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Review Article

Efficacy of Iron-Fortification in Complementary Feeding for Prevention of Iron Deficiency Anemia in Children of Bangladesh

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Abstract: Iron deficiency anemia is a worldwide public health issue, and the best cost-effective prophylactic technique is to fortify foods with iron. The right mix of iron form and food carrier, as well as the dietary context in which it is consumed, are critical. It raises the chances of preterm birth and a low birth weight baby. IDA slows development affects cognitive function and lowers physical activity in youngsters. It also increases the risk of death and morbidity in women. Dietary iron requirement, socioeconomic level, and illness condition are all important considerations. Disease management methods, dietary variety, supplementation, and iron fortification in food have all been used to combat IDA. Iron fortification of food is now thought of as a long-term and sustainable option. For a fortification program to be successful, the combination of iron fortificants and food vehicles must be secure, well-tolerated, and consumed by the target population. Additionally, it shouldn't have a detrimental effect on the stability and acceptability of the final product. This article provides a comprehensive summary of the current state of iron deficiency in women and children in Bangladesh. This research also discusses the efficacy and current issues with existing intervention strategies. Interventions to prevent iron deficiency should take precedence in high-risk groups. However, there is a risk of negative side effects, and the long-term benefits are questionable. Although significant progress has been achieved and a variety of methodologies and treatments are being supported, significant issues including coverage, quality, and compliance still exist. The results show that iron deficiency and anemia continue to be major problems in Bangladesh, despite the fact that current intervention programs have had some success in addressing severe deficiencies. More well-integrated strategies are required to support present therapeutic initiatives. New treatment and prevention strategies for specific iron deficiencies and anemia are also offered.

Keywords: Iron Deficiency, Complementary Feeding, Anemia, Bioavailability, Management

1. Introduction

The two billion instances of anemia that are caused by iron deficiency account for almost half of all micronutrient deficits worldwide. Infants and young children are particularly susceptible to iron deficiency or anemia (IDA) because of their rapid growth. Iron is important for neurodevelopment, thus this is problematic since low iron levels may impair brain development. With irreversible harm being posited, at least when IDA develops during childhood, there is a well-established relationship between iron deficiency and decreased cognitive function in infants and young children [1-3]. This association has been challenging to prove in randomized controlled trials because to the requirement for large sample sizes and prolonged follow-up periods. As a result, it has been difficult to translate findings into recommendations. The majority of previous and current intervention research have instead concentrated on short-term laboratory outcomes. Our knowledge of the possible side effects of iron supplements has improved during the past 10 years of industry research, underscoring the need of evidence-based practices for weighing benefits and risks [4].

Iron deficiency anemia (IDA) is common in both developing and developed nations, particularly among newborns, teens, and women of reproductive age. 1 This nutritional condition affects 3.5 billion people1 in the poor world, with 30–60 percent of women and children afflicted [6]. Anemia affects 52 percent of pregnant women worldwide and 76 percent of pregnant women in South Asia. 94 Anemia affects almost all pregnant and breastfeeding women in Pakistan, as well as roughly two-thirds of small children, half of all women of childbearing age, and more than 30% of adult males. According to multi-center research, iron deficiency causes 78 to 85 percent of anemia in children under the age of five. 42 In a study of poor children aged five in Karachi, it was shown that 67 percent of the youngsters were anemic, with Hb less than 11 g/dL [27]. Another research done by Paracha and Jamil 67 on children aged 6 months to 5 years in the Northwest Frontier Province revealed a 50.1 percent prevalence of anemia.

Anemia in children has been related to an iron deficit in mothers during pregnancy, prompting a few surveys in Pakistan on iron insufficiency in women. According to Khan and Jalil[43], 83 percent of pregnant women, 78 percent of nursing women, 85 percent of teenage females, and 82.9 percent of youngsters are anemic. Although the predicted trends in hemoglobin concentration distributions from 1995 to 2011 suggest a decline in worldwide anemia prevalence, the statistics are still astonishing. Around 800 million children and women are anemic, according to the World Health Organization (WHO), due to iron deficiency.

