International Journal of Food Science and Biotechnology
2022; 7(3): 66-77
http://www.sciencepublishinggroup.com/j/ijfsb
doi: 10.11648/j.ijfsb.20220703.14
ISSN: 2578-9635 (Print); ISSN: 2578-9643 (Online)

The Efficacy of Major Micronutrients Supplement in Early Childhood and the Impact on Psychomotor Development in Children of Rural Bangladesh

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To cite this article:

Ziaur Rahman Chowdhury, Muazzem Hossain, AHM Khairul Bashar, Akhlaq Ahmed, Md. Benzamin, Iqbal Hossain, Ruzina Rahman, Akter Hossain. The Efficacy of Major Micronutrients Supplement in Early Childhood and the Impact on Psychomotor Development in Children of Rural Bangladesh. *International Journal of Food Science and Biotechnology*. Vol. 7, No. 3, 2022, pp. 66-77.
doi: 10.11648/j.ijfsb.20220703.14

Received: June 20, 2022; **Accepted**: July 26, 2022; **Published**: September 27, 2022

Abstract: Micronutrients, which include vitamins and minerals, are needed in trace levels for growth, brain and body development, and disease resistance. They must be taken from diet and other sources since the body is unable to synthesize them. In vulnerable groups such as young infants, pregnant and nursing women, and the elderly, malnutrition causes poor physical and mental development, mental retardation, and blindness. Food fortification is a safe and effective approach for enhancing micronutrient intake and recovering levels lost during processing by providing key elements in food. Micronutrient deficiency has an influence on long-term development objectives. Nearly half of all pregnant and nursing moms suffer from anemia. Inadequate nutrition, poor hygiene, disease, and infestation are only a few of the fundamental characteristics connected to high levels of deficiency. While several strategies and treatments are being promoted, major issues like coverage, quality, and compliance persist. Despite the fact that current intervention initiatives have had some success in treating severe deficiencies, micronutrient deficiencies continue to be a major problem in Bangladesh. This article gives a detailed discussion of MND and is the impact on psychomotor development in children. Essential micronutrients are required for human survival, and these micronutrients can only be acquired from food. To improve the dietary variety, reduce nutritional losses, and boost nutritional bioavailability, food-based interventions need an innovative approach. Many poor nations' efforts have shown that food-based methods offer a cost-effective and long-term solution to the issue of micronutrient deficiencies in people. Unless appropriate attention is paid to avoiding communicable illnesses like diarrhea, lowering morbidity, and improving basic health care facilities, strategies to address the issue of micronutrient deficiencies will basically fail to have an effect. There are several benefits to expanding food-based strategies, including improved nutritional well-being, increased incomes, and increased access to and availability of a variety of micronutrient-rich foods, all of which will lead to improved micronutrient status for not only individuals but also the community as a whole.

Keywords: Micronutrient Deficiencies, Food Fortification, Psychomotor Development, Strategies, Policies

1. Introduction

Micronutrients (vitamins and minerals) are required for appropriate cellular and molecular function and are an important component of the diet Micronutrient shortage may have a broad range of deleterious health consequences, even though they are only required in trace levels. Micronutrient deficiencies are particularly prevalent in low- and middle-income countries (LMICs), owing to insufficient food intake, a lack of dietary variety, and poor nutrient absorption caused by infection, inflammation, and chronic disease [1]. Also frequent are concurrent deficits. Children under the age of five are especially susceptible since their fast growth and development demand a greater requirement for micronutrients [1]. Despite considerable uncertainty in these estimates, an estimated 43% of children under the age of five have anemia [2]. 29% of children under the age of five in LMICs are vitamin A deficient [3] 30% of school-aged children are iodine deficient [4] and 17% of the population are zinc deficient [5]. Due to a lack of resources, different definitions and procedures for evaluating the nutritional status, and improper aggregation of country-level data, assessing micronutrient status in children under the age of five is difficult, particularly in LMICs. Physical, developmental, and cognitive impairment, greater susceptibility to infections, higher morbidity and mortality, and lower productivity later in life are all linked to micronutrient deficiencies [6-9]. Iron deficiency anemia, for example, has been linked to poor motor development and permanent cognitive impairments in infancy and early childhood, both of which hinder learning and lower educational achievement [7, 10]. The developmental delay has been linked to iodine shortage in children [11]. Vitamin A deficiency raises the risk of childhood blindness as well as mortality from common illnesses like diarrhea and measles [12]. Finally, zinc deficiency has been associated with stunting, wasting, and more severe infections as a consequence of lowered immune function and reduced growth [13, 14]. Undernutrition, which includes micronutrient deficiencies, stunting, and wasting, is estimated to be responsible for 45% of all children's mortality, or 3.1 million fatalities every year [15].

According to WHO statistics, 0.8 million people die each year as a consequence of iron deficiency, with a similar number dying from vitamin A deficiency. Food fortification may be used to treat nutritional deficiencies such as goitre, rickets, beriberi, and pellagra. Emergent deficiency causes neural tube defects, zinc hinders child development, and selenium promotes cancer, and the consequences aren't only health-related; they may also have a financial impact owing to physical and mental issues that hamper employment productivity. Iodine deficiency affects 28.5 percent of the world's population, or 1.9 billion people, according to a Lancet series on maternal and child nutrition published in 2013. While the World Health Organization estimates that roughly 50 million individuals suffer from mental impairment as a consequence of iodine deficiency (defined as a urine iodine content of 50–99 ug/L) (WHO 2011c). Over 34 million newborns were protected from the long-term consequences of iodine deficiency-related brain damage in 2012 (UNICEF Data). Additionally, around 1.62 billion people are anemic, due to iron deficiency. The situation is even worse in developing countries, where several micronutrient deficiencies typically occur at the same time as a consequence of insufficient bioavailability and vitamin concentration in meals. Micronutrient deficiencies may occur at any age, although they are more common in children and pregnant and breastfeeding women, who need more micronutrients to maintain growth and reproduction.

