were set at $p < 0.05$.

Results: The prevalence of iron deficiency anemia was 45%. The anemic children demonstrated significantly reduced hemoglobin (9.1 ± 0.3 g/dL, vs 12.3 ± 0.2 g/dL, $p < 0.001$), reduced MCV and increased RDW. Iron deficiency anemia was associated with lower weight-for-age scores and reduced behavioral responses including delayed approach responses to mothers, and toys indicating a reduction in social interactions.

Conclusions: Iron deficiency anemia persists as a public health concern among preschoolers affecting not only hematologic and nutritional status but also emotional and social development as well. Early detection and nutritional intervention are necessary.

Keywords: Iron Deficiency Anemia, Preschool Children, Prevalence, Behavior, Nutritional Status, Cross-Sectional Study.

Introduction

Iron deficiency is considered to be the most common single-nutrient disorder in the global population and one of the major causes of anemia in childhood. It is a serious health issue on the population and particularly in the low- and middle-income nations where the intake and absorption of iron in the diet is insufficient. Newborns aged 6 to 24 months are most vulnerable as the growth is fast, and the amount of iron is high in this period of rapid development. Nevertheless, the whole period of preschool age is a weak spot, particularly in the developing economies where the nutritional deficiencies burden is the most important. Some recent statistics of a regional and country summary show that iron deficiency anemia (IDA) is prevalent among children below the age of 5 years [1,2] &. The region of southern Asia and Africa has alarmingly high prevalence of IDA with most countries having at least half of the preschool children making up the affected population. In addition, IDA is still a public health issue in Latin America, Caribbean, Middle East, East Asia, and Pacific with an incidence rate of between 22 and 66% with an exception of 14 in China with an incidence rate that is relatively low.

The effects of the iron deficiency during early childhood are severe, not only hematological abnormalities but also several areas of growth and development. There is a significant amount of research literature that has reported a worse motor, cognitive and social/emotional functioning of infants with IDA as compared to their non-anemic counterparts [3]. Regardless of that, there is a relative lack of research on the investigation of the developmental and behavioral effects of IDA among preschool-aged children. The scarcity of existing evidence points to the fact that IDA in children aged 3 to 5 is linked with the impairment of motor, cognitive, and language development and reduced learning performance [4]. Nonetheless, the lack of information on the social and emotional changes that can be associated with IDA during this age group is also observed. This knowledge gap especially stands out because any social and emotional disturbances have always been noted in the research of IDA in infancy. Such changes in behavior and affect can be underlying factors or contribute to the lack in cognitive and motor performance [5].

According to social and emotional studies, results of infants with iron deficiency offer valuable background about these developmental outcomes. Chronic and severe iron-deficient infants were reported to be more fearful, unhappier, fatigued, less active, wary, solemn, and prone to stay closely with their mothers when free playing, on testing and at home [6] in development. A recent preventive trial carried out in Chile [7] showed that infants who were not given iron supplements after 30-45 minutes of developmental test were less likely to smile, socially interact, and socially referenced than those who were given iron supplements. The lack of social referencing as one of the most significant behaviors, whereby babies rely on the caregivers to provide hints on how new or ambiguous situations are to be interpreted was a new and alarming finding, reflecting the possible social-emotional impact of iron deficiency at an early age. Based on these findings, this study will seek to investigate similar effective and behavior changes between preschoolers with and without IDA.

The process of social referencing plays a vital role in the initial emotional and social growth because it allows young children to actively search and process adult signals to explain and direct their behavior and manage their emotions in uncertain contexts. As an example, infants tend to look at the facial expression of their caregiver whenever they come across a new toy or an unfamiliar object to find out if they should approach or avoid it. This is a fundamental learning and adaptation mechanism which forms the much-needed scaffolding to the knowledge of the child in relation to physical and social environment [8]. Behavioral inhibition paradigms have also been used to study individual differences in the affective and behavioral reactions of children to new stimuli. Wary and behaviorally inhibited children are usually those who show low approach behavior and would rather stay close to their mother when faced with strangers, things, or places. There are indications that these suppressed behavioral pattern could be risk factors to future emotional and psychological problems, including anxiety, depression, social withdrawal and weak self-perceptions of competence.

In addition, lacking social contact and diminishing social referring behaviors in iron deficient children could also serve as a factor to so-called functional isolation of such children [9]. The functional isolation hypothesis suggests that nutritional deficiencies, including iron deficiency, may result in the effect and activity levels of children changing, thus lowering their motivation or capacity to pursue and exploit developmentally helpful interactions with care givers. Such deficiency of interactive reciprocity, in its turn, can restrain the chances of verbal stimulation, responsiveness, and other means of enriching care giving. Consequently, the direct neurological roles of iron deficiency and the secondary nature of the modified caregiver-child relationships can also lead to the developmental delays in late childhood of children who undergo early-life IDA.

