

# Hidden Hunger in South Kivu Province, Eastern Democratic Republic of Congo: A Review

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## Abstract

Hidden hunger is also known as micronutrient deficiency, a form of malnutrition that occurs when individuals consume an inadequate amount of essential vitamins and minerals. In this review paper, we aim to provide a comprehensive overview of hidden hunger, including its causes, consequences, and interventions, as well as identify research gaps and future directions. We hope to contribute to the development of effective strategies for addressing this problem in South Kivu Province, Eastern DRC. In South Kivu Province, the focus has historically been on addressing undernutrition, which is characterized by a lack of sufficient calories. This focus on undernutrition has led to successful programs and interventions such as food supplementation and fortification, which have helped to reduce the prevalence of undernutrition. However, these programs have not necessarily addressed hidden hunger, which requires a different approach focused on increasing access to nutrient-rich foods and promoting healthy dietary habits. Addressing hidden hunger requires a multifaceted approach that includes improving access to nutritious foods, promoting healthy dietary habits, and increasing awareness of the importance of micronutrients for health. The prevalence of hidden hunger highlights the need for targeted interventions to improve nutrition and increase access to nutritious foods, particularly in vulnerable populations. Hidden hunger can affect populations, and addressing it requires a comprehensive approach that takes into account factors such as food access, health status, socioeconomic conditions, and the unique nutritional needs and challenges faced by each population. While each intervention (supplementation or Biofortifi-

cation) has its strengths and limitations, a combination of approaches that address the underlying causes of hidden hunger can be effective in reducing micronutrient deficiencies and improving nutritional status. Additionally, interventions that are sustainable and integrated into existing systems and programs can have a more lasting impact on addressing hidden hunger. Addressing the gaps in our knowledge on hidden hunger will require involving researchers, policymakers, and community stakeholders working together to develop and implement effective strategies to improve nutrition and health outcomes. It is essential to prioritize and invest in interventions aimed at addressing hidden hunger, including food-based approaches, fortification, supplementation, and biofortification. Moreover, research and monitoring efforts should be enhanced to improve our understanding of the effectiveness of these interventions and to identify areas for improvement. Ultimately, addressing hidden hunger is critical for achieving health and development goals, including the Sustainable Development Goals.

### **Keywords**

Fortification, Supplementation, Biofortification, Micronutrient Deficiencies, Vitamins and Minerals

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## **1. Introduction**

Hidden hunger, also known as micronutrient deficiency, is a form of malnutrition that occurs when individuals consume an inadequate amount of essential vitamins and minerals [1]-[5]. Despite the prevalence of hidden hunger, it remains a neglected public health issue, particularly in developing countries [6] [7]. This is alarming given that hidden hunger can lead to a range of negative health outcomes, including impaired growth and development, weakened immune systems, and decreased productivity [8]-[10]. In this review paper, we aim to provide a comprehensive overview of hidden hunger, including its causes, consequences, and interventions, as well as identify research gaps and future directions. Specifically, we will examine the prevalence and distribution of hidden hunger, the various causes and consequences of this condition, and the interventions that have been used to address it. By doing so, we hope to raise awareness of hidden hunger as a health issue and contribute to the development of effective strategies for addressing this problem in South Kivu Province, Eastern DRC.

While many people may consume enough calories to meet their energy needs, they may not be getting enough of the micronutrients required for proper growth and development, immune function, and overall health [11]-[14].

According to the World Health Organization (WHO), hidden hunger affects approximately two billion people worldwide, with the highest rates found in developing countries (United Nations, 2020). In these regions, hidden hunger is often linked to poverty, food insecurity, and inadequate access to nutritious foods

[15] [16]. However, hidden hunger can also affect individuals in wealthier countries who may have limited access to fresh, healthy foods or who consume diets that are low in essential micronutrients [15] [16].

In many developing countries, people rely heavily on staple foods such as rice, wheat, and maize, which are often deficient in essential micronutrients [17] [18]. For example, polished rice is a common staple food in many parts of Asia, but it is low in iron and vitamin A. Similarly, corn-based diets in Africa are often low in protein and essential amino acids [17] [18]. Inadequate access to fresh fruits and vegetables, which are rich sources of vitamins and minerals, also contributes to hidden hunger in developing countries [19] [20].

In wealthier countries, hidden hunger can affect for example, people who rely on highly processed foods or fast food may consume diets that are high in calories but low in nutrients [21] [22]. Similarly, people who follow restrictive diets, such as vegans or vegetarians, may be at risk of micronutrient deficiencies if they do not carefully plan their diets [23]-[25].

The consequences of hidden hunger can be severe and long-lasting [26]. For example, children who experience hidden hunger may experience stunted growth, delayed cognitive development, and impaired immune function, all of which can have lifelong impacts on their health and well-being [26]. Hidden hunger can also lead to increased susceptibility to infectious diseases and chronic conditions such as anemia and blindness [26].

Children who experience hidden hunger are especially vulnerable to these consequences. When children do not receive adequate nutrition during critical periods of growth and development, it can lead to stunted growth and developmental delays [26]. Children who experience hidden hunger may also be more susceptible to infectious diseases such as diarrhea, respiratory infections, and malaria [26].

In addition to the short-term consequences, hidden hunger can have long-lasting impacts on health and well-being. For example, iron deficiency anemia, which is a common consequence of hidden hunger, can lead to fatigue, weakness, and decreased productivity, and can also increase the risk of complications during pregnancy and childbirth [17] [27]. Vitamin A deficiency can cause blindness and increase the risk of infectious diseases, while iodine deficiency can lead to goiter and impaired cognitive development [6].

Furthermore, the impacts of hidden hunger can have a ripple effect on entire communities and even countries. Hidden hunger can limit educational attainment, decrease productivity, and increase healthcare costs [28]-[31]. These effects can, in turn, contribute to a cycle of poverty and malnutrition, making it even more difficult to break the cycle of hidden hunger [28]-[31].

Despite the significant impact of hidden hunger on global health, this issue remains relatively unknown and under-prioritized [32]. This is particularly true in developing countries, where resources and attention are often directed towards addressing other forms of malnutrition, such as undernutrition and overnutrition, which are more visible and have more immediate consequences [32].

In many developing countries, D.R. Congo in particular, the focus has histori-

cally been on addressing undernutrition, which is characterized by a lack of sufficient calories and protein [33]. This focus on undernutrition has led to successful programs and interventions, such as food supplementation and fortification, which have helped to reduce the prevalence of undernutrition [34] [35]. However, these programs have not necessarily addressed hidden hunger, which requires a different approach focused on increasing access to nutrient-rich foods and promoting healthy dietary habits [35] [36].

Similarly, in developed countries, the focus on nutrition has often been on addressing overnutrition, which is characterized by excessive calorie intake and can lead to obesity and related health problems [37] [38]. While overnutrition is a significant public health issue, it has led to a relative lack of attention and resources directed towards hidden hunger, which is less visible and less well-understood.

Micronutrients are essential vitamins and minerals that our bodies need in small quantities to function properly. These include vitamins A, C, D, E, K, and B-complex vitamins, as well as minerals such as iron, zinc, iodine, and calcium (WHO, 2022; CDC, 2022; NHS, 2020). These micronutrients play critical roles in a wide range of bodily functions, including metabolism, immune function, bone health, and cognitive development (WHO, 2022; CDC, 2022; NHS, 2020).

When individuals do not consume enough of these micronutrients, it can lead to hidden hunger, which can have serious health consequences (NHS, 2020). For example, vitamin A deficiency can cause blindness and weaken the immune system, while iron deficiency can lead to anemia and impaired cognitive development [39]. Zinc deficiency can impair growth and increase the risk of infections, while iodine deficiency can cause goiter and impaired cognitive development [40]-[42].

Hidden hunger is prevalent in DRC, where access to nutritious foods can be limited, and diets may be heavily reliant on staple foods that are low in micronutrients [43] [44]. However, hidden hunger can also occur in wealthier countries, particularly among vulnerable populations such as children, pregnant and breast-feeding women, and the elderly.

Hidden hunger is a health issue that requires attention and action from policymakers, health professionals, and communities to ensure that everyone has access to the nutrients they need to live healthy and productive lives [45].

Addressing hidden hunger requires a multifaceted approach that includes improving access to nutritious foods, promoting healthy dietary habits, and increasing awareness of the importance of micronutrients for health [46]. Addressing hidden hunger is essential for improving health outcomes and breaking the cycle of poverty and malnutrition [47].

## **2. Causes and Consequences of Hidden Hunger**

### **2.1. Various Causes of Hidden Hunger**

Hidden hunger, or micronutrient deficiency, can have multiple causes, including insufficient nutrient intake, poor dietary diversity, and low bioavailability of nu-

trients [1] [45].

Insufficient nutrient intake occurs when individuals do not consume enough essential vitamins and minerals in their diet [48]. This can be due to a variety of factors, including poverty and limited access to nutritious foods, which is particularly common in DRC [43] [49]. It can also be due to dietary choices, such as a preference for processed or refined foods that are low in essential nutrients [50].

Poor dietary diversity can also contribute to hidden hunger. When individuals consume a limited range of foods, they are more likely to miss out on essential micronutrients [51]. This is particularly true for those who rely on a small number of staple foods for the majority of their calorie intake [52].

Dietary diversity refers to the variety of different foods and food groups consumed in a diet [53] [54]. A diverse diet is important for ensuring that the body receives all the essential vitamins and minerals required for optimal health and well-being. When individuals consume a limited range of foods, they are more likely to miss out on key micronutrients [55].

Poor dietary diversity is often linked to poverty and limited access to nutritious foods [56]. Many people may rely on a small number of staple foods, such as rice or maize, for the majority of their calorie intake. While these foods may provide energy, they may not provide all the essential micronutrients required for optimal health [57].

In addition to poverty and limited access to nutritious foods, poor dietary diversity can also be linked to cultural and social factors [21]. For example, certain cultures or regions may have dietary restrictions or preferences that limit the variety of foods consumed (C. Nfundiko, 2018).

Addressing poor dietary diversity requires a multi-faceted approach, including increasing access to a diverse range of nutritious foods, promoting education and awareness of the importance of dietary diversity, and addressing the root causes of poverty and food insecurity [58]. This may involve interventions such as promoting home gardens, diversifying crops and food systems, and encouraging the consumption of a wider range of foods.

Low bioavailability of nutrients is another contributing factor to hidden hunger. Even when individuals consume sufficient quantities of essential nutrients, their bodies may not be able to absorb and utilize these nutrients effectively [59]. This can be due to factors such as chronic infections or inflammation, which can interfere with nutrient absorption, or to the presence of anti-nutrients in certain foods, such as phytates in legumes, which can bind to minerals and make them less available for absorption [60]-[62].

The bioavailability of a nutrient refers to the degree to which it can be absorbed and utilized by the body [60]-[62]. Nutrient bioavailability is influenced by a range of factors, including the form of the nutrient (e.g. heme iron vs non-heme iron), the presence of other nutrients (e.g. vitamin C can enhance iron absorption), and the presence of anti-nutrients (e.g. phytates, tannins) or enhancers (e.g. citric acid) in foods.

In some cases, chronic infections or inflammation can interfere with nutrient

absorption, leading to low bioavailability of certain nutrients [63]. For example, chronic diarrhea or intestinal infections can impair the absorption of nutrients such as zinc and vitamin A. Similarly, inflammation caused by conditions such as Crohn's disease or celiac disease can reduce the absorption of nutrients from the diet [64] [65].

Anti-nutrients are compounds found in certain foods that can reduce the bioavailability of nutrients [66] [67]. For example, phytates are found in legumes, nuts, and whole grains and can bind to minerals such as iron and zinc, making them less available for absorption. Similarly, tannins in tea and coffee can reduce the absorption of iron [68] [69].

Addressing low bioavailability of nutrients requires a multi-faceted approach. Strategies may include promoting the consumption of nutrient-rich foods that are easily absorbed and utilized by the body, such as animal source foods, as well as promoting food processing techniques that can reduce the levels of anti-nutrients in foods, such as soaking, fermenting, and sprouting [66] [70]. In addition, addressing chronic infections or inflammation through improved sanitation and access to healthcare can also improve nutrient absorption and utilization [71] [72].

Other factors that can contribute to hidden hunger include poor sanitation and hygiene, which can increase the risk of infections that can lead to nutrient loss or impaired absorption, and limited access to healthcare and education, which can limit knowledge and awareness of the importance of proper nutrition [73].

Poor sanitation and hygiene can increase the risk of infections, such as diarrhea, which can lead to nutrient loss or impaired nutrient absorption [74]. This is because diarrhea can cause the body to lose essential nutrients such as zinc and vitamin A, which are important for maintaining a healthy immune system and growth and development [75]. In addition, repeated episodes of diarrhea can lead to malabsorption of nutrients and chronic nutrient deficiencies [76].

Limited access to healthcare and education can also contribute to hidden hunger by limiting knowledge and awareness of the importance of proper nutrition [77]. For example, in some communities, there may be traditional beliefs or practices that lead to inadequate dietary intake of essential nutrients [78] [79]. Additionally, lack of access to healthcare services may result in missed opportunities for nutrition counseling, testing for nutrient deficiencies, and treatment of infections or conditions that can affect nutrient absorption [80].

Furthermore, factors such as climate change, urbanization, and food insecurity can also contribute to hidden hunger. Climate change can affect agricultural productivity, leading to decreased availability and diversity of nutritious foods [81] [82]. Urbanization can result in a shift towards processed and convenience foods, which may be low in essential nutrients [83] [84]. Food insecurity, which is defined as limited access to sufficient, safe, and nutritious food, can lead to inadequate nutrient intake and increased risk of micronutrient deficiencies [85].

Insufficient nutrient intake is a major cause of hidden hunger, particularly in South-Kivu province, where poverty and limited access to nutritious foods are

common. Many people in this region may rely on a limited range of staple foods for the majority of their calorie intake, which can result in a lack of essential micronutrients in their diet [86].

## 2.2. Consequences of Hidden Hunger

Hidden hunger, or micronutrient deficiency, can have several consequences on human health and well-being [87]-[89]. These consequences can vary depending on the specific nutrients that are deficient and the severity and duration of the deficiency [90]-[92]. Some of the most common consequences of hidden hunger include:

**Malnutrition:** Hidden hunger can lead to malnutrition, which occurs when the body does not receive enough essential nutrients to support normal growth, development, and function. Malnutrition can result in a weakened immune system, delayed wound healing, and increased risk of infections and diseases [93]-[95] [71].

In addition to the weakened immune system, delayed wound healing, and increased risk of infections and diseases that result from malnutrition, hidden hunger can also lead to other forms of malnutrition [96]. For example, hidden hunger can contribute to undernutrition, which occurs when individuals do not consume enough calories to meet their energy needs. Undernutrition can lead to a range of health problems, including stunted growth, weight loss, and muscle wasting [97] [98].

Hidden hunger can also contribute to overnutrition, which occurs when individuals consume more calories than they need, often in the form of unhealthy foods that are high in fat, sugar, and salt but low in essential nutrients [99] [100]. Overnutrition can lead to obesity, which is a major risk factor for a range of chronic diseases, including heart disease, diabetes, and certain types of cancer [100].

Moreover, hidden hunger can have particularly severe consequences for pregnant women and young children. Pregnant women who experience hidden hunger may be at increased risk of complications during pregnancy and childbirth, and their infants may be born with low birth weight and a higher risk of mortality [101]. Children who experience hidden hunger are at risk of stunted growth, impaired cognitive development, and reduced school performance, which can have lifelong impacts on their health and well-being [102] [103].

**Stunted growth:** Micronutrient deficiencies during early childhood can lead to stunted growth, which is characterized by low height-for-age. Stunted growth can have long-lasting effects on physical and cognitive development, leading to reduced adult height, lower cognitive abilities, and reduced earning potential in adulthood [103].

Stunted growth is a serious consequence of hidden hunger, particularly among children. The lack of essential micronutrients such as vitamin A, zinc, and iron can significantly affect the growth and development of children. Inadequate in-

take of these nutrients can lead to a failure in the production of new tissue and cell division, which results in stunted growth [104] [105].

Stunted growth can have several long-term effects on an individual's health and well-being. Children who experience stunted growth may be at a higher risk of developing chronic diseases later in life, such as diabetes and heart disease [106]-[108]. Additionally, stunted growth can negatively impact cognitive development and academic performance, leading to reduced earning potential and economic productivity in adulthood [103]. In developing countries, stunted growth is often associated with poverty and limited access to nutritious foods, which can perpetuate a cycle of poor health and reduced economic opportunities.

**Impaired cognitive development:** Hidden hunger can also impair cognitive development, particularly in young children. Deficiencies in iron, zinc, and iodine have been linked to impaired cognitive function, including reduced attention span, memory, and learning ability [26].