The most often fortified foods include wheat, wheat products, maize, rice, milk and milk products, salt, sugar, cooking oils, sauces, and morning cereals. They provide micronutrient delivery pathways and are affordable in developing nations such as Bangladesh, India, Sri Lanka, and others. In 2009, the US Preventive Service Task Force modified its recommendations. These strategies were widely used in wealthy countries, and many middle-income countries followed suit [13]. In affluent countries, nutrient deficiencies have been eliminated owing to a varied diet and the use of fortified foods such as juices, salt, wheat, margarine, sugar, and milk. Most individuals in Bangladesh's diets are deficient in one or more micronutrients, such as vitamin A, iron, iodine, and zinc. Because the poor eat a lot of plant-based food, micronutrient bioavailability is low, especially for iron, zinc, and vitamin A. The most significant predictor of low micronutrient status in this population is poor dietary quality, not quantity. Micronutrient deficiencies are more frequent in young children and moms who are pregnant or lactating.

Despite several attempts over the years to address the problem, the prevalence of micronutrient deficiency remains high and is considered a serious public health concern. The National Micronutrients Status Survey 2011–2012 (NMS 2011–2012) has offered an opportunity to examine the current micronutrient status of children and women in the nation, as well as the successes and difficulties of existing programs. This article tried to focus on the efficacy of major micronutrient supplementation in early childhood and also showed the long-term health impact on psychomotor development in children of Rural Bangladesh.

2. Major Micronutrient Deficiency in Bangladesh

Micronutrient deficiencies affect individuals of all ages and genders in both developed and developing countries, impacting 2 billion people worldwide. Micronutrient deficiency has been related to a variety of non-specific physiological issues, such as decreased infection resistance, metabolic irregularities, and physical and psychomotor development. Vitamin A deficiency was discovered in 21% of children over the globe, and it was linked to greater death rates from diarrhea, measles, and malaria. Vitamin A deficiency is responsible for approximately 800,000 fatalities in newborns and pregnant women throughout the globe, as well as 1.8$ of all eye issues inadequate micronutrient intake, particularly during crucial growth years, may have a substantial impact on a child's healthy growth and development. Micronutrient deficiencies have little consequences initially, but they gradually deteriorate over time, leading to physical symptoms or clinical signs (DGHS, 2012). Worst of all, the damage has already been done by the time it emerges as a symptom. Some of these effects/consequences, such as a child's cognitive growth being impeded, are permanent.

The normal Bangladeshi diet is low in one or more micronutrients, particularly vitamin A, iron, iodine, and/or zinc. Poor dietary quality, not quantity, is the most important predictor of reduced micronutrient status in this population [2]. Young children, pregnant and lactating women, and the elderly are more prone to micronutrient deficiencies. According to the National Micronutrient Survey (NMS) 2011-12, a large proportion of preschool children are deficient in a variety of micronutrients, with one out of every five preschool children suffering from vitamin A insufficiency. Zinc deficiency affects 44% of preschoolers, while vitamin D deficiency affects two out of every five preschoolers. Calcium insufficiency affects 24.4 percent of preschool children, while anemia affects one-third of them, with iron deficiency anemia accounting for 7.2 percent [10]. Household food insecurity, poor diet quality (predominantly 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 are identified as the major underlying causes of micronutrient deficiencies in all segments of the population [5]. Increased rural-to-urban migration and population density, which is accompanied by a lack of basic living standards (water, sanitation, etc.); being a slum dweller or rural resident; lack of affordable diversified foods, particularly animal food sources; and lack of awareness about the consequences of deficiencies and the health benefits of adequate micronutrient intake.

Micronutrient	Deficiencies can lead to
Iron	• Iron-deficiency anaemia; associated with retardation in growth and cognitive development
Vitamin A	• Growth retardation of foetus/baby, along with various types of congenital malformations • Eye-related problems, e.g. night blindness, impaired vision (including blindness)
Iodine	• Abnormal growth and development that may cause mental retardation or brain damage • Prolonged deficiency can cause goitre or enlarged thyroid gland
Calcium & Vitamin D	• Poor bone density, leading to skeletal deformations or easily fractured bones • Calcium deficiency may lead to stunting
Zinc	• Impaired growth & development of infants, children and adolescents • Weakened immune system, leading to increased susceptibility to infections and higher risk of mortality

***Figure 1.** Micronutrients & Causes of Deficiencies.*

2.1. Micronutrient Deficiency

2.1.1. Vitamin A

Bangladesh has acknowledged VAD as serious public health concern since the 1960s. The frequency of VAD (defined by the WHO as a serum retinol concentration of 070 mol/l) has remained steady over the previous decade, especially among preschool-age (6-59 months) children. Vitamin A is necessary for appropriate vision, growth and development, epithelial cellular integrity, immunological function, and reproduction. According to the National Micronutrient Survey 2011-12 [14], only 5.4% of non-pregnant and non-lactating women had low serum retinol concentrations, which is similar to the findings of the 1997-98 National Vitamin A Survey. According to the research, around 34% of NPNL women had poor vitamin A status (Serum retinol 1.005 mol/L) in 2011-2012, up from 29% in 1997-98 [19]. Since 2011, the Bangladeshi government has sponsored a National Vitamin A Plus Campaign for children aged 6 to 59 months. VAC (100,000 IU retinol equivalent) is given to children aged 6 to 11 months, while VAC is given to children aged 12 to 59 months (200, 000 IU). Vitamin A reserves in patients with VAD may fall below optimal levels in three to six months following high-dose vitamin A supplementation, according to global studies; nevertheless, dosing at four to six-month intervals is anticipated to be adequate to avoid catastrophic VAD consequences (WHO 2011b). VAD has been linked to low socioeconomic status, living in a slum, a lack of knowledge of vitamin A-rich foods and/or their health benefits, low intake of animal sources of vitamin A, especially in households with severe food insecurity, and a preponderance of plant-based vitamin A with low bioavailability in all population groups.

