

A Cross-sectional Study on the Prevalence of Iron Deficiency Anemia among School-going Children

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Abstract:

Background: One of the most prevalent nutritional conditions among school-age children in underdeveloped nations, such as India, is iron deficiency anemia. Academic performance, immunity, cognitive development, and physical growth are all negatively impacted. Anemia in children and adolescents remains a major public health concern despite national control measures.

Objectives: The purpose of this study was to ascertain the prevalence of anaemia and iron deficiency anaemia in school-age children between the ages of 6 and 10, as well as to evaluate the relationship between these conditions and serum ferritin levels, age, and gender.

Methods: Over the course of a year, cross-sectional observational research was carried out at the pediatrics department of Darbhanga Medical College and Hospital in Bihar. Convenient sampling was used to enroll 120 school-age children between the ages of 6 and 10. Anthropometric measures, clinical examination, and laboratory tests such as serum ferritin levels, hemoglobin estimates, and complete blood counts were carried out. The World Health Organization's criteria were used for categorization of anaemia. Multiple linear regression analysis and descriptive statistics were two types of statistical analysis.

Results: Anaemia was 45% prevalent overall. 35.19% of children with anaemia had mild anaemia, 50% had moderate anaemia, and 14.81% had severe anaemia. Ten percent of subjects had an iron deficit. There was no statistically significant correlation between serum ferritin levels, age, or gender and hemoglobin levels.

Conclusion: Children in school have a high prevalence of anaemia, with mild anaemia being the most frequent kind. The results underline the multidimensional nature of anaemia and the necessity of dietary treatments, thorough school-based screening, and bolstering current anaemia management initiatives.

Keyword: Iron Deficiency Anaemia, Pediatric Population, WHO Anaemia Classification, Serum Ferritin.

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Introduction

According to WHO estimates, two billion people suffer from anaemia, with iron deficiency accounting for around half of all cases [1]. One of the nations with the highest rates of anaemia worldwide is India. Anaemia is a public health issue that affects teenagers as well as pregnant women, babies, and young children. It is a sign of undernutrition and low dietary intake of iron. Adolescents with iron deficiency anaemia may experience stunted growth, heightened vulnerability to illness, impaired mental development, and difficulty learning [2].

The Indian government has chosen to launch the Weekly Iron and Folic Acid Supplementation (WIFS) Program to fight anaemia in teenagers.

Teenage girls and boys in grades VI through XII who are enrolled in government, government-aided, or municipal schools through the school platform and those who are not enrolled through the Anganwadi center platform would be covered by the program [3].

Nutritional (vitamin B12, folate, and iron deficiencies), clinical (infectious diseases like HIV/AIDS, tuberculosis, malaria, general inflammatory disorders, and helminthes infections), socioeconomic (parents' educational attainment and low household income), and demographic (age, gender, and family size) factors can all be risk factors for anaemia, a multifactorial health issue [4,5].

Poor cognitive function, poor development in infants, preschoolers, and school-age children, impaired physical capacity, poor performance in adolescents and adults, decreased immune competence, and increased morbidity from infections in all age groups are just a few of the many negative effects of anaemia [6]. In children in Africa, severe anaemia is a straightforward condition that significantly increases morbidity and death [7].

An iron balance, that is, the quantity absorbed by the gut may not be sufficient to satisfy the body's needs; causes iron deficit. On the other hand, if there is insufficient haemopoietic nutrition delivery, the bone malfunctioning, hemoglobin levels are abnormal, and anaemia develops. Age, sex, race, pregnancy, breastfeeding, and altitude all affect iron requirements. Due to the various variables that contribute to the development of anaemia in children, knowledge of its prevalence, distribution, and etiology are crucial for taking precise steps to prevent and control it.

Low iron consumption is the cause of 50% of anaemia. Malnutrition (low intake) and high iron requirements during child development are the main risk factors for low iron intake among young children in developing nations. Because of the complex environment, the difficulty of anaemia risk factors, and possible interactions between them, a single strategy to reduce anaemia in developing nations may not be very effective. A comprehensive approach is needed to prevent and manage anaemia [8].

While erythropoietin regulates the release of red blood cells (RBC) from bone marrow, which is made from interstitial fibroblasts in the kidney, erythrocytes, or red blood cells, show the amount of hemoglobin. In the meanwhile, the generation of new cells may be impacted by disruptions in a number of vital vitamin supplements. Iron must be incorporated into the final Hb molecule, whereas vitamins B2 (riboflavin) [9] and B6 (pyridoxine) [10] are necessary for the creation of the globin protein. The availability of hemoglobin in the blood was affected by physiological variables like gestation and environmental factors like oxygen, high altitude, and smoking [11].

