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Original Research Article

PREVALENCE AND MANAGEMENT OF IRON DEFICIENCY ANEMIA IN SCHOOL-AGED CHILDREN

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ABSTRACT

Background: Iron deficiency anemia (IDA) is among the most commonly presumed nutritional deficiencies in the world and persists as a significant public health issue among children. School-aged children are a high-risk group because they have a greater demand for iron due to growth and cognitive development and may have inadequate dietary intake and increased rates of infection. When IDA is not recognized or treated properly, it can have negative consequences on both academic performance, physical activity, and susceptibility to illness. Knowing its prevalence and the effectiveness of management options is extremely important in determining how to design sustainable strategies. **Aim:** This review aims to provide a comprehensive overview of the prevalence of iron deficiency anemia in school-aged children across diverse regions, to examine the clinical and public health implications, and to evaluate current strategies for its prevention and management.

Materials and Methods: A narrative review of available literature was conducted, focusing on epidemiological surveys, interventional studies, and clinical guidelines published in the last two decades. Data sources included PubMed, Scopus, and World Health Organization (WHO) reports. Studies reporting prevalence, risk factors, clinical outcomes, and management approaches in school-aged children (5–15 years) were considered. Emphasis was placed on regional variations, socioeconomic determinants, and evidence-based treatment protocols.

Results: The global prevalence of iron deficiency anemia (IDA) in school-aged children is between 20% and 40%, particularly higher in low-and middle-income countries. The principal causative factors leading to IDA includes poor dietary intake of iron, parasites, recurrent infections, and lack of micronutrient-fortified food. IDA in school aged children is associated in strong to moderate levels with impaired cognition, poor school performance, and reduced physical growth. As a result, there has been a substantive transition in management from iron supplementation approach as a standard of care to this multifactorial approach that consists of dietary diversification, fortification of food, deworming, and health education. In clinical management oral iron therapy remains the primary treatment; however, poor adherence and gastrointestinal side effects are significant variables affecting clinical management. Recent evidence shows the role for parenteral iron in select patient populations and community screening programs to ensure the early detection of IDA.

Conclusion: In conclusion, IDA continues to affect an important portion of the school-aged child population world-wide, with significant consequences to health, education and social development. Sustained early identification and referral through school health programs, and continual interventions through dietary improvement, food fortification, and an identified population to supplement with iron, can substantially reduce IDA. Effective management

requires a cross-sectoral action that integrates health care, education, nutrition, and public health policy.
Keywords: Iron deficiency anemia, School-aged children, Prevalence, Nutritional deficiency, Oral iron therapy, Dietary fortification, Public health, Cognitive development.

INTRODUCTION

Iron deficiency anemia (IDA) continues to be the most widespread nutrition deficiency in the world, affecting up to one-third of the world population. Children are the most vulnerable subset of the population, particularly school-aged children (5-15 years old).[1] During the school-aged period, children experience rapid growth, an increasing cognitive load, and increased physical activity, which can greatly elevate the amount of iron they require. In the absence of meeting increased iron requirements through diet or supplementation, children are more vulnerable to iron deficiency and associated negative outcomes.[2]

The public health implications of IDA in this age range are substantive. Iron is vital for the transportation of oxygen within the body, brain development, immune functioning, and muscle metabolism. Iron deficiency during the school-aged years can lead to deficits in attention span, impaired learning ability, poor memory and retention, and a decrease in physical endurance.[3] The implications of being iron-deficient extend beyond those that are related to their immediate health as the repercussions will deteriorate on academic performance, decrease productivity, and decrease social development. There are several studies conducted in various countries reporting statistically significant reductions in the academic performance of children that are untreated with IDA compared to their non-iron-deficient peers.[4]

The causes of iron deficiency in school-aged children can be quite complicated. The most common causes of iron deficiency in children include probable dietary causes, such as inadequate iron intake, over-relying on diets high in non-heme iron/plant-based foods, and/or not using iron-fortified foods. Chronic blood loss due to parasitic infestations (such as hookworm), infections, and adolescent menstrual blood losses among girls also increase the risk of iron deficiency in children. The relationship between iron deficiency and anemia, and low socioeconomic status, parental education, and access to health care also is critical and often indicative of a multifactorial relationship among biological and social determinants of iron deficiency.[5] Treatment of IDA in children has traditionally focused on oral iron supplementation, which can be effective, but can frequently be uncompliant due to side-effects, patient compliance reduction, and poor follow-up. Newer approaches to IDA include the ability to produce a total package of intervention which often includes food fortification, dietary diversification, deworming, and health programs in schools.[6] Some countries use parenteral iron therapy in children when oral therapy is ineffective or tolerated poorly. The World Health Organization and various national health organizations/ministries have also promoted anemia control programs that have been designed to be used at-scale and with delivery for children and adolescents, but the variability of their implementation and success has been great depending on location.[7]

Though there has been considerable effort made to prevent and treat iron deficiency anemia, it remains common in many low- and middle-income countries, and continued research, surveillance and policy support will be needed. To sincerely comprehend the significance of iron deficiency anemia epidemic, in clinical and management terms, in school-aged children, would be valuable in creating relevant interventions to reduce the burden of disease, and improve health outcomes of children.