2.1.2. Iodine

Iodine deficiency diseases have been recognized as a public health problem in Bangladesh for decades, despite the lack of adequate data. Iodine deficiency in school-aged children is as high as 40% countrywide, as measured by a mean urine iodine concentration (UIC) below 100 g/L (ICDDR, 2014). While there is no current data on the prevalence of severe iodine deficiency (goitre rates) in school-aged children, previous research has shown that the prevalence of goitre has decreased significantly from 50% in 1993 to 6.3 percent in 2004-05 [7]. In the Bangladeshi population, household food insecurity, lack of access to iodized packaged salt, rural residency, low levels of awareness about the health benefits of I and iodized salts, consumption of industrial salt (non-iodized), and lack of preservation knowledge about iodized salts have all been identified as major risk factors for I deficiency.

2.1.3. Iron

According to the NMS 2011-2012, 33% of children aged 6-59 months and 26% of NPNL women had anemia, which is defined as a Hb concentration of 120 g/l in NPNL women and 110 g/l in children aged 6-59 months [23]. From 1997-1998 (47% in children aged 6-59 months and 45% in NPNL women) to 2003 (55.7% in children aged 6-59 months and 45% in NPNL women), these figures reflect a significant decrease. Anemia is characterized by pale inner eyelids, nailbeds, gums, tongue, lips, and skin due to an iron deficiency. Tiredness, headaches, and shortness of breath are further signs and symptoms. Pregnant women and children were shown to be particularly vulnerable. Iron deficiency may result in maternal and neonatal deaths.

2.1.4. Zinc

According to the NMS 2011-2012, Zn insufficiency affects 44.6% of preschoolers and 57.3% of NPNL women, with the slums having the highest percentage [23]. Zn deficiency is defined as a serum quantity of 109 mmol/l in preschool-aged children and 101 mmol/l in NPNL women, according to the International Zinc Consultative Group. A high incidence of low serum Zn is regarded to be a reasonable indicator of a very severe shortage since serum Zn is homeostatically maintained and incapable of detecting marginal deficits. Poor Zn nutrition is caused by a combination of low socioeconomic level, family food insecurity, low consumption of animal sources of Zn, and a high intake of plant-based diets rich in phytate (a Zn absorption inhibitor) [10].

2.2. Vitamin Deficiency

2.2.1. Vitamin D

Vitamin D is necessary for our bodies because it assists bone mineralization, muscle contraction, nervous system activity, and cellular functioning by regulating calcium and phosphate levels in the blood [20]. Vitamin D deficiency was found in 39.6% of preschoolers and 45.5 percent of school-aged children with a blood vitamin D level of less than 50.0 nmol/L. Vitamin D deficiency was shown to be greatest among preschool children from the poorest and most severely food-insecure families. However, it is greatest among school-aged children from the richest and most food-secure families [14]. Furthermore, the National Rickets Survey in 2008 discovered a 1% incidence of rickets in children aged 1 to 15, with children under the age of five accounting for 62% of rachitic cases [9]. There is presently no national strategy or program in place to protect the country's high-risk demographic groups against vitamin D deficiency. A homogenous community, the availability of common fortifying food carriers, women's empowerment, and a prospective school feeding program have all been mentioned as feasible treatments [15]. To raise vitamin D status in the general population, however, significant political commitment is required. It's important to note that vitamin D supplementation during pregnancy is currently not recommended as part of routine prenatal care by the WHO [11].

2.2.2. Vitamin B

There are no national estimates of B vitamin deficiency in babies and children available at this time. According to the NMS 2011–2012, 9% of NPNL women are folate deficient, while 23% are vitamin B12 deficient (ICDDR, 2009).

2.3. Etiology of Micronutrient Deficiency

Plant-based meals make up the bulk of Bangladeshis' diets. They eat a little number of animal items such as eggs, milk, and milk derivatives and have restricted nutritional diversification. As a consequence, a low-quality diet with limited bioavailability might be the country's top source of micronutrient shortages. Based on estimated average requirements, a study of dietary micronutrient consumption among young children and their main female caregivers in rural Bangladesh discovered a relatively low overall mean prevalence of micronutrient sufficiency in children (43%) and women (26%) [19]. Low levels of knowledge in relation to a sufficient diet and hygiene practices, as well as disease and infestation, have all been identified as major underlying causes of micronutrient deficiencies in the country [21].