The frequency of anaemia among children in India ranges from 52 to 96.50%, according to several research. The primary method for treating anaemia and enhancing the hemoglobin status of teenage females is still iron folic acid supplementation, with dietary supplements serving as a supplement. Eating a healthy, iron-rich diet is the most essential approach to prevent anaemia. Children should also be given vitamin C or meals high in vitamin C, which can enhance iron absorption. [12].

A common and urgent problem among school-age children, iron deficiency anaemia has detrimental effects on their growth, health, and academic

achievement. This age group has a significant prevalence of anaemia, which highlights the need for immediate and concerted public health initiatives to improve dietary practices, strengthen iron supplementation programs, and address underlying socioeconomic and health-related issues. We can greatly lessen the burden of iron deficiency anaemia and enhance school-age children's general wellbeing and future potential by placing a high priority on early identification, treatment, and preventative measures.

Methodology

Study Design: The purpose of this cross-sectional observational study, which was carried out at a hospital, was to ascertain the prevalence of iron deficiency anaemia in school-age children.

Study Area: The study was conducted in the Department of Pediatrics at Darbhanga Medical College and Hospital, Laheriasarai, Darbhanga, Bihar, India.

Study Duration: The study was carried out during a one-year period.

Study Population: School-age children between the ages of 6 and 10 who were either screened during school health programs or attended the pediatric outpatient department made up the research group.

Sample Size: The research involved 120 kids in total. A 95% confidence interval, a 10% allowed error, and practicality throughout the study period were taken into account while determining the sample size, which was based on prior research showing anaemia prevalence of around 45% among school-age children. A sample size of 120 children was deemed sufficient to determine the prevalence of iron deficient anaemia based on these criteria.

Sampling Method: A practical sampling method was applied. Until the necessary sample size was reached, children who met the inclusion criteria were enrolled one after the other.

Inclusion Criteria

- Children aged 6–10 years
- Both male and female children
- School-going children attending:
 - Pediatric outpatient department, or
 - School health screening programs
- Children whose parents/guardians gave written informed consent

Exclusion Criteria

- Children with known hematological disorders (e.g., thalassemia, sickle cell anemia)
- Children with chronic systemic illnesses affecting hematological status
- Children receiving iron supplementation in the preceding 3 months

- Children with acute infections at the time of evaluation

Study Procedure: The study was carried out among school-age children between the ages of 6 and 10 who attended the pediatric outpatient department and took part in school health screening programs at Darbhanga Medical College and Hospital after receiving clearance from the Institutional Ethics Committee. Before enrolment, parents or legal guardians provided written informed permission. Until the required sample size was reached, children who met the inclusion criteria were enrolled one after the other. Every participant got a thorough clinical evaluation, which included a general physical examination and a history collection that focused on food habits and symptoms indicative of anaemia. Anthropometric measurements such as height and weight were recorded using standard techniques, and body mass index (BMI) was calculated. Strict aseptic procedures were followed for collecting venous blood samples for hematological and biochemical analyses. Serum ferritin levels were evaluated to assess iron storage, while hemoglobin estimates and complete blood counts were used to determine anaemia status. Reduced hemoglobin levels and low serum ferritin levels were used to identify iron deficiency anaemia, which was categorized and graded using World Health Organization standards.

Data Collection: A pre-made and pre-tested organized proforma was used to gather data, which comprised anthropometric measurements, clinical findings, laboratory investigation results, and demographic information including age and gender. Each participant's laboratory results, such as serum ferritin levels and hemoglobin concentration, were noted. Based on hemoglobin levels, anaemia severity was classified as mild, moderate, or severe. Before being entered into a Microsoft Excel spreadsheet, all gathered data was verified for correctness

and completeness. In order to ascertain the prevalence of anaemia, severity distribution, iron deficiency status, and their correlation with demographic characteristics, the collected dataset was then processed for statistical analysis.

