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Effectiveness and Function of Dietary and Medical Iron Interventions in Treating Iron-Deficiency Anemia: A Systematic Review

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ABSTRACT

Iron-deficiency anaemia is a widespread nutritional disorder affecting individuals across all age groups, particularly children, pregnant women, and those with chronic illnesses. It arises due to insufficient dietary intake, impaired absorption, or increased iron loss, reducing haemoglobin and oxygen-carrying capacity. **Objectives:** To compare the effectiveness of dietary and medical iron interventions in preventing and treating iron-deficiency anaemia across different populations. **Methods:** A comprehensive search was conducted in PubMed, Scopus, Google Scholar, and Cochrane Library for studies published between 2017 and February 2025.Eligible studies included randomized controlled trials and clinical trials evaluating iron interventions in individuals with or at risk of iron-deficiency anaemia.Primary outcomes included changes in haemoglobin, serum ferritin, total body iron, and anaemia prevalence. **Results:** Both dietary and medical interventions were effective in improving iron status.Iron-fortified foods, micronutrient powders, and bioavailability enhancers such as vitamin C and probiotics were cost-effective for population-level prevention.Medical therapies, including oral and intravenous iron, provided rapid correction in individuals with moderate to severe anaemia. Adherence and long-term sustainability remained key challenges across both approaches. **Conclusions:** It was concluded that integrating dietary strategies with medical interventions offers the most effective approach for managing iron-deficiency anaemia.Future research should focus on enhancing adherence, improving iron bioavailability, and personalizing treatment based on individual needs.

INTRODUCTION

Iron-deficiency anaemia (IDA) is one of the most prevalent nutritional disorders globally, affecting millions across all age groups [1]. It remains a significant public health concern due to its wide-ranging impact on physical performance, cognitive development, maternal health, and productivity, especially among children, pregnant women, and individuals with chronic illnesses. IDA primarily arises from insufficient dietary iron intake, poor absorption, or increased iron loss, resulting in reduced haemoglobin production and impaired oxygen delivery to tissues [2]. The burden of IDA is particularly severe in low- and middle-income countries due to limited access to iron-rich foods, parasitic infections, and poor health infrastructure [3]. However, it also persists in high-income countries, especially among women of reproductive age, individuals with inflammatory bowel diseases, and those following restrictive diets [4]. Multiple intervention strategies exist, including dietary approaches such as iron fortification, micronutrient powders, and bioavailability enhancers (vitamin C, probiotics), and medical treatments like oral or

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intravenous iron therapy[5, 6]. While dietary strategies are generally affordable and suitable for public health programs, their effectiveness can be limited by inhibitors (e.g., phytates, calcium), poor compliance, and absorption variability[7].

On the other hand, medical interventions, particularly intravenous iron, offer rapid correction but are costly and invasive, with concerns over adherence and side effects. Despite the abundance of studies on individual interventions , there is limited synthesis comparing the overall effectiveness of dietary and medical strategies across different populations and clinical contexts. This lack of comparative evidence presents a gap in guiding practical, context-specific decision-making for health providers and policymakers.This study aims to critically assess and compare the effectiveness of dietary and medical iron interventions in improving iron status, identify challenges associated with each strategy, and evaluate their roles in prevention versus treatment across diverse populations.