Anemia and iron deficiency not only limit people's ability to work, but they may also have major economic effects and stymie national progress. As a result of all of this, reducing the worldwide burden of iron deficiency and iron deficiency anemia is widely regarded as a public health nutrition priority. In fact, the World Health Assembly Resolution 65.6 in 2012 endorsed a "Comprehensive implementation plan on maternal, infant, and young child nutrition," which set six Global Nutrition Targets for 2025 (World Health Organization, 2012), with the second target being to "achieve a 50% reduction in anemia in women of reproductive age". Several techniques for delivering iron are now available in public health programs to prevent and treat anemia, but iron dietary fortification seems to provide the greatest risk-benefit balance.

2. Role of Iron Fortification in Complementary Feeding

Due to the rapid rate of development at this time, the World Health Organization (WHO) [42] and the US Institute of Medicine recommend iron intakes for children aged 6 to 12 months of 9.3 mg and 11 mg daily, respectively. For children between the ages of 12 and 24 months, the recommended iron intakes vary from 5.8 mg to 7 mg per day, which is less than for infants between the ages of 6 and 12 months [1, 2]. Only 0.2 mg of iron per day is found in breastmilk, thus a net quantity of 9 to 10 mg per day at 6 to 8 months and 5 to 7 mg per day at 12 to 24 months must be obtained from other sources. The majority of infants need an external source of iron by 6 months (or even earlier if they are at high risk for iron deficiency), whereas some infants have sufficient iron stores at birth to last until 8 to 9 months of age (if they are of normal birth weight, were born to mothers who were iron depleted, and received placental blood transfer via delayed umbilical cord clamping).

At this age, iron is typically the most restricted nutrient [3-5] because of the significant disparity between the amount of iron needed from complementary meals and the iron content of such foods. In Bangladesh, children aged 6 to 8 months had a daily iron intake of 0.5 mg and children aged 9 to 12 months had a daily iron intake of 0.7 mg [7]. After accounting for the amount supplied by nursing (0.2 mg/day), the total iron intake (0.7 to 0.9 mg/day) was only 8% to 9% of the WHO-recommended amount (9.3 mg/day). Average daily iron intake from supplemented meals in Malawi ranged from 1.2 milligrams at 6 to 8 months to 2.8 milligrams at 9 to 11 months to 3.5 milligrams from 12 to 23 months [7]. As a result of iron's poor estimated bioavailability (ranging from 5.5% to 7.4%), supplemented meals only met 6% of expected iron needs at 6–8 months, 13% at 9–11 months, and 30% at 12–23 months. 0% to 4% of the diet's iron came from meat, poultry, and fish. In spite of the fact that the average daily intake of iron was just 2.9 mg, 31% of infants aged 6 to 12 months in a rural area of South Africa consumed iron-fortified baby cereal on the day of the food recall [8]. Even among babies who ate iron-fortified cereal, the average iron intake (5.3 mg/day) fell significantly short of the advised intakes due to the relatively small portion size (20 g/day dry cereal) and low degree of fortification (15 mg of iron per 100 g of dry product). As a result, the majority of inhabitants in underdeveloped countries have a considerable gap between their iron intake and requirements.

3. Requirements for Iron in Infants from the Age of Six Months

Despite the fact that iron requirements are highest (per kg) during the first six to twelve months of life, well-nourished people frequently do not require supplements throughout this period. Instead, it is advisable to consume a significant amount of dietary iron from supplemental meals [11, 12, 19]. These improved guidelines have been linked to a decrease in the occurrence of IDA and iron deficiency, according to many recent studies [3]. In an epidemiological study carried out in Iceland, the iron status of two cohorts of infants was compared before and after the revision of the Icelandic dietary recommendations. In contrast to the 20% iron deficit and 2.7 percent IDA found in analogous study from 1995 to 1997, there were no anemic 12-month-old newborns and a decreased prevalence of iron deficiency (1.4%). The switch from cow's milk to iron-fortified formulae and cereals among Icelandic newborns was blamed for the decline in prevalence [20, 21]. This is consistent with a recent meta-analysis [22], which discovered that milk or cereals supplemented with iron are a useful approach to lower anemia rates in infants and kids who are at risk for iron deficiency. Another factor that affects iron requirements is dietary iron content. In the United States, a recent randomized trial compared weaning neonates with pureed meat and iron-fortified cereals. The meat intervention led to a reduction in daily iron intake (3.3 mg vs. 7–12 mg/day), but the iron status at 9 months of age remained the same, indicating that the higher bioavailability of heme-bound iron reduces requirements. But mild anemia and low ferritin levels were significantly more common in both groups [25, 26].