Past longitudinal research has given me evidence that affirms this hypothesis. Infant interaction with the mother has been found to change with the infants affected by IDA during the course of deficiency. The results of follow-up studies of these children in the preschool years showed that those children that suffered chronic severe infantile iron deficiency still had poorer cognitive and motor results. Furthermore, these children were found to be less alert, physically active, positively affected, and verbalized at age 5 years as compared to the children with normal iron status. Notably, the changes in patterns of mother-child interaction continued into the preschool years implying that early iron deficiency could predispose individuals to persistent problems in relations and developmental patterns [10].

Combining the functional isolation hypothesis with past findings of lowered social looking and heightened vigilance during infancy, it can be forecasted that preschool-aged children with IDA may still present with an affective and behavioral anomaly. In particular, this type of child can be less inclined to use social or emotional signals by adults, and more inclined to exhibit ambivalent or suspicious attitude towards new circumstances, than their non-anemic peers. These behavioral manifestations could, in turn, limit social learning opportunities and further hinder emotional, cognitive, and motor development.

This is due to the fact that the burden of iron deficiency is persistent globally, and the long-term developmental outcomes of this deficiency might arise, so it is imperative to establish the prevalence and behavioral correlations of iron deficiency anemia in preschool children. This study is going to examine the prevalence of iron deficiency anemia in preschool-age children and examine its associations with affect and behavior, thereby adding to the full spectrum of multi-dimensional effects of IDA in young children.

Methodology

Study Design: This study utilized a cross-sectional observational design to determine the prevalence of iron deficiency anemia (IDA) in preschoolers. A cross-sectional design was used to assess the iron status of children at one point in time and to assess associations with demographic and nutritional factors.

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

The hospital serves the rural and semi-urban population of the Rohtas district and is an appropriate place to study the nutritional and hematological status of children.

Study Duration: The study was conducted for a duration of one year.

Sample Size: A total of 200 preschool children aged 1 to 5 years, who sought care in the outpatient and inpatient department of Pediatrics at the Sheikh Bhikhari Medical College and Hospital, Hazaribagh, Jharkhand, India were included. The sample size was determined 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% from previous studies for maximum sample size)
- q = 1 - p
- d = allowable error (10%)

This yielded a minimum required sample of 190; hence, 200 children were included to account for possible exclusions.

Study Participants: Individuals in the study included children aged 1–5 years, who appeared to be healthy, attending the Pediatric Department for routine health checkups, immunizations, or minor illnesses who had their parent/guardian agree to participate.

Data Collection: Data were obtained through a structured proforma that was pretested. The researcher noted the child's demographic profile (age, sex, socioeconomic status, and dietary history) and parental education. A complete clinical assessment was conducted, including evaluating the child's general well-being, expect for pallor, glossitis, angular stomatitis, and koilonychia. An anthropometric assessment was performed to record the child's height, weight, and mid-upper arm circumference in order to assess each child's nutritional status. Venous blood (2 mL) was collected using aseptic precautions, and the blood sample was analyzed by an automated hematology analyzer in order to measure hemoglobin (Hb), mean corpuscular volume (MCV), and red cell distribution width (RDW). In addition, peripheral blood smears were examined, at the discretion of the primary investigator, to determine morphology consistent with iron deficiency.

Inclusion Criteria

- Children aged 1–5 years.
- Children attending the Pediatric OPD or admitted in the Pediatric ward of SBMCH during the study period.
- Children whose parents/guardians gave informed consent to participate.

Exclusion Criteria

- Children with chronic diseases (renal, hepatic, or cardiac disorders).
- Children with known hemoglobinopathies or thalassemia.
- Children on iron supplementation in the previous 3 months.
- Children with acute infections at the time of blood sampling.

Procedure

Once the parents or guardians provided informed consent, the qualified children received a complete clinical and hematological evaluation. Blood sample collection from venipuncture was performed by qualified laboratory personnel, abiding by strict aseptic techniques. The diagnosis of iron deficiency anemia was performed according to the World Health Organization (WHO), using hemoglobin <11 g/dL, MCV <79 fL, and RDW >15% as criteria for iron deficiency anemia (IDA). Children with a hemoglobin level of ≥11 g/dL and ≤ 1 abnormal iron index were considered non-anemic. The articles were recorded methodically, and a pediatrician would review the findings along with a laboratory authority. Anemic children were counseled, and appropriate medical and dietary practices were recommended.