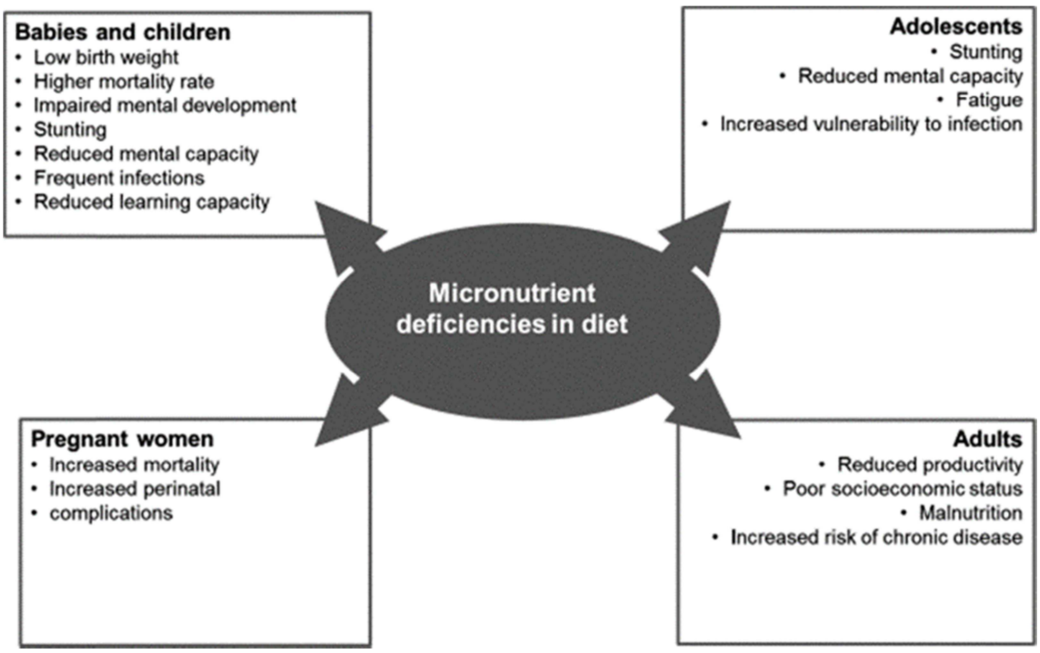

Figure 2. *Micronutrients Deficiencies in Diet.*

2.4. Role of Major Micronutrient

Iron, iodine, folic acid, zinc, vitamin A, and vitamin D are the primary micronutrients examined in this study.

Iron: Anemia affects 47.4% of preschool children and 25.4% of school-aged children worldwide, with iron deficiency accounting for the majority of cases. As a result, iron deficiency anemia is one of the most common but overlooked dietary deficits worldwide. Several research on the effects of iron deficiency in children has come to similar results. It has been shown that it has a negative impact on developmental outcomes in infancy and childhood, including motor, cognitive, social-emotional, and neurophysiologic development, both in the short and long term [19-24]. Reduced myelination, striatal dopamine metabolism abnormalities, and hippocampal energy metabolism changes are all symptoms of early iron insufficiency [25]. New research also highlights the need of paying greater attention to the developmental impacts of prenatal iron shortage. The maternal iron shortage is the most prevalent cause of diminished iron delivery to the baby, and the fetal and neonatal iron deficit has a negative impact on developing brain-behavioral systems [23]. Iron had no effect on the rate of length or weight increase in babies aged 6 to 12 months in Bangladesh, even when stratified by baseline hemoglobin concentration. 40 Lind et al. found that weight-for-age Z score (WAZ) from 6 to 12 months and mean WAZ at 12 months were significantly lower in the iron-replete iron-supplemented group compared to iron-replete non–iron-supplemented infants in a secondary analysis of 6-month-old Indonesian infants participating in a randomized trial [14]. Medicinal iron was related with a slight but substantial decrease in length increase and a tendency toward lower weight gain at the end of supplementation at 9 months in another recent randomized study on breastfed babies recruited at 1 month and supplemented from 4 months.

2.5. Supplementation with Iodine, Zinc, Folic Acid

Iodine is a good example of a vitamin that has long-term negative implications if it is insufficient during a vital phase of brain development [3]. Iodine deficiency is the leading cause of avoidable mental impairment and brain damage. It is necessary for the creation of thyroid hormones, which are crucial for brain development, and iodine shortage is especially dangerous for the fetus, infant, and young kid. Severe iodine shortage during pregnancy causes irreparable fetal brain damage during the middle of the pregnancy, resulting in cretinism and decreased cognitive performance in offspring [13]. Mild-to-moderate maternal hypothyroxinemia may lead to delayed neurodevelopment. 54 Even mild-to-moderate insufficiencies has been linked to lower IQs and more disruptive conduct in youngsters [25-27].

Zinc: Zinc is involved in the action of nearly 200 enzymes, including those involved in DNA and RNA synthesis. Zinc deficiency affects 17.3% of the world's population [11]. Although zinc is required for normal development both before and after birth, its function in the brain is unknown. Zinc deficiency during pregnancy and breastfeeding causes permanent cognitive damage in animals [3]. Zinc deficiency in babies may affect cognitive behaviors including activity and attentiveness.

Folic Acid: Folic acid is necessary for brain development because it plays a role in nucleotide synthesis, DNA integrity, and transcription [11]. It has been shown to have a function in preventing neural tube abnormalities during pregnancy. Although the evidence is limited, Gross et al. [19] discovered that children born to mothers who had significant folate deficit during pregnancy developed abnormally or late. However, some studies have shown no link between folate level in the second part of pregnancy and children's neuropsychological development at age 5. This might be due to the fact that they classify low-folate status based on biochemical measurements rather than megaloblastic anemia [12].

2.6. Benefits of Food Fortification

Food fortification, according to the World Health Organization, is the addition of one or more ingredients to food, whether or not they are already present, to prevent or improve a known deficiency associated with one or more ingredients in the general population or specific groups of the general population. The technique of selecting extensively eaten and centrally processed goods in order to ensure fortification throughout the manufacturing and distribution of food is known as food fortification. Condiments and basic meals are ideal fortification options since they are eaten by a bigger section of the population. Fortification may be done using vitamins A, D, iodine, iron, folic acid, zinc, and B-complex vitamins [8]. Fortification of basic foods is cost-effective on a broad scale. A larger distribution of micronutrients throughout the population, especially among the poor, is achieved by fortifying a few expensive basic goods. Foods eaten by certain demographic segments, such as infants, that lead to increased consumption for that population are considered targeted fortification. Supplemental meal fortification for young children is addressed in a focused way. The aim of mass and targeted fortification are micronutrients that are needed by the majority of the population [5]. Staples (wheat, oils, and rice), condiments (salt, soy sauce, sugar), and processed commercial foods are the three most often used food vehicles (noodles, newborn supplementary meals, and dairy products). Vitamin A, a fat-soluble vitamin found in common foods such as rice, cereal grains, and oils, is essential for the immune system and vision. Vitamin A fortification helps to avoid vitamin A deficiency, which may cause visual difficulties and make people more susceptible to illness. Wheat, maize flour, and rice are fortified to prevent nutritional anemia, brain and spine birth defects, and enhance productivity, all of which contribute to economic growth and highlight the effects of fortification of wheat, flour, and maize [10].