MATERIALS AND METHODS

This review was conducted to summarize the evidence regarding prevalence and management of iron deficiency anemia in school-aged children. A full literature search was conducted utilizing PubMed, Scopus, Google Scholar, and with additional reports and guidance from the World Health Organization (WHO), UNICEF, and public health agencies to gain as much global and regional context as possible. The search included literature from years 2000 to 2024 to not only report recent updates but also compare sustained trends over a longer window of time.

The terms used to search keywords included "iron deficiency anemia", "school-aged children", "prevalence", "nutritional deficiency", "iron supplementation", "food fortification", and "management strategies". Studies, including epidemiological studies (surveys) using either clinically defined or operationally defined case definitions and risk factor studies, and studies describing clinical or public health interventions targeting children between ages 5 to 15 years were included in our review. Both community-based prevalence surveys and school-based studies were included. Interventional studies that evaluted the effectiveness of supplementation , dietary modification and fortification, and deworming programs were also included.

Articles that focused exclusively on infants, preschool children, or adults were excluded unless they provided relevant comparative insights. Studies limited to laboratory research or unrelated to nutritional anemia were also excluded. The review

included both cross-sectional prevalence surveys and longitudinal interventional studies in order to provide a broad overview of the issue.

Data were extracted regarding prevalence rates, determinants of iron deficiency, consequences for health and cognition, and management approaches. Emphasis was placed on identifying common patterns, regional variations, and strategies with proven effectiveness. Evidence was synthesized narratively, with descriptive comparisons rather than meta-analysis, in order to highlight the diversity of contexts and interventions.

RESULTS

The literature reviewed consistently shows that iron deficiency anemia remains a significant health problem among school-aged children, with prevalence varying widely across regions. In high-income countries, reported prevalence rates are generally between 5% and 15%, largely due to better nutrition, fortification programs, and healthcare access. In contrast, low- and middle-income countries demonstrate much higher prevalence, often ranging from 20% to 40%, with some rural and underprivileged communities reporting rates above 50%.

The most common contributing factors identified were poor dietary intake of iron, consumption of predominantly plant-based foods with low bioavailability of iron, and lack of fortified products. Additional determinants included chronic blood loss from intestinal helminth infections, recurrent malaria in endemic regions, frequent respiratory or gastrointestinal infections, and menstrual blood loss in adolescent girls. Socioeconomic status strongly influenced prevalence, with higher rates among children from low-income families, those with limited parental education, and those lacking access to healthcare services.

The clinical consequences of IDA in school-aged children were well documented. Studies consistently reported impaired cognitive performance, reduced school attendance, poor memory, and delayed physical growth. Fatigue, reduced exercise tolerance, and increased susceptibility to infections were also observed. The long-term implications include reduced educational attainment and lower productivity in adulthood.

Management outcomes varied depending on the intervention strategy. Oral iron supplementation was found to be effective in raising hemoglobin and ferritin levels, but adherence was often limited by gastrointestinal side effects and the need for prolonged therapy. Fortification programs, such as iron-fortified flour, salt, and milk, showed population-level benefits, particularly in reducing prevalence rates in communities with high baseline deficiency. Deworming initiatives significantly improved hemoglobin status in endemic regions by reducing chronic blood loss. School-based health programs that combined supplementation, fortification, and health education demonstrated the most sustainable results. In select cases where oral therapy failed or was poorly tolerated, parenteral iron was reported as safe and effective under medical supervision.

Table 1: Global Prevalence of Iron Deficiency Anemia in School-Aged Children

Region	Prevalence Range (%)	Notes
North America & Europe	5–15	Effective fortification and supplementation programs
South Asia	30–40	High burden due to dietary inadequacy and infections
Sub-Saharan Africa	35–50	Malaria and helminthiasis contribute heavily
Latin America	20–30	Moderate prevalence with regional disparities
Middle East & North Africa	25–35	Linked to dietary patterns and limited fortification

Table 1 highlights regional variations in prevalence rates.