Iron is essential for the production of hemoglobin, which carries oxygen to the brain [109]. Iron deficiency in children can lead to decreased oxygen supply to the brain, resulting in impaired cognitive function [110]. Zinc is important for brain development and function, and deficiency in this micronutrient can lead to impaired memory and attention, as well as delayed motor development [111] [112]. Iodine is essential for the production of thyroid hormones, which play a crucial role in brain development and function [113] [114]. Iodine deficiency during pregnancy and early childhood can lead to irreversible brain damage and impaired cognitive function, including reduced IQ and learning ability. [115].

These cognitive impairments can have long-lasting effects on individuals and their communities, as reduced cognitive abilities can lead to lower academic achievement, reduced earning potential, and decreased economic growth [107] [116]. Additionally, impaired cognitive function can lead to increased risk-taking behaviors, poor decision-making skills, and reduced mental health. Overall, hidden hunger can have significant negative impacts on individuals and societies, highlighting the need for greater attention and action to address this issue [117].

**Increased risk of chronic diseases:** Micronutrient deficiencies can increase the risk of several chronic diseases, including anemia, blindness, and impaired immune function. For example, iron deficiency can lead to anemia, which is characterized by a decrease in the number of red blood cells in the body and can result in fatigue, weakness, and impaired physical performance [118].

In addition to anemia, hidden hunger can also increase the risk of other chronic diseases [119]. For instance, vitamin A deficiency can lead to blindness, particularly in children, and is a leading cause of preventable blindness worldwide [120] [121]. Zinc deficiency is associated with impaired immune function and increased susceptibility to infectious diseases [122]. Iodine deficiency can result in goiter, a condition characterized by the enlargement of the thyroid gland, as well as impaired cognitive development and increased risk of infant mortality [123].

Furthermore, hidden hunger can also increase the risk of non-communicable

diseases (NCDs) such as cardiovascular disease, cancer, and diabetes [124] [125]. For example, deficiencies in micronutrients such as vitamin D, magnesium, and calcium have been linked to an increased risk of cardiovascular disease, while low intake of antioxidants such as vitamins C and E have been associated with an increased risk of cancer [126]. These chronic diseases have a significant impact on global health and can result in increased morbidity and mortality rates [127].

**Maternal and child health:** Micronutrient deficiencies during pregnancy can increase the risk of adverse outcomes such as preterm birth, low birth weight, and infant mortality. Additionally, deficiencies in certain micronutrients, such as vitamin A and zinc can increase the risk of maternal mortality [128].

Maternal and child health is another area where hidden hunger can have severe consequences. Micronutrient deficiencies during pregnancy can lead to adverse outcomes such as preterm birth, low birth weight, and infant mortality [129]. For example, inadequate intake of iron, folic acid, and other micronutrients during pregnancy can increase the risk of maternal anemia, which can lead to low birth weight and preterm birth, and increases the risk of infant mortality [129]. Similarly, deficiencies in vitamin A and zinc during pregnancy can lead to complications such as night blindness and increased risk of infections, which can increase the risk of maternal mortality [130].

In addition to the risks during pregnancy, children who experience hidden hunger may experience stunted growth, delayed cognitive development, and impaired immune function, which can have lifelong impacts on their health and well-being [131]. These consequences can further perpetuate the cycle of poverty, as poor health outcomes can limit educational attainment and reduce earning potential in adulthood.

### 3. Prevalence and Distribution of Hidden Hunger

#### 3.1. Prevalence of Hidden Hunger at Global and Regional Levels

Hidden hunger is a significant issue that affects millions of people worldwide, with the highest rates found in developing countries [45]. According to the World Health Organization (WHO), approximately two billion people worldwide suffer from hidden hunger, with the majority of cases occurring in Africa, Asia, and Latin America (WHO, Accessed on 2 May 2022).

The prevalence of hidden hunger varies across different regions and populations. In many developing countries, hidden hunger is a pervasive and chronic issue, affecting large segments of population [45]. In sub-Saharan Africa, it is estimated that up to 40% of children under the age of five suffer from vitamin A deficiency, while up to 50% of women of reproductive age are anemic [132]. In South Asia, more than half of children under the age of five are estimated to be affected by one or more micronutrient deficiencies [132].

In Africa, hidden hunger is particularly widespread, with many countries experiencing high rates of malnutrition and micronutrient deficiencies [133]. In sub-Saharan Africa, more than 30% of children under the age of five suffer from

stunted growth due to malnutrition [116].

In addition to stunted growth, many African countries also have high rates of anemia, which is often caused by iron deficiency. According to the WHO, an estimated 50% of children and 40% of women in sub-Saharan Africa are anemic. This can have significant implications for maternal and child health, as anemia during pregnancy increases the risk of preterm birth, low birth weight, and maternal mortality [129].

In Asia, the prevalence of hidden hunger varies depending on the region and country. In South Asia, approximately 39% of children under the age of five suffer from stunted growth due to malnutrition, while in East Asia, the prevalence is lower, at around 17%. Micronutrient deficiencies are also common in many parts of Asia, particularly deficiencies in iron, vitamin A, and iodine [134].

Latin America is another region where hidden hunger is a significant issue. In many countries in the region, particularly in Central America and the Andean region, stunted growth is a major problem, affecting up to 25% of children under the age of five [135]. Micronutrient deficiencies are also common, particularly deficiencies in iron and vitamin A.

The prevalence of hidden hunger varies widely across regions and countries, but it is clear that it remains a significant global health challenge, particularly in developing countries.

In Asia, hidden hunger is also a significant problem, with many countries experiencing high rates of micronutrient deficiencies [136]. For example, in India, more than half of all children under the age of five are anemic due to iron deficiency [137].

In addition to Guatemala, many other countries in Latin America also experience high rates of hidden hunger. For example, in Bolivia, about one-third of children under the age of five suffer from stunted growth due to malnutrition, while in Haiti, about one in five children suffer from acute malnutrition [138]. In Brazil, while overall hunger rates have decreased in recent years, there are still pockets of population, particularly in rural areas and among indigenous communities, that experience high rates of hidden hunger and malnutrition [139]. Additionally, in some countries in the region, such as Mexico and Peru, obesity rates are also increasing, highlighting the importance of addressing both undernutrition and overnutrition in the fight against hidden hunger [140].

In developed countries, hidden hunger may not be as widespread as in developing countries, but it can still be a significant issue for certain populations. For example, low-income families in developed countries may have limited access to nutritious foods due to financial constraints, which can lead to micronutrient deficiencies and hidden hunger [141]. In addition, the elderly may be at increased risk of hidden hunger due to factors such as limited mobility, social isolation, and changes in appetite and digestion that can occur with aging [142].

Furthermore, certain health conditions and medications can interfere with nutrient absorption and increase the risk of hidden hunger [88]. For example, indi-

viduals with gastrointestinal disorders such as Crohn's disease or celiac disease may have impaired nutrient absorption, and those taking medications such as proton pump inhibitors for acid reflux may have reduced absorption of certain micronutrients like magnesium and vitamin B12 [143].

### 3.2. Distribution of Hidden Hunger across Different Populations

Hidden hunger affects different populations in different ways, with children, women, and elderly individuals being particularly vulnerable [144].

Children are one of the most affected populations by hidden hunger, as they require adequate nutrition for proper growth and development [88]. According to UNICEF, approximately 149 million children under the age of five in developing countries suffer from stunted growth due to malnutrition. Micronutrient deficiencies can also impair cognitive development in children, leading to reduced learning abilities and decreased future earning potential.

Children are particularly vulnerable to hidden hunger because they have high nutrient needs during growth and development, and their diets may not always meet these needs [88]. In addition, young children may have limited access to diverse and nutritious foods, particularly in low-income households.

According to the World Health Organization (WHO), around 45% of child deaths globally are linked to malnutrition, which includes hidden hunger [145]. Micronutrient deficiencies during early childhood can lead to stunted growth and impaired cognitive development, as previously mentioned.

It is worth noting that even in high-income countries, children can still be affected by hidden hunger. For example, in the United States, approximately one in six children experiences food insecurity, which can lead to inadequate nutrient intake and micronutrient deficiencies [146]. This highlights the need for comprehensive and equitable nutrition interventions for all children, regardless of socioeconomic status.

Furthermore, women often face higher rates of micronutrient deficiencies due to social and cultural factors [147]. In many cultures, women are expected to prioritize the nutritional needs of their families over their own, leading to maternal malnutrition and micronutrient deficiencies [29]. In addition, women may experience menstrual blood loss, which can lead to iron deficiency anemia if not properly addressed [118] [148]. Women who breastfeed also require increased amounts of certain micronutrients to support the growth and development of their infants, further increasing their risk of hidden hunger [149].

Elderly individuals are also vulnerable to hidden hunger due to a variety of factors, such as reduced appetite, decreased ability to absorb nutrients, and limited access to nutritious foods [150] [151]. Micronutrient deficiencies in elderly individuals can lead to a weakened immune system, decreased bone density, and impaired cognitive function [152].

As individuals age, their nutritional needs may change due to changes in metabolism, health status, and physical activity levels. Elderly individuals may expe-

rience reduced appetite, dental problems, or difficulty chewing and swallowing, which can contribute to inadequate nutrient intake [151]. Additionally, older adults may have reduced ability to absorb nutrients due to changes in the digestive system.

Micronutrient deficiencies in elderly individuals can have significant health consequences. For example, vitamin D deficiency can increase the risk of osteoporosis and fractures, while inadequate intake of calcium and vitamin K can also contribute to reduced bone density [153]. Deficiencies in vitamin B12 and folate can lead to anemia and impaired cognitive function, while deficiencies in vitamin C and zinc can impair immune function and increase the risk of infections [92].

In some cases, elderly individuals may also face barriers to accessing nutritious foods, such as limited mobility, transportation, or financial constraints. These factors can exacerbate the risk of hidden hunger in this population. It is important for healthcare professionals to be aware of the unique nutritional needs of elderly individuals and to work with them to ensure that they are receiving adequate nutrition to support their health and well-being.

### 3.3. Prevalence of Hidden Hunger in DRC and South Kivu Province

#### 3.3.1. Prevalence of Hidden Hunger in DRC

Hidden hunger, is a widespread issue in DRC, as it is in many sub-Saharan African countries. Several factors contribute to the prevalence of hidden hunger in DRC [45]:

**Dietary Patterns:** The typical diet in many parts of the DRC is often characterized by limited diversity and access to nutrient-rich foods [154]. A diet primarily based on staple crops such as cassava, maize, and rice can lack essential nutrients, contributing to hidden hunger [155]. This can result in inadequate intake of essential micronutrients like vitamins and minerals.

**Poverty:** High levels of poverty in the DRC can limit access to a balanced and diverse diet, making individuals and communities more vulnerable to hidden hunger [154].

**Inadequate Healthcare:** Limited access to healthcare, including antenatal and postnatal care, contribute to micronutrient deficiencies, particularly among pregnant women and children [156].

**Conflict and Displacement:** Ongoing conflicts and displacement in certain regions of the DRC disrupt food security and access to essential healthcare services, exacerbating hidden hunger [157].

#### 3.3.2. Prevalence of Hidden Hunger in South Kivu Province

South Kivu province, located in eastern DRC, has been particularly affected by conflict and displacement [158]. This has made the situation more complex regarding hidden hunger:

**Conflict and Displacement:** The region has experienced long-standing conflicts and population displacement, which have disrupted food supply chains and access to healthcare, increasing the risk of hidden hunger [159].

**Vulnerable Populations:** Vulnerable populations, such as internally displaced persons (IDPs) and refugees, are at heightened risk of hidden hunger due to limited access to nutritious food and healthcare [159].

**Data Gaps:** Data on the prevalence of hidden hunger in South Kivu is limited due to the challenging security situation and the difficulties in conducting comprehensive surveys. This is the reason for carrying out this research to fill the gap and direct interventions to combat hidden hunger in the South-Kivu province.

It's important to note that efforts are being made by international organizations, NGOs, and the government of the DRC to address hidden hunger through various interventions, including food fortification, nutrition education, and support for vulnerable populations [159]. However, the situation is complex, and ongoing conflict and instability have hindered progress in combatting hidden hunger.

Addressing hidden hunger in DRC, particularly in South Kivu, requires a multifaceted approach. This includes improving dietary diversity, fortifying staple foods with essential micronutrients, expanding access to healthcare services, and addressing the underlying causes of food insecurity and conflict. Additionally, raising awareness about proper nutrition and implementing targeted interventions for vulnerable populations is crucial to reducing the prevalence of hidden hunger in both the DRC and South Kivu province.

### 3.4. Distribution of Hidden Hunger Across DRC and South-Kivu Province

The distribution of hidden hunger, or micronutrient deficiencies, across the Democratic Republic of Congo (DRC) and its specific region, South Kivu province, is a complex and multifaceted issue influenced by various factors. Understanding how hidden hunger is distributed across these areas is crucial for designing effective interventions and addressing the specific needs of different populations.

#### 1) Distribution of Hidden Hunger in the DRC

**Regional Disparities:** Hidden hunger is not evenly distributed across the DRC. There are notable regional disparities due to differences in geography, climate, access to resources, and socio-economic conditions. Generally, areas with limited access to diverse, nutrient-rich foods tend to have higher prevalence rates.

**Urban vs. Rural Disparities:** Within the DRC, urban areas often have better access to a variety of foods and improved healthcare services. Rural areas, on the other hand, face challenges related to agricultural productivity, food access, and healthcare infrastructure, which contribute to higher rates of hidden hunger [159].

**Conflict and Displacement:** Ongoing conflicts in some regions of the DRC, particularly in the eastern part of the country, have exacerbated hidden hunger. Displacement, insecurity, and disruptions to food supply chains have led to increased vulnerability to malnutrition, including hidden hunger [159].

#### Vulnerable Populations:

The distribution of hidden hunger also varies based on the vulnerability of specific populations. For instance, pregnant women, infants, and young children are particularly susceptible due to their increased nutritional needs.

Conflict-affected areas, which have experienced displacement and disruption of food supply chains, exhibit higher rates of hidden hunger compared to stable regions.

**Dietary Habits and Cultural Practices:** Dietary habits and cultural practices influence the distribution of hidden hunger. Regions with traditional diets that lack diversity are at greater risk.

Some cultural practices, such as food taboos or restrictions, limit the intake of certain nutrient-rich foods, contributing to deficiencies [160].

**Nutrient-Specific Variations:** Different regions may have varying prevalence rates of specific micronutrient deficiencies. For example, regions with limited access to iodized salt experience higher rates of iodine deficiency disorders, while areas with dietary restrictions see higher rates of Vitamin B12 deficiency.

## 2) Distribution of Hidden Hunger in South Kivu Province

**Geographical Diversity:** South Kivu province, located in the eastern part of the DRC, encompasses diverse geographical features, including hills, plateaus, and lowlands. These varying terrains affect agricultural practices and dietary diversity [161], leading to differences in the distribution of hidden hunger within the province.

**Conflict Dynamics:** Like other parts of eastern DRC, South Kivu has faced conflict and displacement. These factors have disrupted food production, access to healthcare, and the overall nutritional status of the population, contributing to hidden hunger.

**Ethnic and Cultural Diversity:** South Kivu is known for its ethnic and cultural diversity. Different communities have unique dietary practices and nutritional habits influencing the prevalence of specific micronutrient deficiencies.

**Access to Healthcare:** Disparities in healthcare infrastructure and access to services affect the distribution of hidden hunger. Some areas have better access to healthcare facilities that provide essential nutrition services, while others lack such resources.

**Seasonal Variability:** Agricultural productivity in South Kivu have been affected by seasonal variations, which have impacted the availability and diversity of foods [161]. This has led to seasonal fluctuations in the prevalence of hidden hunger.

To effectively address hidden hunger in both the DRC and South Kivu province, tailored interventions are essential. These interventions should take into account the specific nutritional needs of different regions, consider the impact of conflicts and displacement, and aim to improve food security, dietary diversity, and access to essential healthcare services. Additionally, raising awareness about proper nutrition and implementing sustainable agricultural practices can contribute to reducing the distribution of hidden hunger in these areas.

### 3.5. Factors That Contribute to the Uneven Distribution of Hidden Hunger

The uneven distribution of hidden hunger can be attributed to a variety of factors, including:

**Poverty:** Poverty is one of the most significant contributing factors to hidden hunger, as individuals living in poverty often have limited access to nutritious foods. Poverty can also limit access to healthcare and education, which can further exacerbate the problem of hidden hunger [141].

**Limited access to healthcare:** Individuals who do not have access to healthcare may not receive adequate nutrition education or may not be diagnosed and treated for micronutrient deficiencies. This is particularly true in rural areas where healthcare infrastructure may be limited [162].

**Climate and environmental factors:** Climate and environmental factors such as drought, floods, water quality and soil degradation can impact the quality and availability of food [36] [163].

