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Review Article

The Significance of Food Fortification for Prevention of Major Health Challenges due to Micronutrient Deficiencies (MND) for Under 5 Years Children in Bangladesh

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Abstract

Vitamins and minerals, known as micronutrients, are needed in trace levels for healthy growth and development as well as heightened immunity against illness. They need to come from outside sources because the body isn't able to produce them. Inadequate and inappropriate physical and intellectual development results from malnutrition in vulnerable people, including early childhood, expectant and nursing mothers, and the aged people. Meals fortification is a safe and practical way to boost consumption of macronutrients by providing essential nutrients in meals. Long-term developmental goals are impacted by vitamin deficiencies. In order to raise public awareness of the advantages of food fortification, an educational program is required. An extensive summary of Bangladesh's current women's and children's micronutrient deficient status is provided in this article. This study also covers the effectiveness of current intervention programs as well as their current issues. Almost half of all expectant and nursing mothers suffer from anemia. High levels of deficiencies are associated with several critical factors, including sickness, malabsorption, infestation, inadequate nutrition, and poor cleanliness. There have been several attempts at interventions, and some success has been achieved. Issues with coverage, quality, and compliance still exist. Even though severe deficiencies have been somewhat addressed by current intervention initiatives, micronutrient deficiencies in Bangladesh continue to be a major concern. A more comprehensive strategy is required to enhance the current intervention initiatives. Additionally, fresh approaches of intervention are proposed in order to prevent and treat specific micronutrient deficiencies.

Keywords

Food Fortification, Micro Nutrient Deficiencies, Micronutrients, Children of Bangladesh, Supplementation, Strategies, Policy

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1. Introduction

The World Health Organization estimates that over 2 billion individuals worldwide are deficient in important vitamins and minerals, especially zinc, iron, iodine, and vitamin A [35]. Young children and expectant or nursing mothers are reported to be the most susceptible to micronutrient deficits. When micronutrient deficits coexist, populations from wealthy nations are impacted. Food fortification is a safe and effective method that can be used to improve health by preventing vitamin and mineral deficiencies. Worldwide, 19.1 million pregnant women and 190 million preschoolers were estimated by the WHO to be vitamin A deficient (serum retinol less than 0.70 mol/l). Almost 100 million women who are of reproductive age suffer from iodine deficiency [2, 17], and 82% of pregnant women worldwide do not receive enough zinc to meet their needs [7]. 1.62 billion people worldwide suffer from iron insufficiency, with preschoolers accounting for the highest percentage of cases (47%), followed by expectant mothers (42%).

According to WHO estimates, vitamin A insufficiency and iron deficiency together account for 0.8 million deaths globally. Treatment for nutritional deficiencies like as pellagra, beriberi, rickets, and goiter can be effectively achieved by food fortification. Neural tube deformities are caused by emerging folic acid deficiency, premature birth is stunted by zinc, and cancer is encouraged by selenium. Physical and mental disorders that reduce work productivity can also have an economic impact, thus these consequences are not just confined to medical parameters [9].

The most commonly fortified foods are wheat, wheat products, corn, rice, milk, and milk products, as well as cooking oils, sauces, salt, sugar, and breakfast cereals. They provide a means of distributing micronutrients and are accessible to consumers in developing nations like Bangladesh, India, Sri Lanka, and many more. New guidelines were released in 2009 by the U.S. Preventive Service Task Force. These strategies were widely used in wealthy nations, and many middle-income nations also adopted them. Rich diets and consumption of fortified foods and beverages, including juices, salt, wheat, margarine, sugar, and milk, have eliminated nutrient shortages in industrialized countries [34].

Most people's diets in Bangladesh are deficient in one or more micronutrients, such as zinc, iodine, iron, and vitamin A [23]. Micronutrients, especially iron, zinc, and vitamin A, have limited bioavailability since a large portion of the food that the impoverished eat is plant-based. It is believed that the most significant predictor of decreased micronutrient status in this group is poor dietary quality rather than quantity. Micronutrient deficiencies are more prevalent in young children and in moms who are nursing or pregnant.

Micronutrient insufficiency continues to be a serious public health concern despite the fact that many approaches have been tried over the years to address the issue. Analysis of the nation's current micronutrient status for women and children, as well as the successes and shortcomings of current programs, has been made possible by the recently concluded National Micronutrients Status Survey 2011-2012 [13]. This study also discusses the recommended intervention strategies for Bangladesh's micronutrient deficiencies and their impact on the Sustainable Development Goals (SDG).