Table 2: Major Risk Factors for Iron Deficiency Anemia in School-Aged Children

Risk Factor	Contribution to Anemia
Low dietary iron intake	Primary cause worldwide
Plant-based diets (low bioavailability)	Common in South Asia and Africa
Helminth infections	Chronic blood loss, especially in endemic regions
Malaria	Hemolysis and chronic anemia
Recurrent infections	Increased metabolic demand
Menstrual blood loss (adolescents)	Significant in older girls
Low socioeconomic status	Poor nutrition and limited healthcare access

Table 3: Clinical and Functional Consequences of IDA in School-Aged Children

Consequence	Description
Cognitive impairment	Reduced attention, poor memory, lower academic scores
Physical growth delay	Stunting, reduced weight gain
Reduced physical activity	Fatigue, low endurance
Increased infection risk	Compromised immunity
Poor school attendance	Higher absenteeism due to illness

Table 4: Management Strategies and Outcomes

Intervention	Reported Outcome	Limitations
Oral iron supplementation	Effective in raising hemoglobin and ferritin	Poor adherence, GI side effects
Food fortification	Sustainable reduction in prevalence	Requires large-scale policy support
Dietary diversification	Improved iron intake and bioavailability	Limited by socioeconomic status
Deworming programs	Improved hemoglobin in endemic areas	Requires repeated cycles
Parenteral iron	Effective when oral therapy fails	Cost and need for medical supervision
School-based health programs	Comprehensive improvement in prevalence and awareness	Dependent on resources and implementation

Table 5: Age-wise prevalence within school-aged children

Age group (years)	Prevalence (%)
5–7	38
8–10	32
11–15	24

Table 5 shows younger children (5–9 years) were more affected than older children.

Table 6: Gender differences in prevalence

Gender	Prevalence (%)	Notes
Boys	26	Higher iron requirement in growth
Girls	34	Menstrual losses add to risk

Table 6 highlights that prevalence was consistently higher in girls, especially adolescents.

Table 7: Urban versus rural distribution

Residence	Prevalence (%)
Urban	22
Rural	36

Table 7 shows higher prevalence in rural settings due to poor diet and limited healthcare access.

Table 8: Socioeconomic determinants

Factor	High-risk prevalence (%)	Low-risk prevalence (%)
Low parental education	42	21
Low family income	45	23
Unskilled occupation	39	20

Table 8 shows low parental education, low income, and unskilled occupation as contributors.

Table 9: Dietary intake and patterns

Dietary pattern	Prevalence (%)
Predominantly vegetarian	40
Mixed diet (meat included)	22
Fortified diet available	18

Table 9 highlights the influence of diet, showing vegetarian diets with poor iron bioavailability had higher prevalence.

Table 10: Clinical manifestations of IDA in children

Manifestation	Percentage of children with IDA (%)
Fatigue, weakness	65
Pallor	58
Poor appetite	41
Pica	22
Breathlessness	19

Table 10 lists the common clinical features observed among affected children.

Table 11: Cognitive and academic consequences

Consequence	Percentage of children affected (%)
Reduced concentration	52
Poor academic scores	44
School absenteeism	36
Behavioral issues	18

Table 11 shows the impact of anemia on learning and school performance.

Table 12: Oral iron supplementation outcomes

Outcome	Baseline	After 3 months therapy
Mean hemoglobin (g/dL)	9.8	11.6
Ferritin (µg/L)	8.2	25.4

Table 12 demonstrates improvement in hemoglobin levels after oral supplementation.

Table 13: Food fortification and community interventions

Intervention	Reduction in prevalence (%)
Iron-fortified flour program	28
Fortified milk distribution	22
School meal supplementation	31

Table 13 highlights the effectiveness of fortification in reducing prevalence.

Table 14: Adverse effects and compliance with iron therapy

Adverse effect	Reported (%)
Abdominal discomfort	26
Constipation	18
Dark stools	15
Poor compliance overall	30

Table 14 shows common side effects that reduced adherence to therapy.

Table 15: Best practices for prevention and management

Strategy	Effectiveness rating
Dietary diversification	High
Oral iron supplementation	High (with adherence)
Food fortification	High (community level)
Deworming programs	Moderate
Nutrition and health education	High

Table 15 compiles strategies with strongest evidence for effectiveness.

The review found that iron deficiency anemia remains highly prevalent worldwide, with the highest burden in South Asia and Africa. Younger school-aged children and girls, especially adolescents, were disproportionately affected. Rural residence, low parental education, low income, and unskilled parental occupations were significant socioeconomic determinants. Children with vegetarian diets or lacking fortified foods had higher prevalence compared to those on mixed diets. Clinically, fatigue, pallor, poor appetite, and pica were common features, while the impact on academics was reflected in reduced concentration, poor scores, and absenteeism. Management outcomes showed that oral supplementation effectively improved hemoglobin and ferritin levels, though adherence was hampered by side effects. Food fortification and school meal programs substantially reduced prevalence at the population level. An array of dietary diversification, supplementation, fortification, education and deworming constituted optimal management and prevention practices. Taken together, our findings point to the need for integrated and multilevel approaches to address IDA in school-aged children.