METHODS

This systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure transparency and methodological rigor. The primary objective was to evaluate the effectiveness of dietary and medical iron interventions in treating iron-deficiency anaemia (IDA) across different populations. A comprehensive search of the literature was conducted using the following databases: PubMed, Scopus, Cochrane Library, and Google Scholar. The search was limited to original research articles published between January 2017 and February 2025 to ensure inclusion of the most recent and relevant studies on iron interventions. Keywords and MeSH terms included: "iron deficiency anaemia," "iron supplementation," "dietary iron intervention," "intravenous iron therapy," "fortified foods," "iron bioavailability," and "nutritional anaemia treatment." Boolean operators (AND/OR) were used to combine keywords and refine the search. Additionally, the reference lists of included studies were manually screened to identify other relevant articles. To ensure inclusion of high-quality and relevant studies, clear inclusion and exclusion criteria were established: Study Types: Randomized controlled trials (RCTs), cluster-RCTs, clinical trials, and open-label trials, Population: Individuals with diagnosed or at-risk IDA, including children, adolescents, pregnant women, adults, and elderly, Interventions, Dietary: Iron-fortified foods, micronutrient powders, lipid-based nutrient supplements, iron-rich diets, and probiotic-enhanced strategies, Medical: Oral iron supplementation (ferrous sulfate, bisglycinate) and intravenous iron therapies (ferric carboxymaltose, ferric derisomaltose, ferric citrate hydrate), Outcomes Measured: Haemoglobin, serum ferritin, total body iron, transferrin saturation, anomia prevalence, and bioavailability, Publication Period: Articles published between 2017 and March 2025 and Language: Only English-language studies were included. Study Type: Systematic reviews, meta-analyses, case reports, editorials, and animal/in-vitro studies, Population: Studies involving participants without iron deficiency or IDA, Intervention Focus: Studies evaluating iron supplementation for non-anaemia purposes (e.g., athletic performance) or combined with unrelated pharmaceutical treatments, Outcome Reporting: Studies without quantifiable outcomes related to iron status or reporting only short-term changes (<2 weeks) were excluded. All search results were imported into a reference manager, and duplicates were removed. Two reviewers independently screened the titles and abstracts of identified articles. Full texts of eligible studies were assessed in detail. Discrepancies were resolved through discussion, and if needed, a third reviewer was consulted for final decisions. Data were extracted using a standardized form. The following information was recorded: Author(s), year of publication, country, Study design and setting, Population (age group, gender), Type of intervention (dietary or medical), Dosage and duration, Outcomes assessed (e.g., haemoglobin, ferritin), Function of intervention (e.g., absorption enhancer, anaemia corrector), Role (prevention vs. treatment), Key findings. Studies were grouped into two categories: Dietary Interventions: Fortified foods, micronutrient powders, vitamin C-enhanced meals, probiotics and Medical Interventions: Oral iron tablets, intravenous iron infusions. The Cochrane Risk of Bias Tool was used to evaluate randomized trials. For non-randomized studies, the Newcastle-Ottawa Scale (NOS) was applied. Key quality indicators included: Adequate randomization and blinding. Transparent outcome reporting and definitions. Low attrition rates. Sufficient follow-up duration. Studies with low or moderate risk of bias were prioritized for final inclusion. Given the variability in study designs, populations, interventions, and outcome measures, a narrative synthesis approach was used. Studies were analyzed within their respective categories (dietary or medical) to identify overall trends, variations in effectiveness, influencing factors (adherence, baseline iron status), and potential limitations. In dietary interventions, the impact of iron enhancers(e.g., vitamin C, probiotics) and inhibitors (e.g., phytates, calcium) was discussed. For medical interventions, factors such as intravenous versus oral routes, dosage, and patient compliance were evaluated. The study selection process is

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illustrated in the PRISMA flow diagram, detailing identification, screening, eligibility, and inclusion stages (Figure 1).

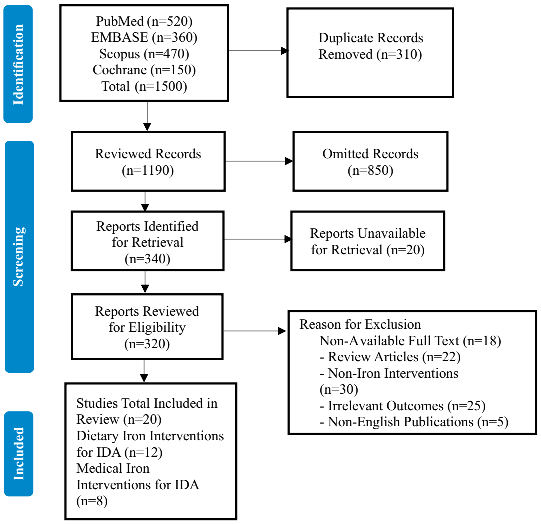

Figure 1: Prisma Flow Chart of Study Included

To enhance clarity and accessibility, the study provides a structured summary of the key characteristics of all included studies, including study design, setting, population, intervention type, outcome focus, and primary findings (Table 1).

