International Journal of Pharmaceutical Research and Applications
Volume 9, Issue 4 July-Aug 2024, pp: 1625-1639 www.ijprajournal.com ISSN: 2456-4494

Iron Deficiency Anemia: Nutritional Causes, Health Impact, and Treatment Approaches

Ritesh Patil

Date of Submission: 20-08-2024 Date of Acceptance: 30-08-2024

ABSTRACT
Iron deficiency is the most common of all nutritional disorders, affecting more than 1.2 billion people causing iron-deficiency anemia (IDA). This is mostly results from the lack of an essential element iron needed for making hemoglobin in red blood cells which carries oxygen to every part of your body from the lung. The defect of IDA is smaller and paler red blood cell production, resulting in microcytic anemia with hypochromia. Iron deficiency anemia is commonly due to insufficient dietary intake, poor absorption of iron in the gastrointestinal tract, turnover of erythrocytes (essential for recycling available iron), or chronic blood loss from increased demands on pregnant women and growing children. Clinical presentation of IDA is subtle and may develop insidiously. These can over time develop into more moderate signs such as shortness of breath, lightheadedness, and cold limbs. In some extreme cases; IDA leads to cognitive and immune system dysfunctioning, neonatal deterioration in pregnancy (preterm labor and low birth weight), or even maternal mortality. Diagnosis of IDA entails low values of the hemoglobin, hematocrit, and mean corpuscular volume as well as serum ferritin blood test results. An FBC, and iron studies may be done to corroborate the findings and determine the degree of anemia.The management of IDA mainly concentrates on iron replacement where oral iron is given or intravenous depending on the severity of the deficiency and the patients' ability to take oral iron. Hence, the actual cause needs to be treated for the recurrence problem to be avoided. The prognosis for IDA, once treated appropriately therefore is very good as the majority of affected persons experience marked relief from the manifestations of the disease and enhanced quality of life.

I. INTRODUCTION

Iron Deficiency Anemia (IDA)is an observable worldwide concern, it is characterized by a lack of iron levels that results in a decrease in the generation of red blood cells and ensuing low oxygen transport throughout the body (WHO, 2008). It is one of the foremost common nutritional insufficiencies worldwide, influencing individuals of all ages, sexual orientations, and financial foundations (Kassebaum et al., 2014). IDA applies a prominent burden on public health systems, contributing to morbidity, mortality, and impaired quality of life (Horton & Ross, 2003).

This investigation comprehensively dives into the multifaceted nature of IDA, covering its study of disease transmission, etiology, clinical appearances, diagnosis, management, prevention, and public health implications. By scrutinizing each viewpoint, the point is to supply a nuanced understanding of IDA and its effect on people, communities, and healthcare frameworks. Besides, it underscores the significance of evidence-based approaches in tending to IDA while recognizing crevices in current information requiring further research and investigation.

Beginning withthe study of disease transmission of iron deficiency anemia, the focus will be on illustrating global predominance rates, territorial incongruities, and affected demographic bunches. Understanding the epidemiological landscape of IDA is vital for recognizing high-risk populations and educating focused on mediation to alleviate its burden. In this way, consideration will move to the etiology and hazard components associated with IDA, analyzing the complex exchange of dietary, physiological, and neurotic variables contributing to iron insufficiency,byunraveling the basic component of IDA, the aim is to educate strategies for prevention, early detection, and management.The examination will be placed on the clinical appearances and diagnosis of iron deficiency anemia, explaining common signs and indications, symptomatic criteria, and research facility tests utilized in clinical practice (Camaschella, 2015). Recognizing the clinical introduction of IDA is essential for prompt diagnosis and mediation, thus deflecting complications and upgrading understanding of outcomes. Following this, the management and treatment alternatives accessible for IDA, encompass iron supplementation, dietary

International Journal of Pharmaceutical Research and Applications
Volume 9, Issue 4 July-Aug 2024, pp: 1625-1639 www.ijprajournal.com ISSN: 2456-4494

alterations, pharmacological mediations, and non-pharmacological approaches.

Besides, consideration will be drawn to the complications and long-term consequences associated with untreated or insufficiently overseen IDA, emphasizing the significance of early intervention to prevent unfavorable outcomes (Goddard et al., 2011). The role of anticipation and public health mediations in moderating the burden of IDA at the population level will be examined, encompassing strategies for primary and secondary avoidance, public well-being approaches, and programs aimed at pushing iron-rich diets and iron supplementation (Lozoff & Georgieff, 2006).

This investigation, endeavors to provide a comprehensive understanding of iron deficiency anemia as a predominant worldwide health issue, highlighting the significance of addressing IDA across different populations. e evidence-based approaches to combatting IDA and advancing health outcomes around the world.

Epidemiology of iron deficiency anemia

IDA is a broad nutritional disorder influencing millions of individuals around the world, with especially high predominance rates dwelling in low-income locales. The probe appears sub-Saharan Africa and South Asia are defying the most notable burden. In 2021, Western sub-Saharan Africa (47.4), South Asia (35.7), and Central sub-Saharan Africa (35.7) had the most elevated iron insufficiency ascendance. The locales with the most reduced iron insufficiency are Australasia (5.7), Western Europe (6), and North America (6.8)(Osei Bonsu et al., 2024).Among the foremost vulnerable demographic groups are ladies of reproductive age, who experience increased iron demands during pregnancy and menstruation. Additionally, children, especially infants, toddlers, and teenagers undergoing rapid development spurts, are at heightened risk of developing IDA due to their increased iron requirements (Lozoff, Beard, Connor, Felt, & Georgieff, 2006). Besides, low-income populations confront a higher predominance of IDA due to restricted access to nutrient-rich nourishments containing iron, worsening the issue in districts with already strained healthcare frameworks (Garcia-Casal et al., 2016). Moreover, the elderly are vulnerable to IDA due to factors such as diminished dietary intake, malabsorption issues, and the presence of chronic diseases (Guralnik et al., 2004).

Regional disparities in IDA predominance rates are impacted by a bunch of socio-economic, social, and natural variables (Lassi et al., 2022). Low and middle-income countries (LMICs), especially those in sub-Saharan Africa, South Asia, and parts of Southeast Asia, bear the highest burden of IDA (McLean et al., 2009). This is often attributed to destitute nourishment, predominance of infectious diseases, and restricted access to healthcare administrations(Tula et al., 2020). Rural populations within these regions tend to encounter higher rates of IDA compared to urban regions, fundamentally due to agricultural practices, insufficient healthcare infrastructure, and higher levels of poverty (Balarajan et al., 2011). Furthermore, dietary patterns play a significant part in IDA prevalence, with regions depending heavily on cereal-based diets and lacking in animal-source foods being more susceptible (Balarajan et al., 2011). Infectious illnesses, such as hookworm infestations, contribute to IDA by causing intestinal bleeding and disabling iron absorption, further compounding the burden of the illness in **i**nfluenced regions(Brooker et al., 2000).

The impact of IDA on public health and healthcare frameworks is profound and multifaceted (Kassebaum et al., 2014). Iron Deficiency AnemiaIDAnegatively influences cognitive function, work capacity, and overall productivity, leading to decreased efficiency.. Maternal and child health outcomes are too intensely affected by IDA, with pregnant ladies confronting an expanded hazard of unfavorable results such as preterm birth, low birth weight, and maternal mortality (Haider et al., 2013). Essentially, children with IDA may encounter disabled growth, advancement, and cognitive function, driving to long-term results for their health and well-being (Sachdev et al., 2005). In addition, the financial burden of treating IDA and its complications is considerable, especially in low-resource settings where access to iron supplements and blood transfusions may be restricted (Peña-Rosas et al., 2016). This strain on healthcare budgets underscores the critical require for comprehensive strategies to address IDAeffectively (Stevens et al., 2013).