**Food insecurity:** Food insecurity, which is the lack of access to adequate amounts of nutritious food, can contribute to hidden hunger. This can be caused by a variety of factors, such as poverty, natural disasters, conflict, and climate change [164].

**Dietary patterns:** Certain dietary patterns, such as those that rely heavily on staple foods such as rice, maize, and wheat, may not provide adequate amounts of essential micronutrients [165].

**Gender inequality:** Gender inequality can also contribute to hidden hunger, as women and girls may have limited access to education and healthcare, leading to poorer nutritional outcomes [166].

**Lack of agricultural diversity:** The focus on monoculture farming, where only one type of crop is grown on a large scale, can limit the diversity of nutrients in the food system, leading to micronutrient deficiencies [36].

Addressing these contributing factors and implementing interventions such as improving access to nutritious foods, increasing nutrition education and healthcare, promoting agricultural diversity, and addressing poverty and inequality can help to reduce the prevalence of hidden hunger.

## 4. Interventions to Address Hidden Hunger

### 4.1. Various Interventions That Have Been Used to Address Hidden Hunger

There are several interventions that have been used to address hidden hunger, including food-based approaches, supplementation programs, and biofortification [167].

Food-based approaches aim to increase the availability and accessibility of nutritious foods through a variety of methods, such as agricultural development, food fortification, and food diversification. For example, promoting the cultivation of nutrient-rich crops such as legumes and vegetables can increase the avail-

ability of nutritious foods in communities [35]. Fortifying staple foods such as flour, salt, and oil with essential vitamins and minerals also helps address micronutrient deficiencies [168]. Additionally, promoting the consumption of a diverse range of foods improve overall nutritional intake and reduce the risk of hidden hunger.

*Food-based approaches* are effective in addressing hidden hunger because they focus on addressing the underlying cause of micronutrient deficiencies, which is often inadequate access to nutritious foods. Here are some specific examples of food-based approaches:

**Agricultural development:** Encouraging the cultivation of nutrient-rich crops such as vegetables, fruits, legumes, and grains can increase the availability of nutritious foods in communities [35]. This approach can be particularly effective in rural areas where access to a diverse range of foods is limited [169]. Agricultural development can also provide income opportunities for farmers, which can improve food security and overall health outcomes [170].

**Food fortification:** Fortifying staple foods such as flour, salt, and oil with essential vitamins and minerals helps address micronutrient deficiencies [168]. This approach is often cost-effective and can be easily implemented through existing food production and distribution channels [168]. For example, the fortification of salt with iodine has been successful in preventing iodine deficiency disorders such as goiter and cretinism [171].

**Food diversification:** Promoting the consumption of a diverse range of foods can improve overall nutritional intake and reduce the risk of hidden hunger [172]. This approach involves encouraging the consumption of locally available, nutrient-dense foods or introducing new foods that are rich in essential vitamins and minerals [173]. For example, promoting the consumption of vitamin A-rich fruits and vegetables helps prevent vitamin A deficiency.

**Nutrition education:** Providing education on healthy eating habits and the importance of a balanced diet can help individuals and communities make informed decisions about their food choices [174]. This approach involves providing nutrition education through schools, health clinics, community centers, and media campaigns. Nutrition education can also help address cultural and social barriers to healthy eating, such as traditional beliefs about food or gender roles [175].

Food-based approaches are often sustainable and can lead to long-term improvements in health outcomes [35]. However, they may require significant investments in infrastructure, education, and policy change to be effective [176]. Additionally, food-based approaches may not be feasible in areas with limited resources or those facing environmental or political challenges [176].

Therefore, in addition to food-based approaches, other interventions such as supplementation programs and biofortification may be necessary to address hidden hunger in certain populations.

Supplementation programs involve providing individuals with dietary supplements such as vitamins and minerals to address micronutrient deficiencies [177].

This approach is often used in emergency situations or in areas where food-based approaches are not feasible [178]. For example, providing children with vitamin A supplements reduces the risk of blindness and improve immune function [179]. Supplementation programs can also be targeted towards specific populations such as pregnant women or individuals with certain medical conditions [92].

Supplementation programs can be an effective way to quickly address micronutrient deficiencies in specific populations. For example, iron supplements can be provided to pregnant women to prevent anemia and reduce the risk of preterm birth and low birth weight [180]. In areas with high rates of vitamin D deficiency, supplements can be provided to improve bone health.

Supplementation programs can be delivered through various channels, including health clinics, schools, and community-based programs [181]. They can also be integrated with other interventions, such as food fortification and education programs to promote healthy eating practices [182].

However, there are some limitations to supplementation programs. First, the effectiveness of the program depends on compliance, which can be affected by factors such as taste, availability, and cultural beliefs [183]. Second, supplementation programs may not address the underlying causes of malnutrition, such as poverty and limited access to nutritious foods [99]. Finally, excessive intake of certain micronutrients can be harmful, leading to toxicities and adverse health effects [184]. Therefore, careful monitoring and evaluation of supplementation programs are necessary to ensure that they are safe and effective.

Supplementation programs have been successful in addressing micronutrient deficiencies in many settings. In some cases, such programs have been implemented through routine health services or mass campaigns. For example, iron and folic acid supplements are provided to pregnant women to prevent anemia and reduce the risk of adverse pregnancy outcomes. Similarly, vitamin A supplements are often distributed to children under the age of five in high-risk areas to prevent deficiency and associated health problems [179].

One of the advantages of supplementation programs is that they can be relatively easy and cost-effective to implement compared to other interventions. However, there are also potential challenges and limitations to this approach [185]. For example, compliance with supplement regimens can be an issue, especially in situations where access to health services is limited or where there is low awareness of the importance of supplementation [186]. In addition, over-reliance on supplements can lead to a lack of emphasis on improving dietary intake, which is the most sustainable long-term solution to addressing hidden hunger [187] [188].

*Biofortification* is a process of breeding crops to increase their nutrient content [189]. This approach involves selecting and breeding crops with naturally higher levels of key micronutrients such as iron, zinc, and vitamin A [190] [191]. Biofortification can be an effective and sustainable approach to addressing hidden hunger as it involves improving the nutrient content of the food itself, rather than

relying on external interventions such as supplementation or fortification [192].

Biofortification is a promising strategy to address hidden hunger because it can provide a long-term solution to micronutrient deficiencies [189]. Unlike food fortification or supplementation, biofortification focuses on increasing the nutrient content of crops at the source, rather than adding nutrients to processed foods or providing supplements [192]. This approach can be particularly effective in areas where access to diverse diets or supplements is limited.

There are two types of biofortification: agronomic biofortification and genetic biofortification [193]. Agronomic biofortification involves modifying soil nutrients and fertilization techniques to enhance the uptake of micronutrients by crops [194]. This approach can be effective for increasing the content of some micronutrients, such as selenium and zinc, in crops. Genetic

One example of successful biofortification is the development of orange-fleshed sweet potatoes (OFSP) in South-Kivu [195]. Sweet potatoes are a staple food in many territories, but traditional white-fleshed varieties have low levels of vitamin A. Through breeding, researchers developed OFSP, which contain up to 10 times more vitamin A than white-fleshed varieties [196] [197]. The development and promotion of OFSP has been successful in reducing vitamin A deficiency in several African countries [196].

While biofortification has shown promise in addressing hidden hunger, there are still challenges to implementing this approach on a large scale [198]. One of the main challenges is developing crops that are both biofortified and have high yields, as farmers may be hesitant to switch to crops that do not produce as much as their current varieties [198]. Additionally, genetic biofortification raises concerns about potential unintended consequences and the safety of genetically modified crops [199].

In addition to these approaches, education and awareness-raising programs can also be effective in addressing hidden hunger [200]. These programs aim to increase knowledge and awareness of the importance of proper nutrition and the risks associated with micronutrient deficiencies. Community-based initiatives and partnerships between governments, non-governmental organizations, and private sector actors can also be effective in addressing hidden hunger [201].

## **4.2. Effectiveness of These Interventions in Addressing Hidden Hunger**

The effectiveness of interventions to address hidden hunger can vary depending on the specific approach and context. However, several studies have shown that food-based approaches, supplementation programs, and biofortification can be effective in reducing micronutrient deficiencies and improving nutritional status [202].

Food-based approaches have been found to be effective in increasing the availability and consumption of nutritious foods [55]. For example, a study conducted in Bangladesh found that a food-based approach that promoted the cultivation of

home gardens and the consumption of diverse nutrient-rich foods resulted in a significant reduction in anemia and vitamin A deficiency in women and children [203]. Similarly, a program in Uganda that promoted the consumption of nutrient-rich foods such as beans, vegetables, and fruits was found to significantly improve the nutritional status of pregnant and lactating women [204].

In addition to the examples mentioned above, other food-based interventions have also been found to be effective in addressing hidden hunger. For instance, a study in India found that providing school meals that included fortified biscuits led to a significant increase in the intake of micronutrients such as iron, vitamin A, and folate among children [205]. Similarly, a program in Mozambique that promoted the cultivation and consumption of orange-fleshed sweet potatoes, which are rich in vitamin A, was found to significantly reduce the prevalence of vitamin A deficiency among children and women [206].

Supplementation programs have also been found to be effective in addressing hidden hunger, particularly in emergency situations where food-based approaches are not feasible [48]. For example, a study in Kenya found that providing vitamin A supplements to children under the age of five resulted in a significant reduction in the incidence of blindness and improved immune function [207]. Similarly, a program in Nepal that provided iron supplements to pregnant women was found to reduce the risk of anemia and improve birth outcomes [133] [208].

Several studies have shown the effectiveness of iron and folic acid supplementation programs in reducing the prevalence of anemia in pregnant women [209] [210]. A review of randomized controlled trials conducted in low- and middle-income countries found that iron and folic acid supplementation during pregnancy reduced the risk of anemia by 70% and significantly improved birth outcomes such as birth weight and gestational age [211] [212]. Another study conducted in India found that weekly iron and folic acid supplementation during pregnancy significantly reduced the incidence of low birth weight and preterm delivery [213].

However, supplementation programs can be challenging to implement on a large scale due to issues such as distribution, compliance, and sustainability [201]. Additionally, there is a risk of overdose with certain micronutrients, which can have adverse health effects. Therefore, careful monitoring and evaluation are necessary to ensure the safety and effectiveness of supplementation programs [214].

Biofortification has shown promising results in increasing the nutrient content of crops and improving nutritional status [189]. For example, a study conducted in India found that consuming iron-biofortified pearl millet resulted in a significant reduction in anemia in adolescent girls [215]. Similarly, a study in Rwanda found that consuming vitamin A-biofortified orange-fleshed sweet potatoes resulted in improved vitamin A status in children [197].

Furthermore, biofortification has the potential to be a sustainable and cost-effective approach to addressing hidden hunger, as it involves improving the nutrient content of the food itself and does not require external interventions such as

supplementation or fortification [216]. Biofortification can also help to improve food security by increasing the availability of nutrient-rich crops in areas where access to diverse foods is limited.

However, there are also challenges to the implementation of biofortification programs. Developing biofortified crop varieties can be a long and expensive process, and there may be resistance to adopting new crop varieties among farmers and consumers [217]. Additionally, the effectiveness of biofortification may depend on factors such as soil conditions and crop management practices, which can vary across different regions and may limit the impact of biofortified crops in certain areas [216].

Biofortification is a relatively new approach to addressing hidden hunger, and its effectiveness is still being evaluated [218] [219]. However, several studies have shown promising results. For example, a study in India found that consuming iron-biofortified pearl millet resulted in a significant increase in blood hemoglobin levels among women [215]. Similarly, a study in Zambia found that consuming provitamin A-biofortified maize led to a significant increase in serum retinol levels among children [220].

While each intervention has its strengths and limitations, a combination of approaches that address the underlying causes of hidden hunger can be effective in reducing micronutrient deficiencies and improving nutritional status. Additionally, interventions that are sustainable and integrated into existing systems and programs can have a more lasting impact on addressing hidden hunger.

### 4.3. Challenges Associated with Implementing These Interventions

While food-based approaches, supplementation programs, and biofortification have shown promise in addressing hidden hunger, there are several challenges associated with implementing these interventions. Some of the challenges include:

**Cost:** Many interventions can be expensive to implement and may require significant financial resources. For example, fortifying staple foods with micronutrients can be costly, particularly in areas where the infrastructure for food fortification is not well established [221].

Cost is a major challenge associated with implementing interventions to address hidden hunger. Many of these interventions can be expensive and require significant financial resources, making them difficult to implement in areas with limited funding [222]. The costs associated with developing and implementing biofortification programs can also be significant [223].

Another cost-related challenge is the sustainability of interventions. Many interventions require ongoing resources and support to be effective, which can be difficult to sustain in the long term [224]. This is particularly true for supplementation programs, which require a consistent supply of supplements to be effective.

Infrastructure and logistics are also major challenges associated with implementing interventions to address hidden hunger [96]. For example, distributing supplements to remote or hard-to-reach areas can be challenging due to transpor-

tation issues and the need for specialized storage and handling. Similarly, establishing food fortification programs requires a well-developed infrastructure to ensure that the fortified foods are widely available and accessible [225].

Cultural and social factors can also pose challenges to implementing interventions. For example, promoting the consumption of certain foods or dietary supplements may be met with resistance in some communities due to cultural beliefs or preferences [226]. In addition, reaching certain vulnerable populations, such as women and children, may require overcoming social barriers such as gender roles and access to education [226].

Finally, ensuring the quality and safety of interventions is crucial to their effectiveness. For example, food fortification requires careful monitoring to ensure that the fortification levels are accurate and that the fortified foods are safe for consumption [227] [228]. Similarly, supplementation programs require rigorous quality control to ensure that the supplements are of high quality and free from contamination [229].

**Sustainability:** The sustainability of interventions can be a challenge, particularly in areas with limited resources. For example, food-based approaches such as home gardening require ongoing support and resources to maintain [230].

Sustainability is a critical challenge associated with implementing interventions to address hidden hunger. Many interventions require ongoing resources and support to be effective in the long term [185]. For example, food-based approaches such as promoting the cultivation of nutrient-rich crops and home gardening require ongoing support and resources to maintain [231]. Communities need access to resources such as seeds, fertilizers, and irrigation systems to continue to grow nutrient-rich crops. Additionally, they need education and support on how to grow and prepare these crops to ensure they are consumed in ways that maximize their nutritional value [232].

Similarly, biofortification requires ongoing support to ensure that nutrient-rich crops continue to be developed and made available to communities [233]. This involves ongoing research to identify crops with higher nutrient content, as well as breeding programs to develop these crops. It also requires ongoing efforts to promote the consumption of these crops and to ensure that they are integrated into local food systems.

Supplementation programs can also face sustainability challenges. These programs require ongoing resources to ensure that supplements are available and distributed to the target population [234]. Additionally, they require ongoing monitoring to ensure that supplements are being used appropriately and that they are having the desired impact on micronutrient status [235].

**Sustainability is a critical factor to consider when implementing interventions to address hidden hunger. Without ongoing support and resources, interventions may be effective in the short term but may not have a lasting impact on improving the nutritional status of communities.**

**Access:** Limited access to nutritious foods and supplements can hinder the ef-

fectiveness of interventions. This is particularly true in areas with limited infrastructure and transportation, which can make it difficult to distribute food and supplements to those who need them [236].

Limited access to nutritious foods and supplements is a major challenge in addressing hidden hunger, especially in remote and underprivileged areas. Access to markets, transportation, and storage facilities can significantly impact the availability and affordability of nutritious foods [236]. In some cases, people may not have access to fresh fruits, vegetables, and animal-source foods due to limited availability or high cost [237]. This can be compounded by poor road infrastructure, which makes it difficult to transport food to remote areas, and poor storage facilities, which can lead to spoilage and loss of nutrients.

In the case of supplementation programs, limited access to health services and trained health workers can pose a challenge. In areas where health services are limited or under-resourced, individuals may not have access to supplements or may not be aware of their importance. Additionally, individuals may not have the financial resources to purchase supplements, particularly if they are not subsidized or provided free of charge [238].

Addressing the issue of access requires a multi-faceted approach, including improving infrastructure and transportation, promoting local production and processing of nutritious foods, and strengthening health systems to improve access to supplements and other interventions. It also requires a focus on the needs of vulnerable populations, such as women, children, and individuals living in remote areas.

**Cultural barriers:** Cultural beliefs and practices also pose a challenge to implementing interventions. In some cultures, certain foods may be considered taboo or may not be consumed by certain groups of people [239].

Cultural barriers can be a significant challenge in implementing interventions to address hidden hunger. Dietary habits and preferences are often deeply rooted in cultural traditions and beliefs, which can affect the acceptability and effectiveness of interventions [240] [241]. For example, some cultures may have taboos on certain foods, such as pork or beef, which can limit the availability of key nutrients. Additionally, in some cultures, certain foods may be considered more desirable than others, which limit the consumption of other nutritious foods.