Table 1: Study Characteristics of Included Articles

Sr. No.	References	Design	Country	Population	Intervention Type	Role	Main Outcome
1	[10]	Cluster-RCT	Bangladesh	Adolescent Girls	Fortified Lentils (Dietary)	Treatment	↓ Iron Deficiency
2	[11]	RCT	Thailand	Elderly	Rice Drink (Dietary)	Treatment	↑ Hemoglobin
3	[12]	RCT	Burkina Faso	Malnourished Children	Rutf (Dietary)	Treatment	↑ Iron, Persistent Anemia
4	[13]	RCT	India	Children	Mungbean + Guava (Dietary)	Treatment	↑ Hb, No Ferritin Gain
5	[14]	RCT	Thailand	Pregnant Women	Ferrous Bisglycinate (Medical)	Prevention	↑ Hb & Better Tolerance
6	[15]	RCT	Malawi	Malnourished Children	Soya-Maize RUTF (Dietary)	Treatment	↑ Iron Stores
7	[16]	Cluster-RCT	Kenya & Bangladesh	Infants	Lipid-Based Supplements (Dietary)	Prevention	Effective In Kenya Only
8	[17]	Cluster-RCT	China	Infants	Micronutrient Powder (Dietary)	Prevention	↑ Hb, No Cognitive Gain
9	[18]	RCT	Ethiopia	Adolescent Girls	Weekly Ifa (Medical)	Prevention	↑ Ferritin, Hb
10	[19]	RCT	Sweden	Pregnant Women	Probiotic + Iron (Dietary)	Prevention	↑ Absorption
11	[20]	Cluster-RCT	Ghana	Children	Fortified Powder (Dietary)	Prevention	↓ Anemia Prevalence
12	[21]	Clinical Trial	Italy	Celiac Women	High-Iron Diet (Dietary)	Treatment	Less Effective Than Oral Iron
13	[22]	RCT	Switzerland	Surgical Patients	IV Ferric Carboxymaltose (Medical)	Treatment	No Phosphate Effect
14	[23]	RCT	UK	HF Patients	IV Ferric Derisomaltose (Medical)	Treatment	↓ Infection -Related Admissions
15	[24]	Open-RCT	Japan	CKD Patients	Ferric Citrate Hydrate (Medical)	Treatment	↑ Iron, ↓ Platelets
16	[25]	RCT	International	HF Patients	IV Ferric Carboxymaltose (Medical)	Treatment	No Admission Reduction
17	[26]	RCT	International	HF Patients	IV Ferric Carboxymaltose (Medical)	Treatment	Effective at Hb ≥12 g/dL
18	[27]	RCT	Indonesia	HF Patients	Oral Ferrous Sulphate (Medical)	Treatment	↑ Hb and Function

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19	[28]	RCT	UK	HF Patients	IV Ferric Derisomaltose (Medical)	Treatment	↑ QoL, ↓ Admissions
20	[29]	RCT	Uganda	Pregnant Women	Iron + Folic Acid (Medical)	Prevention	↑ Hb, No Adherence Change

RESULTS

This review analyzed dietary and medical interventions for iron-deficiency anaemia (IDA), focusing on their effectiveness, role, and population-specific outcomes. Dietary strategies, including iron-fortified foods, micronutrient powders, and bioavailability enhancers, proved effective in improving iron status, especially for prevention in at-risk groups. Iron-fortified lentils and rice drinks improved haemoglobin and ferritin levels in adolescents and older adults, respectively. Co-fortification with vitamin C, such as mungbean dal with guava, enhanced absorption but had limited effects on iron stores, emphasizing the need for long-term strategies. Micronutrient powders and lipid-based nutrient supplements were moderately effective in infants and young children, though outcomes varied by region. For instance, lipid-based supplements reduced anaemia in Kenya but not in Bangladesh, likely due to baseline nutritional differences. Similarly, probiotic-supported interventions showed improved absorption in pregnant women, indicating improved gut health in iron bioavailability. Therapeutic foods like RUTF improved iron levels in malnourished children, though over half remained anaemic post-treatment, suggesting the need for combination strategies. A high-iron gluten-free diet improved iron stores in celiac patients but was less effective than oral supplementation. Overall, dietary approaches were cost-effective and suitable for population-level prevention, but their effectiveness depended on adherence, baseline iron status, and nutrient absorption. While dietary strategies offer preventive and treatment benefits, medical iron interventions are often necessary for individuals with moderate to severe iron deficiency anaemia. Findings summarize key studies examining intravenous (IV) iron therapies and oral iron supplementation(Table 2).