2. Food Fortification Play the Key Influencing Factor for Micronutrient Deficiency Prevention

Food fortification, according to the World Health Organization, is the addition of one or more elements to food, whether or not they are already present in the food, with the goal of preventing or improving a known deficiency associated with one or more ingredients in the general population or specific groups within the general population.

The process of identifying commonly consumed and centrally processed foods in order to ensure fortification throughout food manufacturing and distribution is known as food fortification. Basic foods and condiments are attractive alternatives for fortification since they are consumed by a bigger section of the population. Fortification can make use of vitamins A, D, iodine, iron, folic acid, zinc, and B-complex vitamins [34].

It is economical to fortify staple foods on a wide scale. The population, especially the impoverished, receives a greater distribution of micronutrients as a result of the fortification of a few costly basic commodities. Foods disbursed by specific demographic subgroups—such as newborns—that support higher intake for that population are included in targeted fortification. The supplement meal fortification of young infants is addressed with specificity. The focus of mass and targeted fortification is on micronutrients that are needed by most people [1]. The most often used food vehicles fall into three categories: processed commercial foods (dairy products, noodles, infant supplemental meals, and oils), condiments (salt, sugar, and soy sauce), and staples (wheat, oils, and rice).

The immune system and vision depend on vitamin A, a fat-soluble vitamin that is added to staple foods including rice, cereal grains, and oils. Fortification with vitamin A aids in preventing vitamin A deficiency, which can cause visual impairments and heightened vulnerability to illness. The fortification of rice, wheat, and maize flour is done to prevent birth anomalies, brain and spinal disorders, and nutritional anemia. It also increases productivity, which promotes economic growth and illustrates the benefits of fortifying wheat, flour, and maize.

Table 1. Role of vitamins and minerals used in flour and rice fortification includes.

Micronutrients	Functions
Folic acid (vitamin B9)	Reduces neural tube birth defects
Zinc	Strengthens immune system
Niacin (vitamin B3)	Prevents Pellagra, a skin disease
Riboflavin (vitamin B2)	Boosts carbohydrates, proteins, and fats metabolism
Thiamine (vitamin B1)	Prevents beriberi, a nervous system disease
Vitamin B12	Enables functioning of the brain and nervous system
Vitamin D	Improves bone health by allowing absorption of calcium
Vitamin A	Childhood blindness lowers the ability of individuals to tackle infections
Calcium	Makes bones stronger, helps nerve muscles to transmit messages, functioning of muscles and blood clotting
Selenium	Helps in thyroid gland functioning and reproduction
Vitamin B6	Metabolism involves enzyme reactions

The principal objective of food fortification was to mitigate the emergence of nutritional deficits, particularly those resulting from insufficient availability of essential components. Staple foods produced in a particular location may lack essential nutrients because of their reliance on soil area or inherent adequacy from a regular diet [1]. Addition of micronutrients to staples and condiments can help prevent widespread disease deficiency. Food fortification also saves the expense of transporting perishable goods to remote regions of the world, such as fruits, vegetables, meats, and dairy products. The fortification of meat, poultry, and fish products, as well as unprocessed meals, is prohibited by law in the United States and Europe [1].

Many countries have a high prevalence of vitamin D insufficiency because most people do not get enough vitamin D from their foods and are not exposed to sunlight. Bread, yogurt, spaghetti, and juice are a few foods fortified with vitamin D. Blood levels of vitamin D and 25-hydroxyvitamin D, are elevated by fortified meals, and the vitamin D bioavailability of both fortified foods and pharmaceutical preparations is similar [28]. Fortification works by making regularly eaten foods more nutritious rather than pressuring consumers to change their behavior.

Table 2. Micronutrient deficiencies with health issues and their prevalence throughout the world [6, 8].

Micronutrient	Deficiency Pervasiveness	Major Deficiency Disorders	Fortifyingvehicle
Iodine	2 billion at risk	Goitre, hypothyroidism, iodine deficiency disorders, increased risk of stillbirth, birth defects infant mortality, cognitive impairment	Salt, bread
Iron	2 billion	Iron deficiency, anaemia, reduced learning, and work capacity, increased maternal and infant mortality, low birth weight	Wheat and cornflours, bread, pasta, rice, salt, infant formulas and cookies
Zinc	Largely estimated in the developing countries	Poor pregnancy outcome, impaired growth (Stunting), genetic disorders,decreased resistance to infectious disease	Breakfast cereals, infantformulas, cookies, and diet beverages
Vitamin A	254millionpreschool children	Night blindness, xerophthalmia, increasedrisk of mortality in children and pregnant women	Milk, margarine,yogurts, soft cheese, sugar,monosodium glutamate and tea
Folate (Vitamin B9)	Insufficient data	Megaloblastic Anemia, neural tube, andother birth defects, heart disease, stroke, impaired cognitive function, depression	Wheat and cornflours, bread, pasta, rice, cookies, andinfant formulas