Cultural beliefs and practices also affect the acceptability of supplementation programs. Some cultures may be hesitant to accept dietary supplements or may have misconceptions about their use [242]. For example, in some cultures, there may be a belief that supplements are only needed for the sick or weak, which can limit their use among healthy individuals.

It is important to consider cultural barriers when designing and implementing interventions to address hidden hunger. Involving community members in the planning and implementation of interventions can help ensure that they are culturally appropriate and acceptable. Additionally, education and awareness-raising efforts can help address misconceptions and promote the importance of a diverse

and nutritious diet.

**Coordination:** Coordinating interventions across multiple sectors and organizations can be challenging, particularly in areas with weak health systems and limited resources [243] [244].

Coordination is crucial for effective implementation of interventions to address hidden hunger. However, it can be challenging to coordinate interventions across multiple sectors and organizations. Different sectors such as health, agriculture, and education may have different priorities and objectives, which can make coordination difficult. Additionally, limited resources and weak health systems can make it challenging to effectively coordinate interventions.

For example, if a food-based approach is being implemented, it may require coordination between the agriculture and health sectors. The agriculture sector may need to promote the cultivation of specific crops, while the health sector may need to promote the consumption of these crops to address hidden hunger [245] [246]. However, if these sectors are not effectively coordinated, the promotion of the crops may not result in increased consumption by the target population.

Similarly, coordination may be necessary between government agencies, non-governmental organizations (NGOs), and international organizations to effectively implement supplementation or fortification programs [247]. If these organizations are not effectively coordinated, there may be duplication of efforts, or certain populations may be missed due to incomplete coverage.

**Monitoring and evaluation:** Monitoring and evaluating the effectiveness of interventions can be challenging, particularly in areas with limited resources and weak health systems. This can make it difficult to assess the impact of interventions and make adjustments as needed [248].

Proper monitoring and evaluation are essential to determine the effectiveness of interventions and ensure that resources are being used appropriately [249]. However, this can be challenging in areas with limited resources and weak health systems, where monitoring and evaluation capacity may be limited. Some of the specific challenges associated with monitoring and evaluation of interventions to address hidden hunger include:

**Lack of baseline data:** Many areas with high rates of hidden hunger lack basic data on the prevalence of micronutrient deficiencies, making it difficult to establish a baseline for monitoring and evaluation [96].

**Limited resources:** Monitoring and evaluation require significant resources, including trained personnel, equipment, and funding. In areas with limited resources, it may be difficult to establish a robust monitoring and evaluation system.

**Limited health system capacity:** In areas with weak health systems, there may be limited capacity to conduct monitoring and evaluation, particularly at the community level [250].

**Data quality:** Even when monitoring and evaluation is conducted, there may be concerns about the quality of the data collected, particularly in areas with limited resources and weak health systems [250].

**Long-term monitoring:** Many interventions to address hidden hunger require long-term monitoring to assess their impact over time. However, this can be challenging in areas with limited resources and weak health systems, where sustained monitoring may be difficult to maintain [208].

To address these challenges, it is important to invest in monitoring and evaluation capacity building, particularly at the community level. This can involve training community health workers to collect data and monitor the effectiveness of interventions, as well as investing in infrastructure and equipment to support monitoring and evaluation activities [251]. Additionally, partnerships between governments, NGOs, and other stakeholders can help to coordinate monitoring and evaluation efforts and ensure that resources are being used effectively [252].

## 5. Future Research Directions

### 5.1. Gaps in the Current Knowledge on Hidden Hunger

Despite the progress made in addressing hidden hunger, there are still several gaps in the current knowledge. Some of these gaps include:

**Data:** There is a lack of comprehensive and accurate data on the prevalence and distribution of hidden hunger. This makes it difficult to identify the populations that are most affected and to develop targeted interventions [136] [192] [253] [254].

**Impact of interventions:** While several interventions have been implemented to address hidden hunger, there is limited information on the long-term impact of these interventions. It is important to evaluate the effectiveness of interventions to determine their sustainability and to identify areas where improvements can be made.

**Micronutrient interactions:** There is a lack of understanding of the interactions between different micronutrients and how these interactions can affect nutritional status. For example, consuming high levels of one micronutrient may interfere with the absorption of another [255].

**Bioavailability:** The bioavailability of micronutrients, or the amount that can be absorbed and utilized by the body, can vary depending on factors such as the form in which the nutrient is consumed and the presence of other nutrients. More research is needed to better understand these factors and how they can affect nutritional status [256].

**Nutrient requirements:** There is still much to learn about the nutrient requirements of different populations, particularly in developing countries where dietary patterns may differ from those in developed countries [257].

**Environmental factors:** Environmental factors such as soil quality and climate change can affect the nutrient content of crops, but more research is needed to understand these relationships and to develop strategies to mitigate their impact on nutritional status [258].

**Economic and social factors:** The economic and social factors that contribute to hidden hunger, such as poverty and inequality, are complex and interrelated.

More research is needed to better understand these factors and to develop effective interventions to address them [259].

## 5.2. Future Research Directions to Address These Gaps

There are several key research directions that could help address the current gaps in the knowledge on hidden hunger:

**Understanding the underlying causes of hidden hunger:** More research is needed to better understand the underlying causes of hidden hunger, particularly in specific populations or geographic regions [260]. This could involve conducting surveys and interviews with affected communities to gain insights into their food habits, dietary patterns, and nutritional status.

**Developing more effective interventions:** Future research could focus on developing and testing new interventions to address hidden hunger, particularly those that are cost-effective, sustainable, and culturally appropriate [261]. For example, research could explore the use of innovative technologies, such as mobile apps or SMS messaging, to deliver nutrition education and promote healthy dietary practices.

**Assessing the impact of interventions:** Evaluating the impact of interventions is critical to determining their effectiveness and identifying areas for improvement. Future research could focus on developing and testing evaluation methods that are practical, reliable, and valid, particularly in resource-limited settings.

**Identifying the most vulnerable populations:** More research is needed to identify the most vulnerable populations affected by hidden hunger, including those who may be at increased risk due to socioeconomic factors, health status, or geographic location [9]. This could involve using data from existing surveys and studies, as well as conducting new research to identify populations at risk.

**Understanding the long-term health consequences of hidden hunger:** There is a need for more research on the long-term health consequences of hidden hunger, particularly in children and pregnant women. This could involve conducting longitudinal studies to track the health outcomes of individuals who have experienced hidden hunger over time.

## 5.3. Potential Impact of this Research on Addressing Hidden Hunger

Addressing the gaps in knowledge related to hidden hunger through future research can have significant impacts on improving the nutritional status of populations affected by this issue. Here are some potential impacts:

**Development of targeted interventions:** By gaining a better understanding of the causes and underlying factors contributing to hidden hunger in different populations, researchers can develop more targeted and effective interventions to address this issue.

**Identification of high-risk populations:** Through research, it may be possible to identify populations that are particularly vulnerable to hidden hunger, such as

children, pregnant women, and individuals with certain medical conditions. This can help in targeting interventions towards these populations.

**Improved nutrition policies:** Research on hidden hunger can inform the development of nutrition policies at the national and international levels. This can lead to the implementation of more effective and sustainable interventions, including food-based approaches, fortification, and supplementation.

**Health benefits:** Addressing hidden hunger can have significant health benefits, including reducing the prevalence of micronutrient deficiencies and related health conditions, such as anemia, blindness, and stunted growth.

**Economic benefits:** Addressing hidden hunger can have economic benefits, such as increased productivity, reduced healthcare costs, and improved overall well-being of populations. This can lead to long-term improvements in economic development and poverty reduction.

## 6. Conclusion

### 6.1. Key Findings of the Review Paper

Hidden hunger, also known as micronutrient deficiency, is a form of malnutrition characterized by inadequate intake of essential vitamins and minerals, even when caloric intake is sufficient.

The World Health Organization (WHO) estimates that approximately two billion people worldwide suffer from hidden hunger, with the highest prevalence in developing countries. It is often associated with poverty, food insecurity, and limited access to nutritious foods.

Hidden hunger can have severe and long-lasting consequences, including stunted growth, delayed cognitive development, impaired immune function, susceptibility to infectious diseases, and the risk of chronic conditions such as anemia and blindness.

Despite its significant impact on global health, hidden hunger remains relatively unknown and under-prioritized, especially in developing countries where resources are often directed toward other forms of malnutrition.

The causes of hidden hunger include insufficient nutrient intake, poor dietary diversity, and low bioavailability of nutrients. These factors can be attributed to poverty, dietary choices, and chronic infections or the presence of anti-nutrients in certain foods.

Other contributing factors to hidden hunger include poor sanitation and hygiene, which increase the risk of infections, and limited access to healthcare and education, which can limit nutrition knowledge and awareness.

Hidden hunger affects a wide range of populations, including children, women (especially during pregnancy and lactation), and elderly individuals, all of whom have unique vulnerabilities to micronutrient deficiencies.

The consequences of hidden hunger encompass malnutrition, stunted growth, impaired cognitive development, increased risk of chronic diseases, and adverse maternal and child health outcomes, including preterm birth and low birth

weight.

While hidden hunger is most prevalent in developing countries, it is not limited to them. Vulnerable populations in wealthier countries, such as low-income families and the elderly, may also experience hidden hunger due to limited access to nutritious foods.

Addressing hidden hunger requires a multi-faceted approach, including food-based approaches (promoting nutrient-rich crops and dietary diversity), supplementation programs, and biofortification (breeding crops with higher nutrient content).

The effectiveness of these interventions varies but has shown promise in improving the nutritional status of affected populations. Challenges in implementation include cost, sustainability, access, cultural barriers, coordination, and monitoring and evaluation.

Future research should focus on better understanding the causes of hidden hunger, developing more effective interventions, assessing the impact of interventions, identifying vulnerable populations, and exploring the long-term health consequences of hidden hunger.

## 6.2. Recommendations for Future Action to Address Hidden Hunger

Based on the key findings of the review paper, the following recommendations can be made for future action to address hidden hunger:

**Improve access to diverse, nutrient-rich foods:** Strategies to improve access to diverse, nutrient-rich foods, particularly in rural and low-income areas, should be prioritized. This can include promoting local food production, increasing market availability of nutritious foods, and improving transportation infrastructure to ensure that nutritious foods are accessible to all.

**Implement food-based approaches:** Food-based approaches, such as promoting home gardening and diversification of crops, have been found to be effective in addressing hidden hunger. Such interventions should be prioritized, particularly in areas where external interventions such as supplementation and fortification are not feasible.

**Strengthen health systems:** Strengthening health systems is essential for the successful implementation of interventions to address hidden hunger. This includes increasing access to health services, improving health education and awareness, and promoting community participation in health initiatives.

**Increase research:** Research is needed to further understand the extent of hidden hunger, particularly in vulnerable populations such as children and pregnant women. Additionally, research is needed to evaluate the effectiveness of interventions and identify best practices for addressing hidden hunger in different contexts.

**Foster partnerships:** Partnerships between governments, NGOs, and other stakeholders are essential for the successful implementation of interventions to

address hidden hunger. Such partnerships can facilitate the sharing of resources, expertise, and best practices, and can help to ensure that interventions are sustainable and have a lasting impact.

By implementing these recommendations, it is possible to make significant progress in addressing hidden hunger and improving the nutritional status of vulnerable populations.

### **6.3. Importance of Addressing Hidden Hunger for Good Health and Development**

Addressing hidden hunger is crucial for good health and development. Malnutrition, including micronutrient deficiencies, is a leading cause of morbidity and mortality worldwide, particularly in low- and middle-income countries. It not only affects individuals' health and well-being but also has long-term consequences for economic development, social stability, and environmental sustainability.

By addressing hidden hunger through various interventions, we can improve the health and well-being of individuals, particularly women and children, and reduce the burden of disease and mortality associated with malnutrition. Moreover, improving the nutritional status of individuals can have long-term positive effects on cognitive development, educational attainment, and economic productivity, leading to sustainable economic growth and development.

Therefore, it is essential to prioritize and invest in interventions aimed at addressing hidden hunger, including food-based approaches, fortification, supplementation, and biofortification. Additionally, research and monitoring efforts should be enhanced to improve our understanding of the effectiveness of these interventions and to identify areas for improvement. Ultimately, addressing hidden hunger is critical for achieving global health and development goals, including the Sustainable Development Goals.

### **Conflicts of Interest**

The authors declare no conflicts of interest regarding the publication of this paper.

### **References**

- [1] Bhandari, S. and Banjara, M.R. (2015) Micronutrients Deficiency, a Hidden Hunger in Nepal: Prevalence, Causes, Consequences, and Solutions. *International Scholarly Research Notices*, **2015**, 1-9. <https://doi.org/10.1155/2015/276469>
- [2] Thankachan, P., Selvam, S., Surendran, D., Chellan, S., Pauline, M., Abrams, S.A., *et al.* (2012) Efficacy of a Multi Micronutrient-Fortified Drink in Improving Iron and Micronutrient Status among Schoolchildren with Low Iron Stores in India: A Randomised, Double-Masked Placebo-Controlled Trial. *European Journal of Clinical Nutrition*, **67**, 36-41. <https://doi.org/10.1038/ejcn.2012.188>
- [3] Thapa, S. (2014) High and Equitable Coverage of Vitamin A Supplementation Program in Nepal. *Journal of Community Medicine and Health Education*, **4**, 272-278.
- [4] Qasemzadeh, M.J., Fathi, M., Tashvighi, M., Gharehbeglou, M., Yadollah-Dama-

- vandi, S., Parsa, Y., *et al.* (2014) The Effect of Adjuvant Zinc Therapy on Recovery from Pneumonia in Hospitalized Children: A Double-Blind Randomized Controlled Trial. *Scientifica*, **2014**, 1-4. <https://doi.org/10.1155/2014/694193>
- [5] Gorstein, J., Sullivan, K.M., Parvanta, I. and Begin, F. (2007) Indicators and Methods for Cross-Sectional Surveys of Vitamin and Mineral Status of Populations.
- [6] WHO (2014) Xerophthalmia and Night Blindness for the Assessment of Clinical Vitamin A Deficiency in Individuals and Populations. World Health Organization.
- [7] Zimmermann, M.B. and Andersson, M. (2012) Update on Iodine Status Worldwide. *Current Opinion in Endocrinology, Diabetes & Obesity*, **19**, 382-387. <https://doi.org/10.1097/med.0b013e328357271a>
- [8] Lowe, N.M. (2021) The Global Challenge of Hidden Hunger: Perspectives from the Field. *Proceedings of the Nutrition Society*, **80**, 283-289. <https://doi.org/10.1017/s0029665121000902>
- [9] Gödecke, T., Stein, A.J. and Qaim, M. (2018) The Global Burden of Chronic and Hidden Hunger: Trends and Determinants. *Global Food Security*, **17**, 21-29. <https://doi.org/10.1016/j.gfs.2018.03.004>
- [10] Eggersdorfer, M. and Bird, J.K. (2016) How to Achieve Transparency in Public-Private Partnerships Engaged in Hunger and Malnutrition Reduction. In: *World Review of Nutrition and Dietetics*, S. Karger AG, 224-232. <https://doi.org/10.1159/000442109>
- [11] Misner, B. (2006) Food Alone May Not Provide Sufficient Micronutrients for Preventing Deficiency. *Journal of the International Society of Sports Nutrition*, **3**, Article 51. <https://doi.org/10.1186/1550-2783-3-1-51>
- [12] Onyango, A.W., Borghi, E., de Onis, M., Casanovas, M.D.C. and Garza, C. (2013) Complementary Feeding and Attained Linear Growth among 6–23-Month-Old Children. *Public Health Nutrition*, **17**, 1975-1983. <https://doi.org/10.1017/s1368980013002401>
- [13] Issaka, A.I., Agho, K.E., N. Page, A., L. Burns, P., Stevens, G.J. and Dibley, M.J. (2015) Comparisons of Complementary Feeding Indicators among Children Aged 6–23 Months in Anglophone and Francophone West African Countries. *Maternal & Child Nutrition*, **11**, 1-13. <https://doi.org/10.1111/mcn.12196>
- [14] du Plessis, L. (2013) Infant and Young Child Feeding in South Africa: Stop the Crying, Beloved Country. *South African Journal of Clinical Nutrition*, **26**, 4-5. <https://doi.org/10.1080/16070658.2013.11734433>
- [15] De Irala-Estévez, J., Groth, M., Johansson, L., Oltersdorf, U., Prättälä, R. and Martínez-González, M. (2000) A Systematic Review of Socio-Economic Differences in Food Habits in Europe: Consumption of Fruit and Vegetables. *European Journal of Clinical Nutrition*, **54**, 706-714. <https://doi.org/10.1038/sj.ejcn.1601080>
- [16] James, W.P.T., Nelson, M., Ralph, A. and Leather, S. (1997) Socioeconomic Determinants of Health: The Contribution of Nutrition to Inequalities in Health. *British Medical Journal*, **314**, 1545-1545. <https://doi.org/10.1136/bmj.314.7093.1545>
- [17] Black, R.E., Victora, C.G., Walker, S.P., Bhutta, Z.A., Christian, P., de Onis, M., *et al.* (2013) Maternal and Child Undernutrition and Overweight in Low-Income and Middle-Income Countries. *The Lancet*, **382**, 427-451. [https://doi.org/10.1016/s0140-6736\(13\)60937-x](https://doi.org/10.1016/s0140-6736(13)60937-x)
- [18] Manjeru, P., Van Biljon, A. and Labuschagne, M. (2017) The Development and Release of Maize Fortified with Provitamin a Carotenoids in Developing Countries. *Critical Reviews in Food Science and Nutrition*, **59**, 1284-1293. <https://doi.org/10.1080/10408398.2017.1402751>