Table 2: Summary of Dietary Iron Interventions for IDA

Sr. no	References	Design	Population	Intervention	Outcome	Role	Key Finding
1	[10]	Cluster-RCT	Adolescent Girls	Fortified Lentils	↑ Ferritin	Treatment	57% Lower Iron Deficiency
2	[11]	RCT	Elderly	Rice Drink	↑ Hb	Treatment	↑ Hb by 0.6 G/dl
3	[12]	RCT	Malnourished Children	Rutf	↑ Hb, Ferritin	Treatment	55% Remained Anaemic
4	[13]	RCT	Children	Mungbean + Guava	↑ Hb	Treatment	No Change in Iron Stores
5	[14]	RCT	Pregnant Women	Ferrous Bisglycinate	↑ Hb, Ferritin	Prevention	Better Tolerated Than Fumarate
6	[15]	RCT	Malnourished Children	Soya-Maize Rutf	↑ Iron Stores	Treatment	More Effective Than Standard RUTF
7	[16]	Cluster-RCT	Infants	Lipid-Based Supplement	↓ Anemia	Prevention	Effective in Kenya, Not in Bangladesh
8	[17]	Cluster-RCT	Infants	Micronutrient Powder	↑ Hb	Prevention	No Cognitive Gain
9	[18]	RCT	Adolescent Girls	Weekly Iron-Folic Acid	↑ Hb, Ferritin	Prevention	↑ Hb By 0.9 G/Dl
10	[19]	RCT	Pregnant Women	Probiotic + Iron	↑ Absorption	Prevention	Enhanced Bioavailability
11	[20]	Cluster-RCT	Young Children	Fortified Powder	↓ Anemia	Prevention	Prevalence ↓ : from 42% to 27%
12	[21]	Clinical trial	Celiac Women	High-Iron Diet	↑ Ferritin	Treatment	Less Effective Than Oral Iron

Intravenous iron therapies provide a direct and rapid approach to correcting iron deficiency, particularly in clinical settings. Ferric carboxymaltose was evaluated in patients undergoing elective surgery, but results indicated that phosphate supplementation had no significant effect on treatment outcomes [22]. Ferric derisomaltose was studied in heart failure patients and was found to reduce the risk of first hospitalization due to infection, suggesting that correcting iron deficiency may have broader immune and health benefits beyond anaemia management [23]. In patients with anaemia due to chronic

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kidney disease and who are not yet dialysis-dependent, ferric citrate hydrate was equally capable of regulating iron homeostasis by increasing ferritin levels but showed a reduction in platelet counts [24]. Ferric carboxymaltose was assessed for its use in treating hospitalized heart failure patients with iron deficiency; no statistically significant reductions in hospitalizations occurred due to the intervention [25]. A different study showed that the use of ferric carboxymaltose was more effective in patients with haemoglobin levels of ≥12 g/dL, indicating that strategies for treatment should be patient-specific [26]. Iron deficiency anaemia is usually treated with iron supplementation through the oral route. Ferrous sulphate has recently been tested for its possible effect on functional capacity and haemoglobin levels in heart failure patients [27]. Ferric derisomaltose was evaluated in patients with chronic heart failure and iron deficiency, showing potential to reduce hospitalizations and improve quality of life [28]. In pregnant women, iron supplementation plays a critical role in preventing anaemia and supporting maternal and fetal health. Iron and folic acid supplementation using blister-packaged tablets was found to improve haemoglobin levels, though adherence rates did not significantly change [29]. This suggests that while medical interventions can be effective, ensuring compliance remains a challenge. Overall, medical interventions provide effective solutions for correcting iron deficiency, particularly in clinical populations with significant anaemia or comorbid conditions. However, the effectiveness of IV iron therapies appears to vary by patient characteristics, and oral iron supplements, while beneficial, require adherence strategies for long-term success. In summary, medical interventions offer targeted, rapid correction of IDA but require careful selection and adherence strategies. Dietary interventions are preventive and sustainable but need optimization for long-term impact (Table 3).

Table 3: Summary of Medical Iron Interventions for IDA

Sr. no	Author (Year)	Design	Population	Intervention	Outcome	Role	Key Finding
1	[22]	RCT	Surgical patients	IV ferric carboxymaltose	Hb, phosphate	Treatment	Phosphate had no added effect
2	[23]	RCT	Heart failure patients	IV ferric derisomaltose	↓ Hospitalizations	Treatment	Fewer infection -related admissions
3	[24]	Open-RCT	CKD patients	Ferric citrate hydrate	↑ Ferritin	Treatment	↓ Platelets, ↑ Iron
4	[25]	RCT	Heart failure	IV ferric carboxymaltose	Hospitalization	Treatment	No significant change
5	[26]	RCT	Heart failure	IV ferric carboxymaltose	↑ Hb	Treatment	Better in Hb ≥12 g/dL
6	[27]	RCT	HF patients	Oral ferrous sulfate	↑ Hb, function	Treatment	Improved capacity
7	[28]	RCT	HF with IDA	IV ferric derisomaltose	↓ CV risk	Treatment	Fewer admissions, ↑ QoL
8	[29]	RCT	Pregnant women	Iron + folic acid tabs	↑ Hb	Prevention	No adherence change

The systematic review categorizes iron interventions into dietary and medical approaches, both of which demonstrate effectiveness in treating or preventing iron-deficiency anaemia. Dietary interventions are highly accessible and suitable for preventive strategies, particularly when iron is combined with bioavailability enhancers like vitamin C and probiotics. However, medical interventions, such as IV iron and oral supplements, provide rapid correction of anaemia in clinical populations, particularly those with heart failure, kidney disease, or malabsorption disorders. A multifaceted approach, integrating both dietary and medical interventions, appears to be the most effective strategy in managing iron-deficiency anaemia across different populations. Future research should continue to explore bioavailability improvements, long-term adherence strategies, and personalized treatment approaches to optimize iron interventions worldwide.

