ORIGINAL ARTICLE

INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE

ISSN: 2692-515-x, Impact Factor: 9.23
American Academic publishers, volume 6, issue 01,2026

Journal: https://www.academicpublishers.org/journals/index.php/ijai

IRON DEFICIENCY ANEMIA: EPIDEMIOLOGY, PATHOGENESIS, CLINICAL MANIFESTATIONS, AND MODERN TREATMENT APPROACHES

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Abstract. Iron deficiency anemia (IDA) is one of the most widespread hematological disorders worldwide and develops as a result of depleted iron stores required for hemoglobin synthesis. According to the World Health Organization (WHO), more than 50% of anemia cases globally are associated with iron deficiency, with particularly high prevalence among children under five years of age, pregnant women, and women of reproductive age[1]. This condition imposes a significant burden on healthcare systems and is associated with reduced work productivity, delayed cognitive development, and impaired immune function.

The etiology of IDA is multifactorial and includes insufficient dietary iron intake, impaired intestinal absorption, chronic blood loss, and increased physiological demand. The pathogenesis involves a gradual depletion of iron stores, decreased hemoglobin synthesis, and the formation of microcytic hypochromic erythrocytes. These changes lead to tissue hypoxia and disruption of metabolic processes.

Clinically, IDA presents with both general and specific manifestations. General symptoms include fatigue, weakness, dizziness, and dyspnea, while specific signs include koilonychia, hair loss, angular stomatitis, and pica syndrome. In children, iron deficiency negatively affects intellectual and psychomotor development.

Diagnosis is based not only on hemoglobin levels but also on ferritin, serum iron, transferrin saturation, and total iron-binding capacity (TIBC). Treatment strategies include oral or parenteral iron supplementation, nutritional optimization, and elimination of underlying etiological factors. Modern approaches emphasize individualized treatment and strengthened preventive measures.

Keywords: iron deficiency anemia, hemoglobin, ferritin, microcytic anemia, hypochromia, iron preparations, blood loss, WHO, childhood anemia, pregnancy.

Introduction

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Iron deficiency anemia (IDA) is a globally prevalent hematological disorder characterized by reduced hemoglobin levels. According to WHO data, approximately one-third of the world's population is affected by anemia, and more than half of these cases are related to iron deficiency[1]. This condition remains a serious public health problem, particularly in low- and middle-income countries.

Iron plays a crucial biological role in the human body as a component of hemoglobin, myoglobin, and numerous oxidative enzymes. Iron deficiency disrupts oxygen transport, leads to tissue hypoxia, and slows metabolic processes. In childhood, iron deficiency may result in impaired cognitive development and reduced learning capacity[2].

The main causes of IDA include inadequate dietary intake, impaired intestinal absorption, chronic blood loss (gastrointestinal and gynecological disorders), and increased demand during pregnancy and periods of rapid growth. These factors often coexist and potentiate each other.

Clinically, IDA may initially remain latent; however, once iron stores are depleted, evident clinical symptoms develop. Therefore, early detection and prevention are essential components of healthcare practice.

The aim of this article is to systematically review the epidemiology, pathogenesis, clinical features, and modern diagnostic and therapeutic approaches to iron deficiency anemia based on an analysis of current scientific literature.

Literature Review

Recent studies on iron deficiency anemia confirm its significant impact on global public health. Reports by WHO and UNICEF indicate that IDA has the highest prevalence among children and pregnant women[14]. McLean et al. reported that more than half of global anemia cases are associated with iron deficiency[6].

Studies by Camaschella and DeLoughery describe the pathogenesis of IDA as a process involving depletion of iron stores, impaired hemoglobin synthesis, and the formation of microcytic hypochromic erythrocytes[34]. Ferritin is recognized as the most reliable biomarker of iron stores, although its interpretation requires caution in inflammatory conditions.

Treatment studies demonstrate that oral iron supplementation is the first-line therapy, while parenteral iron is more effective in severe cases or in patients with malabsorption[212]. Tolkien et al. highlight that gastrointestinal side effects of iron preparations negatively affect patient adherence to therapy[12].

Overall, the literature emphasizes the importance of identifying etiological factors, applying individualized treatment strategies, and strengthening preventive measures to effectively manage IDA.

Main Part

Epidemiology and Risk Factors

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Iron deficiency anemia is the most common type of anemia worldwide, accounting for approximately 50–60% of all anemia cases according to WHO. The condition is particularly prevalent in low- and middle-income countries due to inadequate nutrition, limited access to healthcare, and socio-economic challenges.

High-risk groups include children under five years of age, adolescents, pregnant and lactating women, and elderly individuals. In children, iron deficiency leads to impaired growth and cognitive development, while in women, menstrual blood loss and increased demands during pregnancy significantly raise the risk of IDA.