- [19] Sivaprasad, M., Shalini, T., Reddy, P.Y., Seshacharyulu, M., Madhavi, G., Kumar, B.N., et al. (2019) Prevalence of Vitamin Deficiencies in an Apparently Healthy Urban Adult Population: Assessed by Subclinical Status and Dietary Intakes. *Nutrition*, **63**, 106-113. <https://doi.org/10.1016/j.nut.2019.01.017>
- [20] Das, P.K., Bhavani, R.V. and Swaminathan, M.S. (2014) A Farming System Model to Leverage Agriculture for Nutritional Outcomes. *Agricultural Research*, **3**, 193-203. <https://doi.org/10.1007/s40003-014-0119-5>
- [21] Crush, J., Frayne, B. and McLachlan, M. (2011) Rapid Urbanization and the Nutrition Transition in Southern Africa.
- [22] Tull, K. (2018) Urban Food Systems and Nutrition. Institute of Development Studies.
- [23] Baldassarre, M.E., Panza, R., Farella, I., Posa, D., Capozza, M., Mauro, A.D., et al. (2020) Vegetarian and Vegan Weaning of the Infant: How Common and How Evidence-Based? A Population-Based Survey and Narrative Review. *International Journal of Environmental Research and Public Health*, **17**, Article 4835. <https://doi.org/10.3390/ijerph17134835>
- [24] Agnoli, C., Baroni, L., Bertini, I., Ciappellano, S., Fabbri, A., Papa, M., et al. (2017) Position Paper on Vegetarian Diets from the Working Group of the Italian Society of Human Nutrition. *Nutrition, Metabolism and Cardiovascular Diseases*, **27**, 1037-1052. <https://doi.org/10.1016/j.numecd.2017.10.020>
- [25] Lemoine, A., Giabicani, E., Lockhart, V., Grimprel, E. and Tounian, P. (2020) Case Report of Nutritional Rickets in an Infant Following a Vegan Diet. *Archives de Pédiatrie*, **27**, 219-222. <https://doi.org/10.1016/j.arcped.2020.03.008>
- [26] Biesalski, H.K. (2016) The 1,000-Day Window and Cognitive Development. In: *World Review of Nutrition and Dietetics*, S. Karger AG, 1-15. <https://doi.org/10.1159/000442377>
- [27] Black, R.E., Allen, L.H., Bhutta, Z.A., Caulfield, L.E., de Onis, M., Ezzati, M., et al. (2008) Maternal and Child Undernutrition: Global and Regional Exposures and Health Consequences. *The Lancet*, **371**, 243-260. [https://doi.org/10.1016/s0140-6736\(07\)61690-0](https://doi.org/10.1016/s0140-6736(07)61690-0)
- [28] Stein, A.J. and Qaim, M. (2007) The Human and Economic Cost of Hidden Hunger. *Food and Nutrition Bulletin*, **28**, 125-134. <https://doi.org/10.1177/156482650702800201>
- [29] Darnton-Hill, I., Webb, P., Harvey, P.W., Hunt, J.M., Dalmiya, N., Chopra, M., et al. (2005) Micronutrient Deficiencies and Gender: Social and Economic Costs. *The American Journal of Clinical Nutrition*, **81**, 1198S-1205S. <https://doi.org/10.1093/ajcn/81.5.1198>
- [30] Stein, N. (2014) Public Health Nutrition. Jones & Bartlett Publishers.
- [31] Deitchler, M., Mason, J., Mathys, E., Winichagoon, P. and Tuazon, M.A. (2004) Lessons from Successful Micronutrient Programs Part I: Program Initiation. *Food and Nutrition Bulletin*, **25**, 5-29. <https://doi.org/10.1177/156482650402500102>
- [32] Rauniar, G. and Kanbur, R. (2010) Inclusive Growth and Inclusive Development: A Review and Synthesis of Asian Development Bank Literature. *Journal of the Asia Pacific Economy*, **15**, 455-469. <https://doi.org/10.1080/13547860.2010.517680>
- [33] Ubesie, A.C., Ibeziako, N.S., Ndiokwelu, C.I., Uzoka, C.M. and Nwafor, C.A. (2012) Under-Five Protein Energy Malnutrition Admitted at the University of in Nigeria Teaching Hospital, Enugu: A 10 Year Retrospective Review. *Nutrition Journal*, **11**, Article No. 43. <https://doi.org/10.1186/1475-2891-11-43>
- [34] De Moura, F.F., Palmer, A.C., Finkelstein, J.L., Haas, J.D., Murray-Kolb, L.E.,

- Wenger, M.J., *et al.* (2014) Are Biofortified Staple Food Crops Improving Vitamin A and Iron Status in Women and Children? New Evidence from Efficacy Trials. *Advances in Nutrition*, **5**, 568-570. <https://doi.org/10.3945/an.114.006627>
- [35] Thompson, B. and Amoroso, L. (2011) Combating Micronutrient Deficiencies: Food-Based Approaches. Food and Agriculture Organization.
- [36] Kennedy, E.T. and Bouis, H.E. (1993) Linkages between Agriculture and Nutrition: Implications for Policy and Research. International Food Policy Research Institute.
- [37] Min, J., Zhao, Y., Slivka, L. and Wang, Y. (2017) Double Burden of Diseases Worldwide: Coexistence of Undernutrition and Overnutrition-Related Non-Communicable Chronic Diseases. *Obesity Reviews*, **19**, 49-61. <https://doi.org/10.1111/obr.12605>
- [38] Mohan, V., Ranjani, H., Mehreen, T., Pradeepa, R., Anjana, R., Garg, R., *et al.* (2016) Epidemiology of Childhood Overweight & Obesity in India: A Systematic Review. *Indian Journal of Medical Research*, **143**, 160-174. <https://doi.org/10.4103/0971-5916.180203>
- [39] Scott, S.P., Wenger, M.J., Murray-Kolb, L.E., Udipi, S.A., Ghugre, P.S., Boy, E., *et al.* (2012) Relations between Iron Status and Cognitive Measures in Indian Adolescents. Wiley.
- [40] Black, R.E. and Fischer Walker, C. (2012) Role of Zinc in Child Health and Survival. In: *Nestlé Nutrition Institute Workshop Series*, S. Karger AG, 37-42. <https://doi.org/10.1159/000337393>
- [41] Black, R.E. (1998) Therapeutic and Preventive Effects of Zinc on Serious Childhood Infectious Diseases in Developing Countries. *The American Journal of Clinical Nutrition*, **68**, 476S-479S. <https://doi.org/10.1093/ajcn/68.2.476s>
- [42] Penny, M.E. (2013) Zinc Supplementation in Public Health. *Annals of Nutrition and Metabolism*, **62**, 31-42. <https://doi.org/10.1159/000348263>
- [43] Ngozi, U.F. (2013) The Role of Biofortification in the Reduction of Micronutrient Food Insecurity in Developing Countries. *African Journal of Biotechnology*, **12**, Article No. 37.
- [44] Uchendu, F.N. and Tola, A. (2011) The Silent and Neglected Crisis of Malnutrition: Scientific Evidence for Taking Decisive Action. *Global Journal of Health Science*, **3**, 193-202. <https://doi.org/10.5539/gjhs.v3n1193>
- [45] Muthayya, S., Rah, J.H., Sugimoto, J.D., Roos, F.F., Kraemer, K. and Black, R.E. (2013) The Global Hidden Hunger Indices and Maps: An Advocacy Tool for Action. *PLOS ONE*, **8**, e67860. <https://doi.org/10.1371/journal.pone.0067860>
- [46] Biesalski, H.K., Black, R.E. and Koletzko, B. (2016) Hidden Hunger: Malnutrition and the First 1,000 Days of Life: Causes, Consequences and Solutions, vol. 115. Karger Medical and Scientific Publishers.
- [47] Amoroso, L. (2018) Post-2015 Agenda and Sustainable Development Goals: Where Are We Now? Global Opportunities to Address Malnutrition in All Its Forms, Including Hidden Hunger. In: *World Review of Nutrition and Dietetics*, S. Karger AG, 45-56. <https://doi.org/10.1159/000484334>
- [48] Redón Lago, A. (2021) Hidden Hunger in the Current World: Causes, Consequences and Solutions to a Global Public Health Challenge and a Particular Look at Spain.
- [49] Evans, A., Banks, K., Jennings, R., Nehme, E., Nemeč, C., Sharma, S., *et al.* (2015) Increasing Access to Healthful Foods: A Qualitative Study with Residents of Low-Income Communities. *International Journal of Behavioral Nutrition and Physical Activity*, **12**, S5. <https://doi.org/10.1186/1479-5868-12-s1-s5>

- [50] Pereira, L.J. and van der Bilt, A. (2016) The Influence of Oral Processing, Food Perception and Social Aspects on Food Consumption: A Review. *Journal of Oral Rehabilitation*, **43**, 630-648. <https://doi.org/10.1111/joor.12395>
- [51] Holst, B. and Williamson, G. (2008) Nutrients and Phytochemicals: From Bioavailability to Bio-Efficacy beyond Antioxidants. *Current Opinion in Biotechnology*, **19**, 73-82. <https://doi.org/10.1016/j.copbio.2008.03.003>
- [52] Zingel, W., Keck, M., Etzold, B. and Bohle, H. (2011) Urban Food Security and Health Status of the Poor in Dhaka, Bangladesh. In: *Contributions to Statistics*, Physica-Verlag HD, 301-319. [https://doi.org/10.1007/978-3-7908-2733-0\\_19](https://doi.org/10.1007/978-3-7908-2733-0_19)
- [53] Steyn, N., Nel, J., Nantel, G., Kennedy, G. and Labadarios, D. (2006) Food Variety and Dietary Diversity Scores in Children: Are They Good Indicators of Dietary Adequacy? *Public Health Nutrition*, **9**, 644-650. <https://doi.org/10.1079/phn2005912>
- [54] Ruel, M.T. (2003) Is Dietary Diversity an Indicator of Food Security or Dietary Quality? A Review of Measurement Issues and Research Needs. *Food and Nutrition Bulletin*, **24**, 231-232. <https://doi.org/10.1177/156482650302400217>
- [55] Tontisirin, K., Nantel, G. and Bhattacharjee, L. (2002) Food-Based Strategies to Meet the Challenges of Micronutrient Malnutrition in the Developing World. *Proceedings of the Nutrition Society*, **61**, 243-250. <https://doi.org/10.1079/pns2002155>
- [56] Frison, E., Smith, I.F., Cherfas, J., Eyzaguirre, P. and Johns, T. (2005) Using Biodiversity for Food, Dietary Diversity, Better Nutrition and Health. *South African Journal of Clinical Nutrition*, **18**, 112-114. <https://doi.org/10.1080/16070658.2005.11734050>
- [57] Abeshu, M.A., Lelisa, A. and Geleta, B. (2016) Complementary Feeding: Review of Recommendations, Feeding Practices, and Adequacy of Homemade Complementary Food Preparations in Developing Countries—Lessons from Ethiopia. *Frontiers in Nutrition*, **3**, Article 41. <https://doi.org/10.3389/fnut.2016.00041>
- [58] Fanzo, J. (2014) Strengthening the Engagement of Food and Health Systems to Improve Nutrition Security: Synthesis and Overview of Approaches to Address Malnutrition. *Global Food Security*, **3**, 183-192. <https://doi.org/10.1016/j.gfs.2014.09.001>
- [59] Zehnder, J., Katzung, S.M. and Trevor, A. (2009) Basic and Clinical Pharmacology. McGraw-Hill Medical.
- [60] Urbano, G., López-Jurado, M., Aranda, P., Vidal-Valverde, C., Tenorio, E. and Porres, J. (2000) The Role of Phytic Acid in Legumes: Antinutrient or Beneficial Function? *Journal of Physiology and Biochemistry*, **56**, 283-294. <https://doi.org/10.1007/bf03179796>
- [61] Nissar, J., Ahad, T., Naik, H.R. and Hussain, S.Z. (2017) A Review Phytic Acid: As Antinutrient or Nutraceutical. *Journal of Pharmacognosy and Phytochemistry*, **6**, 1554-1560.
- [62] Sandberg, A. (2002) Bioavailability of Minerals in Legumes. *British Journal of Nutrition*, **88**, 281-285. <https://doi.org/10.1079/bjn/2002718>
- [63] Millward, D.J. (2017) Nutrition, Infection and Stunting: The Roles of Deficiencies of Individual Nutrients and Foods, and of Inflammation, as Determinants of Reduced Linear Growth of Children. *Nutrition Research Reviews*, **30**, 50-72. <https://doi.org/10.1017/s0954422416000238>
- [64] Gasaly, N., de Vos, P. and Hermoso, M.A. (2021) Impact of Bacterial Metabolites on Gut Barrier Function and Host Immunity: A Focus on Bacterial Metabolism and Its Relevance for Intestinal Inflammation. *Frontiers in Immunology*, **12**, Article 658354. <https://doi.org/10.3389/fimmu.2021.658354>

- [65] Stefanelli, G., Viscido, A., Longo, S., Magistrone, M. and Latella, G. (2020) Persistent Iron Deficiency Anemia in Patients with Celiac Disease Despite a Gluten-Free Diet. *Nutrients*, **12**, Article 2176. <https://doi.org/10.3390/nu12082176>
- [66] Thakur, P. and Kumar, K. (2019) Nutritional Importance and Processing Aspects of Pseudo-Cereals. *Journal of Agricultural Engineering and Food Technology*, **6**, 155-160.
- [67] Thakur, N.S. and Kumar, P. (2017) Anti-Nutritional Factors, Their Adverse Effects and Need for Adequate Processing to Reduce Them in Food. *AgricINTERNATIONAL*, **4**, 56-60. <https://doi.org/10.5958/2454-8634.2017.00013.4>
- [68] Zijp, I.M., Korver, O. and Tijburg, L.B.M. (2000) Effect of Tea and Other Dietary Factors on Iron Absorption. *Critical Reviews in Food Science and Nutrition*, **40**, 371-398. <https://doi.org/10.1080/10408690091189194>
- [69] Delimont, N.M., Haub, M.D. and Lindshield, B.L. (2017) The Impact of Tannin Consumption on Iron Bioavailability and Status: A Narrative Review. *Current Developments in Nutrition*, **1**, 1-12. <https://doi.org/10.3945/cdn.116.000042>
- [70] Singh, A., Dikshit, H.K., Ramawat, N. and Kumar, S. (2022) Novel Bioactive Compounds for Enhancing Micronutrient Bioavailability. In: *Bioactive Components*, Springer, 481-488. [https://doi.org/10.1007/978-981-19-2366-1\\_27](https://doi.org/10.1007/978-981-19-2366-1_27)
- [71] Katona, P. and Katona-Apte, J. (2008) The Interaction between Nutrition and Infection. *Clinical Infectious Diseases*, **46**, 1582-1588. <https://doi.org/10.1086/587658>
- [72] Martin, C. and Li, J. (2017) Medicine Is Not Health Care, Food Is Health Care: Plant Metabolic Engineering, Diet and Human Health. *New Phytologist*, **216**, 699-719. <https://doi.org/10.1111/nph.14730>
- [73] Bezabih, A., Wereta, M., Kahsay, Z., Getahun, Z. and Bazzano, A. (2018) Demand and Supply Side Barriers That Limit the Uptake of Nutrition Services among Pregnant Women from Rural Ethiopia: An Exploratory Qualitative Study. *Nutrients*, **10**, Article 1687. <https://doi.org/10.3390/nu10111687>
- [74] McKay, S., Gaudier, E., Campbell, D.I., Prentice, A.M. and Albers, R. (2010) Environmental Enteropathy: New Targets for Nutritional Interventions. *International Health*, **2**, 172-180. <https://doi.org/10.1016/j.inhe.2010.07.006>
- [75] Bhutta, Z.A. (2006) Effect of Infections and Environmental Factors on Growth and Nutritional Status in Developing Countries. *Journal of Pediatric Gastroenterology and Nutrition*, **43**, S13-S21. <https://doi.org/10.1097/01.mpg.0000255846.77034.ed>
- [76] Bhutta, Z.A., Ghishan, F., Lindley, K., Memon, I.A., Mittal, S. and Rhoads, J.M. (2004) Persistent and Chronic Diarrhea and Malabsorption: Working Group Report of the Second World Congress of Pediatric Gastroenterology, Hepatology, and Nutrition. *Journal of Pediatric Gastroenterology and Nutrition*, **39**, S711-S716. <https://doi.org/10.1097/00005176-200406002-00019>
- [77] Biesalski, H.K. (2013) First International Conference on Hidden Hunger, Hohenheim, Stuttgart, Germany March 6-9, 2013. *Food Security*, **5**, 457-473. <https://doi.org/10.1007/s12571-013-0267-7>
- [78] Chakona, G. and Shackleton, C. (2019) Food Taboos and Cultural Beliefs Influence Food Choice and Dietary Preferences among Pregnant Women in the Eastern Cape, South Africa. *Nutrients*, **11**, Article 2668. <https://doi.org/10.3390/nu11112668>
- [79] Chakona, G. (2020) Social Circumstances and Cultural Beliefs Influence Maternal Nutrition, Breastfeeding and Child Feeding Practices in South Africa. *Nutrition Journal*, **19**, 1-15. <https://doi.org/10.1186/s12937-020-00566-4>
- [80] Kramer, C.V. and Allen, S. (2015) Malnutrition in Developing Countries. *Paediatrics*