Addressing IDA requires collaboration across different divisions like healthcare, horticulture, education, and social welfare. Executing strategies such as advancing iron-rich diets, supplementation programs, and progressing sanitation policies is vital for decreasing IDA's effect on public health globally (Petry et al., 2016). Education and awareness campaigns on the significance of iron-rich nourishments, standard screening, and early mediation are too imperative (Pasricha et al., 2014). Through interdisciplinary endeavors and targeted mediation for defenseless populations, critical advances can be made in lightening the worldwide burden of IDA and improving the health and well-being of millions (Gupta et al., 2016).

Etiology and risk factors

TheEtiology of IDAincludes a multifaceted transaction of dietary, physiological, and obsessive factors (Camaschella, 2015). Dietary components play a pivotal part, as iron is fundamentally obtained through dietary sources (Mehri, 2020). In any case, insufficient intake of iron-rich foods, particularly in regions with limited access to different diets, may significantly support iron insufficiency (Rasmussen, 2001). Moreover, variables such as the presence of substances that hinder iron retention, including phytates and tannins, can assist in exacerbating iron insufficiency in vulnerable people (Hurrell & Egli, 2010).

Physiological components also contribute to the advancement of iron insufficiency, particularly during life stages characterized by expanded iron necessities. For instance, pregnancy imposes significant iron requests to support fetal growth and development, (James, 2021). Similarly, infants and young children have increased iron necessities due to fast growth and development, emphasizing the importance of adequate iron intake during early childhood (Cusick & Georgieff, 2016).

Pathological factors represent another critical supporter of iron insufficiency, especially in people with fundamental health conditions that disturb iron metabolism or lead to chronic blood misfortune(Lopez et al, 2016). Gastrointestinal disorders, such as inflammatory bowel infections and gastrointestinal bleeding, can cause constant blood misfortune, driving to iron exhaustion over time (Gasche et al., 2004). Also, conditions that influence iron retention within the gastrointestinal tract, such as celiac disease or gastric bypass surgery, can disable the body's capacity to absorb dietary iron, contributing to iron insufficiency (Bermejo, F., & García-López, S., 2009).

Understanding the risk factors associated with IDA is pivotal for focusing on mediation strategies pointed at defenseless populations. For example, pregnant women's involvement expanded iron necessities to support maternal and fetal hemoglobin generation (Tamburini et al., 2016), making them especially susceptible to iron insufficiency in case dietary intake is insufficient. Additionally, infants and young children require sufficient iron intake to support quick development and improvement (Georgieff, 2017), emphasizing the significance of iron-rich complementary nourishment during the earliest stages and early childhood.

The elderly populations also face unique challenges concerning iron insufficiency, counting age-related changes in dietary intake, retention, and chronic infection burden (Guralnik et al., 2004). Diminished dietary intake and gastrointestinal changes that disable iron absorption increase the hazard of iron insufficiency in older adults(Cook et al., 2003). Chronic illnesses, such as constant kidney infection and heart failure, are frequently related to iron insufficiency due to disturbances in iron metabolism, irritation, and erythropoietin generation (Anker et al., 2009). Subsequently, tending to iron deficiency within the context of chronic disease management requires a comprehensive understanding of the basic pathophysiology and the execution of focused on therapeutic mediations (Jankowska et al., 2010).

Chronic diseases, such as incendiary bowel illnesses, rheumatoid joint pain, and chronic kidney illness (Ganz, 2013), are habitually related to iron deficiency due to disturbances in the iron digestion system and erythropoiesis (Andrews, 1999). Inflammatory cytokines, such as interleukin-6, invigorate the generation of hepcidin, a key controller of iron homeostasis, driving useful iron insufficiency and disabled erythropoiesis (Weiss & Goodnough, 2005). Thus, tending to iron insufficiency within the context of chronic infection management requires anall-encompassing approach that considers both the basic infection process and the associated nutritional deficiencies (Kroot et al., 2011).

Essentially, diseases can contribute to the development of iron deficiency through numerous mechanisms, including blood loss aggravation, and modifications in iron metabolism (Rego et al., 2021). Parasitic infections, such as hookworm infestation, can cause intestinal bleeding and iron misfortune, compounding iron deficiency in influenced people, especially in resource-limited settings (Fiseha et al., 2024). Systemic diseases trigger inflammatory reactions that modify iron homeostasis, leading to the sequestration of iron inside macrophages and the concealment of erythropoiesis (Shou N et al., 2022). In this manner, overseeing iron insufficiency within the context of unavoidablediseases requires a multifaceted approach that addresses both the basic disease and the related dietary insufficiency (Cusick et al., 2020).

International Journal of Pharmaceutical Research and Applications
Volume 9, Issue 4 July-Aug 2024, pp: 1625-1639 www.ijprajournal.com ISSN: 2456-4494

Iron Deficiency Anemia IDA presents with extended signs; and symptoms that reflect the body's diminished capacity to provide oxygen to tissues. Extraordinary weakness is a hallmark feature, often debilitating and affecting day-by-day working (Sendeku et al., 2020). Weakness is additionally common, contributing to decreased physical and mental stamina. Paleness, or pallor of the skin, is recognizable due to decreased hemoglobin levels, reflecting insufficient oxygenation of blood.

Some individuals may encounter chest pain, palpitations, or a fast pulse, indicating the heart's exertion to compensate for the decreased oxygen-carrying capacity of the blood(Richards et al., 2023). Dyspnea, particularly during exertion, is common due to insufficient oxygen delivery to tissues. Migraines, dizziness, and sentiments of light-headedness may happen as a result of cerebral hypoxia.

Peripheral side effects such as cold hands and feet may be created due to diminished bloodstream to the limits (Costa, D. B., & Drews, R. E. 2009). These appearances collectively contribute to the clinical picture of IDA, highlighting the systemic effect of iron insufficiency on different organ frameworks and emphasizing the significance of early detection and management (Camaschella, 2019).

Clinical manifestations and diagnosis

IDA diagnosis depends on a combination of clinical evaluation and laboratory tests. These tests give important bits of knowledge regarding the patient's iron status and offer assistance and appropriate management procedures.

Complete Blood Count (CBC) with Red Blood Cell Records

Mean Corpuscular Volume (MCV)

This parameter measures the normal volume of red blood cells. In IDA, MCV is regularly diminished due to microcytosis, reflecting smaller-than-normal red blood cells. The extent for MCV is more often than not 80 to 100 femtoliters (fL). In IDA, MCV values frequently fall below 80 fL (Cappellini, M. D., & Motta, I., 2015).

Mean Corpuscular Hemoglobin (MCH) and Mean Corpuscular Hemoglobin Concentration (MCHC)

MCH represents the average sum of hemoglobin per red blood cell, whereas MCHC measures the concentration of hemoglobin in a given volume of stuffed red blood cells. In IDA, both MCH and MCHC are typically decreased due to decreased haemoglobin substance. Reference ranges for MCH are usually 27 to 32 picograms (pg), and for MCHC, 32 to 36 grams per deciliter (g/dL)(Schrier, S. L., & Auerbach, M., 2018). In IDA, values for both MCH and MCHC may fall below these ranges (Chernecky, C. C., & Berger, B. J., 2018).