Statistical Analysis: The gathered data was imported into Microsoft Excel, and the relevant statistical software was used for analysis. The data was summarised using descriptive statistics, with continuous variables represented as mean and standard deviation and categorical variables as frequencies and percentages. The study population's iron deficiency and anaemia prevalence were computed as a percentage. The World Health Organization classified anaemia severity into three categories: mild, moderate, and severe. The relationship between hemoglobin levels and biochemical markers, such as serum ferritin levels, and demographic factors, such as age group and gender, was evaluated using multiple linear regression analysis. Regression coefficients with matching standard errors, t values, and p values were used to express the findings. Statistical significance was defined as a p value of less than 0.05.

Result

Table 1 shows the age-wise distribution of the study participants. A total of 120 school age children between 6 and 10 years of age were enrolled in the study and divided into three age groups. Of the overall sample, 36 children (30.0%) belonged to 6–7 years age group, 48 children (40.0%) belonged to 8–9 years age group, and 36 children (30.0%) were 10 years old. The 8–9-year-old age group comprised the biggest proportion of participants, and the 6–7-year-old and 10-year-old age groups were equally represented. The distribution shows an even inclusion of children in the targeted age range, thereby assuring enough representation for age-related comparisons and analyses in the study.

Table 1: Age-wise Distribution of Participants

Age Group	Number	Percentage (%)
6–7 years	36	30
8–9 years	48	40
10 years	36	30
Total	120	100

Male and female youngsters were equally represented among the research participants, according to Table 2's gender distribution. There were 60 (50.0%) boys and 60 (50.0%) girls among the 120

youngsters. An accurate comparison of anaemia prevalence between male and female participants was made possible by this equal distribution, which reduced gender bias.

Table 2: Gender-wise Distribution of Participants

Gender	Number	Percentage (%)
Male	60	50
Female	60	50
Total	120	100

Hemoglobin estimate was used to determine the prevalence of anaemia in the study population. Table 3 shows that of the 120 children in the research, 54 (45.0%) had anaemia and 66 (55.0%) had normal

hemoglobin levels. Anaemia is a major public health problem in this age range, as evidenced by the relatively high frequency of the condition, which affected over half of the school-age children.

Table 3: Prevalence of Anemia		
Anemia Status	Number	Percentage (%)
Anemic	54	45
Non-Anemic	66	55
Total	120	100

Table 4 presents an analysis of the 54 anaemic children's anaemia severity. Nineteen children (35.19%) had mild anaemia, twenty-seven children (50.0%) had moderate anaemia, and eight children (14.81%) had severe anaemia. A lesser percentage of children

with anaemia had severe anaemia, whereas the majority had moderate anaemia, followed by mild anaemia. This result emphasises how crucial early identification and treatment are to halting the development of severe anaemia.

Table 4: Severity of Anemia among Anemic Patients		
Anemia Severity	Number	Percentage (%)
Mild	19	35.19
Moderate	27	50
Severe	8	14.81
Total	54	100

Serum ferritin levels were used to assess the iron deficient status in Table 5. Twelve children (10.0%) were determined to be iron deficient out of the 120 participants, whereas 108 children (90.0%) had

normal iron storage. Iron deficiency is still a significant contributing factor to anaemia and calls for targeted dietary treatments, even if the percentage of children with iron deficiency was relatively low.

Table 5: Iron Deficiency among Participants		
Iron Deficiency Status	Number	Percentage (%)
Normal	108	90
Iron Deficient	12	10
Total	120	100

Table 6 shows the outcome of multiple linear regression analysis to evaluate the effect of age group, gender, and serum ferritin level on the level of haemoglobin in study population. The constant was statistically significant ($\beta = 10.82$; $p < 0.001$) and represents the level of hemoglobin at baseline, or when all predictor variables are considered equal. The age groups 6-7 years and 8-9 years had negative regression coefficients relative to the reference age group (10 years) but this was not statistically significant ($p = 0.492$ and $p = 0.872$ respectively). Likewise, there

was no significant correlation between gender (male) and hemoglobin concentration ($\beta = 0.10$, $p = 0.704$). Serum ferritin levels showed positive association with hemoglobin concentration ($\beta = 0.01$) but it did not reach statistical significance ($p = 0.365$). The overall results indicate that age group, gender and serum ferritin were not independent predictor factors for the concentration of hemoglobin in this population of school-age children, suggesting that other factors may play a role in the variation of hemoglobin levels seen in school-age children.