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 fat 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 major purpose of food fortification was to prevent nutritional deficits, particularly those induced by a lack of appropriate access to critical nutrients. Staple foods produced in a certain location may be lacking in some nutrients due to soil area or intrinsic adequacy from a regular diet. (UN, 1995) Micronutrients may be introduced to condiments and staples to prevent widespread disease deficit. Another advantage is that food fortification reduces the cost of delivering perishable goods like vegetables and fruits, meats, and dairy products to far-flung corners of the world. Fortification of meat, poultry, and fish products, as well as fortification of unprocessed foods, is prohibited by the United States and European governments. (UN, 1995) Many people do not get enough vitamin D through their diets, and most people do not get enough sunlight, resulting in a large incidence of vitamin D deficiency in many countries [15]. Vitamin D-fortified foods include yogurt, bread, spaghetti, and juice. Fortified foods and pharmaceutical preparations have equivalent vitamin D bioavailability, and fortified meals boost blood vitamin D and 25-hydroxyvitamin D levels [15]. Fortification works because it makes regularly eaten foods more nutritious rather than forcing people to change their behavior.

Table 2. *Micronutrients and their fortifying vehicle around the world.*

Micronutrient	Major Deficiency Disorders	Fortifying vehicle
Iodine	Goiter, hypothyroidism, iodine deficiency disorders, increased risk of stillbirth, birth defects infant mortality, cognitive impairment	Salt, bread
Iron	Iron deficiency, anemia, reduced learning, and work capacity increased maternal and Infant mortality, low birth weight	Wheat and corn flours, bread, pasta, rice, salt,
Zinc	Poor pregnancy outcome, impaired growth (Stunting), genetic disorders, decreased resistance to factious disease	Breakfast cereals, Infant formulas, cookies, and diet beverages
Vitamin A	Night blindness, xerophthalmia, increased risk of mortality in children and pregnant women	Milk, margarine, yogurts, soft cheese, sugar, monosodium Glutamate and tea
Folate (Vitamin B9)	Megaloblastic anemia, neural tube, and other birth defects, heart disease, stroke, impaired cognitive function, depression	Wheat and corn flours, bread, pasta, rice, cookies and infant formulas
Cobalamin (Vitamin B12)	Megaloblastic anemia (associated with Helicobacter pylori-induced gastric atrophy)	Breakfast cereals, diet beverages, Wheat and corn flours, bread, pasta, rice
Thiamine (Vitamin B1)	Beriberi (cardiac and neurologic), Wernicke's, and Korsakov syndromes (alcoholic confusion and paralysis)	Wheat and corn flours, bread, pasta, rice, infant formulas, cookie breakfast cereals, vegetable mixtures, and amino acids
Riboflavin (Vitamin B2)	Non-specific fatigue, eye changes, dermatitis, brain dysfunction, impaired iron absorption	Wheat and corn flours, bread, pasta, rice, vegetable mixtures, and amino acids, breakfast cereals and infant formulas, and cookies
Niacin (Vitamin B3)	Pellagra (dermatitis, diarrhea, dementia, death)	Wheat and corn flours, bread, pasta, rice, breakfast cereals,

2.7. Complementary Feeding

It is critical for the future of newborns and children, as well as the development of the society in which they live, to maintain optimum growth and development [14]. Inappropriate feeding habits, such as the loss of exclusive breastfeeding and the early introduction of weaning foods, are common causes of malnutrition in children. Inadequate dietary quantity and quality later in infancy are major contributors [15]. Household food poverty has been related in studies to the likelihood of stunting and underweight in preschool children, as well as detrimental consequences on development and learning ability [15, 16]. Similarly, food security in the home has been linked to increased child development [14]. Children aged 6 to 24 months are often targeted for complementary/supplementary feeding therapies since this is when growth faltering, micronutrient deficits, and infectious diseases are most common [7]. Preschool years (ages 1-5) are a period of fast and dramatic postnatal brain growth (i.e., neural plasticity) as well as fundamental cognitive development (i.e., working memory, attention, and inhibitory control). A food-based, holistic approach may be more effective and long-term than programs that address specific nutritional shortages.

2.8. Benefits of Proper Complementary Feeding

1) Nutrition is critical throughout the first two years of life. Young children need a range of nutritious meals, including meat, fish, legumes, grains, eggs, fruits, and vegetables, as well as breastfeeding, to develop and remain healthy.
2) Mash vegetables with chopped meat, eggs, or fish should be included in the child's diet as frequently as feasible.
3) Feed newborns freshly prepared energy and nutrient-rich complimentary meals starting at six months of age, while continuing to nurse the baby for at least two years.
4) Because a child's stomach is smaller than an adult's, he or she cannot consume as much food in one sitting. Children, on the other hand, have high energy and body-building requirements. Children must eat regularly in order to meet all of their requirements.
5) Complementary feeding maintains a child's healthy growth and development by introducing a range of nutritional foods to supplement breastfeeding.
6) To prevent children from being excessively short for their age, good diet, care, and cleanliness are essential, particularly in the first two years of life (stunted).
7) Breastfeed your baby whenever you want, day or night, to keep him or her healthy and strong since breast milk is still the most vital portion of his or her nutrition.
8) Breast milk should always come first when feeding a baby between the ages of 6 and 8 months. HIV-positive women who have chosen to discontinue nursing should give their kids at least one full NICE cup of milk each day. (A 500 mL NICE cup is a full cup).
9) When offering complimentary meals to the infant, keep the following qualities in mind: F stands for frequency, A for amount, T for thickness (consistency), V for variety (various types of food), A for active/responsive feeding, and H for hygiene (FATVAH).