4. Interventions with Iron in Toddlers and School-Aged Kids

Two recent meta-analyses looked at the effects of iron supplements given to preschoolers and school-aged kids. However, there is a lack of information on the effects on iron deficiency, IDA, and, in particular, cognitive development. Thompson et al. [38] reviewed 15 studies with children ages 2 to 5 and discovered evidence of improved iron status. Children aged 5 to 12 were assessed in 32 research reviewed by Low et al, 31 of which were from low- or middle-income countries [39]. The researchers found that iron supplementation improved longitudinal development and reduced the frequency of IDA and iron insufficiency in high-risk environments. Additionally, they found that children who received supplements had significantly higher global cognitive scores (0.50 points) as well as improved measures of attention and focus. The impact on the intelligence quotient was 4.55 points in subsamples of anemic children [38].

5. Iron Status and Growth Effects

According to a recent Cochrane meta-analysis [26], home fortification with multiple micronutrient powder (MNP) including iron is a successful method to prevent anemia and iron deficiency in infants and early children. Bangladeshi case-control investigation has confirmed the previously mentioned connection between IDA in newborns and long-term cognitive harm. The study examined the effects of a nine-month training regimen designed to accelerate newborns' motor development. Even after receiving treatment for their IDA, individuals who had it at 6 months still responded to the intervention worse than controls, showing that there had been persistent harm [33]. Only two studies involving kids between the ages of 1 and 5 were reported in a recent meta-analysis that looked at the effects of iron supplementation on neurodevelopment in kids with non-anemic iron shortage [36]. In the Bangladesh experiment, children who received supplements also grew taller more quickly, although ferritin levels were unaffected [42]. In these trials using numerous micronutrients, the possible interaction with other micronutrients is a challenge. Children who received a variety of micronutrients had significantly higher hemoglobin levels and weight-for-height ratios than children who only got iron [44]. This suggests that micronutrients have synergistic effects. Using a two-by-two factorial design, another Chinese RCT demonstrated a similar synergy between iron and vitamin A supplementation in children aged 3-6 who were at high risk of malnutrition. They found that taking iron or vitamin A supplements alone had no positive or negative effects, but that giving the two together for six months resulted in a lower incidence of respiratory tract infections and diarrhea-related sickness [45]. In the aforementioned Chinese MNP experiment, researchers found that youngsters who received supplements had less anxiety. A skewed baseline proportion of anemia, the fact that the participants weren't blinded to the intervention, and the potential for confounding effects from other micronutrients were the trial's drawbacks [39].

6. Condition of Anemia and Iron Deficiency in Bangladesh

According to the NMS 2011-2012, anemia was classified as having a Hb concentration of 110 g/l in children aged 6-59 months and 120 g/l in NPNL women [42]. Anemia was also present in 33 percent of children aged 6-59 months and 26 percent of NPNL women. The prevalence recorded in 1997-1998 (47 percent in children aged 6-59 months and 45 percent in NPNL women) [45] and 2003 (557% in children aged 6-59 months and 329 percent in NPNL women) has significantly decreased, as seen by these numbers [42]. However, the NMS 2011–2012 findings indicate that the national prevalence of Fe deficiency is only 107% in preschool-age children and 71% in NPNL women, which is lower than the earlier small-scale studies' findings that Fe deficiency is a major cause of anemia [45, 46]. Additionally, only 48% of NPNL mothers and 72% of toddlers reported having iron deficiency anemia (IDA). IDA was established using Hb values of 110 g/l, serum ferritin concentrations of 120 g/l in preschool-aged children, and Hb concentrations of 120 g/l, serum ferritin concentrations of 150 g/l in NPNL women [11]. IDA is significantly less frequent among children who are in school [11], indicating that Fe deficiency might not be the main reason for anemia in the Bangladeshi population. Fe, however, only meets the RDA in distinct demographic groups to varying degrees (41–82%) [42]. In certain areas of Bangladesh, the groundwater's Fe content appears to be high [53]. mostly in the bioavailable ferrous (Fe2+) form rather than the ferric form. The low frequency of Fe insufficiency in the NMS 2011–2012 was attributable to the high Fe content in drinking water from tube wells [43]. A small-scale study in rural northern Bangladesh demonstrated a connection between plasma ferritin and total body Fe in women and daily Fe intake from drinking water [49]. Anemia and Fe deficiency were found to be more common among Bangladeshi NPNL women living in high Fe groundwater districts than in low Fe groundwater regions, according to a recent research [30] that used NMS 2011–2012 data. IDA can only explain around 10% of the anemia, though, because to the high anemia rates in children and women. Reiterating the significance of other hematopoietic micronutrients in controlling and preventing 90–95 percent of anemia cases, additional factors to consider include vitamin B6 deficiency, vitamin B12 deficiency, vitamin A deficiency, vitamin C deficiency, folic acid deficiency, and riboflavin [41] deficiency. Among the non-nutritional causes of anemia are malaria, worm infestation, chronic infections, and genetic diseases (such as hemoglobinopathies). [42-44] Despite the lack of national data on the incidence of thalassemia, it is believed to be a contributing factor, with one study showing a 28 percent frequency of thalassemia and a higher risk of anemia. [45].