Serum Iron Levels

Serum iron levels, measuring the iron substance within the blood plasma, serve as a vital marker in diagnosing iron deficiency anemia IDA, with levels regularly diminished due to inadequate iron stores. Whereas, the reference range for adults ordinarily falls around 60 to 170 micrograms per deciliter (µg/dL), in IDA, levels often plunge below this range, reflecting reduced iron accessibility for erythropoiesis and metabolic forms (DeLoughery, 2017). In many cases, modern symptomatic approaches emphasize the integration of serum iron levels with other iron status markers, such as Total iron binding capacity (TIBC), serum ferritin, and transferrin immersion, to provide a comprehensive evaluation of iron status (Pasricha & Drakesmith, 2016). Recent advancements in laboratory procedures, including more delicate tests utilizing colorimetric strategies or mass spectrometry, have improved the precision of measuring serum iron levels, thereby progressing symptomatic accuracy. Healthcare suppliers depend on these combined evaluations to affirm IDA determination, direct custom-made management strategies, such as iron supplementation, and screen treatment viability over time. The evolving understanding of serum iron levels and their translation within a broader context underscores continuous efforts to optimize the diagnosis and management of IDA.

In present-day healthcare practice, the diagnosis and management of iron deficiency anemia IDA frequently depend on the integration of various iron status markers to provide a comprehensive appraisal of the patient's condition. Considering a local case where, a 35-year-old woman presented with side effects suggestive of IDA, including fatigue, weakness, and shortness of breath, with a history of massive menstrual bleeding,laboratory tests were conducted to assess her iron status, disclosinglow serum iron levels at 30 µg/dL, alongside a typical Total Iron Binding Capacity (TIBC) of 400 µg/dL. However, the women displayed essentially low levels of serum ferritin at 10 mg/mL and a transferrin saturation (TSAT) of 7%. After integrating these, it became apparent that she was enduring iron deficiency

International Journal of Pharmaceutical Research and Applications
Volume 9, Issue 4 July-Aug 2024, pp: 1625-1639 www.ijprajournal.com ISSN: 2456-4494

anemia despite the ordinary TIBC esteem. The combined interpretation of these markers gives a more exact diagnosis, highlighting the seriousness of her condition and guiding tailored management strategies.

Moreover, progressing monitoring ofiron status will be essential to survey the effectiveness of iron supplementation and ensure recuperation over time. This case underscores the significance of coordination to different iron status markers in clinical practice to improve demonstrative accuracy and direct personalized management approaches for patients with IDA.

Techniques and Practices

Within the realm of healthcare, headways in laboratory strategies play a significant role in refining symptomatic exactness and tailoring personalized management methodologies for different therapeutic conditions. Recent strides in laboratory techniques, especially within the realm of measuring serum iron levels, have essentially contributed to the precision of diagnoses, particularly concerningIDA (Mandal et al., 2023). This evolution is owed to the development and appropriation of more sensitive tests utilizing colorimetric methods and mass spectrometry, introducing an era of enhanced understanding and management of IDA. However, the adoption of colorimetric strategies and mass spectrometry has markedly progressed precision. Colorimetric tests detect colour changes corresponding to iron ions, advertising more prominent accuracy even at low concentrations (Staniek et al.,2020), whereas mass spectrometry permits direct quantification of iron particles with unparalleled affectability and specificity, shedding light on iron metabolism mechanisms (Jin et al., 2024). These progressions not only refine diagnostic accuracy but also empower tailored treatment strategies based on individual iron profiles, extending from dietary interventions to intravenous iron treatment(Almashjary, 2024).

Additionally, the improved precision encourages monitoring treatment reactions over time, optimizing patient results, and minimizing dangers associated with improper supplementation (Gómez-Ramírez et al., 2023). Interdisciplinary collaboration between laboratory researchers, clinicians, and analysts is vital in driving development and translating advancements into unmistakable improvements in patient care (Robbins-Welty et al., 2023). In conclusion, recent laboratory advancements revolutionize the diagnosis and management of IDA, clearing the way for more personalized and viable intercessions while highlighting the significance of proceeded speculation in research and technology to develop hematological medication, eventually improving patient outcomes and quality of life.

Complexity in Diagnosis

Diagnosing Iron Deficiency Anemia IDA is challenging due to overlapping indications with other therapeutic conditions, inconstancy in laboratory tests like serum ferritin and iron, and complexities in the interpretation of the results, particularly within the presence of inflammation or chronic infections (Larson et al., 2021). Differential diagnosis contemplations incorporate distinguishing IDA from Anemia of Chronic Disease (ACD) by surveying markers of irritation, separating thalassemia through hereditary testing, confirming Sideroblastic Anemia with bone marrow examination (Bottomley & Fleming, 2014), and recognizing Haemolytic Anemia through specialized tests like direct ant globulin test (DAT). Chronic gastrointestinal bleeding may mimic IDA (Rockey, D. C., 2010), requiring endoscopic assessment, while renal anemia from chronic kidney diseases requires evaluating renal function near iron studies (Babitt et al., 2012). Additionally, multifactorial etiology can contribute to anemia, requiring a careful clinical assessment and interdisciplinary collaboration among healthcare providers for precise diagnosis and management.

Management and treatment of iron deficiency anemia

The management and treatment of Iron Deficiency Anemia include procedures for iron supplementation and dietary intercession points at recharging iron stores and improving hemoglobin levels. Iron supplementation is ordinarily endorsed to adjust iron deficiency instantly and successfully. This may include oral iron supplements such as ferrous sulfate, ferrous gluconate, or ferrous fumarate, which are promptly accessible and generally well-tolerated (WHO, 2008). The dose and duration of iron supplementation depend on the seriousness of anemia, patient resistance, and underlying causes (McCarthy et al, 2022).

Pharmacological and non-pharmacological approach

Procedures for overseeing IDA include both pharmacological medications and non-pharmacological approaches adapted towards re-establishing iron levels and improving hemoglobin

International Journal of Pharmaceutical Research and Applications
Volume 9, Issue 4 July-Aug 2024, pp: 1625-1639 www.ijprajournal.com ISSN: 2456-4494

concentrations. Pharmacological mediations include the organization of oral iron supplements or intravenous (IV) iron treatment. Oral supplements like ferrous sulfate, ferrous gluconate, or ferrous fumarate are ordinarily the initial treatment choice for gentle to direct IDA, known for their availability and the most part favorable tolerability (Camaschella, 2019). However, when oral supplementation fails, particularly in serious cases or occurrences of malabsorption, Intravenous iron treatment becomes a practical alternative (Auerbach & Macdougall, 2017). Intravenous iron treatment encourages quick iron renewal, especially advantageous for patients with destitute oral resistance or gastrointestinal conditions preventing iron retention (Bregman et al., 2013).

In addition to pharmacological medications, non-pharmacological approaches play a significant part in managing IDA. These approaches incorporate blood transfusions and erythropoiesis-stimulating agents (ESAs). Blood transfusions may be vital in cases of serious iron deficiency or intense blood misfortune to quickly increase haemoglobin levels and restore oxygen-carrying capacity (Mikulic, 2021). In any case, they are regularly reserved for crisis circumstances or cases where other treatments have failed. ESAs, such as erythropoietin-stimulating agents, invigorate the generation of red blood cells within the bone marrow and may be utilized in conjunction with iron treatment to treat anemia related with chronic kidney disease or certain sorts of cancer (Aapro et al., 2019). Non-pharmacological approaches are frequently considered in conjunction with pharmacological medicines to tailor the administration approach to the individual patient's needs and basic conditions.

Complications and Long-term Consequences

ChronicIDA can result in critical cardiovascular complications. Diminished oxygen-carrying capacity leads, to expanded cardiac output as the heart works harder to compensate. This could show as tachycardia, palpitations, and in extreme cases, heart failure. Studies indicate that IDA is related to a higher chance of cardiovascular occasions, with one meta-analysis uncovering a 72% increased chance of heart failure in people with IDA compared to those without (Afonso et al., 2007). These discoveries emphasize the significance of addressing IDA to moderate its adverse cardiovascular impacts.