A child's optimal IYCF protects them against both under- and over-nutrition, as well as the long-term repercussions of both. Breastfeeding is a cost-effective obesity strategy, according to a review of multiple research [22, 23], Breastfed infants have a lower risk of asthma, diabetes [14], heart disease [15, 26], and cardiac risk factors such as hypertension [27] and high cholesterol levels [28] as well as cancers such as childhood leukemia [19] and breast cancer later in life [20] when compared to artificially-fed infants. Because of the significant link between diet quality and obesity, proper complementary feeding with a variety of nutrient-dense meals may help prevent overweight and obesity. For countries in the midst of a nutrition transition and facing a double burden of malnutrition (both under and overnutrition), optimal IYCF and early intervention is even more important to ensure that investments are directed toward children under the age of two to avoid the risk of stunting and obesity. Rapid catch-up weight gain in the first two years is critical for avoiding long-term undernutrition and lowering morbidity and death in babies who have previously experienced poor growth. Rapid weight growth in later childhood is not ideal if a kid does not have the chance to catch up before the age of two since it raises the risk of chronic illness greatly. A worst-case scenario for chronic illnesses such as cardiovascular and metabolic disorders is a low-birth-weight kid who is stunted and underweight over childhood and adulthood, eventually becoming overweight.

Figure 3. *Benefits of Proper Complementary Feedings.*

2.9. Major Micronutrients Deficiency (MND) Impact on Psychomotor Development in Children

Micronutrient deficits are quite widespread all around the globe. They are known to have an impact on growth and health, but we will concentrate on their involvement in behavioral and cognitive development in this research. A few research on vitamin deficits have been undertaken, and we will quickly discuss them. We'll also concentrate on children. Other micronutrient deficiencies may have an impact on behavior, although information on them is scarce. There are various issues in studying the impact of specific nutritional deficits on behavior. Deficiencies are more common in areas of relative poverty, and they are often linked to protein-energy malnutrition, other micronutrient deficiencies, and infections in poor nations. All of these elements may have an impact on behavioral development; however, some of them may interact with one another, changing their impact. Due to the many confounding variables, proving a causal association between a deficit and behavioral development is challenging, and the only genuinely adequate method is to conduct randomized therapy trials in deficient populations. Animal studies are also beneficial, although caution should be used when extrapolating results to people. In underdeveloped nations, 46-51% of children under the age of five suffer from anemia, compared to 7-12%t in industrialized countries. Although the frequency of anemia has recently decreased in several affluent nations, it remains widespread in the United Kingdom, with rates as high as 39% among inner-city children [2]. The most prevalent cause of anemia is iron deficiency, which is caused by a lack of bioavailable iron in the diet and/or excessive loss owing to parasite infections. Rapid growth periods are the most susceptible, and anemia is most common between the ages of 6 and 24 months. However, certain severely contaminated groups of schoolchildren are in very high danger. Children with iron deficiency anemia have lower work capacity and adults have lower work capacity and productivity. A link between changed behavior and impaired cognition and iron deficiency anemia has been recognized since the late 1960s, and a significant amount of study has been undertaken since then. Preventive studies eliminate the ethical concerns associated with placebo anemic groups. Children were randomly randomized to iron therapy or placebo in the first few months of life before anemia became obvious in six preventative studies. There are no details on two recent trials that found no benefit. Non-anemic Chilean youngsters. Lozoff [2] recently discussed the processes that relate iron insufficiency to behavior. Poor settings have immediate consequences, as well as long-term alterations in neuron maturation, altered neurotransmitter function, and 'functional isolation.' Despite therapy, iron shortage during the rat's brain development spurt resulted in a permanent decrease in the quantity of iron in the brain. Myelination requires iron, and iron-deficient rats have hypomyelination. There are also lasting dopamine receptor deficiencies in the brain, as well as altered dopaminergic and serotonergic neurotransmission. Changes in behavior and arousal are assumed to be the cause of these disparities. Stress response in iron-deficient rats is abnormal [25]. Children with iron deficiency anemia have delayed auditory evoked potentials, which remain after anemia is corrected and may be related to hypomyelination. Anemic children also exhibit greater apprehension, hesitancy, sadness, fearfulness, and exhaustion. They spend more time with their moms, engage less with their surroundings, and are more likely to be carried. Their moms like playing less and are less supportive when their kid is tested [12]. Because the testers responded differently toward anemic children during developmental evaluations, it's possible that part of the moms' behavior is in reaction to the child's changing behavior. Children that are malnourished in protein and energy react similarly, and it is assumed that they 'functionally separate' themselves from their surroundings, which has a negative impact on their development. Because it is difficult to assess zinc levels in the general population, the real frequency of zinc insufficiency is unclear; nonetheless, it is likely to be widespread. Zinc deficiency is common in people whose diets are heavy in compounds that prevent absorption, such as phytates, fiber, and cow's milk. Zinc requirement is increased during periods of fast development, such as childhood, adolescence, and pregnancy. Furthermore, diarrhea and other parasite illnesses cause high zinc losses [26]. Although zinc insufficiency is more common in children in impoverished nations, it may also occur in rich countries [27, 28]. Growth failure, poor taste acuity and hunger, a diminished immunological response, diarrhea, and pregnancy difficulties have all been linked to zinc deficiency [26]. There has lately been worry that children's development may be negatively impacted. Stunted (low height-for-age) children frequently have poor development [13] and zinc deficiency is one of the reasons for growth retardation. It's probable that zinc deficiency is contributing to their delayed development. Iodine deficiency is still a major public health issue in many countries [30]. Accounting for 5.7 million instances of cretinism and 43 million cases of less severe cognitive impairment [21]. Iodine deficiency diseases (IDD) is a term used to represent a wide range of iodine-deficient symptoms, including goitre, endemic cretinism, neuromotor delays, and increased pre-and post-natal mortality. Although Western diets are generally sufficient, demographic pockets with subclinical vitamin deficits exist [27, 28]. It is generally known that severe vitamin insufficiency has negative neurological and intellectual consequences (e.g., thiamine and beriberi, niacin and pellagra, vitamin B2, and coupled cord degeneration) [19]. However, it is debatable whether vitamin supplementation of already healthy adolescents and young adults would provide any further advantage to their cognitive performance.