7. Stability, and Bioavailability of Iron Fortificants

Minerals, as opposed to vitamins, are more resistant to processing. When exposed to heat, air, or light, they do, nevertheless, undergo modifications. Moisture affects minerals like copper, iron, and zinc, which may react with proteins and carbohydrates in the diet. Fortifying iron is possible using a variety of fortifiers. The most difficult task is to find an iron compound that is well-absorbed, stable, and does not change the look or flavor of the food vehicle.

The causes for unsuccessful iron-fortification plans have included consumer rejection, unappealing flavor, and food discoloration. Ferrous iron is easier to acquire than ferric iron because it dissolves more readily in the stomach. However, ferric iron may be converted to more soluble ferrous iron in the gut by the actions of gastric hydrochloric acid and reducing agents such ascorbic acid [39].

The term "bioavailability of dietary components" originated in pharmacology from the phenomena of drugs taken orally appearing in plasma. In the case of mineral bioavailability, notably in the case of iron, it was once believed that bioavailability and absorption were interchangeable. In vitro solubility was used to determine bioavailability. An iron complex is more soluble the greater its potential absorption and, hence, bioavailability. This solubility approach pertains to the idea of iron availability, or dialysability, if the digestive process is replicated using a semipermeable membrane and transit over it is evaluated. Iron bioavailability is the term used to describe the proportion of ingested iron that is absorbed by the intestines, used through regular metabolic pathways, or stored. Known to be influenced by dietary and environmental factors, it is expressed as a percentage of total consumption [36]. This larger view of iron bioavailability considers processes such as release from its matrix, absorption into the systemic circulation, distribution to tissues, metabolic utilization, or storage in the body. In terms of food science and technology, the first two are the ones that should be prioritized the most.