Iron deficiency in children and adolescents essentially impacts cognitive function and academic performance. Considers having reliably appeared affiliations between iron deficiency anemia IDA and destitute cognitive improvement, including shortages in consideration, memory, and executive function (Jáuregui-Lobera, 2014). Also, IDA during early stages has been connected to poorer object stability and short-term memory encoding and revival (Carter et al., 2010). Long-term outcomes of early iron deficiency can be increased into adulthood, influencing educative consciousness, employment possibilities, and financial status (Bastian et al., 2020). Early mediation through iron supplementation and dietary alterations is significant to avoid these unfavourable impacts and optimize cognitive improvement and academic accomplishment in children and young people affected by IDA.

Persistent fatigue and weakness, common indications of iron insufficiency, essentially affect daily working and decrease overall quality of life (Oshin et al., 2020). Even after treatment initiation, if iron levels are not enough re-established, these side effects can persist. Moreover, IDA compromises immune function, expanding vulnerability to diseases and delaying recovery from sickness, particularly concerning defenceless populations such as children and pregnant ladies (Murphy & Cockrell, 2015). As mentioned earlier, during pregnancy IDA is related to antagonistic maternal and fetal outcomes, including preterm birth, low birth weight, and maternal morbidity, emphasizing the significance of adequate iron supplementation and management to anticipate these complications (Churchill et al., 2022). IDA limits oxygen delivery to tissues, resulting in decreased exercise resistance and disabled physical execution, which can affect activities of everyday living and contribute to a sedentary way of life. The collective burden of these side effects and complications underscores the urgent requirement for successful strategies to address and oversee iron insufficiency, particularly in high-risk populations, to improve health results and quality of life worldwide(Jimenez et al., 2015).

Besides the physical impact of IDA, the psychological and emotional effects of iron deficiency anemia IDA are significant and multifaceted. Beyond the physical side effects, such as fatigue and weakness, IDA can altogether affect mental health and well-being (Reid & Georgieff, 2023). Depression, anxiety, and irritability are common psychological indications related to iron deficiency. Research suggests that lacking iron levels can disturb neurotransmitter work and modify brain chemistry, contributing to mood disturbances (Murray-Kolb, 2013). Moreover,

International Journal of Pharmaceutical Research and Applications
Volume 9, Issue 4 July-Aug 2024, pp: 1625-1639 www.ijprajournal.com ISSN: 2456-4494

chronic weakness and impaired cognitive function related to IDA can exacerbate these symptoms, causing a cycle of decreased inspiration, cognitive fog, and emotional distress (Munoz & Humeres, 2012). The unavoidable nature of these mental impacts can have ripple effects on various angles of daily life including work, relationships, and social activities. People with IDA may struggle to maintain efficiency, feel strain in individual relationships due to mood fluctuations, and withdraw from social engagements due to sentiments of fatigue and low temperament (Mantadakis et al., 2020).

Prevention and Public Health Interventions

Promoting iron-rich diets through instruction and access to nutritious nourishments is without a doubt vital for anticipating iron deficiency. Encouraging utilization of foods rich in heme iron found in animal products and non-heme iron found in plant-based sources can improve iron intake (Basrowi & Dilantika, 2021). This approach makes a difference in people meeting their day to day iron necessities and decreases the hazard of developing iron deficiency anemia. By raising awareness about the significance of dietary iron and giving resources to back healthy eating propensities (Shubham et al., 2020) essential prevention endeavors can viably address iron insufficiency at its root cause.

Screening high-risk populations, such as menstruating or pregnant women, infants, and youth, for iron insufficiency, empowers early discovery and intervention, constituting a fundamental component of secondary prevention (Bathla & Arora, 2022). Schedule iron supplementation and fortification of staple foods are successful strategies to address iron insufficiency in these vulnerable groups. By executing regular screening conventions and providing targeted mediations, healthcare suppliers can recognize individuals at hazard of iron insufficiency, and start suitable treatment promptly (Schrage et al., 2021). This approach makes a difference in avoiding the movement of iron deficiency anemia and reduces the related morbidity and mortality among high-risk populations.

Public health policies should indeed prioritize education around the significance of iron-rich diets and iron supplementation during demanding life stages. Alert campaigns focusing on healthcare suppliers and the common population can advance early detection and treatment. By emphasizing the significance of maintaining satisfactory iron levels, especially during periods of expanded demand such as pregnancy, infancy, and puberty, these activities can help to anticipate iron insufficiencyand its related complications (Bathla & Arora, 2022). Also, giving open and reasonable iron supplementation programs, particularly in communities with high predominance rates of iron insufficiency, can advance support efforts to improve iron status and by and large health outcomes (Kinyoki et al., 2021). By joining education, mindfulness, and access to mediation, public health approaches can viably address iron deficiency anemia and advance superior health for all individuals.

Implementing required food fortification programs with iron-fortified staples, such as flour and cereals, can in fact progress iron intake at the population level. These programs are cost-effective and have illustrated success in reducing iron deficiency anemia IDA predominance (Collings et al., 2013). By fortifying commonly expended foods with iron, such as wheat flour, maize flour, and rice, public wellbeing activities can upgrade the dietary quality of the food supply and address micronutrient insufficiencies on a large scale (Gharibzahedi & Jafari, 2017). Required nourishment fortification programs have been especially compelling in reaching defenseless populations, including ladies of reproductive age and young children, who may be at higher chance of iron insufficiency (Muthayya et al., 2013). By expanding the accessibility of iron-fortified foods within the market, these programs guarantee that people have access to adequate dietary iron, indeed in regions where differing and nutritious food choices may be restricted (Pachón et al., 2015). The cost-effectiveness of food fortification makes it an appealing strategy for tending to IDA within resource-constrained healthcare frameworks (Kumar et al., 2022). By anticipating iron insufficiency and its related health complications, such as anemia and impeded cognitive advancement, food fortification programs contribute to improved health outcomes and reduced healthcare costs in the long term. Implementing required food fortification programs with iron-fortified staples represents a proactive and feasible approach to making strides iron intake and decreasing IDA predominance at the population level.

Despite the strides made by interventions, determined obstacles such as access to fortified foods, adherence to supplementation programs, and the supportability of public health activities endure (Lopez et al., 2016). Long-term success pivots on

International Journal of Pharmaceutical Research and Applications
Volume 9, Issue 4 July-Aug 2024, pp: 1625-1639 www.ijprajournal.com ISSN: 2456-4494

the nonstop monitoring, assessment, and adaptation of strategies. Ensuring evenhanded access to fortified nourishments remains challenging, especially in farther or underserved communities where conveyance may be obstructed by framework limitations (Bailey et al., 2015). Similarly, maintaining reliable adherence to supplementation programs faces impediments impacted by social convictions, money-related limitations, and the need for awareness (Suchdev et al.,2017), maintaining public well-being activities requires continuous speculation in framework, capacity-building, and promotion to gather political commitment and budgetary backing. By efficiently observing advance, assessing program adequacy, and adjusting procedures based on emerging prove and stakeholder criticism, public wellbeing specialists can confront these challenges and optimize intercessions to decrease the predominance of iron deficiency anemia IDA and progress overall wellbeing outcomes,

Challenges and future directions

Incongruities in healthcare get to decline in the diagnosis and treatment of iron deficiency anemia IDA, especially in underserved regions. Constrained facilities, money-related barriers, and the need for prepared staff delay screening and management. This leads to undetected or untreated IDA until it becomes serious, expanding health dangers. Targeted medications like portable clinics and telemedicine are pivotal for early discovery and successful management in underserved populations.

Diagnostic restrictions endure for IDA due to unclear symptoms and deficiencies in current tests, causing underdiagnosis and inappropriate treatment. Side effects like fatigue and weakness are nonspecific, regularly neglected, or attributed to other conditions, common diagnostic tests such as serum ferritin levels may not accurately reflect iron status in certain circumstances, leading to misinterpretation. These challenges highlight the requirement for progressed diagnostic tools and increased clinical awareness to ensure accurate identification and management of IDA.