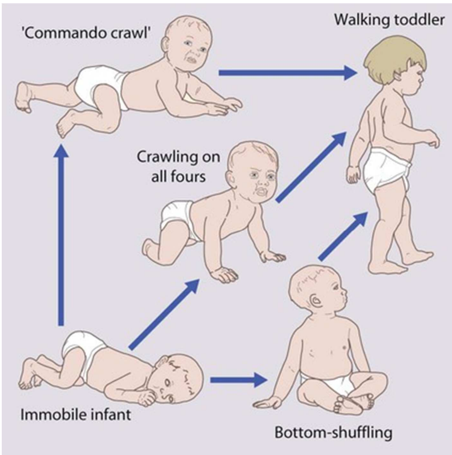

Figure 4. *Impact of Psychomotor Development in Children.*

2.10. Current Policies and Intervention Programs to Overcome MND

The following are the current micronutrient intervention programs in Bangladesh, along with their coverage rates:

2.10.1. Infant and Small Child Feeding Programs

The Bangladeshi government, UN agencies, non-governmental organizations, and donors have all supported interventions aimed at improving infant and young child feeding practices from birth, when exclusive breastfeeding is encouraged, to the various stages of complementary food introduction from 6 months and beyond, using a variety of means and methods. These programs are sometimes integrated with others that focus on health, food, livelihoods, water, sanitation, and hygiene.

2.10.2. Controlling Anemia in Children Aged 6 to 59 Months

To prevent anemia and other micronutrient deficiencies, Bangladesh's National Strategy for the Prevention and Control of Anaemia suggests that children aged 6 to 23 months (and 24 to 59 months if resources are available) use multiple micronutrient powder (MNP) in their diet. [18] The Bangladesh Rural Advancement Committee (BRAC)/Global Alliance for Improved Nutrition (GAIN) is now funding one large-scale area-based MNP program that uses the government-approved five-component (Fe, folic acid, zinc, and vitamins A and C) powder. In 2013, BRAC's community health workers (ShasthyaShebika) visited rural regions and distributed 145 million MNP sachets.

2.10.3. Supplementing Edible Oil with Vitamin A

Bangladesh started adding vitamin A to edible oils in December of 2011. Vitamin A-fortified edible oil is produced by only sixteen of the twenty-two edible oil refineries. Despite the government's adoption of the 'National Edible Oil Fortification Law 2013', which mandates that all refined edible oil be fortified with vitamin A, the program has fallen short of its coverage targets [13]. While the NMS 2011–2012 found that children and NPNL mothers in Bangladesh had low Fe deficit and IDA, a Fe–folic acid (IFA) supplementation program for pregnant women has been in operation for decades to prevent and treat Fe deficiency and anemia. Pregnant women receive IFA vitamins from the second trimester until 90 days after delivery (60 mg Fe and 400 g folic acid daily). Supplementation with IFAs is one of the elements of the Health, Population, and Nutrition Sector Development Program (HPNSDP). According to a 2011 assessment on Bangladesh's Food Security and Nutrition, 37% of pregnant women did not use any IFA supplements, and more than half of those who did began in the third trimester [12].

2.10.4. Dietary Diversity Promotion

Many government and non-government groups in Bangladesh have funded a variety of projects and programs aimed at increasing the diversity and quality of the country's food. The Bangladesh Country Investment Plan is a "roadmap for investment in agriculture, food security, and nutrition," according to its Plan of Action 2008-2015 [11]. The Bangladesh Country Investment Plan promotes community-based household gardening, small-scale animal husbandry, aquaculture, and education with the objective of enhancing family food supply and access, especially to micronutrient-rich foods. To optimize the potential of these initiatives to treat micronutrient deficiencies, further targeting, outcome monitoring, and communication interventions would be required [12]. Despite the fact that the National Nutrition Services supports mass media campaigns, social mobilization, and behavior change communication activities at the health facility and community clinic levels, the Ministry of Agriculture and other food-related ministries must also reinforce these specific nutrition-related messages.

Table 3. *Current intervention programs for the prevention and control of various micronutrient deficiencies in Bangladesh.*

Intervention program	Target group	Current coverage rate	Comments
Vitamin A supplementation	Children under 5 years	Infants aged 6-11 months: 85·4%	No remarkable variation in coverage between urban and rural areas
Fortification of Edible oil with vitamin A	Whole population	Children aged 12-59 months: 93·7%	Recently initiated, no monitoring data available
Fe-folate supplementation	Pregnant women/ adolescent girls and non-pregnant women	Not available	ANC care is weak-less than 30% of women attending ANC in the first trimester, and attendance at 4+ visits is around inadequate supply at ANC or inadequate knowledge and Practice.
		Not available	Provides very weak counseling. Poor monitoring. No nationwide program for adolescent girls and non-pregnant women 30%
Universal salt iodization	Whole population	Pregnant women: received IFA through ANC: around 60%	Coverage is lowest in rural areas due to the availability of non-iodized salts which are less costly
Home fortification with MNP	Children under 5 years	Adequately iodized salt Retailer's level: 66·4% Household level: 57·6% (>20 ppm)	A small study conducted in an intensive program area
Promotion of diversified diet	Whole population	Not available	Policies are in place to improve diversified agriculture, fisheries and aquaculture and livestock development, and community-based nutrition programs, but much stronger efforts are needed to achieve a goal

2.10.5. Bio-enhancement

Bio-fortification is a long-term solution that can be achieved using both traditional plant breeding techniques and current biotechnology and genetic engineering [25]. In India, the nutritional benefit of iron bio fortification seems to be positive [26]. To add genes directly into breeding varieties, genetic engineering demands modern technological tools. This strategy is designed to improve mineral transport from roots to storage tissues, reduce antinutrient levels that inhibit micronutrient absorption, increase mineral uptake from soil to roots, improve mineral mobilization in soil, and increase the level of absorption enhancers that increase mineral absorption in the body [7]. Golden Rice is a grain product that has been genetically modified to manufacture -carotene (pro-vitamin A) to aid in the prevention of VAD [8].