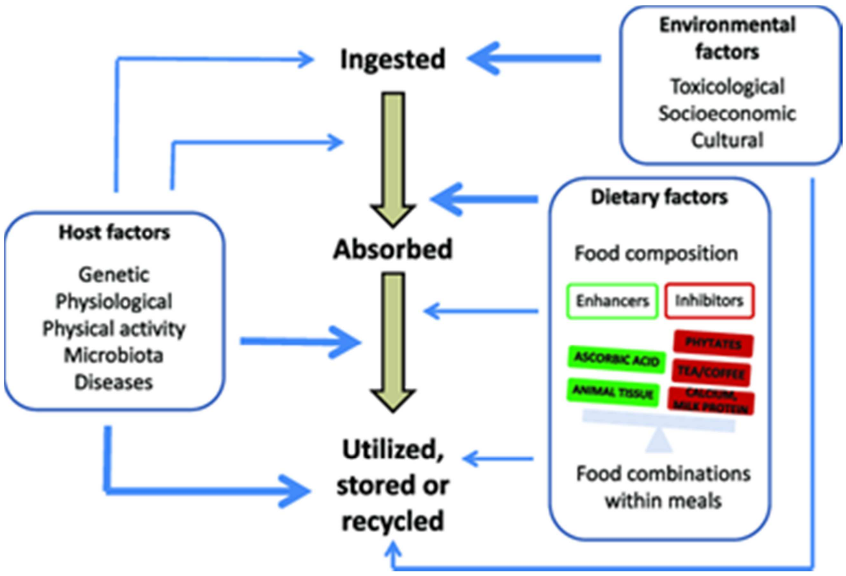

Figure 1. *Iron Bioavailability [54].*

Iron-EDTA, ferrous sulfate, elemental iron (reduced iron), ferric orthophosphate, ferrous fumarate, sodium ferric pyrophosphate, and other substances are examples of non-heme sources that have been widely used in fortification [36]. There are benefits and drawbacks to each fortifier. The most stable form of iron is ferric orthophosphate, but it's hard to get. Ferrous fumarate is likewise a stable compound; however, it alters the color of wheat flour. It's a better fit for maize flour. Iron absorption is improved by ferric phosphate, although it is expensive and unstable. Iron-EDTA, ferrous sulfate, and elemental iron are therefore the most practicable alternatives for fortification of flour [35]. Because ascorbic acid stimulates the duodenal ferric reductase, it has a direct relationship with ferric iron absorption in meals [24].

The amount of iron in a single fortified product shouldn't exceed the maximum need. A single food item should have 20–40% of the recommended daily intake of fortification. When stored for up to three months at ambient temperatures of 35°C and 90% humidity, fortification with iron at a level of 60 ppm elemental iron and 1.5 ppm folic acid has been recommended by many international organizations without affecting the sensory qualities of the flour or foods made from fortified wheat flour. 14 Wheat flour and wheat-based products maintained for up to three months below 30°C in hot, humid locations can have up to 40 ppm ferrous sulfate and up to 15 ppm iron EDTA added to them without generating any negative effects. 75 The best relative bioavailability of all the iron fortifiers is ferrous sulfate, a water-soluble iron supplement. 32,33 However, it is quite unstable and may have an impact on the quality and shelf life of the vehicle-food due to likely oxidized off-tastes, color changes, and metallic flavors. [40] Elemental iron is more stable and just half as bioavailable as ferrous sulfate [26]. If elemental iron is used as the fortifier to make up for the decreased bioavailability, higher doses (two or three times those needed for ferrous sulfate) may be needed. As a result, utilizing elemental iron for fortification is more costly than using ferrous sulfate. However, there is considerable overlap between studies because of different preparation and baking techniques. The elemental iron fortification at a higher rate also had a detrimental impact on chapatti quality. [29, 31]

The amount of iron required by the body is determined by the age of the person. The mineral is essential for increased hemoglobin mass, tissue synthesis, and storage of iron to develop a reserve in newborns, children, and adolescents. Losses of iron in feces (physiologically controlled) and small losses in urine and perspiration, as well as exfoliation of skin cells, occur in all demographic groups. Menstrual blood loss may account for a significant amount of iron loss in women of childbearing age. Despite the fact that various studies have shown a link between the length of the menstrual period, the volume of menstrual losses, and serum ferritin, the distribution is thought to be skewed and difficult to assess. It is widely known that iron absorption is strongly influenced by the individual's physiological state and iron status. In healthy people, dietary iron absorption is inversely associated to serum ferritin levels, especially below 60 g/L. In addition, enhanced iron absorption efficiency is found to meet the increased requirement for iron in pregnant women. As a result of the complexity and unpredictability of the different components involved in iron homeostasis, as shown in Table 1, there is no agreement on the Recommended Dietary Allowance (RDA) for iron.

Table 1. *Recommended Dietary Intake of iron (mg/day) by age and gender among different agencies and countries selected.*

	Spain (2015) a	**United Kingdom (1991)**	**Nordic CM (2014)**	**Brazil (2005) d**	**IOM (2001)**	**FAO/WHO (2004)**	**EFSA (2015)**
0-12 months	7	7.8	8	0.27	0.27	6-19	11
1-3 years	7	6.9	8	9	11	4-12	7
4-6 years	9	6.1	8	6	7	4-13	7
7-9 years	9	8.7	9	9	10	4-18	11

In summary, the highest recommended iron intakes are for women of reproductive age (except in Brazil) and pregnant women, with the FAO/WHO highlighting the significance of dietary iron bioavailability.