- and *Child Health*, **25**, 422-427. <https://doi.org/10.1016/j.paed.2015.04.002>
- [81] Yadav, S.S., Hegde, V.S., Habibi, A.B., et al. (2019) Climate Change, Agriculture and Food Security. In: *Food Security and Climate Change*, Wiley.
- [82] Dwivedi, S., Sahrawat, K., Upadhyaya, H. and Ortiz, R. (2013) Food, Nutrition and Agrobiodiversity under Global Climate Change. In: *Advances in Agronomy*, Elsevier, 1-128. <https://doi.org/10.1016/b978-0-12-407686-0.00001-4>
- [83] Ruel, M.T., Garrett, J., Yosef, S. and Olivier, M. (2017) Urbanization, Food Security and Nutrition. In: *Nutrition and Health in a Developing World*, Springer, 705-735. [https://doi.org/10.1007/978-3-319-43739-2\\_32](https://doi.org/10.1007/978-3-319-43739-2_32)
- [84] Mendez, M.A. and Popkin, B.M. (2004) Globalization, Urbanization and Nutritional Change in the Developing World. *Journal of Development and Agricultural Economics*, **1**, 220-241.
- [85] Anderson, A., Lazarus, J. and Anderson Steeves, E. (2022) Navigating Hidden Hunger: An Exploratory Analysis of the Lived Experience of Food Insecurity among College Students. *International Journal of Environmental Research and Public Health*, **19**, Article 12952. <https://doi.org/10.3390/ijerph191912952>
- [86] Gómez, M.I. and Ricketts, K.D. (2013) Food Value Chain Transformations in Developing Countries: Selected Hypotheses on Nutritional Implications. *Food Policy*, **42**, 139-150. <https://doi.org/10.1016/j.foodpol.2013.06.010>
- [87] Mangusho, G. (2013) Socio-Economic Manifestations of Hidden Hunger in Schoolchildren in Sub-Saharan Africa. *International Journal of Nutrition and Food Sciences*, **2**, 17-23. <https://doi.org/10.11648/j.ijnfs.20130201.14>
- [88] Biesalski, H.K. (2013) Hidden Hunger. Springer. [https://doi.org/10.1007/978-3-642-33950-9\\_2](https://doi.org/10.1007/978-3-642-33950-9_2)
- [89] Welch, R.M. (2001) Micronutrients, Agriculture and Nutrition; Linkages for Improved Health and Well-Being. In: *Perspectives on the Micronutrient Nutrition of Crops*, Scientific Publishers, 247-289.
- [90] Hambidge, K.M. (1992) Zinc and Diarrhea. *Acta Paediatrica*, **81**, 82-86. <https://doi.org/10.1111/j.1651-2227.1992.tb12377.x>
- [91] Sommer, A. (1995) Vitamin A Deficiency and Its Consequences: A Field Guide to Detection and Control. World Health Organization.
- [92] Bailey, R.L., West, Jr. and Black, R.E. (2015) The Epidemiology of Global Micronutrient Deficiencies. *Annals of Nutrition and Metabolism*, **66**, 22-33. <https://doi.org/10.1159/000371618>
- [93] Stechmiller, J.K. (2010) Understanding the Role of Nutrition and Wound Healing. *Nutrition in Clinical Practice*, **25**, 61-68. <https://doi.org/10.1177/0884533609358997>
- [94] Chandra, R. (1997) Nutrition and the Immune System: An Introduction. *The American Journal of Clinical Nutrition*, **66**, 460S-463S. <https://doi.org/10.1093/ajcn/66.2.460s>
- [95] Rytter, M.J.H., Kolte, L., Briend, A., Friis, H. and Christensen, V.B. (2014) The Immune System in Children with Malnutrition—A Systematic Review. *PLOS ONE*, **9**, e105017. <https://doi.org/10.1371/journal.pone.0105017>
- [96] Maberly, G.F., Trowbridge, F.L., Yip, R., Sullivan, K.M. and West, C.E. (1994) Programs against Micronutrient Malnutrition: Ending Hidden Hunger. *Annual Review of Public Health*, **15**, 277-301. <https://doi.org/10.1146/annurev.pu.15.050194.001425>
- [97] Bhutta, Z.A., Berkley, J.A., Bandsma, R.H.J., Kerac, M., Trehan, I. and Briend, A.

- (2017) Severe Childhood Malnutrition. *Nature Reviews Disease Primers*, **3**, 1-18. <https://doi.org/10.1038/nrdp.2017.67>
- [98] Saunders, J., Smith, T. and Stroud, M. (2011) Malnutrition and Undernutrition. *Medicine*, **39**, 45-50. <https://doi.org/10.1016/j.mpmed.2010.10.007>
- [99] Tanumihardjo, S.A., Anderson, C., Kaufer-Horwitz, M., Bode, L., Emenaker, N.J., Haqq, A.M., et al. (2007) Poverty, Obesity, and Malnutrition: An International Perspective Recognizing the Paradox. *Journal of the American Dietetic Association*, **107**, 1966-1972. <https://doi.org/10.1016/j.jada.2007.08.007>
- [100] Biesalski, H.K. (2013) Hidden Hunger in the Developed World. In: *The Road to Good Nutrition*, Karger, 39-50. <https://doi.org/10.1159/000355992>
- [101] Zimmermann, M.B. (2016) The Importance of Adequate Iodine during Pregnancy and Infancy. In: *World Review of Nutrition and Dietetics*, S. Karger AG, 118-124. <https://doi.org/10.1159/000442078>
- [102] Tandoh, M. and Asamoah, M. (2022) The Magnitude of Hidden Hunger and Cognitive Deficits among Children Living in Orphanages in Kumasi, Ghana. *Advances in Public Health*, **2022**, 1-8. <https://doi.org/10.1155/2022/9684785>
- [103] Hoddinott, J., Behrman, J.R., Maluccio, J.A., Melgar, P., Quisumbing, A.R., Ramirez-Zea, M., et al. (2013) Adult Consequences of Growth Failure in Early Childhood. *The American Journal of Clinical Nutrition*, **98**, 1170-1178. <https://doi.org/10.3945/ajcn.113.064584>
- [104] MacDonald, R.S. (2000) The Role of Zinc in Growth and Cell Proliferation. *The Journal of Nutrition*, **130**, 1500S-1508S. <https://doi.org/10.1093/jn/130.5.1500s>
- [105] Savarino, G., Corsello, A. and Corsello, G. (2021) Macronutrient Balance and Micro-nutrient Amounts through Growth and Development. *Italian Journal of Pediatrics*, **47**, Article No. 109. <https://doi.org/10.1186/s13052-021-01061-0>
- [106] Bhowmik, D., Chiranjib, K. and Kumar, S. (2010) A Potential Medicinal Importance of Zinc in Human Health and Chronic. *International Journal of Pharmaceutics*, **1**, 5-11.
- [107] Delisle, H.F. (2008) Poverty. *Annals of the New York Academy of Sciences*, **1136**, 172-184. <https://doi.org/10.1196/annals.1425.026>
- [108] DeBoer, M.D., Lima, A.A., Oría, R.B., Scharf, R.J., Moore, S.R., Luna, M.A., et al. (2012) Early Childhood Growth Failure and the Developmental Origins of Adult Disease: Do Enteric Infections and Malnutrition Increase Risk for the Metabolic Syndrome? *Nutrition Reviews*, **70**, 642-653. <https://doi.org/10.1111/j.1753-4887.2012.00543.x>
- [109] Gupta, D.C.P. (2014) Role of Iron (Fe) in Body. *IOSR Journal of Applied Chemistry*, **7**, 38-46. <https://doi.org/10.9790/5736-071123846>
- [110] Johnson, D. (2018) Iron-Induced Oxidative Stress is Associated with Decreased Brain L-DOPA in Sickle Cell Disease. Augusta University.
- [111] Mattei, D. and Pietrobelli, A. (2019) Micronutrients and Brain Development. *Current Nutrition Reports*, **8**, 99-107. <https://doi.org/10.1007/s13668-019-0268-z>
- [112] Bhatnagar, S. and Taneja, S. (2001) Zinc and Cognitive Development. *British Journal of Nutrition*, **85**, S139-S145. <https://doi.org/10.1079/bjn2000306>
- [113] Kapil, U. (2007) Health Consequences of Iodine Deficiency. *Sultan Qaboos University Medical Journal*, **7**, 267-272. <https://doi.org/10.18295/2075-0528.2681>
- [114] Pérez-López, F.R. (2007) Iodine and Thyroid Hormones during Pregnancy and Postpartum. *Gynecological Endocrinology*, **23**, 414-428.

- <https://doi.org/10.1080/09513590701464092>
- [115] Sethi, V. and Kapil, U. (2004) Iodine Deficiency and Development of Brain. *The Indian Journal of Pediatrics*, **71**, 325-329. <https://doi.org/10.1007/bf02724099>
- [116] Bain, L.E., Awah, P.K., Geraldine, N., Kindong, N.P., Sigal, Y., Bernard, N., et al. (2013) Malnutrition in Sub-Saharan Africa: Burden, Causes and Prospects. *Pan African Medical Journal*, **15**, Article 120. <https://doi.org/10.11604/pamj.2013.15.120.2535>
- [117] Initiative, M. (2009) Investing in the Future: A United Call to Action on Vitamin and Mineral Deficiencies. The Micronutrient Initiative, Ottawa, Canada.
- [118] Clark, S.F. (2008) Iron Deficiency Anemia. *Nutrition in Clinical Practice*, **23**, 128-141. <https://doi.org/10.1177/0884533608314536>
- [119] Lenaerts, B. and Demont, M. (2021) The Global Burden of Chronic and Hidden Hunger Revisited: New Panel Data Evidence Spanning 1990–2017. *Global Food Security*, **28**, Article 100480. <https://doi.org/10.1016/j.gfs.2020.100480>
- [120] Xu, Y., Shan, Y., Lin, X., Miao, Q., Lou, L., Wang, Y., et al. (2021) Global Patterns in Vision Loss Burden Due to Vitamin a Deficiency from 1990 to 2017. *Public Health Nutrition*, **24**, 5786-5794. <https://doi.org/10.1017/s1368980021001324>
- [121] Vijayaraghavan, K. (2018) National Control Programme against Nutritional Blindness Due to Vitamin A Deficiency. *Indian Journal of Medical Research*, **148**, 496-502. [https://doi.org/10.4103/ijmr.ijmr\\_1781\\_18](https://doi.org/10.4103/ijmr.ijmr_1781_18)
- [122] Shankar, A.H. and Prasad, A.S. (1998) Zinc and Immune Function: The Biological Basis of Altered Resistance to Infection. *The American Journal of Clinical Nutrition*, **68**, 447S-463S. <https://doi.org/10.1093/ajcn/68.2.447s>
- [123] Pearce, E.N. (2014) Iodine Deficiency in Children. In: *Endocrine Development*, S. Karger AG, 130-138. <https://doi.org/10.1159/000363160>
- [124] Crawford, M.A. (2013) Non-Communicable Diseases, Mental Ill-Health. *Nutrition and Health*, **22**, 171-179. <https://doi.org/10.1177/0260106015613866>
- [125] Mwenda, V., Mwangi, M., Nyanjau, L., Gichu, M., Kyobutungi, C. and Kibachio, J. (2018) Dietary Risk Factors for Non-Communicable Diseases in Kenya: Findings of the STEPS Survey, 2015. *BMC Public Health*, **18**, Article No. 1218. <https://doi.org/10.1186/s12889-018-6060-y>
- [126] Rock, C.L., Jacob, R.A. and Bowen, P.E. (1996) Update on the Biological Characteristics of the Antioxidant Micronutrients. *Journal of the American Dietetic Association*, **96**, 693-702. [https://doi.org/10.1016/s0002-8223\(96\)00190-3](https://doi.org/10.1016/s0002-8223(96)00190-3)
- [127] Koehlmoos, T.P., Anwar, S. and Cravioto, A. (2011) Global Health: Chronic Diseases and Other Emergent Issues in Global Health. *Infectious Disease Clinics of North America*, **25**, 623-638. <https://doi.org/10.1016/j.idc.2011.05.008>
- [128] Black, R. (2003) Micronutrient Deficiency: An Underlying Cause of Morbidity and Mortality. *Bulletin of the World Health Organization*, **81**, 79.
- [129] Gernand, A.D., Schulze, K.J., Stewart, C.P., West, K.P. and Christian, P. (2016) Micronutrient Deficiencies in Pregnancy Worldwide: Health Effects and Prevention. *Nature Reviews Endocrinology*, **12**, 274-289. <https://doi.org/10.1038/nrendo.2016.37>
- [130] Christian, P. (2002) Maternal Nutrition, Health, and Survival. *Nutrition Reviews*, **60**, S59-S63. <https://doi.org/10.1301/00296640260130759>
- [131] Branca, F. and Ferrari, M. (2002) Impact of Micronutrient Deficiencies on Growth: The Stunting Syndrome. *Annals of Nutrition and Metabolism*, **46**, 8-17. <https://doi.org/10.1159/000066397>

- [132] Ritchie, H. and Roser, M. (2017) Micronutrient Deficiency. Our World Data.
- [133] Allen, L.H. (2000) Ending Hidden Hunger: The History of Micronutrient Deficiency Control. World Bank.
- [134] Akhtar, S., Ismail, T., Atukorala, S. and Arlappa, N. (2013) Micronutrient Deficiencies in South Asia—Current Status and Strategies. *Trends in Food Science & Technology*, **31**, 55-62. <https://doi.org/10.1016/j.tifs.2013.02.005>
- [135] Iglesias Vázquez, L., Valera, E., Villalobos, M., Tous, M. and Arija, V. (2019) Prevalence of Anemia in Children from Latin America and the Caribbean and Effectiveness of Nutritional Interventions: Systematic Review and Meta-Analysis. *Nutrients*, **11**, Article 183. <https://doi.org/10.3390/nu11010183>
- [136] Harding, K.L., Aguayo, V.M. and Webb, P. (2017) Hidden Hunger in South Asia: A Review of Recent Trends and Persistent Challenges. *Public Health Nutrition*, **21**, 785-795. <https://doi.org/10.1017/s1368980017003202>
- [137] Kotecha, P. (2011) Nutritional Anemia in Young Children with Focus on Asia and India. *Indian Journal of Community Medicine*, **36**, 8-16. <https://doi.org/10.4103/0970-0218.80786>
- [138] Weisstaub, G., Aguilar, A.M. and Uauy, R. (2014) Treatment and Prevention of Malnutrition in Latin America: Focus on Chile and Bolivia. *Food and Nutrition Bulletin*, **35**, S39-S46. <https://doi.org/10.1177/15648265140352s106>
- [139] Darnton-Hill, I. and Coyne, E. (1998) Feast and Famine: Socioeconomic Disparities in Global Nutrition and Health. *Public Health Nutrition*, **1**, 23-31. <https://doi.org/10.1079/phn19980005>
- [140] Hernández-Ruiz, Á., Madrigal, C., Soto-Méndez, M.J. and Gil, Á. (2022) Challenges and Perspectives of the Double Burden of Malnutrition in Latin America. *Clínica e Investigación en Arteriosclerosis (English Edition)*, **34**, 3-16. <https://doi.org/10.1016/j.artere.2022.07.001>
- [141] Siddiqui, F., Salam, R.A., Lassi, Z.S. and Das, J.K. (2020) The Intertwined Relationship between Malnutrition and Poverty. *Frontiers in Public Health*, **8**, Article 453. <https://doi.org/10.3389/fpubh.2020.00453>
- [142] Dent, E., Hoogendijk, E.O., Visvanathan, R. and Wright, O.R.L. (2019) Malnutrition Screening and Assessment in Hospitalised Older People: A Review. *The Journal of Nutrition, Health and Aging*, **23**, 431-441. <https://doi.org/10.1007/s12603-019-1176-z>
- [143] Losurdo, G., Caccavo, N.L.B., Indelicati, G., Celiberto, F., Ierardi, E., Barone, M., et al. (2023) Effect of Long-Term Proton Pump Inhibitor Use on Blood Vitamins and Minerals: A Primary Care Setting Study. *Journal of Clinical Medicine*, **12**, Article 2910. <https://doi.org/10.3390/jcm12082910>
- [144] Mander, H. and Jacob, S. (2010) Eating Rough, Hidden Hunger on City Streets: Searching for Solutions.
- [145] Vassilakou, T. (2021) Childhood Malnutrition: Time for Action. *Children*, **8**, 103. <https://doi.org/10.3390/children8020103>
- [146] Alaimo, K. (2005) Food Insecurity in the United States. *Topics in Clinical Nutrition*, **20**, 281-298. <https://doi.org/10.1097/00008486-200510000-00002>
- [147] Madjdian, D.S., Azupogo, F., Osendarp, S.J.M., Bras, H. and Brouwer, I.D. (2018) Socio-Cultural and Economic Determinants and Consequences of Adolescent Undernutrition and Micronutrient Deficiencies in LLMICs: A Systematic Narrative Review. *Annals of the New York Academy of Sciences*, **1416**, 117-139. <https://doi.org/10.1111/nyas.13670>