Micronutrient	Deficiency Pervasiveness	Major Deficiency Disorders	Fortifyingvehicle
Cobolamine (Vitamin B12)	Insufficient data	Megaloblastic anaemia (associated with Helicobacter pylori-induced gastric atrophy)	Breakfast cereals, dietbeverages, Wheat and cornflours, bread, pasta, rice
Thiamine (VitaminB1)	Insufficient data estimated as in developingcountries and infamines, displaced persons	Beriberi (cardiac and neurologic), Wernicke's, and Korsakov syndromes (alcoholic confusion and paralysis)	Wheat and cornflours, bread,pasta, rice, infant formulas andcookies, breakfast cereals,vegetable mixtures, and amino acids
Riboflavin (Vitamin B2)	Insufficient data, estimated as in developingcountries	Non-specific-fatigue, eye changes,dermatitis, brain dysfunction, impairediron absorption	Wheat and cornflours, bread, pasta, rice,vegetable mixtures, amino acid breakfast cereals,and infant formulas andcookies
Niacin (Vitamin B3)	Insufficient data, estimated as in developing countries and in famines, displaced persons	Pellagra (dermatitis, diarrhoea, dementia, death)	Wheat and cornflours, bread, pasta, rice,breakfast cereals, cookies andinfant formulas
Vitamin B6	Insufficient data, estimated as in developingcountries and infamines, displaced persons	Dermatitis, neurological disorders,convulsions, anaemia, elevated plasmahomocysteine	Wheat and cornflours, bread,pasta, rice, infantformulas, cookies, andbreakfast cereals
Vitamin C	Commonfamines, displaced person	Scurvy (fatigue, haemorrhages, lowresistance to infection, anaemia)	Diet beverages, juices, andsubstitute drinks
Vitamin D	Extensive in all age groups, low exposure to ultraviolet raysof the sun	Rickets, osteomalacia, osteoporosis,colorectal cancer	Diet beverages, juices, andsubstitute drinks
Calcium	Insufficient data, estimated to be widespread	Decreased bone mineralization, rickets, osteoporosis	Soymilk,breakfast cereals, infant formulas and cookies,juices, diet beverages and substitute drinks
Selenium	Insufficient data, common in Asia, Scandinavia, Siberia	Cardiomyopathy, increased cancer andcardiovascular risk, osteoarthropathy	Milk, pasta, cornand wheat flours, breakfast cereals,infant formulas, and cookies,juices and spreads
Fluoride	Widespread	Increased dental decay risk	Infant formulas and cookies, breakfast cereals,wheat, and rice flour, milk, juices

A well-considered public health tactic, food fortification may enable a greater number of at-risk individuals to be served through current food delivery systems without necessitating significant adjustments to consumption patterns. Fortified meals also have the added benefit of preserving body storage, making it a cost-effective method of increasing nutritious consumption in the population [9].

3. Micronutrient Deficiency Is the Global Burden for Developing Countries Like Bangladesh

Two billion people worldwide suffer from micronutrient deficiencies, which affect people of all sexes and ages in both developed and developing countries [3]. Numerous nonspecific physiological issues, such as impaired infection resistance, irregular metabolic processes, and impaired physical and psychomotor development, have been connected to micronutrient deficiency [14]. Worldwide, 21% of children were found to be vitamin A deficient, and these children had greater risks of diarrhea, measles, and malaria death. 1.8 percent of eye disorders and over 800,000 baby and maternal deaths worldwide were attributed to vitamin A insufficiency [27].

The normal meals taken in Bangladesh are usually lacking in one or more micronutrients, particularly zinc, iodine, iron, and/or vitamin A. It is inadequate dietary quality rather than quantity that is the main indicator of low micronutrient status in this group. Micronutrient deficiencies are more prevalent in older adults, pregnant and nursing mothers, and small children. A significant proportion of preschool-aged children experience

several micronutrient deficits, with one in five experiencing a deficiency in vitamin A, as per the National Micronutrient Survey [13]. It is noteworthy that 44% of preschool-aged children experience zinc insufficiency, and 2 out of every 5 preschool-aged children experience vitamin D inadequacy. Twenty-four percent of preschoolers are deficient in calcium, and thirty-three percent of them suffer from anemia, of which seven and a half have iron deficiency anemia [10].