For iron fortification, a variety of fortificants are available. The most difficult task is to find an iron compound that is well absorbed, stable, and does not change the look or flavor of the food vehicle. Others, such as the practicality of use in a real-world setting and desired bioavailability, should be balanced with solubility. In this case, it could be desirable to use a chemical that has a lower iron bioavailability but can be added to food in larger quantities without causing organoleptic problems. The most accessible form of iron, ferrous sulfate, oxidizes when fortified foods are stored at higher temperatures and moisture levels. During oxidation, the ferrous form changes into the ferric form. 32 The browning of the food product by ferric complexes may result in brown precipitates. Intestinal lumen absorption of the produced ferric complexes is low because they are insoluble [28]. By using EDTA, ferrous sulfate's stability may be increased. 19,23 Iron absorption from bread rolls supplemented with FeSO4 increases by 1.9–3.9 times when the same product is fortified with FeSO4 and Na2EDTA. However, excessive haem intake has been connected to colorectal and prostate cancer, therefore there are concerns about its use. Haem iron, on the other hand, has not been proven to be safe. Sodium iron EDTA (NaFeEDTA) is the only non-haeme source of iron that is two to three times more bioavailable than ferrous salts and can withstand the inhibitory effects of phytates [34, 37]. Recent studies found that NaEDTA increased the bioavailability of native and added iron in fortified chapattis in vitro. EDTA, on the other hand, did not boost iron absorption in Caco-2 cells in research [34]. Cereal meals, whether for weaning or adulthood, are attractive candidates for fortification since they are stapled foods in many cultures throughout the globe and can be processed in solid form to provide iron-fortified cereal-based foods. Ferrous sulfate, ferrous fumarate, ferric pyrophosphate, and electrolytic iron are the iron compounds suggested by the WHO to fortify cereals. Cooking or industrial heat processing should also be considered since these processes might reduce iron bioavailability by altering the fortifier or the dietary components around it.

8. Prevention and Treatment of Iron Deficiency Anemia in Children

Unfortunately, existing solutions used in South Asia have not shown to be helpful in lowering the burden of pediatric anemia, as seen by the high prevalence estimates. The explanations seem to be many.

8.1. Current Public Health Programs to Prevent Iron Deficiency Anemia in Children

Due to a combination of insufficient coverage and poor adherence to the intervention, it is projected that the prevalence of IDA among young children in India would remain high even after the implementation of the National Anemia Control Program. The data currently available indicate that iron drops are unlikely to be effective in treating children's iron deficiency anemia due to low compliance and insufficient dispersion. [I5-17] Iron drop utilization is influenced by the gastrointestinal side effects, strong metallic taste, darkening of a child's teeth if not removed soon, and unclear dispensing instructions [3].

Utilizing liquid iron preparations has additional technical limitations, such as a short shelf life and expensive delivery because of the weight of the bottles. Other South Asian interventions focus on a food-based strategy that encourages healthier eating behaviors and weaning techniques like the introduction of food at the right time in addition to proper consumption of supplementary foods and dietary diversity to increase breast milk intake. High nutritional value foods are readily available, usable, and accessible. Micronutrients are widely distributed and highly bioavailable.

For newborns, young children, and mothers in Bangladesh, the risk of developing anemia is decreased by delayed cord clamping, sleeping beneath a bed net, exclusive nursing, spacing out births, and handwashing. By taking iron-folic acid (IFA) supplements, increasing dietary variety, using a bed net, getting intermittent preventive treatment (IPT) for malaria, washing your hands often, and taking deworming medications, anemia during pregnancy can be avoided. In order to avoid anemia and encourage healthy development in young infants, it is important to continue nursing, provide a sufficient supplementary diet (containing micronutrients), treat and prevent malaria, wash your hands, and take deworming medications. IFA supplements, deworming medications, and hand washing throughout adolescence all work to avoid anemia. The IDA at birth is postponed by good family planning.

The creation of new iron fortifiers is now under progress. Iron produced through nanotechnology engineering is easily absorbed through physiological routes. Industrial manufacturing must be carried out under the tightest safety conditions, nevertheless, because too much free iron in biological systems may be harmful. In an animal model, we discovered that Fe (III) oxide nanoparticles were absorbed via the ferric pathway with no negative effects on hematology or organ function, indicating that certain iron forms and fractions may be created with the aim of reducing iron solubility and absorption.

