

NUTRITIONAL ANAEMIA IN THE PEDIATRIC AGE GROUP: A COMPREHENSIVE REVIEW

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ABSTRACT

Nutritional anaemia is an important nutritional disorder affecting children worldwide. It develops when deficiencies of essential nutrients required for erythropoiesis lead to reduced haemoglobin concentration and impaired oxygen delivery to tissues. Iron deficiency is the most frequent nutritional contributor, while folate and vitamin B12 deficiencies may also cause anaemia. Rapid growth during infancy, childhood and adolescence increases nutritional requirements and may increase vulnerability. Inadequate dietary intake, poor absorption, recurrent infections, parasitic infestation and increased physiological requirements can further aggravate the problem. Clinical manifestations range from pallor and fatigue to reduced exercise tolerance, irritability and impaired concentration. Prolonged deficiency during childhood may adversely affect physical and neurodevelopmental outcomes.

Diagnosis requires appropriate clinical assessment and laboratory evaluation, with haemoglobin estimation and, when indicated, red-cell indices, ferritin and additional investigations. Management should address the underlying cause and may include dietary improvement, appropriate micronutrient supplementation and treatment of associated conditions. Prevention requires a life-course approach involving maternal nutrition, optimal infant feeding, dietary diversification, food fortification, supplementation and infection control.

KEYWORDS: Nutritional anaemia, children, iron deficiency, micronutrients, haemoglobin,

pediatric nutrition, iron deficiency anaemia.

1. INTRODUCTION

Anaemia is a condition in which haemoglobin concentration is below the level appropriate for an individual's age, sex and physiological status. Because haemoglobin carries oxygen to tissues, clinically important anaemia can affect several organ systems. WHO updated its haemoglobin cut-offs for defining anaemia in 2024 and emphasized age- and population-appropriate interpretation.

Nutritional anaemia refers to anaemia associated with inadequate availability of nutrients needed for normal erythrocyte production. Iron deficiency is the best-known nutritional cause, but deficiencies of folate and vitamin B12 may also contribute. Nutritional deficiencies can coexist with infection, inflammation, chronic disease, blood loss and inherited haemoglobin disorders; therefore, anaemia should not automatically be equated with iron deficiency.

Children are particularly vulnerable because nutrient requirements change rapidly during periods of growth. Infancy, early childhood and adolescence are important periods of increased demand. Poor dietary diversity, recurrent infections, intestinal parasitic infestation and chronic gastrointestinal conditions may increase the risk.

The consequences of childhood anaemia extend beyond a low haemoglobin value. Children may develop tiredness, reduced physical performance, poor concentration and, in prolonged deficiency, adverse developmental effects. Early recognition and appropriate management are therefore important.

2. OBJECTIVES

1. To describe the major nutritional causes of anaemia in children.
2. To discuss important risk factors for nutritional anaemia.
3. To describe clinical manifestations and the diagnostic approach.
4. To discuss principles of treatment and prevention.
5. To emphasize early recognition and appropriate nutritional intervention.

3. MAJOR NUTRITIONAL CAUSES

3.1 Iron deficiency

Iron deficiency is the most important nutritional contributor to anaemia in childhood. Iron is

required for haemoglobin synthesis and numerous cellular processes. Deficiency can develop when dietary intake is insufficient, absorption is impaired, requirements increase or iron losses occur.

Important risk factors include low dietary iron intake, inadequate complementary feeding, prematurity or low birth weight, rapid growth, chronic blood loss, intestinal parasitic infestation and malabsorption.

3.2 Folate deficiency

Folate is necessary for DNA synthesis and normal red-cell maturation. Inadequate intake, malabsorption and increased physiological requirements can lead to deficiency. Folate deficiency typically produces megaloblastic changes and macrocytic anaemia.

3.3 Vitamin B12 deficiency

Vitamin B12 is required for DNA synthesis and normal neurological function. Deficiency may cause megaloblastic anaemia and neurological manifestations. Risk may increase with severely restricted diets, malabsorption or gastrointestinal disease.

3.4 Multiple micronutrient deficiencies

Children with inadequate overall nutrition may have simultaneous deficiencies of several vitamins and minerals. Nutritional anaemia may consequently have multiple contributing factors rather than a single nutrient deficiency.

4. RISK FACTORS

Age/period	Important risk factors
Infancy	Prematurity, low birth weight, rapid growth, inadequate complementary feeding, low iron intake
Childhood	Poor dietary diversity, recurrent infections, parasitic infestation, chronic gastrointestinal disease, malabsorption
Adolescence	Rapid growth, increased nutrient requirements, restrictive diets, and menstrual blood loss in adolescent girls

5. CLINICAL MANIFESTATIONS

The clinical presentation depends on the severity, duration and underlying cause.

- Easy fatigability
- Weakness
- Reduced exercise tolerance
- Breathlessness on exertion

- Headache or dizziness
- Irritability or reduced concentration
- Pallor, particularly conjunctival pallor
- Tachycardia in significant anaemia
- Flow murmur in severe anaemia
- Poor weight gain or growth in prolonged nutritional deficiency

Severe or prolonged anaemia may result in cardiovascular stress, particularly when haemoglobin falls substantially or the decline occurs rapidly.

6. DIAGNOSTIC APPROACH

6.1 Complete blood count

Important parameters include haemoglobin, mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), red-cell distribution width (RDW) and red blood cell count. Iron deficiency commonly produces a microcytic, hypochromic pattern, although early deficiency may precede marked microcytosis.