Treatment compliance is a critical obstacle in effectively managing IDA, affecting treatment viability and patient results. Components contributing to poor adherence incorporate the repulsive side effects of iron supplementation such as gastrointestinal distress, clogging, and metallic taste. The long term of treatment required to renew iron stores can lead to patient fatigue and lack of engagement. Additionally, financial factors like restricted access to healthcare, reasonableness of drugs, and competing needs encourage worsening non-adherence. Tending to these challenges requires a comprehensive approach including patient education, close observing, personalized treatment plans, and support frameworks to upgrade adherence and improve outcomes in IDA management.

Enhancing diagnostic tools for IDA, particularly with accessible point-of-care technologies, holds promise for early detection and precise management. These advancements can streamline diagnosis, reducing reliance on conventional tests that may be cumbersome or inaccessible. Portable devices capable of rapid and accurate assessment of iron levels could revolutionize screening in various healthcare settings, particularly in underserved areas or regions lacking sophisticated infrastructure. By enabling timely interventions, such innovations have the potential to significantly improve health outcomes and reduce the burden of IDA globally.

Developing our understanding of IDA's pathophysiology, including genetic inclinations and interactions with coexisting health conditions, promises to refine treatment techniques and elevate patient care. Examining the genetic underpinnings of iron metabolism and investigating how they meet with different health components can divulge individualized hazard profiles and treatment reactions. Such insights clear the way for tailored mediations that address basic mechanisms, optimizing helpful outcomes and minimizing unfavorable impacts. Grasping personalized approaches educated by strong research, healthcare suppliers can way better navigate the complexities of IDA management, eventually progressing the well-being of influenced individuals.

Collaborating with healthcare suppliers, public health offices, and policymakers is crucial for conveying all-encompassing procedures handling IDA prevention, diagnosis, and management Championing approaches that emphasize nourishment, healthcare, and early screening for IDA can surrender a better understanding of outcomes and reduce the disease burden. Giving ceaseless education to healthcare experts and the public on the centrality of iron-rich diets, supplementation, and regular screening cultivates awareness and empowers proactive IDA management.

International Journal of Pharmaceutical Research and Applications
Volume 9, Issue 4 July-Aug 2024, pp: 1625-1639 www.ijprajournal.com ISSN: 2456-4494

II. CONCLUSION

Iron deficiency anemia (IDA) is a worldwide social problem that interferes with the manufacture of hemoglobin reducing the capacity of blood to carry oxygen. It is present in more than one billion people, and they manifest its symptoms through fatigue and weakness or potentially devastating effects such as reduced mental health and higher rates of maternal and infant mortality. The condition affects special groups more than the other groups in the population such as the children, pregnant women, and the elderly. The causes of IDA are hence complex and these include; malnutrition, constant bleeding, and the inefficient absorption of food iron so it is crucial to control these factors besides the use of iron compounds.Practical approaches to the management and prevention of IDA thus involves a right combination of early daignosis, medical treatment and public health measures. Therefore, the target is to achieve efficient methods of nutritional education about the importance of taking iron, supplementing the iron that is lacking in the human body, and also making staple foods that are consumed daily portable sources of iron, all of which are all in the effort of reducing instances of IDA. By doing this, it not only addresses the health needs of one person, but it also serves to address the needs of the society, as it increases the productivity of the people and contributes to the development of the country's economy. Therefore, to decrease IDA related burdens and enhance lower quality life, the global society must prioritize the fight against IDA disease.

REFERENCES

[1]. WHO. (2008). Worldwide prevalence of anaemia 1993-2005: WHO global database on anaemia. Geneva, Switzerland: World Health Organization.

[2]. Kassebaum, N. J., Jasrasaria, R., Naghavi, M., Wulf, S. K., Johns, N., Lozano, R., ... & Lopez, A. D. (2014). A systematic analysis of global anemia burden from 1990 to 2010. Blood, 123(5), 615-624.https://doi.org/10.1182/blood-2013-06-508325

[3]. Horton, S., & Ross, J. (2003). The economics of iron deficiency. Food policy, 28(1), 51-75.https://doi.org/10.1016/S0306-9192(02)00070-2

[4]. Suryadewara, A. (2023). Commonality Of Iron Deficiency Anemia In 2023 And Its Relevance-A Literature Review. Latin American Journal of Pharmacy: A Life Science Journal, 42(10), 339-346.).

[5]. World Health Organization. (2023). Accelerating anaemia reduction: a comprehensive framework for action.

[6]. Milman, N. (2006) Iron and pregnancy—a delicate balance. Ann Hematol **85**, 559–565. https://doi.org/10.1007/s00277-006-0108-2

[7]. Lozoff, B., & Georgieff, M. K. (2006). Iron deficiency and brain development. Seminars in Pediatric Neurology, 13(3), 158-165.

[8]. Osei Bonsu, E., Addo, I. Y., Boadi, C., Boadu, E. F., & Okeke, S. R. (2024). Determinants of iron-rich food deficiency among children under 5 years in sub-Saharan Africa: a comprehensive analysis of Demographic and Health Surveys. BMJ open, 14(3), e079856. https://doi.org/10.1136/bmjopen-2023-079856

[9]. Robert D. Baker, Frank R. Greer, The Committee on Nutrition; Diagnosis and Prevention of Iron Deficiency and Iron-Deficiency Anemia in Infants and Young Children (0–3 Years of Age). Pediatrics November 2010; 126 (5): 1040–1050. 10.1542/peds.2010-2576

[10]. Etienne Joosten; Strategies for the Laboratory Diagnosis of Some Common Causes of Anaemia in Elderly Patients. Gerontology 1 July 2004; 50 (2): 49–56. https://doi.org/10.1159/000075555

[11]. Longo, D. L., & Camaschella, C. (2015). Iron-deficiency anemia. N Engl J Med, 372(19), 1832-43.

[12]. Goddard, A. F., James, M. W., McIntyre, A. S., & Scott, B. B. (2011). Guidelines for the management of iron deficiency anaemia. Gut, 60(10), 1309-1316. https://doi.org/10.1136/gut.2010.228874

[13]. Lozoff, B., & Georgieff, M. K. (2006). Iron deficiency and brain development. Seminars in Pediatric Neurology, 13(3), 158-165.https://doi.org/10.1016/j.spen.2006.08.004

[14]. World Health Organization. (2017). Micronutrient deficiencies: iron deficiency anaemia. World Health Organization.

[15]. Stoltzfus, R. J., & Dreyfuss, M. L. (1998). Guidelines for the use of iron supplements

to prevent and treat iron deficiency anemia (Vol. 2). Washington, DC: Ilsi Press.