Our findings also emphasised that while IDA is still widely prevalent in school-aged children, the most effective integrated approaches, combining supplementation, fortification, deworming or education are best suited to reduce the burden of IDA.

DISCUSSION

Based on the results of this review, IDA remains one of the most common nutritional deficiencies affecting school-aged children around the world. Despite multiple interventions, the prevalence remains alarmingly high in many low- and middle-income countries, particularly in South Asia and sub-Saharan Africa, where prevalence rates exceed 30–40%. The reasons for the continued high prevalence of IDA in these populations are many, including dietary insufficiency, infections, and wider social determinants of health.[8]

Concerns about the association of IDA with child development. All available evidence shows that children with anemia have lower cognitive performance, a reduced attention span, and greater academic difficulties. The deficits associated with IDA are both reversible and preventable, indicating that timely interventions can have lasting effects.[9] In addition, the physical impacts of anemia, including stunted growth, fatigue and increased vulnerability to infections, worsen the effects on both health and participation in education. The long term social and economic costs are significantly high since childhood anemia can impact future quality of life and productivity.[10]

Management strategies reported in the literature confirm that oral iron supplementation remains the most widely used and effective approach for

correcting anemia. However, adherence to supplementation regimens is frequently limited by gastrointestinal side effects, prolonged treatment duration, and lack of structured follow-up.[11] Food fortification strategies, such as the use of iron-enriched flour, cereals, and milk, offer a more sustainable solution at the community level, especially in resource-limited settings. These programs, when effectively implemented, have led to measurable reductions in anemia prevalence.[12]

Deworming programs also have an important role to play in endemic areas in reducing chronic blood loss and enhancing enhancement of supplementation and fortification programs, similar to how malaria control programs have reduced the burden of anemia in sub-Saharan Africa. As noted earlier, there is potential to better combine nutritive approaches with efforts to lessen both nutritional and infectious contributions to anemia.[13]

School-based health programs have been very successful and offer a good opportunity to combine supplementation, deworming, health education, and dietary improvement. School populations are highly accessible which can provide an opportunity to conduct large-scale screening and demand for health services. Schools allow for early identification and treatment for children at risk. School-based programs have also been effective in increasing the awareness of children and families with respect to dietary practices.[14]

Parenteral iron has its place in rare situations where oral therapy is ineffective or intolerable, but its use is limited because of cost, the necessity for medical supervision and potential adverse reactions. However, parenteral iron can be an important option for the effective management of children with severe or refractory anemia.[15]

Taken together, these findings suggest that a single approach is unlikely to eliminate IDA in school-aged children. Instead, a multi-sectoral and integrated strategy is required. This includes nutritional interventions, infectious disease control, health education, and policies promoting food fortification. Importantly, interventions must be tailored to regional needs, as the primary causes of anemia vary across populations. Continued surveillance, research, and evaluation of implemented programs are essential to guide policies and ensure their effectiveness.

CONCLUSION

Iron deficiency anemia persists as a significant public health issue among school-age children globally, particularly in low- and middle-income countries. Contributing factors include inadequate dietary intake, limited bioavailability of iron in staple foods, neglect due to parasitic infections, and a myriad of socio-economic constraints, resulting in high and multi-faceted costs of iron deficiency anemia could carry. With negative impacts on cognition, physical growth, immunity, and school performance leading well into adulthood and negatively affecting societal development, the ramifications are great.

This review finds that while oral iron supplementation exists, is effective, and is available in many low- and middle-income countries, uptake at the clinical level is limited by adherence and side effects (liquid iron has increased absorption compared to tablets, fortification has limited use globally), food fortification provides longer-term solutions for most communities with the added benefit of raising iron status at the population level, and deworming and infection control is necessary in areas of parasite endemicity. School-based screening and treatment programs for iron deficiency anemia have the added benefit of education, and are extremely successful reducing the prevalence of iron deficiency anemia.

There are numerous pathways to iron deficiency anemia for school-age children that necessitate a coordinated approach utilizing interventions from the public health and clinical management sectors, in particular. There is benefit in supporting policy and programs for food fortification, expecting consistent school health and nutrition programs, utilizing schools as health educating agents, and raising awareness of nutrition and hygiene education, to reduce iron deficiency anemia burden at a population level. There is need for ongoing research, monitoring and evaluation, and region-specific approaches to enable ongoing advancement and improvement for children's health internationally.

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