The main underlying causes of micronutrient deficiencies in all population segments have been identified as household food insecurity, poor quality diet (predominately plant-based foods with minimal animal foods), poor dietary diversity, lack of knowledge about food value and diversity, intra- and inter-household disparity, gender inequality and inequity, and lack of social positioning of vulnerable and marginalized populations [15]. The most important risk factors also include population density and increased migration from rural to urban areas, which are accompanied by a lack of basic amenities (sanitation, water, etc.); living in a slum or other rural area; not having access to cheap, diverse foods, especially animal sources of nutrition; and not knowing the risks of micronutrient deficiencies and the advantages of consuming enough of them for health [18-20].

3.1. Vitamin A Deficiency Is the Major Public Health Issue for Country Like Bangladesh

Bangladesh has acknowledged VAD as a serious public health concern since the 1960s [16]. The prevalence of VAD (defined by the WHO as a serum retinol content of 070 mol/l) has remained consistent, especially among preschool-age (6–59 months) children, even if the severity of the issue has dramatically decreased over the last ten years. Vitamin A is an essential vitamin for healthy growth and development, immune system function, reproduction, and epithelial cellular integrity preservation. Comparable to findings from the 1997–1998 National Vitamin A Survey, the National Micronutrient Survey 2011–12 [13] reports that only 5.4% of women who are neither pregnant nor nursing have low serum retinol concentrations. According to a study from 2011-2012, roughly 34% of NPNL women had insufficient vitamin A status (Serum retinol 1.005 mol/L), up from 29% in 1997-98. [21, 37].

	Pregnancy	Lactating mother	6–23 mo	2–5 years	5–18 years	WRA (15–49 years)	Adult men	Elderly
Micronutrient need	very high	very high	very high	high	moderate to high	moderate to high	low to moderate	moderate to high
Amount of food eaten	moderate	moderate	low	low, increasing with age	increases with age	moderate	high	moderate
Potential to benefit	high	high	low	low, increasing with age	increases with age	high	high	high
Potential to fully meet need	low	low	no	low, increasing with age	increases with age	high	high	high

Figure 1. *Potential benefits of food fortification across the life cycle. Source: Irizarry, L, Prost, MA, Murillo, D, Lopez de Romaña Daniel et al. 2017. Scaling Up Rice Fortification in Latin America and the Caribbean. World Food Programme and Sight and Life: 2017. WRA = Women of Reproductive Age.*

Since 2011, the National Vitamin A Plus Campaign for children aged 6 to 59 months has been implemented by the government of Bangladesh. VAC (100,000 IU retinol equivalent) is given to infants 6 to 11 months of age, and VAC (200,000 IU) is given to infants 12 to 59 months of age. Although vitamin A reserves in individuals with VAD can drop below optimal levels following a high-dose supplementation, it is believed that dosage at intervals of four to six months is adequate to prevent significant VAD consequences, according to global studies [29, 31].

Every demographic has been connected to VAD. Among these factors are low socioeconomic status, living in a slum, an abundance of foods high in vitamin A and/or their health benefits, a preponderance of low bioavailability plant-based vitamin A, low intake of animal sources of vitamin A, particularly by households experiencing severe food insecurity.

3.2. Iodine Deficiency Is the Burning Nation-Wide Problem for Developing Countries

In Bangladesh, iodine deficiency infections have long been acknowledged as a public health concern, despite the difficulty in obtaining reliable statistics. According to the [13], the mean urine iodine concentration (UIC) for school-aged children across the country is less than 100 g/L, indicating a prevalence of up to 40% iodine insufficiency. This prevalence has stayed relatively constant since 1999. Although the prevalence of severe iodine deficiency, or goiter, among school-aged children is not currently known, previous research has demonstrated a dramatic decline in goiter prevalence, from 50% in 1993 to 6.3% in 2004–05 [37].

3.3. Anemia and Iron Deficiency Can Cause Early Neonatal Mortality and Maternal Mortality

According to the NMS 2011–2012, 26% of NPNL mothers and 33% of children between the ages of 6 and 59 months were diagnosed with anemia. A Hb value of 110 g/l for children ages 6 to 59 months and 120 g/l for women in the NPNL was considered anemia [22, 36]. These data show a considerable drop in prevalence when compared to the reports from 1997–1998 (47 percent in children aged 6–59 months and 45 percent in NPNL women) and 2003 (557% in children aged 6–59 months and 45 percent in NPNL women). An iron deficiency causes anemia, which manifests as pale lips, tongue, gums, inner eyelids, and skin. Additional symptoms include headaches, fatigue, and dyspnea [38]. Pregnant women and small children are said to be more vulnerable.