- [148] Barr, F., Brabin, L., Agbaje, S., Buseri, F., Ikimalo, J. and Briggs, N. (1998) Reducing Iron Deficiency Anaemia Due to Heavy Menstrual Blood Loss in Nigerian Rural Adolescents. *Public Health Nutrition*, **1**, 249-257. <https://doi.org/10.1079/phn19980041>
- [149] Biesalski Hans, K. and Jana, T. (2018) Micronutrients in the Life Cycle: Requirements and Sufficient Supply. *NFS Journal*, **11**, 1-11. <https://doi.org/10.1016/j.nfs.2018.03.001>
- [150] Norman, K., Haß, U. and Pirlich, M. (2021) Malnutrition in Older Adults—Recent Advances and Remaining Challenges. *Nutrients*, **13**, Article 2764. <https://doi.org/10.3390/nu13082764>
- [151] Brownie, S. (2006) Why Are Elderly Individuals at Risk of Nutritional Deficiency? *International Journal of Nursing Practice*, **12**, 110-118. <https://doi.org/10.1111/j.1440-172x.2006.00557.x>
- [152] Rosenberg, I. and Miller, J. (1992) Nutritional Factors in Physical and Cognitive Functions of Elderly People. *The American Journal of Clinical Nutrition*, **55**, 1237S-1243S. <https://doi.org/10.1093/ajcn/55.6.1237s>
- [153] Lanham-New, S.A. (2008) Importance of Calcium, Vitamin D and Vitamin K for Osteoporosis Prevention and Treatment. *Proceedings of the Nutrition Society*, **67**, 163-176. <https://doi.org/10.1017/s0029665108007003>
- [154] Tata Ngome, P.I., Shackleton, C., Degrande, A. and Tieguhong, J.C. (2017) Addressing Constraints in Promoting Wild Edible Plants' Utilization in Household Nutrition: Case of the Congo Basin Forest Area. *Agriculture & Food Security*, **6**, Article No. 20. <https://doi.org/10.1186/s40066-017-0097-5>
- [155] Oniang'o, R.K., Mutuku, J.M. and Malaba, S.J. (2003) Contemporary African Food Habits and Their Nutritional and Health Implications. *Asia Pacific Journal of Clinical Nutrition*, **12**, Article No. 3.
- [156] Young, M.F. and Ramakrishnan, U. (2020) Maternal Undernutrition before and during Pregnancy and Offspring Health and Development. *Annals of Nutrition and Metabolism*, **76**, 41-53. <https://doi.org/10.1159/000510595>
- [157] Teodosijevic, S.B. (2003) Armed Conflicts and Food Security.
- [158] Karume, K., Mondo, J.M., Chuma, G.B., Ibanda, A., Bagula, E.M., Aleke, A.L., et al. (2022) Current Practices and Prospects of Climate-Smart Agriculture in Democratic Republic of Congo: A Review. *Land*, **11**, Article 1850. <https://doi.org/10.3390/land11101850>
- [159] World Bank Group (2018) Women, Business and the Law 2018. World Bank Publications.
- [160] Ishara, J., Cokola, M.C., Buzera, A., Mmari, M., Bugeme, D., Niassy, S., et al. (2023) Edible Insect Biodiversity and Anthro-po-Entomophagy Practices in Kalehe and Idjwi Territories, D.R. Congo. *Journal of Ethnobiology and Ethnomedicine*, **19**, Article No. 3. <https://doi.org/10.1186/s13002-022-00575-z>
- [161] Chuma, G.B. (2022) Farmers' Knowledge and Practices of Soil Conservation Techniques in Smallholder Farming Systems of Northern Kabare, East of DR Congo. *Environmental Challenges*, **7**, Article 100516.
- [162] Briker, S.M., Aduwo, J.Y., Mugeni, R., Horlyck-Romanovsky, M.F., DuBose, C.W., Mabundo, L.S., et al. (2019) A1C Underperforms as a Diagnostic Test in Africans Even in the Absence of Nutritional Deficiencies, Anemia and Hemoglobinopathies: Insight from the Africans in America Study. *Frontiers in Endocrinology*, **10**, Article 533. <https://doi.org/10.3389/fendo.2019.00533>

- [163] Aggarwal, P.K., Baethegan, W.E., Cooper, P., Gommers, R., Lee, B., Meinke, H., *et al.* (2010) Managing Climatic Risks to Combat Land Degradation and Enhance Food Security: Key Information Needs. *Procedia Environmental Sciences*, **1**, 305-312. <https://doi.org/10.1016/j.proenv.2010.09.019>
- [164] Buhaug, H., Gleditsch, N.P. and Theisen, O.M. (2008) Implications of Climate Change for Armed Conflict. World Bank.
- [165] Khush, G.S., Lee, S., Cho, J. and Jeon, J. (2012) Biofortification of Crops for Reducing Malnutrition. *Plant Biotechnology Reports*, **6**, 195-202. <https://doi.org/10.1007/s11816-012-0216-5>
- [166] Ekholuenetale, M., Tudeme, G., Onikan, A. and Ekholuenetale, C.E. (2020) Socioeconomic Inequalities in Hidden Hunger, Undernutrition, and Overweight among Under-Five Children in 35 Sub-Saharan Africa Countries. *Journal of the Egyptian Public Health Association*, **95**, Article No. 9. <https://doi.org/10.1186/s42506-019-0034-5>
- [167] Ritchie, H., Reay, D.S. and Higgins, P. (2018) Quantifying, Projecting, and Addressing India's Hidden Hunger. *Frontiers in Sustainable Food Systems*, **2**, Article 11. <https://doi.org/10.3389/fsufs.2018.00011>
- [168] Olson, R., Gavin-Smith, B., Ferraboschi, C. and Kraemer, K. (2021) Food Fortification: The Advantages, Disadvantages and Lessons from Sight and Life Programs. *Nutrients*, **13**, Article 1118.
- [169] Nair, M.K., Augustine, L.F. and Konapur, A. (2016) Food-Based Interventions to Modify Diet Quality and Diversity to Address Multiple Micronutrient Deficiency. *Frontiers in Public Health*, **3**, Article 277. <https://doi.org/10.3389/fpubh.2015.00277>
- [170] Drammeh, W., Hamid, N.A. and Rohana, A.J. (2019) Determinants of Household Food Insecurity and Its Association with Child Malnutrition in Sub-Saharan Africa: A Review of the Literature. *Current Research in Nutrition and Food Science Journal*, **7**, 610-623. <https://doi.org/10.12944/crnfsj.7.3.02>
- [171] Aburto, N.J., Abudou, M., Candeias, V., *et al.* (2014) Effect and Safety of Salt Iodization to Prevent Iodine Deficiency Disorders: A Systematic Review with Meta-Analyses. World Health Organization.
- [172] Waha, K., van Wijk, M.T., Fritz, S., See, L., Thornton, P.K., Wichern, J., *et al.* (2018) Agricultural Diversification as an Important Strategy for Achieving Food Security in Africa. *Global Change Biology*, **24**, 3390-3400. <https://doi.org/10.1111/gcb.14158>
- [173] Amanto, B.S., Umanailo, M.C.B., *et al.* (2019) Local Consumption Diversification. *International Journal of Scientific & Technology Research*, **8**, 1865-1869.
- [174] Kapelari, S., Alexopoulos, G., Moussouri, T., Sagmeister, K.J. and Stampfer, F. (2020) Food Heritage Makes a Difference: The Importance of Cultural Knowledge for Improving Education for Sustainable Food Choices. *Sustainability*, **12**, Article 1509. <https://doi.org/10.3390/su12041509>
- [175] Lee, Y., Kim, T. and Jung, H. (2022) The Relationships between Food Literacy, Health Promotion Literacy and Healthy Eating Habits among Young Adults in South Korea. *Foods*, **11**, Article 2467. <https://doi.org/10.3390/foods11162467>
- [176] Ruel, M.T. and Levin, C.E. (2002) Food-Based Approaches for Alleviating Micronutrient Malnutrition: An Overview. *Journal of Crop Production*, **6**, 31-53. [https://doi.org/10.1300/j144v06n01\\_05](https://doi.org/10.1300/j144v06n01_05)
- [177] Mannar, M.V. (2006) Successful Food-Based Programmes, Supplementation and Fortification. *Journal of Pediatric Gastroenterology and Nutrition*, **43**, S47-S53. <https://doi.org/10.1097/01.mpg.0000255850.30400.ae>

- [178] Faber, M., Berti, C. and Smuts, M. (2014) Prevention and Control of Micronutrient Deficiencies in Developing Countries: Current Perspectives. *Nutrition and Dietary Supplements*, **6**, 41-57. <https://doi.org/10.2147/nds.s43523>
- [179] Mayo-Wilson, E., Imdad, A., Herzer, K., Yakoob, M.Y. and Bhutta, Z.A. (2011) Vitamin A Supplements for Preventing Mortality, Illness, and Blindness in Children Aged under 5: Systematic Review and Meta-Analysis. *British Medical Journal*, **343**, d5094.
- [180] Ren, A., Wang, J., Ye, R.W., Li, S., Liu, J.M. and Li, Z. (2007) Low First-Trimester Hemoglobin and Low Birth Weight, Preterm Birth and Small for Gestational Age Newborns. *International Journal of Gynecology & Obstetrics*, **98**, 124-128. <https://doi.org/10.1016/j.ijgo.2007.05.011>
- [181] Gianoudis, J., Bailey, C.A., Sanders, K.M., Nowson, C.A., Hill, K., Ebeling, P.R., et al. (2012) Osteo-Cise: Strong Bones for Life: Protocol for a Community-Based Randomised Controlled Trial of a Multi-Modal Exercise and Osteoporosis Education Program for Older Adults at Risk of Falls and Fractures. *BMC Musculoskeletal Disorders*, **13**, Article No. 78. <https://doi.org/10.1186/1471-2474-13-78>
- [182] Wimalawansa, S.J. (2013) Food Fortification Programs to Alleviate Micronutrient Deficiencies. *Journal of Food Processing & Technology*, **4**, Article 257. <https://doi.org/10.4172/2157-7110.1000257>
- [183] Silitonga, H.T.H., Salim, L.A., Nurmala, I. and Wartiningsih, M. (2023) Compliance of Iron Supplementation and Determinants among Adolescent Girls: A Systematic Review. *Iranian Journal of Public Health*, **52**, 37-48.
- [184] Renwick, A.G. (2006) Toxicology of Micronutrients: Adverse Effects and Uncertainty. *Journal of Nutrition*, **136**, 493S-501S.
- [185] Burchi, F., Fanzo, J. and Frison, E. (2011) The Role of Food and Nutrition System Approaches in Tackling Hidden Hunger. *International Journal of Environmental Research and Public Health*, **8**, 358-373.
- [186] Winnick, S., Lucas, D.O., Hartman, A.L. and Toll, D. (2005) How Do You Improve Compliance? *Pediatrics*, **115**, e718-e724.
- [187] Naresh, R.K. (2021) Neglected and Underutilized Crop Species the Key to Improving Soil Nutritional Security for Fighting Poverty, Hunger and Malnutrition in North-Western IGP: A Review. *Journal of Pharmaceutical Innovation*, **10**, 1833-1839.
- [188] Siddique, K.H.M., Li, X. and Gruber, K. (2021) Rediscovering Asia's Forgotten Crops to Fight Chronic and Hidden Hunger. *Nature Plants*, **7**, 116-122. <https://doi.org/10.1038/s41477-021-00850-z>
- [189] Saltzman, A., Birol, E., Bouis, H.E., Boy, E., De Moura, F.F., Islam, Y., et al. (2013) Biofortification: Progress toward a More Nourishing Future. *Global Food Security*, **2**, 9-17. <https://doi.org/10.1016/j.gfs.2012.12.003>
- [190] Garg, M., Sharma, N., Sharma, S., Kapoor, P., Kumar, A., Chunduri, V., et al. (2018) Biofortified Crops Generated by Breeding, Agronomy, and Transgenic Approaches Are Improving Lives of Millions of People around the World. *Frontiers in Nutrition*, **5**, Article 12. <https://doi.org/10.3389/fnut.2018.00012>
- [191] Kumar, S., Palve, A., Joshi, C., Srivastava, R.K. (2019) Crop Biofortification for Iron (Fe), Zinc (Zn) and Vitamin a with Transgenic Approaches. *Heliyon*, **5**, e01914. <https://doi.org/10.1016/j.heliyon.2019.e01914>
- [192] Titcomb, T.J. and Tanumihardjo, S.A. (2019) Global Concerns with B Vitamin Statuses: Biofortification, Fortification, Hidden Hunger, Interactions, and Toxicity. *Comprehensive Reviews in Food Science and Food Safety*, **18**, 1968-1984. <https://doi.org/10.1111/1541-4337.12491>

- [193] Melash, A.A., Mengistu, D.K. and Aberra, D.A. (2016) Linking Agriculture with Health through Genetic and Agronomic Biofortification. *Agricultural Sciences*, **7**, 295-307. <https://doi.org/10.4236/as.2016.75029>
- [194] Cakmak, I. and Kutman, U.B. (2017) Agronomic Biofortification of Cereals with Zinc: A Review. *European Journal of Soil Science*, **69**, 172-180. <https://doi.org/10.1111/ejss.12437>
- [195] Ekesa, B.N., Kimiywe, J., Van den Bergh, I., Blomme, G., Dhuique-Mayer, C. and Davey, M. (2012) Content and Retention of Provitamin A Carotenoids Following Ripening and Local Processing of Four Popular Musa Cultivars from Eastern Democratic Republic of Congo. *Sustainable Agriculture Research*, **2**, 60-75. <https://doi.org/10.5539/sar.v2n2p60>
- [196] Mwanga, R.O.M. and Ssemakula, G. (2011) Orange-Fleshed Sweet Potatoes for Food, Health and Wealth in Uganda. *International Journal of Agricultural Sustainability*, **9**, 42-49. <https://doi.org/10.3763/ijas.2010.0546>
- [197] Low, J.W., Mwanga, R.O.M., Andrade, M., Carey, E. and Ball, A.-M. (2017) Tackling Vitamin A Deficiency with Biofortified Sweet Potato in Sub-Saharan Africa. *Global Food Security*, **14**, 23-30.
- [198] Osendarp, S.J.M. (2018) Large-Scale Food Fortification and Biofortification in Low and Middle-Income Countries: A Review of Programs, Trends, Challenges, and Evidence Gaps. *Food and Nutrition Bulletin*, **39**, 315-331.
- [199] Caradus, J.R. (2022) Intended and Unintended Consequences of Genetically Modified Crops—Myth, Fact and/or Manageable Outcomes? *New Zealand Journal of Agricultural Research*, **66**, 519-619. <https://doi.org/10.1080/00288233.2022.2141273>
- [200] Puett, C. and Guerrero, S. (2014) Barriers to Access for Severe Acute Malnutrition Treatment Services in Pakistan and Ethiopia: A Comparative Qualitative Analysis. *Public Health Nutrition*, **18**, 1873-1882. <https://doi.org/10.1017/s1368980014002444>
- [201] Birner, R. and Sekher, M. (2018) The Devil Is in the Detail: Understanding the Governance Challenges of Implementing Nutrition-Specific Programs on a Large Scale. In: *Hidden Hunger: Strategies to Improve Nutrition Quality*, Karger, 17-44.
- [202] Bhutta, Z.A., Salam, R.A. and Das, J.K. (2013) Meeting the Challenges of Micronutrient Malnutrition in the Developing World. *British Medical Bulletin*, **106**, 7-17. <https://doi.org/10.1093/bmb/ldt015>
- [203] Talukder, A. (2010) Homestead Food Production Model Contributes to Improved Household Food Security and Nutrition Status of Young Children and Women in Poor Populations. Lessons Learned from Scaling-Up Programs in Asia (Bangladesh, Cambodia, Nepal and Philippines). Field Actions Science Reports.
- [204] Ruel, M.T., Quisumbing, A.R. and Balagamwala, M. (2018) Nutrition-Sensitive Agriculture: What Have We Learned So Far? *Global Food Security*, **17**, 128-153. <https://doi.org/10.1016/j.gfs.2018.01.002>
- [205] Bhagwat, S., Sankar, R., Sachdeva, R. and Joseph, L. (2014) Improving the Nutrition Quality of the School Feeding Program (Mid-Day Meal) in India through Fortification: A Case Study. *Asia Pacific Journal of Clinical Nutrition*, **23**, S12-S19.
- [206] Low, J.W., Arimond, M., Osman, N., Cunguara, B., Zano, F. and Tschirley, D. (2007) A Food-Based Approach Introducing Orange-Fleshed Sweet Potatoes Increased Vitamin A Intake and Serum Retinol Concentrations in Young Children in Rural Mozambique. *The Journal of Nutrition*, **137**, 1320-1327. <https://doi.org/10.1093/jn/137.5.1320>
- [207] Villamor, E. and Fawzi, W.W. (2005) Effects of Vitamin a Supplementation on Im-