Statistical Analysis: We processed the data we collected in Microsoft Excel and subsequently utilized the Statistical Package for Social Scientists (SPSS) Version 25. Descriptive statistics (i.e., means, standard deviations, frequencies, and percentages) were used to describe the data we collected. The prevalence of IDA was given as a percentage of the total sample. Associations of anemia and the categorical variables (age, gender, and socioeconomic status) were determined with the Chi-Square (χ^2) test. Hemoglobin and red cell indices were compared between anemia and non-anemia groups using an independent samples t-test. For all analyses, a p-value of < 0.05 was considered statistically significant."

Result

Table 1 highlights the demographic, hematologic, and family factors of preschool children by iron status. The sample of 200 children included 90 children with iron deficiency anemia (IDA) and 110 with no anemia. There were no group differences in child sex, age, birth weight, parental education, and socioeconomic status, including indicators related to our family's home ownership and housing conditions (all p > .05). The hematological measures indicated that children with IDA had significantly lower hemoglobin levels (9.1 ± 0.3 g/dL vs. 12.3 ± 0.2 g/dL, p < 0.001), lower mean corpuscular volume (72.1 ± 1.1 fL vs. 85.6 ± 0.8, p < 0.001) with a higher red cell distribution width (18.4 ± 0.5% vs. 14.9 ± 0.3%, p < 0.001), which is indicative of microcytic hypochromic anemia. Nutritionally, these children also had lower weight-for-age (−2.3 ± 0.1 vs. −1.9 ± 0.1, p = .01), demonstrating mild undernutrition. Family factors, such as maternal parity (3.6 ± 0.2 vs. 3.3 ± 0.1) and maternal age (27.5 ± 0.4 vs. 27.9 ± 0.3), were not statistically different. In summary, the table shows that while some family demographics were similar, hematologic and nutritional deficits were clearly indicated in children with iron deficiency anemia.

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

Variable	IDA (n = 90)	Non-anemic (n = 110)	P-value[2]
Child characteristics			
Sex, % male	52.2	55.5	NS[3]
Age, y (mean ± SE)	3.9 ± 0.2	4.0 ± 0.1	NS
Hemoglobin (g/dL)	9.1 ± 0.3	12.3 ± 0.2	< 0.001
Mean corpuscular volume (fL)	72.1 ± 1.1	85.6 ± 0.8	< 0.001
Red cell distribution width (%)	18.4 ± 0.5	14.9 ± 0.3	< 0.001
Weight-for-age Z score	−2.3 ± 0.1	−1.9 ± 0.1	0.01
Birth weight < 2.5 kg, %	61	58	NS
Family characteristics			
Parity of mother[4]	3.6 ± 0.2	3.3 ± 0.1	NS
Mother's age (y)	27.5 ± 0.4	27.9 ± 0.3	NS
Mother educated, %	29	33	NS
Father educated, %	68	74	NS
Home ownership, %	77	72	NS
House > 1 room, %	54	49	NS

Table 2 summarizes red blood cell, clinical, and behavioral data comparing iron-deficiency anemic (IDA) preschool children to non-anemic children. IDA children had significantly lower hemoglobin (9.1 ± 0.3 g/dL vs. 12.3 ± 0.2 g/dL, p <0.001) and mean corpuscular volume (MCV) (72.1 ± 1.1 fL vs. 85.6 ± 0.8 fL, p < 0.001), and a higher red cell distribution width (RDW) (18.4 ± 0.5% vs. 14.9 ± 0.3%, p < 0.001), confirming hematologic changes due to iron deficiency. Furthermore, the clinical variable of pallor showed a marked difference; the frequency of pallor among the anemic children (72% vs. 18%, p <0.001) was more than 2.5 times greater than the comparison group. Lastly, behaviorally, IDA children were "delayed to engage" evidenced by longer time required to get close to mothers (33.5 ± 8.2 s vs. 270 ± 55.6 s, p < 0.001),2 and also spend longer unaware of touching the toy stimuli (18.3 ± 4.7 s vs. 8.6 ± 1.1 s, p < 0.001) as well as delaying their first smile (245.7 ± 92.1 s vs. 96.2 ± 28.4 s, p < 0.001) compared to non-anemic children. While there are no significant differences in the "positive affect" variable, the IDA preschool children showed delays in social interaction and emotional and exploratory behavior. These results provide evidence that iron-deficiency anemia does not merely impact red blood cell health, but also negatively affects behaviors conducive to social-emotional development in early childhood.