[16]. Lozoff, B., Beard, J., Connor, J., Felt, B., & Georgieff, M. (2006). Long-lasting neural and behavioral effects of iron deficiency in infancy. Nutrition Reviews, 64(5), S34-S43.https://doi.org/10.1111/j.1753-4887.2006.tb00243.x

[17]. Garcia-Casal, M. N., Pasricha, S. R., Martinez, R. X., Pena-Rosas, J. P., Lopez-Perez, L., & Peña-Rosas, J. P. (2016). Fortification of maize flour with iron for preventing anaemia and iron deficiency in populations. Cochrane Database of Systematic Reviews, 2016(9).https://doi.org/10.1002/14651858.CD010187.pub2

[18]. Guralnik, J. M., Eisenstaedt, R. S., Ferrucci, L., Klein, H. G., & Woodman, R. C. (2004). Prevalence of anemia in persons 65 years and older in the United States: evidence for a high rate of unexplained anemia. Blood, 104(8), 2263-2268.https://doi.org/10.1182/blood-2004-05-1812

[19]. Lassi, Z. S., Padhani, Z. A., Salam, R. A., & Bhutta, Z. A. (2022). Prenatal nutrition and nutrition in pregnancy: Effects on long-term growth and development. In Early Nutrition and Long-Term Health (pp. 397-417). Woodhead Publishing. https://doi.org/10.1016/B978-0-12-824389-3.00013-1

[20]. McLean, E., Cogswell, M., Egli, I., Wojdyla, D., & de Benoist, B. (2009). Worldwide prevalence of anaemia, WHO Vitamin and Mineral Nutrition Information System, 1993–2005. Public Health Nutrition, 12(4), 444–454. doi:10.1017/S1368980008002401

[21]. Tura, M. R., Egata, G., Fage, S. G., & Roba, K. T. (2020). Prevalence of Anemia and Its Associated Factors Among Female Adolescents in Ambo Town, West Shewa, Ethiopia. Journal of blood medicine, 11, 279–287. https://doi.org/10.2147/JBM.S263327

[22]. Balarajan, Y., Ramakrishnan, U., Özaltin, E., Shankar, A. H., & Subramanian, S. V. (2011). Anaemia in low-income and middle-income countries. The lancet, 378(9809), 2123-2135. https://doi.org/10.1016/S0140-6736(10)62304-5

[23]. Brooker, S., Hotez, P. J., & Bundy, D. A. (2008). Hookworm-related anaemia among pregnant women: a systematic review. PLoS neglected tropical diseases, 2(9), e291. https://doi.org/10.1371/journal.pntd.0000291

[24]. Haider, B. A., Olofin, I., Wang, M., Spiegelman, D., Ezzati, M., & Fawzi, W. W. (2013). Anaemia, prenatal iron use, and risk of adverse pregnancy outcomes: systematic review and meta-analysis. Bmj, 346. https://doi.org/10.1136/bmj.f3443

[25]. Sachdev, H. P. S., Gera, T., & Nestel, P. (2005). Effect of iron supplementation on mental and motor development in children: systematic review of randomised controlled trials. Public health nutrition, 8(2), 117-132. https://doi.org/10.1079/PHN2004677

[26]. Peña-Rosas, J. P., De-Regil, L. M., Garcia-Casal, M. N., & Dowswell, T. (2015). Daily oral iron supplementation during pregnancy. Cochrane database of systematic reviews, (7).https://doi.org/10.1002/14651858.CD004736.pub5

[27]. Stevens, G. A., Finucane, M. M., De-Regil, L. M., Paciorek, C. J., Flaxman, S. R., Branca, F., ... & Ezzati, M. (2013). Global, regional, and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non-pregnant women for 1995–2011: a systematic analysis of population-representative data. The Lancet Global Health, 1(1), e16-e25. https://doi.org/10.1016/S2214-109X(13)70001-9

[28]. Petry, N., Olofin, I., Hurrell, R. F., Boy, E., Wirth, J. P., Moursi, M., ... & Rohner, F. (2016). The proportion of anemia associated with iron deficiency in low, medium, and high human development index countries: a systematic analysis of national surveys. Nutrients, 8(11), 693. https://doi.org/10.3390/nu8110693

[29]. Pasricha, S. R., Black, J., Muthayya, S., Shet, A., Bhat, V., Nagaraj, S., ... & Shet, A. S. (2010). Determinants of anemia among young children in rural India. Pediatrics, 126(1), e140-e149. https://doi.org/10.1542/peds.2009-3108

[30]. Gupta, P. M., Perrine, C. G., Mei, Z., & Scanlon, K. S. (2016). Iron, anemia, and iron deficiency anemia among young children in the United States. Nutrients, 8(6), 330. https://doi.org/10.3390/nu8060330

[31]. Mehri, A. (2020). Trace elements in human nutrition (II)–an update. International journal of preventive medicine, 11(1), 2. 10.4103/ijpvm.IJPVM_48_19

[32]. Rasmussen, K. M. (2001). Iron-deficiency anemia: Reexamining the nature and magnitude of the public health problem. hemoglobin, 590, 603S.

[33]. Hurrell, R., & Egli, I. (2010). Iron bioavailability and dietary reference values. The American journal of clinical nutrition, 91(5), 1461S-1467S. https://doi.org/10.3945/ajcn.2010.28674F

[34]. James, A. H. (2021). Iron deficiency anemia in pregnancy. Obstetrics & Gynecology, 138(4), 663-674. 10.1097/AOG.0000000000004559

[35]. Cusick, S. E., & Georgieff, M. K. (2016). The role of nutrition in brain development: the golden opportunity of the "first 1000 days". The Journal of pediatrics, 175, 16-21. https://doi.org/10.1016/j.jpeds.2016.05.013

[36]. Lopez, A., Cacoub, P., Macdougall, I. C., & Peyrin-Biroulet, L. (2016). Iron deficiency anaemia. The Lancet, 387(10021), 907-916. https://doi.org/10.1016/S0140-6736(15)60865-0

[37]. Gasche, C., Lomer, M. C. E., Cavill, I., & Weiss, G. (2004). Iron, anaemia, and inflammatory bowel diseases. Gut, 53(8), 1190-1197. https://doi.org/10.1136/gut.2003.035758

[38]. Bermejo, F., & García-López, S. (2009). A guide to diagnosis of iron deficiency and iron deficiency anemia in digestive diseases. World journal of gastroenterology: WJG, 15(37), 4638. doi: 10.3748/wjg.15.4638

[39]. Baker, R. D., & Greer, F. R. (2010). Diagnosis and prevention of iron deficiency and iron-deficiency anemia in infants and young children (0-3 years of age). Pediatrics, 126(5), 1040-1050. 10.1542/peds.2010-2576

[40]. Tamburini, S., Shen, N., Wu, H. C., & Clemente, J. C. (2016). The microbiome in early life: implications for health outcomes. Nature medicine, 22(7), 713-722. https://doi.org/10.1038/nm.4142

[41]. Georgieff, M. K. (2017). Iron assessment to protect the developing brain. The American journal of clinical nutrition, 106, 1588S-1593S. https://doi.org/10.3945/ajcn.117.155846

[42]. Guralnik, J. M., Eisenstaedt, R. S., Ferrucci, L., Klein, H. G., & Woodman, R. C. (2004). Prevalence of anemia in persons 65 years and older in the United States: evidence for a high rate of unexplained anemia. Blood, 104(8), 2263-2268.https://doi.org/10.1182/blood-2004-05-1812

[43]. Cook, J. D., Flowers, C. H., & Skikne, B. S. (2003). The quantitative assessment of body iron. Blood, The Journal of the American Society of Hematology, 101(9), 3359-3363. https://doi.org/10.1182/blood-2002-10-3071

[44]. Anker, S. D., Comin Colet, J., Filippatos, G., Willenheimer, R., Dickstein, K., Drexler, H., ... & Ponikowski, P. (2009). Ferric carboxymaltose in patients with heart failure and iron deficiency. New England Journal of Medicine, 361(25), 2436-2448. DOI: 10.1056/NEJMoa0908355

[45]. Jankowska, E. A., Rozentryt, P., Witkowska, A., Nowak, J., Hartmann, O., Ponikowska, B., ... & Ponikowski, P. (2010). Iron deficiency: an ominous sign in patients with systolic chronic heart failure. European heart journal, 31(15), 1872-1880. https://doi.org/10.1093/eurheartj/ehq158

[46]. Ganz, T. (2013). Systemic iron homeostasis. Physiological reviews, 93(4), 1721-1741. https://doi.org/10.1152/physrev.00008.2013

[47]. Andrews, N. C. (1999). Disorders of iron metabolism. New England Journal of Medicine, 341(26), 1986-1995. DOI: 10.1056/NEJM199912233412607