6.2 Peripheral blood smear

Peripheral smear examination can provide information regarding cell size, colour, anisocytosis, poikilocytosis and other morphological abnormalities.

6.3 Serum ferritin

Serum ferritin is an important indicator of iron stores. Because ferritin is an acute-phase reactant, it can rise with inflammation or infection and should therefore be interpreted in clinical context.

6.4 Additional investigations

- Serum iron and transferrin saturation when indicated
- Reticulocyte count
- Inflammatory markers such as C-reactive protein when clinically appropriate
- Stool examination when parasitic infestation is suspected
- Serum vitamin B12 and folate
- Haemoglobin electrophoresis when a haemoglobinopathy is suspected

The investigation should be individualized. Persistent, severe or atypical anaemia requires evaluation for non-nutritional causes.

7. DIFFERENTIAL DIAGNOSIS

- Iron deficiency anaemia
- Thalassaemia syndromes
- Anaemia associated with chronic inflammation
- Lead toxicity and other disorders of haemoglobin synthesis
- Folate or vitamin B12 deficiency in macrocytic anaemia
- Bone marrow and systemic disorders when clinically suspected

8. MANAGEMENT

8.1 *Dietary management*

Dietary counselling is a central component of treatment. Children should receive a varied diet containing appropriate sources of iron, folate, vitamin B12, protein and other micronutrients. Suitable iron-containing foods may include pulses, legumes, green leafy vegetables, fortified foods, eggs and, where culturally appropriate, meat and other animal-source foods. Vitamin C-containing foods can improve absorption of non-haem iron.

Tea and coffee around meals can reduce iron absorption and should not routinely be given with iron-rich meals in children.

8.2 *Iron supplementation*

When iron deficiency is confirmed or strongly suspected, therapeutic iron should be prescribed according to the child's age, body weight, severity of deficiency and applicable pediatric guideline. Dosing should be expressed in terms of elemental iron rather than the total weight of an iron salt. The preparation, dose and duration should be individualized and monitored.

8.3 *Treatment of associated conditions*

- Treat documented parasitic infestation or other infections when indicated
- Manage chronic gastrointestinal disease and malabsorption
- Investigate and address chronic blood loss
- Correct coexisting nutritional deficiencies
- Evaluate for haemoglobinopathies when clinically appropriate

8.4 Follow-up

Clinical and, when appropriate, laboratory follow-up is necessary to assess response. Poor response should prompt review of diagnosis, adherence, dose, administration, ongoing blood loss, malabsorption, infection or inflammation, haemoglobinopathy and other alternative diagnoses.

9. PREVENTION

1. Promote adequate maternal nutrition during pregnancy.
2. Support recommended breastfeeding and timely, nutritionally adequate complementary feeding.
3. Encourage dietary diversification and regular intake of iron-rich foods.
4. Use food fortification and micronutrient interventions where recommended.
5. Provide iron supplementation according to applicable public-health or clinical guidance.
6. Prevent and treat infections and intestinal parasitic infestation.
7. Educate parents and caregivers about balanced diets, supplementation and adherence.

10. PUBLIC HEALTH IMPORTANCE IN INDIA

Anaemia remains a major public-health concern in India. Its determinants include nutritional deficiencies as well as infections, inflammation, genetic haemoglobin disorders and blood loss. India's Anemia Mukh Bharat strategy uses a multi-component approach that includes iron-folic acid supplementation, deworming, behaviour-change communication, screening and treatment, fortified foods and attention to non-nutritional causes.

A comprehensive approach is therefore preferable to relying on iron supplementation alone. Dietary quality, adherence, infection control, screening and appropriate evaluation of persistent anaemia all contribute to better outcomes.

11. ROLE OF PEDIATRICIANS

1. Identify children at increased risk.
2. Screen and investigate according to clinical and public-health recommendations.
3. Establish the likely cause of anaemia.
4. Prescribe appropriate treatment and monitor response.
5. Provide dietary and adherence counselling to caregivers.
6. Investigate persistent or unexplained anaemia.
7. Coordinate preventive and community-based interventions.

12. DISCUSSION

Nutritional anaemia is multifactorial. Iron deficiency is a major contributor, but folate and vitamin B12 deficiencies, infection, inflammation, blood loss and inherited disorders may coexist. Consequently, treatment should be directed toward the cause rather than haemoglobin concentration alone.

Periods of rapid growth are particularly important. Infants transition to complementary foods, while adolescents have increased nutritional requirements; adolescent girls may have additional iron loss through menstruation. These factors make dietary adequacy and preventive strategies especially relevant.

Prevention should begin before clinically significant anaemia develops. Maternal nutrition, appropriate infant feeding, dietary diversification, fortification, supplementation where indicated and control of infections can collectively reduce risk. Failure to respond to appropriate iron therapy should trigger reassessment rather than indefinite continuation of supplementation.

13. CONCLUSION

Nutritional anaemia is an important and preventable pediatric health problem. Iron deficiency is a major nutritional contributor, but other micronutrient deficiencies and non-nutritional conditions may contribute. Early recognition, appropriate investigation, dietary improvement, rational supplementation and treatment of underlying disorders are essential. A coordinated strategy involving nutrition, supplementation, infection control, health education and appropriate diagnosis is required to reduce the burden of anaemia and support healthy growth and development in children.

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