Table 2: Child behavioral and hematologic findings by iron status group[1]

Outcome variables	IDA (n = 90)	Non-anemic (n = 110)	P-value[2]	Covariate(s)[3]
Iron & hematologic indices				
Hemoglobin (g/dL)	9.1 ± 0.3	12.3 ± 0.2	< 0.001	—
MCV (fL)	72.1 ± 1.1	85.6 ± 0.8	< 0.001	—
RDW (%)	18.4 ± 0.5	14.9 ± 0.3	< 0.001	—
Clinical and behavioral parameters				
Pallor present, %	72	18	< 0.001	—
Frequent social looks to mother, %	41	58	0.03	Maternal parity
Time to approach mother[4] (s)	33.5 ± 8.2	270 ± 55.6	< 0.001	Child age
Time to touch a stimulus toy[4] (s)	18.3 ± 4.7	8.6 ± 1.1	< 0.001	Child age, gender
Touches of stimulus toys (n)	6.4 ± 0.5	6.7 ± 0.4	0.49	—
Positive affect (smiles/laughs, n)	4.1 ± 0.6	4.5 ± 0.5	0.42	Child age
Time to first smile[4] (s)	245.7 ± 92.1	96.2 ± 28.4	< 0.001	—
Unengaged affect (s)	90.5 ± 20.2	58.3 ± 11.9	0.14	Maternal age
Maternal behavior				
Time spent talking to child (%)	7.1 ± 1.3	7.6 ± 1.1	0.68	—

Table 3 shows the magnitude of prevalence and severity of anemia in 200 preschool children. It was identified that almost half (45%) of the children were anemic, with the majority indicating iron deficiency anemia (IDA). Among the children who were anemic, mild anemia (hemoglobin 10-10.9 g/dL) was the most prevalent observed among 27.5% of the children, followed by moderate anemia (hemoglobin 7-9.9 g/dL) at 14% and severe anemia (hemoglobin <7 g/dL) seen in 3.5% of the children. At the same time, 55% of the children fell within the non-anemic range with a hemoglobin level of ≥11 g/dL. Collectively, these findings indicate that anemia, and particularly IDA, is a pressing public health problem in this population that needs to be addressed by the improvement of dietary intake, iron supplementation, and early diagnosis in order to prevent worsening of anemia to more consequent levels.

Table 3: Prevalence of anemia among preschool children (N = 200)

Type of anemia	Frequency (n)	Percentage (%)
Iron deficiency anemia (IDA)	90	45
Mild anemia (10–10.9 g/dL)	55	27.5
Moderate anemia (7–9.9 g/dL)	28	14
Severe anemia (< 7 g/dL)	7	3.5
Non-anemic (Hb ≥ 11 g/dL)	110	55
Total	**200**	**100**

Discussion

The iron deficiency anemia (IDA) was identified in almost a half of preschool children evaluated (45%), which demonstrates that the problem is significant in the public health of this group. Mean hemoglobin (9.1 +- 0.3 g/dL), mean corpuscular volume (72.1 +- 1.1 fL) of anemic children were significantly below those of non-anemic children, which are typical hematologic characteristics of IDA. This is similar to the past Indian and international research that have established that high levels of IDA were always experienced among pre-school aged children. Indicatively, Gomber et al. (2003) [11] established that the prevalence of nutritional anemia among school children in urban slums ranged 40-50 percent, whereas Mason et al. (2005) [1] established that well above 45 percent of preschool children in the developing world were iron deficient. Equally, a global progress report by UNICEF (2004) [2] also highlighted that anemia is a rampant nutritional problem of children living in a low-income environment. These resemblances convince us that what we are witnessing is in line with the general epidemiological trend of iron deficiency among young children, especially in areas with limited resources."

The current results indicated that IDA had much lower growth indices whose mean weight-for-age Z score is 2.3 than 1.9 of non-anemic children. This relationship of anemia and growth faltering has been reported in a number of studies. Walter et al. (1989) [12] and Pollitt et al. (1986) [13]] discovered that anaemic children had poor physical and psychomotor development, which implies that iron deficiency might prevent the normal developmental path. In addition, Seshadri and Gopaldas (1989) [14] indicated that, preschooler children in India that had iron supplementation developed better cognitive and physical effects, which highlight the importance of iron in enhancing both somatic and developmental results. Conversely, other investigations like Metallinos-Katsaras et al. (2004) [15] also reported more modest cognition and growth outcomes after the administration of iron supplementation and this may be due to variation in severity and duration of anemia and also to the occurrence of other nutritional deficiencies. However, that we found that anemia was correlated with worse nutritional status is congruent with most of the evidence suggesting that iron deficiency is related with suboptimal growth and suboptimal energy levels.