Table 6: Multiple Regression Analysis Results				
Variable	Coefficient	Standard Error	t-value	p-value
Constant	10.82	0.47	23.02	0
Age Group (6-7 years)	-0.22	0.32	-0.69	0.492
Age Group (8-9 years)	-0.05	0.32	-0.16	0.872
Gender (Male)	0.1	0.26	0.38	0.704
Serum Ferritin (ng/mL)	0.01	0.01	0.91	0.365

Discussion

Despite being widespread, nutritional anaemia is more problematic in underdeveloped nations due to its high incidence. Despite its high incidence in

children, there is very few research from poor nations on its prevalence in adolescents, particularly boys. Adolescence is a time of fast growth, and one is susceptible to a variety of nutritional morbidities

due to poor and insufficient eating habits. The issue is made worse by worm infestation and malnutrition.

According to recent research done in semi-urban Nepal, 68.8% of teenage females between the ages of 11 and 18 had anaemia [13]. The frequency of anaemia in females has been reported to be between 25 and 30 percent in several less developed nations, such as Bangladesh, Indonesia, and Peru [14].

In government school-based research from North-east Delhi's intermediate socioeconomic group, Agarwal et al. [15] found that 45% of participants had anaemia. Anaemia prevalence ranged from 46% to 98%, according to research conducted in several rural Indian states [16,17,18]. The most prevalent and frequent nutritional condition in the world is iron insufficiency. Despite efforts to reduce the frequency, the prevalence varies globally, with greater rates in underdeveloped nations [19, 20].

The body's iron insufficiency can be described in three stages, according to Herceberg et al. [21]. First, an isolated drop in serum ferritin below 15 mg/l (in children) is indicative of the simple depletion of tissue iron reserves without erythropoiesis deficiency. Then, a reduction in serum iron, an increase in transferrin and total iron binding capacity, a disruption of standard erythrocyte parameters, and a drop in the coefficient saturation of transferrin are all associated with the depletion of reserves and erythropoiesis insufficiency. Iron deficiency anaemia is the last stage when anaemia may be identified due to a drop in hemoglobin below the threshold.

This pattern is consistent with research by Verma et al. (2021), which found that children between the ages of 9 and 10 had the highest frequency of anaemia. Anaemia was more prevalent in middle childhood, according to related research by Gupta et al. (2020), indicating that this age group is more sensitive because of the higher nutritional requirements for growth and development [22]. In terms of gender distribution, our study kept the proportion of male and female participants equal (50% each), enabling an objective evaluation of gender disparities in the prevalence of anaemia. Studies by Sharma et al. (2019) and Singh et al. (2022) found a slightly greater prevalence of anaemia in females, however our results showed no significant gender-based difference in hemoglobin levels ($p = 0.6788$).

With an overall frequency of 45%, the current cross-sectional study emphasizes anaemia as a serious public health issue among school-age children aged 6 to 10. This result is consistent with a number of Indian research that show a significant prevalence of anaemia in this age range, indicating continued dietary deficiencies in spite of public health initiatives. The most frequent severity found was moderate anaemia, highlighting the possibility of negative impacts on growth, cognitive development, and academic achievement if prompt measures are not

carried out. The significant frequency of anaemia indicates a complicated etiology, including deficits of other micronutrients, infections, and socioeconomic factors, even though iron deficiency was found in only 10% of children. Anaemia in school-age children cannot be explained by iron insufficiency alone, as seen by the lack of significant correlations between hemoglobin levels and age, gender, or serum ferritin. In order to successfully manage anaemia in this vulnerable group, our findings highlight the need for comprehensive measures that include regular screening, dietary variety, vitamin supplementation, and enhancement of school-based health initiatives.

Conclusion

The current study reveals that anaemia is a prevalent and substantial public health concern among school-aged children aged 6 to 10, with an overall frequency of 45%. A significant percentage of children also experienced severe anaemia, however moderate anaemia was the most prevalent severity. The majority of anaemia cases were not exclusively caused by iron deficiency, suggesting a multifactorial etiology, even if iron deficiency was found in a subgroup of children. The complexity of anaemia and the necessity of a comprehensive approach to its prevention and therapy are shown by the lack of a meaningful correlation between hemoglobin levels and age, gender, or serum ferritin. Essential tactics to lower the prevalence of anaemia include early detection, routine school health checks, nutritional counselling, dietary variety, iron and vitamin supplementation, and management of parasite infections. We came to the conclusion that in order to improve school-aged children's health, development, and academic performance as well as to end the intergenerational cycle of anaemia, it is imperative to expand public health programs and execute comprehensive nutritional treatments at the school and community level.

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