- immune Responses and Correlation with Clinical Outcomes. *Clinical Microbiology Reviews*, **18**, 446-464. <https://doi.org/10.1128/cmr.18.3.446-464.2005>
- [208] Allen, L.H. (2000) Anemia and Iron Deficiency: Effects on Pregnancy Outcome. *The American Journal of Clinical Nutrition*, **71**, 1280S-1284S.
- [209] Maina-Gathigi, L., Omolo, J., Wanzala, P., Lindan, C. and Makokha, A. (2012) Utilization of Folic Acid and Iron Supplementation Services by Pregnant Women Attending an Antenatal Clinic at a Regional Referral Hospital in Kenya. *Maternal and Child Health Journal*, **17**, 1236-1242. <https://doi.org/10.1007/s10995-012-1120-x>
- [210] Casey, G.J. (2017) Sustained Effectiveness of Weekly Iron-Folic Acid Supplementation and Regular Deworming over 6 Years in Women in Rural Vietnam. *PLOS Neglected Tropical Diseases*, **11**, e0005446.
- [211] Nasir, B.B., Fentie, A.M. and Adisu, M.K. (2020) Adherence to Iron and Folic Acid Supplementation and Prevalence of Anemia among Pregnant Women Attending Antenatal Care Clinic at Tikur Anbessa Specialized Hospital, Ethiopia. *PLOS One*, **15**, e0232625.
- [212] Smith, E.R. (2017) Modifiers of the Effect of Maternal Multiple Micronutrient Supplementation on Stillbirth, Birth Outcomes, and Infant Mortality: A Meta-Analysis of Individual Patient Data from 17 Randomised Trials in Low-Income and Middle-Income Countries. *The Lancet Global Health*, **5**, e1090-e1100.
- [213] Passerini, L. (2012) Increased Birth Weight Associated with Regular Pre-Pregnancy Deworming and Weekly Iron-Folic Acid Supplementation for Vietnamese Women. *PLOS Neglected Tropical Diseases*, **6**, e1608.
- [214] Garcia-Casal, M.N., Mowson, R., Rogers, L. and Grajeda, R. (2018) Risk of Excessive Intake of Vitamins and Minerals Delivered through Public Health Interventions: Objectives, Results, Conclusions of the Meeting, and the Way Forward. *Annals of the New York Academy of Sciences*, **1446**, 5-20. <https://doi.org/10.1111/nyas.13975>
- [215] Finkelstein, J.L., Mehta, S., Udipi, S.A., Ghugre, P.S., Luna, S.V., Wenger, M.J., et al. (2015) A Randomized Trial of Iron-Biofortified Pearl Millet in School Children in India. *The Journal of Nutrition*, **145**, 1576-1581. <https://doi.org/10.3945/jn.114.208009>
- [216] De Valença, A.W., Bake, A., Brouwer, I.D. and Giller, K.E. (2017) Agronomic Biofortification of Crops to Fight Hidden Hunger in Sub-Saharan Africa. *Global Food Security*, **12**, 8-14.
- [217] Adenle, A.A., Aworh, O.C., Akromah, R. and Parayil, G. (2012) Developing GM Super Cassava for Improved Health and Food Security: Future Challenges in Africa. *Agriculture & Food Security*, **1**, Article No. 11. <https://doi.org/10.1186/2048-7010-1-11>
- [218] Van Der Straeten, D., Bhullar, N.K., De Steur, H., Gruijssem, W., MacKenzie, D., Pfeiffer, W., et al. (2020) Multiplying the Efficiency and Impact of Biofortification through Metabolic Engineering. *Nature Communications*, **11**, Article No. 5203. <https://doi.org/10.1038/s41467-020-19020-4>
- [219] Bouis, H. (2020) Food Biofortification: Reaping the Benefits of Science to Overcome Hidden Hunger. Council for Agricultural Science and Technology (CAST).
- [220] Palmer, A.C., Healy, K., Barffour, M.A., Siamusantu, W., Chileshe, J., Schulze, K.J., et al. (2016) Provitamin A Carotenoid-Biofortified Maize Consumption Increases Pupillary Responsiveness among Zambian Children in a Randomized Controlled Trial. *The Journal of Nutrition*, **146**, 2551-2558. <https://doi.org/10.3945/jn.116.239202>

- [221] Gómez-Galera, S., Rojas, E., Sudhakar, D., Zhu, C., Pelacho, A.M., Capell, T., *et al.* (2009) Critical Evaluation of Strategies for Mineral Fortification of Staple Food Crops. *Transgenic Research*, **19**, 165-180. <https://doi.org/10.1007/s11248-009-9311-y>
- [222] Onoja, A.O. and Adione, A.A. (2020) Hidden Hunger Burden and Policy Responses in Nigeria: Implications for Attainment of the Sustainable Development Goal. *Nigerian Agricultural Policy Research Journal*, **7**, 8-20.
- [223] Qaim, M., Stein, A.J. and Meenakshi, J.V. (2007) Economics of Biofortification. *Agricultural Economics*, **37**, 119-133. <https://doi.org/10.1111/j.1574-0862.2007.00239.x>
- [224] Pritchard, C., Duffy, S., Edington, J. and Pang, F. (2006) Enteral Nutrition and Oral Nutrition Supplements: A Review of the Economics Literature. *Journal of Parenteral and Enteral Nutrition*, **30**, 52-59. <https://doi.org/10.1177/014860710603000152>
- [225] Govindaraj, M. (2015) Is Fortification or Bio Fortification of Staple Food Crops Will Offer a Simple Solution to Complex Nutritional Disorder in Developing Countries? *Journal of Nutrition & Food Sciences*, **5**, 1-4.
- [226] Fieldhouse, P. (2013) Food and Nutrition: Customs and Culture. Springer.
- [227] Dary, O. (2008) Establishing Safe and Potentially Efficacious Fortification Contents for Folic Acid and Vitamin B<sub>12</sub>. *Food and Nutrition Bulletin*, **29**, S214-S224. <https://doi.org/10.1177/15648265080292s126>
- [228] WHO (2006) Guidelines on Food Fortification with Micronutrients. World Health Organization.
- [229] Maughan, R.J. (2013) Quality Assurance Issues in the Use of Dietary Supplements, with Special Reference to Protein Supplements. *The Journal of Nutrition*, **143**, 1843S-1847S. <https://doi.org/10.3945/jn.113.176651>
- [230] Thompson, B. (2007) Food-Based Approaches for Combating Iron Deficiency. *Nutritional Anemia*, **337**, 1-21.
- [231] Faber, M. and van Jaarsveld, P.J. (2006) The Production of Provitamin A-Rich Vegetables in Home-Gardens as a Means of Addressing Vitamin a Deficiency in Rural African Communities. *Journal of the Science of Food and Agriculture*, **87**, 366-377. <https://doi.org/10.1002/jsfa.2774>
- [232] Baker, L.E. (2004) Tending Cultural Landscapes and Food Citizenship in Toronto's Community Gardens. *Geographical Review*, **94**, 305-325. <https://doi.org/10.1111/j.1931-0846.2004.tb00175.x>
- [233] Waized, B., Ndyetabula, D., Temu, A., Robinson, E. and Henson, S. (2015) Promoting Biofortified Crops for Nutrition: Lessons from Orange-Fleshed Sweet Potato (OFSP) in Tanzania. Sokoine University of Agriculture and The Institute of Development Studies.
- [234] Dickinson, J.L., Shirk, J., Bonter, D., Bonney, R., Crain, R.L., Martin, J., *et al.* (2012) The Current State of Citizen Science as a Tool for Ecological Research and Public Engagement. *Frontiers in Ecology and the Environment*, **10**, 291-297. <https://doi.org/10.1890/110236>
- [235] Engle-Stone, R., Vosti, S.A., Luo, H., Kagin, J., Tarini, A., Adams, K.P., *et al.* (2019) Weighing the Risks of High Intakes of Selected Micronutrients Compared with the Risks of Deficiencies. *Annals of the New York Academy of Sciences*, **1446**, 81-101. <https://doi.org/10.1111/nyas.14128>
- [236] Mwaniki, A. (2006) Achieving Food Security in Africa: Challenges and Issues. Office of the Special Adviser on Africa.

- [237] Allen, S. and de Brauw, A. (2018) Nutrition Sensitive Value Chains: Theory, Progress, and Open Questions. *Global Food Security*, **16**, 22-28. <https://doi.org/10.1016/j.gfs.2017.07.002>
- [238] Harnack, L., Oakes, J.M., Elbel, B., Beatty, T., Rydell, S. and French, S. (2016) Effects of Subsidies and Prohibitions on Nutrition in a Food Benefit Program. *JAMA Internal Medicine*, **176**, 1610-1619. <https://doi.org/10.1001/jamainternmed.2016.5633>
- [239] Asi, L.N., Teri, D.T. and Meyer-Rochow, V.B. (2018) Influence of Food Taboos on Nutritional Patterns in Rural Communities in Cameroon. *International Review of Social Research*, **8**, 2-6. <https://doi.org/10.2478/irsr-2018-0013>
- [240] Nestle, M. (1998) Behavioral and Social Influences on Food Choice. *Nutrition Reviews*, **56**, S50-S64.
- [241] Aubel, J., Touré, I. and Diagne, M. (2004) Senegalese Grandmothers Promote Improved Maternal and Child Nutrition Practices: The Guardians of Tradition Are Not Averse to Change. *Social Science & Medicine*, **59**, 945-959. <https://doi.org/10.1016/j.socscimed.2003.11.044>
- [242] Marinac, J.S., Buchinger, C.L., Godfrey, L.A., et al. (2007) Herbal Products and Dietary Supplements: A Survey of Use, Attitudes, and Knowledge among Older Adults. *Journal of Osteopathic Medicine*, **107**, 13-23.
- [243] DeSalvo, K.B., Wang, Y.C., Harris, A., Auerbach, J., Koo, D. and O'Carroll, P. (2017) Public Health 3.0: A Call to Action for Public Health to Meet the Challenges of the 21st Century. *Preventing Chronic Disease*, **14**, Article 170017. <https://doi.org/10.5888/pcd14.170017>
- [244] Nordhagen, S., Nielsen, J., van Mourik, T., Smith, E. and Klemm, R. (2019) Fostering CHANGE: Lessons from Implementing a Multi-Country, Multi-Sector Nutrition-Sensitive Agriculture Project. *Evaluation and Program Planning*, **77**, Article 101695. <https://doi.org/10.1016/j.evalprogplan.2019.101695>
- [245] Thrupp, L.A. (2000) Linking Agricultural Biodiversity and Food Security: The Valuable Role of Agrobiodiversity for Sustainable Agriculture. *International Affairs*, **76**, 265-281. <https://doi.org/10.1111/1468-2346.00133>
- [246] Brandt, K. and Mølgaard, J.P. (2001) Organic Agriculture: Does It Enhance or Reduce the Nutritional Value of Plant Foods? *Journal of the Science of Food and Agriculture*, **81**, 924-931. <https://doi.org/10.1002/jsfa.903>
- [247] Chigumula, M. (2017) Exploring Micronutrient Fortification and Supplementation Programme in Malawi: A Review Study of Governmental and Non-Governmental Programs Implementation and Collaboration.
- [248] Aranda-Jan, C.B., Mohutsiwa-Dibe, N. and Loukanova, S. (2014) Systematic Review on What Works, What Does Not Work and Why of Implementation of Mobile Health (mHealth) Projects in Africa. *BMC Public Health*, **14**, Article No. 188. <https://doi.org/10.1186/1471-2458-14-188>
- [249] Riely, F. (1999) Food Security Indicators and Framework for Use in the Monitoring and Evaluation of Food Aid Programs.
- [250] Nash, D., Elul, B., Rabkin, M., Tun, M., Saito, S., Becker, M., et al. (2009) Strategies for More Effective Monitoring and Evaluation Systems in HIV Programmatic Scale-Up in Resource-Limited Settings: Implications for Health Systems Strengthening. *Journal of Acquired Immune Deficiency Syndromes*, **52**, S58-S62. <https://doi.org/10.1097/qai.0b013e3181bbcc45>
- [251] Feroz, A., Jabeen, R. and Saleem, S. (2020) Using Mobile Phones to Improve Com-

- munity Health Workers Performance in Low-and-Middle-Income Countries. *BMC Public Health*, **20**, Article No. 49. <https://doi.org/10.1186/s12889-020-8173-3>
- [252] Kusek, J.Z. (2010) Making Monitoring and Evaluation Systems Work: A Capacity Development Toolkit. World Bank Publications.
- [253] Ruel-Bergeron, J.C., Stevens, G.A., Sugimoto, J.D., Roos, F.F., Ezzati, M., Black, R.E., et al. (2015) Global Update and Trends of Hidden Hunger, 1995-2011: The Hidden Hunger Index. *PLOS ONE*, **10**, e0143497. <https://doi.org/10.1371/journal.pone.0143497>
- [254] Antony, A.C., Vora, R.M. and Karmarkar, S.J. (2022) The Silent Tragic Reality of Hidden Hunger, Anaemia, and Neural-Tube Defects (NTDs) in India. *The Lancet Regional Health—Southeast Asia*, **6**, Article 100071. <https://doi.org/10.1016/j.lansea.2022.100071>
- [255] Sandström, B. (2001) Micronutrient Interactions: Effects on Absorption and Bioavailability. *British Journal of Nutrition*, **85**, S181. <https://doi.org/10.1049/bjn2000312>
- [256] Arshad, R., Gulshad, L., Haq, I., Farooq, M.A., Al-Farga, A., Siddique, R., et al. (2021) Nanotechnology: A Novel Tool to Enhance the Bioavailability of Micronutrients. *Food Science & Nutrition*, **9**, 3354-3361. <https://doi.org/10.1002/fsn3.2311>
- [257] Bennett, G., Bardon, L.A. and Gibney, E.R. (2022) A Comparison of Dietary Patterns and Factors Influencing Food Choice among Ethnic Groups Living in One Locality: A Systematic Review. *Nutrients*, **14**, Article 941. <https://doi.org/10.3390/nu14050941>
- [258] Soares, J.C., Santos, C.S., Carvalho, S.M.P., Pintado, M.M. and Vasconcelos, M.W. (2019) Preserving the Nutritional Quality of Crop Plants under a Changing Climate: Importance and Strategies. *Plant and Soil*, **443**, 1-26. <https://doi.org/10.1007/s11104-019-04229-0>
- [259] Reyers, B. and Selig, E.R. (2020) Global Targets That Reveal the Social-Ecological Interdependencies of Sustainable Development. *Nature Ecology & Evolution*, **4**, 1011-1019. <https://doi.org/10.1038/s41559-020-1230-6>
- [260] Ervin, D., Tuholske, C. and López-Carr, D. (2017) Global Hunger. In: *Food and Place: A Critical Exploration*, Rowman & Littlefield Publishers, 106.
- [261] Sharma, A. and Verma, R.K. (2019) Biofortification: A Promising Approach toward Eradication of Hidden Hunger. In: *Microbial Interventions in Agriculture and Environment*, Springer, 313-327. [https://doi.org/10.1007/978-981-13-8391-5\\_12](https://doi.org/10.1007/978-981-13-8391-5_12)