2.10.6. Health and Nutrition Education

One of the greatest approaches to relieving micronutrient deficiencies is to combine community development initiatives with national programs for reducing malnutrition with the goal of increasing the intake of various foods. Nutritional and health status may be improved by Behavioral Change Communication (BCC) programs for particular target populations. [17] The general public's awareness of the relationship between food, nutrition, health, and illness must be raised. Agriculture's nutritional component must be improved by educating farmers about the need of producing micronutrient-rich foods. For more than two decades, the production and consumption of vitamin A-rich foods have been raised in several South Asian nations by combining home or community gardening with innovative nutrition teaching and social marketing tactics [10]. Two effective social marketing programs utilizing mass media [11], one in Indonesia and the other in Thailand, were claimed to have resulted in a favorable change in knowledge, attitude, and behaviors [7]. In Indonesia, significant positive attitudes toward vitamin A were detected, and intake of vitamin A-rich foods rose by 10 to 33 among the targeted demographic after two years [22]. In northeast Thailand, a trial social marketing effort was launched with the goal of boosting the consumption of a single vitamin A-rich food, the ivy gourd, and fat. This initiative stressed the need of identifying and disseminating dark green leafy vegetables and other -carotene-rich meals. Furthermore, it promoted suitable cooking/processing processes in traditional cooking, preservation, storage, marketing, and enhancing food preparation to achieve optimal nutrient retention [3].

2.10.7. Improving Hygiene

The correct digestion of food, as well as the absorption and use of nutrients inside the body, determines an individual's nutritional status and health. Utilization necessitates not just nutritious food, but also a healthy physical environment, which includes clean drinking water, proper sanitation and hygiene, and early healthcare treatments in the event of sickness. In reality, initiatives to combat micronutrient deficiencies will mostly fail unless significant attention is paid to avoiding communicable illnesses such as diarrhea, lowering morbidity, and improving basic health care facilities. Breaking the vicious cycle of hunger and illness will need a unique effort.

3. Discussion

Bangladesh's most recent national survey, the NMS 2011-2012, offered essential data for public health and nutrition decision-making and planning. It has also brought a number of technological and operational hurdles. While the administration is moving ahead with building a new plan, there are a number of issues that need to be addressed, studied, and explored further. First, despite the country's high coverage of a 6-monthly vitamin A capsule supplementation program for children aged 6-59 months, one out of every five children have VAD, with children living in slums having the greatest frequency. According to various studies, a 6-month high-dose vitamin A pill may only provide a brief and modest increase in serum retinol that can persist for around 2 months. Second, recent findings on the link between natural Fe content in groundwater and Fe status have raised new questions for public health initiatives. [29] The incidence of Fe insufficiency varies throughout the country due to variable Fe levels in groundwater. Third, considering the wide range of prevalence of Fe deficiency and IDA in the country based on the most recent micronutrient survey, MNP programs for children aged 6-59 months should be carefully examined to determine whether the composition of MNP has to be adjusted. Fourth, the USI program in Bangladesh is an excellent example of an area where we know precisely what has to be done yet, despite significant resources and an apparently strong commitment to execution, the outcomes have been less than ideal. Finally, there is debate in Bangladesh and throughout the globe on whether to treat vitamin deficiencies in the short/medium/long term. In the next months and years, it will be vital to maintain a close check on the situation and ensure that the optimal treatment combination is applied using evidence-based procedures. In food-related initiatives, identifying specific nutrition-related indicators will become increasingly important, ensuring that interventions first notice and then address specific dietary deficits, whether seasonal or for specific groups of people (e.g., age or wealth). Agriculture and horticulture initiatives that enhance food quality and diversity must be complemented with supplements that are specifically targeted to address nutritional shortfalls in the short term and to meet the special needs of vulnerable populations [11].

4. Conclusion

While the severity of many micronutrient deficiencies has decreased considerably in Bangladesh over the past few decades, a significant portion of the population, especially children and women, continues to be deficient in critical micronutrients. The study also revealed the consequences of fortifying meals with vitamins and minerals that are vital for human health. A nutritional intervention program with a specific target population is known as food fortification. The acceptance, purchase, and consumption of the fortified food by the target demographic determine success. To address the issue of micronutrient deficiencies, many intervention programs are in place, notably for vitamin A, Fe, and I deficiency. On the other hand, the success of these attempts is far from satisfactory. Given the complexities of the factors that lead to micronutrient deficiencies in Bangladesh and other low-income countries, nutrient-specific nutrition policies and programs are unlikely to prevent and manage micronutrient deficiency. It's also crucial to have appropriate resources and coordination between health and food sector staff to ensure quality service delivery and accurate monitoring and reporting for better outcomes in terms of targeted groups' micronutrient status. Various techniques to ameliorate micronutrient deficiencies, such as fortification, bio-fortification, and genome-wide association studies, have resulted in advances in the micronutrient content of foods in recent technological breakthroughs. Micronutrient deficits have been addressed using a variety of ways across the globe. Short-term profits are the goal of certain methods, while long-term difficulties are the focus of others. Food supplementation programs often fail to treat micronutrient insufficiency because economic constraints prevent the inclusion of micronutrient-rich foods in meals. Dietary diversity, reducing nutritional losses, enhancing nutritional bioavailability, fortification, and bio-fortification are all long-term methods. The effects of food-based interventions are notoriously difficult to assess since they are seldom quantitative. Food-based initiatives for achieving sustainable development have been sluggish to gain traction. Community and health-oriented organizations have disregarded these techniques in favor of initiatives that have produced swift and rapid outcomes. Many poor nations, international agencies, and non-governmental organizations (NGOs) have shown that food-based methods provide a cost-effective and indigenously sustainable solution to micronutrient shortages.

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