In developing countries, inadequate dietary intake of iron-rich foods is the primary risk factor. In developed countries, IDA is more commonly associated with chronic diseases, gastrointestinal disorders, occult bleeding, and malabsorption syndromes. Parasitic infections, chronic inflammatory diseases, and unhealthy dietary habits also contribute significantly.

Epidemiological data indicate that IDA imposes not only health-related but also economic and social burdens, leading to reduced productivity and poorer educational outcomes.

Pathogenesis and Clinical Manifestations

The pathogenesis of IDA begins with depletion of iron stores in the body. Iron is essential for hemoglobin synthesis, and its deficiency results in decreased hemoglobin content within erythrocytes, leading to microcytic and hypochromic red blood cells.

The process progresses in stages: initial depletion of iron stores (reduced ferritin), followed by decreased serum iron levels, and ultimately reduced hemoglobin concentration resulting in clinical anemia. Tissue hypoxia develops, and metabolic processes slow down.

Clinical manifestations are divided into general and specific symptoms. General symptoms include fatigue, weakness, dizziness, dyspnea, and palpitations. Specific signs characteristic of iron deficiency include koilonychia, hair loss, dry skin, angular stomatitis, and pica syndrome.

In children, iron deficiency may lead to behavioral changes and impaired academic performance, while in elderly patients, the risk of cardiovascular complications increases.

Diagnosis and Treatment

Diagnosis of iron deficiency anemia is based on hematological and biochemical laboratory tests. Reduced hemoglobin levels are the primary indicator. Erythrocyte indices (MCV, MCH) reveal microcytic hypochromic anemia. Ferritin is the most important marker for assessing iron stores. Additional tests include serum iron, total iron-binding capacity (TIBC), and transferrin saturation.

Treatment depends on the severity and underlying cause of anemia. Oral iron supplementation is the first-line therapy for mild to moderate cases. Parenteral iron is indicated in severe cases or when absorption is impaired. Treatment should continue for at least 2–3 months after normalization of hemoglobin levels to replenish iron stores.

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Nutritional correction is essential and includes increased consumption of red meat, liver, legumes, green leafy vegetables, and vitamin C-rich foods to enhance iron absorption. Identifying and addressing the underlying cause, such as blood loss or malabsorption, is crucial.

Research Methodology

This study employed a systematic literature review to evaluate the epidemiology, pathogenesis, clinical manifestations, diagnostic criteria, and treatment approaches of iron deficiency anemia. Scientific articles, clinical studies, meta-analyses, and reports published between 2000 and 2025 were analyzed.

Databases such as PubMed, WHO, Scopus, and Google Scholar were used. Keywords included "iron deficiency anemia," "epidemiology," "clinical manifestations," "diagnosis," and "treatment." Only peer-reviewed English-language studies with reliable methodologies were included.

Data were categorized according to epidemiology, risk factors, pathophysiology, diagnostics, and treatment efficacy. Iron preparations, their effectiveness, and adverse effects were analyzed separately. Descriptive and analytical methods were applied to synthesize the findings.

Results

The systematic review confirmed that iron deficiency anemia is among the most prevalent hematological disorders worldwide. More than half of anemia cases globally are attributable to iron deficiency, with the highest prevalence observed among children, women of reproductive age, and pregnant women.

The primary etiological factors identified include inadequate nutrition, chronic blood loss, parasitic infections, and impaired iron absorption. Clinically, fatigue, reduced work capacity, dizziness, dyspnea, and pallor were the most commonly reported symptoms.

Diagnostic analysis confirmed that low ferritin levels are the most sensitive indicator of iron deficiency anemia. Treatment outcomes demonstrated that oral iron therapy is highly effective in mild to moderate cases, while parenteral iron is necessary in severe cases.

The results also emphasize that pharmacological treatment alone is insufficient; dietary correction, preventive strategies, and health education play vital roles in disease control.

Conclusion

Iron deficiency anemia remains one of the most pressing and widespread hematological problems in modern medicine. The findings demonstrate that IDA is not only a medical but also a socio-economic issue, contributing to reduced productivity, delayed cognitive development in children, and poorer health outcomes in vulnerable populations.

The main etiological factors include inadequate nutrition, chronic blood loss, impaired absorption, and increased physiological demand. Children, pregnant women, and women of

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reproductive age constitute the highest-risk groups, highlighting the importance of targeted screening and prevention.

Modern diagnostic methods allow early detection of IDA, with ferritin and iron metabolism indicators improving diagnostic accuracy. Iron supplementation remains the cornerstone of treatment, but therapy must be individualized.

In conclusion, iron deficiency anemia is a preventable condition. Proper nutrition, prophylactic iron supplementation, and increased health awareness can significantly reduce its global burden. Future research should focus on early detection strategies and personalized treatment approaches.

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