DISCUSSION

Iron-deficiency anaemia (IDA) remains a major public health challenge, particularly among children, women, and individuals with chronic illnesses. This review evaluated both dietary and medical interventions, categorizing them by purpose (prevention vs. treatment) and method (dietary vs. medical), providing a clearer understanding of their respective roles. When compared with previous systematic reviews, this study builds on existing knowledge by categorizing interventions and assessing their effectiveness based on patient-specific factors, adherence, and long-term outcomes [30-32]. Dietary strategies proved effective, especially for preventing IDA in at-risk populations. Fortified foods and enhancers like vitamin C and probiotics consistently improved hemoglobin and ferritin levels. For example, Yunus *et al.*, and Lerttrakarnnon et al., showed that iron-fortified lentils and rice drinks enhanced iron status [10, 11]. These findings align with Hurrell *et al.*, who identified staple food

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fortification as a scalable solution [33].However, effects on iron stores were inconsistent.In Rani *et al.,* haemoglobin increased with mung-bean and guava, but ferritin did not [13].This supports Rajagukguk *et al.,* who noted vitamin C helps absorb non-heme iron but may not suffice in severe deficiency.Probiotic strategies also showed promise [34]. Micronutrient powders and lipid-based supplements had mixed results.Luo *et al.,* reported improved haemoglobin but no cognitive gains [17]. Similarly, Stewart *et al.,* found success in Kenya but not Bangladesh, suggesting regional nutrition affects outcomes [16]. Kangas *et al.,* noted that RUTF improved iron status, though anaemia persisted, echoing Imdad *et al.,* [12, 35]. While dietary interventions are affordable and scalable, success depends on adherence, bioavailability, and baseline iron levels. Medical therapies were more suitable for moderate-to-severe anaemia. IV iron therapies produced rapid results. Foley *et al.,* reported reduced hospitalizations in heart failure patients using ferric derisomaltose [23].However, Macdougall *et al.,* found no reduction in admissions [25], consistent with the AFFIRM-AHF trial, which emphasized appropriate patient selection [36]. Kaserer *et al.,* showed no added benefit from phosphate with IV ferric carboxymaltose [22]. Iolascon *et al.,* similarly, emphasized tailoring IV iron based on patient profile [37]. Oral iron improved haemoglobin and function, but adherence remains a barrier [27]. Byamugisha *et al.,* and Afolabi *et al.,* noted poor compliance, especially among pregnant women [29, 38]. While IV iron is fast and effective, it's costlier and invasive. Oral iron is more accessible but requires adherence strategies to ensure impact.

This review is limited by considerable heterogeneity across included studies in terms of study populations, intervention types, dosages, outcome measures, and follow-up durations, which precluded meta-analytic pooling and may limit the generalizability of findings across different geographic and clinical contexts. Variability in adherence rates, baseline nutritional status, and regional dietary patterns further complicates direct comparisons between dietary and medical approaches, introducing potential confounding. Future research should prioritize large-scale, long-term randomized controlled trials that directly compare dietary and medical interventions within the same populations, with a focus on enhancing iron bioavailability, improving patient adherence through innovative delivery strategies, and developing personalized, region-specific treatment protocols that account for individual nutritional profiles and disease burden.

CONCLUSIONS

It was concluded that both dietary and medical iron interventions are effective in addressing iron-deficiency anaemia, each serving distinct roles. Dietary strategies, including fortified foods, micronutrient powders, and enhancers like vitamin C and probiotics, are sustainable and preventive, especially in community and public health settings. However, their effectiveness depends on long-term adherence and individual nutritional status. Medical interventions, particularly intravenous and oral iron therapies, are more appropriate for moderate to severe anaemia, offering rapid correction but requiring clinical monitoring and patient compliance. The findings support a complementary approach, where dietary and medical strategies are integrated based on population needs and anaemia severity. This dual-path strategy can improve outcomes, especially in resource-diverse settings.

Authors' Contribution

Conceptualization: AA
Methodology: AA, NF
Formal analysis: MK, KS, NF, AS, SA
Writing and Drafting: AA, AS, SA
Review and Editing: AA, AS, SA

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflicts of Interest

All the authors declare no conflict of interest.

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