3.4. Zinc Deficiency Prevalence Rate Is High Among Pre-School Age

The NMS 2011–2012 reports that the prevalence of zinc insufficiency is 446 percent in preschool-age children and 573% in NPNL women, with the highest rates found in slum areas [12]. Zn deficiency was determined by the International Zinc Consultative Group as a blood concentration of 101 mmol/l in NPNL women and 109 mmol/l in preschool-aged children [32]. Large prevalence of low blood Zn is considered a probable signal of a very severe shortage because serum Zn is homeostatically maintained and cannot detect marginal shortfall. Low socioeconomic position, food instability in the home, low consumption of animal sources of zinc, and high consumption of a plant-based diet high in phytate [24-26].

3.5. Vitamin D Deficiency Is Common in School-Going Children

Because it helps to maintain appropriate blood levels of calcium and phosphate, which supports bone mineralization, muscular contraction, nervous system activity, and cellular functioning, vitamin D is crucial for human health [33]. A blood vitamin D level of less than 50.0 nmol/L indicated vitamin D insufficiency in 39.6% of preschoolers and 45.5% of school-age children. The highest percentage of vitamin D deficiency in preschoolers was found among the poorest and most severely food insecure households. However, it is highest for school-age children in the wealthiest and most food-secure homes [13]. In addition, the National Rickets Survey conducted in 2008 revealed that children between the ages of one and fifteen had a 1% incidence of rickets, with 62% of cases being children under the age of five [11]. For the high-risk population groups in the nation, there is presently no national policy or program in place to prevent vitamin D insufficiency. A homogeneous society, a fortified food supply, the government's cooperation with stakeholders, adequate sunlight across the country, water bodies for fish culture, women's empowerment, and the potential for a school feeding program are all examples of potential interventions [39].

However, improving the population's vitamin D status will require a significant political commitment. It is important to note that as part of routine prenatal care, the WHO currently does not recommend vitamin D supplementation during pregnancy [29].

3.6. Vitamin B Deficiencies in Infants

There are currently no statistics on the estimates of B vitamin deficiencies in newborns and children at the national level. NMS 2011-2012 reports that 23% of NPNL women had some degree of vitamin B12 insufficiency, and 9% of these women are low in folate [11]

4. Etiology of Micronutrient Deficiency

The diet of the great majority of Bangladeshis consists mostly of plant-based foods. They eat few animal products, such as milk, eggs, and milk derivatives, and have a limited variety of diets. Thus, low bioavailability and low-quality diets might be the main contributors to micronutrient shortages in the nation. Based on estimated average requirements, a study of dietary micronutrient intake among young children and their primary female caregivers in rural Bangladesh revealed a relatively low overall mean prevalence of micronutrient intake sufficiency in children (43%) and women (26%) [23]. The main underlying causes of micronutrient deficiencies in the country have been identified as limited diversity due to poor socioeconomic position and family food insecurity, low levels of knowledge in relation to an appropriate

diet and hygiene practices, as well as illness and infestation.

5. Preventive Measures for the Micronutrient Deficiency

Effective fortification initiatives and addressing the challenges of nutritional deficiencies in vulnerable groups are primarily made possible by the following factors, among others:

Policymakers to assure fortification across the country; a dominant individual to advocate fortification; an organization with the ability for research to assess the impact; the food industry to fortify food; regulatory organizations to guarantee and keep an eye on compliance.

A national coalition is a prerequisite for fortification in the nation. Public, business, and civic sector participation follows, and a deeper understanding of the benefits of fortification for health and the economy emerges [30].

6. Conclusions

Although the severity of many micronutrient deficiencies has significantly decreased in Bangladesh over the past few decades, a sizeable segment of the population—especially women and children—remains low in vital micronutrients. The review also discussed the negative effects on human health that come from fortifying food with essential vitamins and minerals. A nutritional intervention program with a specific target population is food fortification. The program's success is based on whether the target group accepts, buys, and consumes the fortified food [4]. To address the issue of micronutrient deficiencies, a number of intervention programs are in place, with a focus on vitamin A, Fe, and I deficits. However, the degree of success these measures have achieved is far from satisfactory. Nutrient-specific nutrition policies and programs are unlikely to prevent and control micronutrient insufficiency given the complexity of the factors that lead to micronutrient deficiencies in Bangladesh and other low-income countries. Enough resources and effective coordination between workers in the food and health sectors are also essential for guaranteeing the provision of high-quality services, accurate monitoring, and reporting for better outcomes with regard to the micronutrient status of the targeted populations.

Author Contributions

Zahidul Hasan: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Iffat Margana: Conceptualization, Data curation, Methodology, Validation, Visualization, Writing – review & editing

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Conflicts of Interest

The authors declare no conflicts of interest.

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