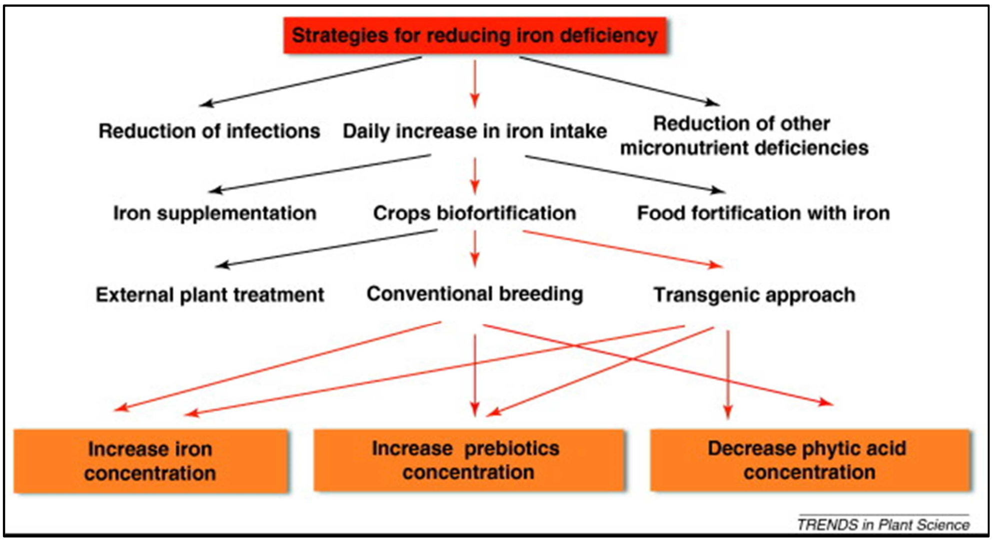

Figure 2. *Strategies for reducing Iron deficiency [55].*

Table 2. *There are some existing plans in Bangladesh that are working on reducing Iron deficiency in children and adolescents shown in.*

Age Group	Department
Infants, children	No national program
Adolescents	DGFP
PLW	DGFP, DGHS, NGOs
NPW	DGFP

Biofortification, which comprises breeding and genetic modification of plants to create a finished plant meal with a greater iron content, is another alternative with high promises. There have been attempts to add micronutrients to common meals, but the end results are still far off, and all safety, cost-benefit, and low environmental effect requirements must be satisfied before implementation.