[48]. Weiss, G., & Goodnough, L. T. (2005). Anemia of chronic disease. New England Journal of Medicine, 352(10), 1011-1023. DOI: 10.1056/NEJMra041809

[49]. Kroot, J. J., Tjalsma, H., Fleming, R. E., & Swinkels, D. W. (2011). Hepcidin in

human iron disorders: diagnostic implications. Clinical chemistry, 57(12), 1650-1669. https://doi.org/10.1373/clinchem.2009.140053

[50]. Rego, R. T. T., Watson, S., Gill, P., & Lilford, R. (2021). The impact of diarrhoea measurement methods for Under-Fives in low and middle income countries on reported diarrhoea rates: a systematic review and meta-analysis of methodological and primary empirical studies. Available at SSRN 3768555. http://dx.doi.org/10.2139/ssrn.3768555

[51]. Fiseha, T., Ekong, N. E., & Osborne, N. J. (2024). Chronic kidney disease of unknown aetiology in Africa: A review of the literature. Nephrology, 29(4), 177-187.https://doi.org/10.1111/nep.14264

[52]. Ni, S., Yuan, Y., Kuang, Y., & Li, X. (2022). Iron metabolism and immune regulation. Frontiers in immunology, 13, 816282. https://doi.org/10.3389/fimmu.2022.816282

[53]. Cusick, S. E., Opoka, R. O., Ssemata, A. S., Georgieff, M. K., & John, C. C. (2020). Delayed iron improves iron status without altering malaria risk in severe malarial anemia. The American Journal of Clinical Nutrition, 111(5), 1059-1067. https://doi.org/10.1093/ajcn/nqaa004

[54]. Sendeku, F. W., Azeze, G. G., & Fenta, S. L. (2020). Adherence to iron-folic acid supplementation among pregnant women in Ethiopia: a systematic review and meta-analysis. BMC pregnancy and childbirth, 20, 1-9. https://doi.org/10.1186/s12884-020-2835-0

[55]. Richards, T., Miles, L. F., Clevenger, B., Keegan, A., Abeysiri, S., Rao Baikady, R., ... & Faulds, J. (2023). The association between iron deficiency and outcomes: a secondary analysis of the intravenous iron therapy to treat iron deficiency anaemia in patients undergoing major abdominal surgery (PREVENTT) trial. Anaesthesia, 78(3), 320-329. https://doi.org/10.1111/anae.15926

[56]. Costa, D.B., Drews, R.E. (2009). Peripheral Effects of Iron Deficiency. In: Yehuda, S., Mostofsky, D. (eds) Iron Deficiency and Overload. Nutrition and Health. Humana Press, Totowa, NJ. https://doi.org/10.1007/978-1-59745-462-9_9

[57]. Camaschella, C. (2015). Iron deficiency: new insights into diagnosis and treatment. Hematology, 2019(1), 202-207. https://doi.org/10.1182/asheducation-2015.1.8

[58]. Chernecky, C. C., & Berger, B. J. (2012). Laboratory Tests and Diagnostic Procedures. Elsevier.

[59]. Cappellini, M. D., & Motta, I. (2015). Anemia in Clinical Practice—Definition and Classification: Does Hemoglobin Change With Aging? Seminars in Hematology, 52(4), 261–269. https://doi.org/10.1053/j.seminhematol.2015.07.004

[60]. Schrier, S. L., & Auerbach, M. (2018). Diagnosis and Treatment of Iron Deficiency Anemia in Patients With Suboptimal Response to Oral Iron. European Journal of Haematology, 101(5), 477–486. https://doi.org/10.1111/ejh.13119

[61]. DeLoughery, T. G. (2017). Iron Deficiency Anemia. Medical Clinics of North America, 101(2), 319–332

[62]. Pasricha, S. R., & Drakesmith, H. (2016). Iron deficiency anemia: Problems in diagnosis and prevention at the population level. Hematology/Oncology Clinics of North America, 30(2), 309–325.DOI: https://doi.org/10.1016/j.hoc.2015.11.003

[63]. Mandal, S., Smith, D. L., Peter, P. J., Louw, V. J., Sil, S., Ibrahim, I. N., ... & Nath, S. (2023). Perioperative anaemia management. Annals of Blood, 8. doi: 10.21037/aob-22-42

[64]. Staniek, H. Z., Król, E., & Wójciak, R. W. (2020). The interactive effect of high doses of chromium (III) and different Iron (III) Levels on the carbohydrate status, lipid profile, and selected biochemical parameters in female wistar rats. Nutrients, 12(10), 3070. https://doi.org/10.3390/nu12103070

[65]. Jin, X., Shi, X., Zhang, T., Li, X., Xie, Y., Tian, S., & Han, K. (2024). MALDI-mass spectrometry imaging as a new technique for detecting non-heme iron in peripheral tissues via caudal vein injection of deferoxamine. Analytical and Bioanalytical Chemistry, 1-11. https://doi.org/10.1007/s00216-024-05289-7

[66]. Almashjary, M. N. (2024). Reticulocyte Hemoglobin Content: Advancing the Frontiers in Iron-deficiency Anemia Diagnosis and Management. Journal of Applied Hematology, 10-4103. DOI: 10.4103/joah.joah_103_23

[67]. Gómez-Ramírez, S., Brilli, E., Tarantino, G., Girelli, D., & Muñoz, M. (2023). Sucrosomial® iron: an updated review of its clinical efficacy for the treatment of iron deficiency. Pharmaceuticals, 16(6), 847. https://doi.org/10.3390/ph16060847

[68]. Robbins-Welty, G. A., Webb, J. A., Shalev, D., El-Jawahri, A., Jackson, V., Mitchell, C., & LeBlanc, T. W. (2023). Advancing palliative care integration in hematology: building upon existing evidence. Current treatment options in oncology, 24(5), 542-564. https://doi.org/10.1007/s11864-023-01084-1

[69]. Larson, L. M., Braat, S., Hasan, M. I., Mwangi, M. N., Estepa, F., Hossain, S. J., ... & Pasricha, S. R. (2021). Preanalytic and analytic factors affecting the measurement of haemoglobin concentration: impact on global estimates of anaemia prevalence. BMJ Global Health, 6(7), e005756.https://doi.org/10.1136/bmjgh-2021-005756

[70]. Bottomley, S. S., & Fleming, M. D. (2014). Sideroblastic anemia: diagnosis and management. Hematology/Oncology Clinics, 28(4), 653-670. https://doi.org/10.1016/j.hoc.2014.04.008

[71]. Rockey, D. C. (2010). Occult and obscure gastrointestinal bleeding: causes and clinical management. Nature reviews Gastroenterology & hepatology, 7(5), 265-279. https://doi.org/10.1038/nrgastro.2010.42

[72]. Babitt, J. L., & Lin, H. Y. (2012). Mechanisms of anemia in CKD. Journal of the American Society of Nephrology, 23(10), 1631-1634. DOI: 10.1681/ASN.2011111078

[73]. McCarthy, E. K., Murray, D. M., & Kiely, M. E. (2022). Iron deficiency during the first 1000 days of life: are we doing enough to protect the developing brain?. Proceedings of the Nutrition Society, 81(1), 108-118. https://doi.org/10.1017/S0029665121002858

[74]. Camaschella, C. (2019). Iron deficiency. Blood, The Journal of the American Society of Hematology, 133(1), 30-39. https://doi.org/10.1182/blood-2018-05-815944

[75]. Auerbach, M., & Macdougall, I. (2017). The available intravenous iron formulations: history, efficacy, and toxicology. Hemodialysis International, 21, S83-S92. https://doi.org/10.1111/hdi.12560

[76]. Bregman, D. B., Morris, D., Koch, T. A., He, A., & Goodnough, L. T. (2013). Hepcidin levels predict nonresponsiveness to oral iron therapy in patients with iron deficiency anemia. American journal of hematology, 88(2), 97-101. https://doi.org/10.1002/ajh.23354

[77]. Mikulic, N. (2021). Strategies to increase safety and efficacy of iron interventions in African infants (Doctoral dissertation, ETH Zurich).