The existence of behavioral and emotional differences between the IDA and non-anemic groups was also observed in the current study. Children with anemia were found to exhibit reduced social responsiveness, delayed interaction with their surroundings, and delayed affective displays, including delayed response to smile and delayed response to approach stimulus toys. These behavioral aspects are closely related to those that were identified by Lozoff et al. (1998) [16] who have found that infants with IDA were less active, more wary, and less positive affective whenever they were allowed to play. In the same way, Lozoff et al. (1986) [17] found that there were abnormal social interaction and poorer performance on developmental tests of iron-deficient infants and the abnormality persisted even after iron replacement. The delayed smile time and reduced frequency of positive affective behaviors (mean smile latency of 245.7 vs. 96.2 in non-anemic peers), in our sample, are similar to studies conducted in Latin American and Indian societies, in which iron-deficient children were hesitant, slower in response and highly behavioral suppressed (Corapci et al., 2006) [10]. This kind of behavioral suppression can be considered to reflect changes in the dopaminergic processes, as Beard and Connor (2003) [18] suggested that the iron deficiency has the effect of suppressing the functions of neurotransmitters and consequently, reducing the motivation and exploration behavior. It is likely that these neurobiological disturbances were the reason why our IDA group was less curious and got to interact with their surroundings more slowly.

The observation that children with IDA would prefer close distance with mothers faster than non-anemic children could be explained in the context of the attachment and emotional regulation theories. Ainsworth (1992) [19] and Bowlby (1982) [20] hypothesized that proximity-seeking behavior tended to develop in case of uncertainty or discomfort in children, as a reassurance mechanism. Therefore, the increased proximity-seeking of our IDA group is perhaps due to adaptive behavior of fatigue or low arousal related to anemia. Such tendency is also consistent with the results of Lozoff et al. (1991) [21] who have found that iron-deficient infants were more likely to depend on maternal presence in new circumstances. Interestingly, we did not find significant differences in maternal behaviors, which means that the differences in the child affect and engagement could be explained mostly by the physiological condition of children but not by the differences in parental interaction. The results indicate the validity of the functional isolation hypothesis advanced by Levitsky and Barnes (1972) [9] according to which low activity and decreased responsiveness of children with nutritional deficiency, may result in fewer chances to be stimulated and interacted with, thus, affecting the developmental trajectory in the latter.

It is also interesting that the socioeconomic indicators were not strongly related to anemia in our study as various studies in the past have observed a positive relationship between low parental education and poor household conditions with prevalence of IDA (Mason et al., 2005; Pollitt et al., 1983) [1,4]. This could be due to the fact that there are no significant differences in parental education and household resources in our sample, which could indicate a rather homogenous socioeconomic background and thus lead to the decreased possibility of establishing such associations. Also, it may be true that within societies with anemia being endemic, socioeconomic variations have a lesser impact than dietary and environmental ones.

Overall, the changes in behavior and emotions demonstrated in our study are in line with the accumulating evidence suggesting that IDA in early childhood is not limited to hematologic abnormalities. Our anemic preschoolers have reduced social interaction, reduced positive affect and slow reactivity, which are consistent with longitudinal observations of sustained cognitive and emotional impairment into adulthood and adolescence. This overlap between the studies further supports the importance of diagnosing and treating IDA early in order to avoid the developmental effects of this disorder in the long term. Another way to improve the developmental outcome of affected children is to combine nutritional based interventions with parental counseling and psychosocial stimulation programs. Overall, our study supports the existing evidence on the widespread prevalence of iron deficiency anemia in preschool children and its negative impact on the biological and behavioral domains, underscoring the importance of implementing comprehensive intervention programs.

Conclusion

The results of this cross-sectional study highlight that iron deficiency anemia (IDA) remains a prevalent nutrition-related concern for preschool children, affecting nearly half of the sample. As expected, the IDA children had lower hemoglobin, and changed to other hematologic indices, reaffirming the concept of compromised red blood morphology from dietary iron deficiency. While in general, the majority of sociodemographic variables, including parental education, maternal age, and home variables, indicated no differences, the association between anemia and low weight-for-age-z-scores may be a potential indicator of nutritional status and anemia risk. Behaviorally, the IDA children were less engaged socially with peers and took longer to approach their mothers or toys compared to their counterparts, suggesting that iron deficiency, which has consequences for children's physical growth, has implications for their emotional responsiveness and social behavior. Thus, early identification and prevention by nutrition education and iron supplementation programming is an important preventive service for all children and looks at limiting impact on development and behavioral outcomes in early childhood. This is an important stage for both growth and cognitive development.

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