8.2. Multiple Sectors Play a Role in Anemia Prevention and Treatment in Bangladesh

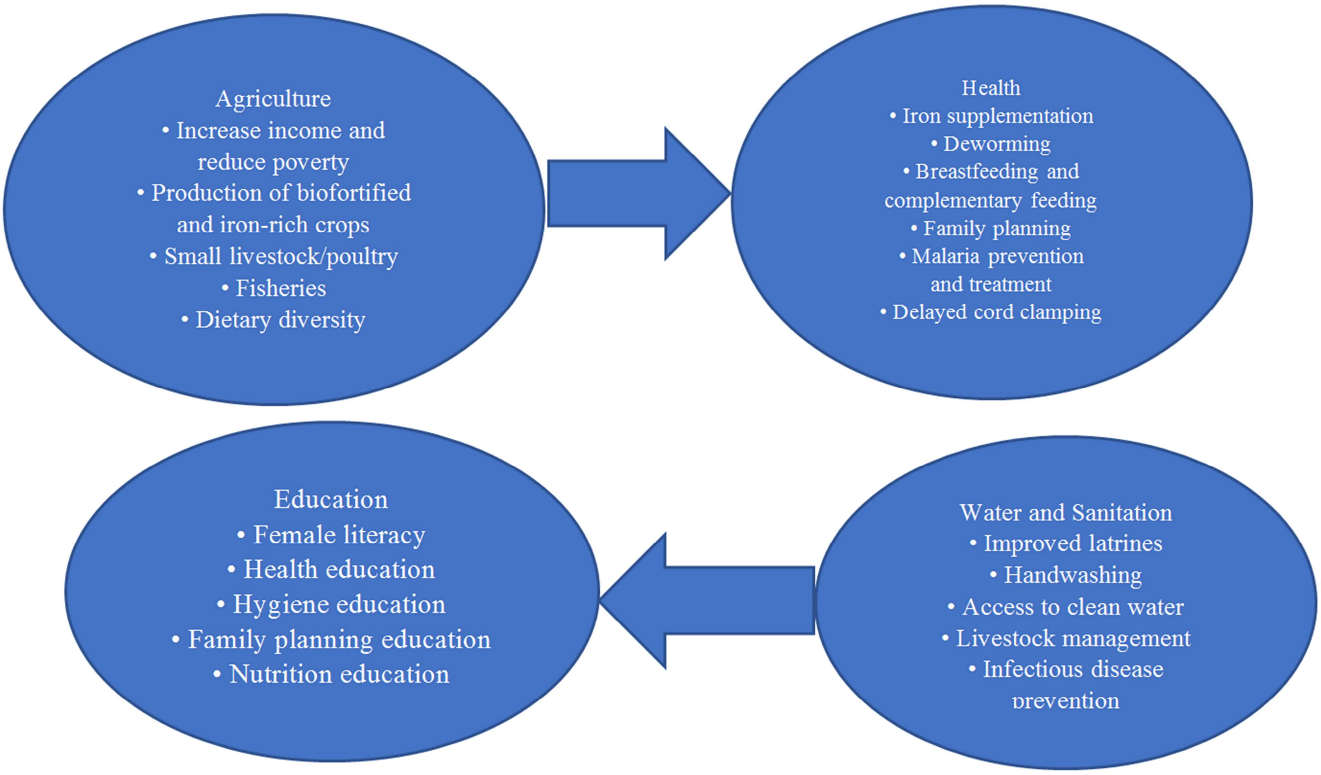

Figure 3. *In Bangladesh, a Variety of Sectors Are Involved in Preventing and Treating Anemia.*

9. Implementing a Comprehensive Approach

We believe one approach to effectively address this important public health concern is to include innovative, alternative approaches into supplemental feeding programs to lower the high prevalence of iron insufficiency among premature babies. "Micronutrient Sprinkles" may be added to such supplemental feeding regimens in order to enhance the total nutritional value of these weaning meals. When combined with supplemental meals, sprinkles can increase their iron and other essential micronutrient content. The sachets are simple to use and distribute and may be incorporated into any program targeted towards enhancing South Asian weaning customs. At least four of the eight Millennium Development Goals—I am eradicating extreme poverty and hunger through increased productivity in adulthood; (ii) achieving universal primary education through increased learning during childhood; (iii) promoting gender equality and empowering women through knowledge of proper weaning practices; and (iv) promoting gender equality and empowering women through knowledge of proper nutrition practices—will be at least partially attained by preventing IDA in young children.

10. Conclusions

It is crucial to promote healthy weaning practices and the intake of nutritionally sufficient, affordable supplemental meals in underdeveloped nations like South Asia to prevent the development of iron deficiency in infants and early children. Sprinkles can be included into current programs for supplemental feeding that support children's health and nutrition to increase the nutritional value of supplemental meals served at home or in the classroom, with simple instructions and at a low cost. Depending on the needs of the target audience, Sprinkles may also supply other essential micronutrients. At least four of the eight Millennium Development Goals might be achieved by reducing the prevalence of iron deficiency and IDA in young children through the adoption of healthy weaning techniques like Sprinkles. Numerous nutritional studies have demonstrated that iron intake from conventional supplemented meals in developing nations is frequently a fraction of the necessary intake, particularly for kids between the ages of 6 and 12. Germination, fermentation, and soaking are examples of traditional food processing techniques that may increase iron bioavailability to some amount, but they don't appear to increase iron intake sufficiently. Diversifying the child's diet and enhancing supplemental meals (by adding fish powder, for example) are both good for the overall nutritional content of the child's diet, but they frequently fall short in terms of bridging the iron deficit. Due to these factors, the majority of people will require some type of iron supplementation, whether it be in the form of commercially available supplemental meals or homemade fortification methods. Commercially enriched complementary meals may undoubtedly aid in lowering rates of anemia and iron deficiency if the dose and chemical type of iron are both suitable. However, a formula made for newborns will give babies older than 12 months too much iron, and a formula made for kids between 12 and 24 months would give babies between 6 and 12 months too little iron. Therefore, it would almost probably be necessary to use another strategy to boost newborns' iron consumption to the recommended level even if commercially fortified supplementary foods become widely available and affordable. None of the studies included in this review discovered any adverse consequences from boosting iron consumption by food fortification or at-home iron supplementation, in contrast to the situation with iron supplements. However, large-scale studies including a sizable number of young people who are iron deficient are necessary. Studies that compare the physiological benefits of iron consumed with food vs iron consumed between meals may also be helpful.

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