[78]. Aapro, M., Gascón, P., Patel, K., Rodgers, G. M., Fung, S., Arantes Jr, L. H., & Wish, J. (2019). Erythropoiesis-stimulating agents in the management of anemia in chronic kidney disease or cancer: a historical perspective. Frontiers in pharmacology, 9, 1498. doi: 10.3389/fphar.2018.01498

[79]. Niraj, A., Pradahan, J., Fakhry, H., Veeranna, V., & Afonso, L. (2007). Severity of coronary artery disease in obese patients undergoing coronary angiography:"obesity paradox" revisited. Clinical Cardiology: An International Indexed and Peer-Reviewed Journal for Advances in the Treatment of Cardiovascular Disease, 30(8), 391-396. https://doi.org/10.1002/clc.20113

[80]. Jáuregui-Lobera, I. (2014). Iron deficiency and cognitive functions. Neuropsychiatric Disease and Treatment, 10, 2087–2095. https://doi.org/10.2147/NDT.S72491

[81]. Carter, R. C., Jacobson, J. L., Burden, M. J., Armony-Sivan, R., Dodge, N. C., Angelilli, M. L., ... & Jacobson, S. W. (2010). Iron deficiency anemia and cognitive function in infancy. Pediatrics, 126(2), e427-e434. https://doi.org/10.1542/peds.2009-2097

[82]. Bastian, T. W., Rao, R., Tran, P. V., & Georgieff, M. K. (2020). The effects of early-life iron deficiency on brain energy

metabolism. Neuroscience Insights, 15, 2633105520935104. https://doi.org/10.1177/2633105520935104

[83]. Oshin, O., Kireev, D., Hlukhova, H., Idachaba, F., Akinwande, D., & Atayero, A. (2020). Graphene-based biosensor for early detection of iron deficiency. Sensors, 20(13), 3688. https://doi.org/10.3390/s20133688

[84]. Murphy, S. R., & Cockrell, K. (2015). Regulation of soluble fms-like tyrosine kinase-1 production in response to placental ischemia/hypoxia: role of angiotensin II. Physiological reports, 3(2), e12310. https://doi.org/10.14814/phy2.12310

[85]. Churchill, D., Ali, H., Moussa, M., Donohue, C., Pavord, S., Robinson, S. E., ... & Stanworth, S. J. (2022). Maternal iron deficiency anaemia in pregnancy: lessons from a national audit. British Journal of Haematology, 199(2), 277-284. https://doi.org/10.1111/bjh.18391

[86]. Jimenez, K., Kulnigg-Dabsch, S., & Gasche, C. (2015). Management of Iron Deficiency Anemia. Gastroenterology & hepatology, 11(4), 241–250.

[87]. Reid, B. M., & Georgieff, M. K. (2023). The interaction between psychological stress and iron status on early-life neurodevelopmental outcomes. Nutrients, 15(17), 3798. https://doi.org/10.3390/nu15173798

[88]. Murray-Kolb, L. E. (2013). Iron and brain functions. Current Opinion in Clinical Nutrition & Metabolic Care, 16(6), 703-707. DOI: 10.1097/MCO.0b013e3283653ef8

[89]. Munoz, P., & Humeres, A. (2012). Iron deficiency on neuronal function. Biometals, 25, 825-835. https://doi.org/10.1007/s10534-012-9550-x

[90]. Basrowi, R. W., & Dilantika, C. (2021). Optimizing iron adequacy and absorption to prevent iron deficiency anemia: the role of combination of fortified iron and vitamin C. World Nutrition Journal, 5(S1), 33-39. https://doi.org/10.25220/WNJ.V05.S1.0005

[91]. Shubham, K., Anukiruthika, T., Dutta, S., Kashyap, A. V., Moses, J. A., & Anandharamakrishnan, C. (2020). Iron deficiency anemia: A comprehensive review on iron absorption, bioavailability and emerging food fortification approaches. Trends in Food Science & Technology, 99, 58-75. https://doi.org/10.1016/j.tifs.2020.02.021

[92]. Bathla, S., & Arora, S. (2022). Prevalence and approaches to manage iron deficiency anemia IDA. Critical Reviews in Food Science and Nutrition, 62(32), 8815–8828. https://doi.org/10.1080/10408398.2021.1935442

[93]. Schrage, B., Rübsamen, N., Ojeda, F. M., Thorand, B., Peters, A., Koenig, W., ... & Karakas, M. (2021). Association of iron deficiency with incident cardiovascular diseases and mortality in the general population. ESC Heart Failure, 8(6), 4584-4592. https://doi.org/10.1002/ehf2.13589

[94]. Kinyoki, D., Osgood-Zimmerman, A. E., Bhattacharjee, N. V., Kassebaum, N. J., & Hay, S. I. (2021). Anemia prevalence in women of reproductive age in low-and middle-income countries between 2000 and 2018. Nature medicine, 27(10), 1761-1782. https://doi.org/10.1038/s41591-021-01498-0t

[95]. Collings, R., Harvey, L. J., Hooper, L., Hurst, R., Brown, T. J., Ansett, J., ... & Fairweather-Tait, S. J. (2013). The absorption of iron from whole diets: a systematic review. The American journal of clinical nutrition, 98(1), 65-81. https://doi.org/10.3945/ajcn.112.050609

[96]. Gharibzahedi, S. M. T., & Jafari, S. M. (2017). The importance of minerals in human nutrition: Bioavailability, food fortification, processing effects and nanoencapsulation. Trends in Food Science & Technology, 62, 119-132. https://doi.org/10.1016/j.tifs.2017.02.017

[97]. Muthayya, S., Rah, J. H., Sugimoto, J. D., Roos, F. F., Kraemer, K., & Black, R. E. (2013). The global hidden hunger indices and maps: an advocacy tool for action. PloS one, 8(6), e67860. https://doi.org/10.1371/journal.pone.0067860

[98]. Pachón, H., Spohrer, R., Mei, Z., & Serdula, M. K. (2015). Evidence of the effectiveness of flour fortification programs on iron status and anemia: a systematic review. Nutrition reviews, 73(11), 780-795. https://doi.org/10.1093/nutrit/nuv037

[99]. Kumar, S. B., Arnipalli, S. R., Mehta, P., Carrau, S., & Ziouzenkova, O. (2022). Iron deficiency anemia: efficacy and limitations of nutritional and comprehensive mitigation strategies. Nutrients, 14(14), 2976. https://doi.org/10.3390/nu14142976

[100]. Lopez, A., Cacoub, P., Macdougall, I. C., & Peyrin-Biroulet, L. (2016). Iron deficiency anaemia. The Lancet, 387(10021), 907-916. https://doi.org/10.1016/S0140-6736(15)60865-0

[101]. Bailey, R. L., West Jr, K. P., & Black, R. E. (2015). The epidemiology of global micronutrient deficiencies. Annals of nutrition and metabolism, 66(Suppl. 2), 22-33. https://doi.org/10.1159/000371618

[102]. Suchdev, P. S., Williams, A. M., Mei, Z., Flores-Ayala, R., Pasricha, S. R., Rogers, L. M., & Namaste, S. M. (2017). Assessment of iron status in settings of inflammation: challenges and potential approaches. The American journal of clinical nutrition, 106, 1626S-1633S. https://doi.org/10.3945/ajcn.117.155937