

Evaluating the Effectiveness of Micronutrient Fortification and Supplementation in Reducing Nutritional Deficiencies in South Punjab, Pakistan

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Received: March 11, 2024 Accepted: August 21, 2024 Published: September 01, 2024

Abstract: Fortification involves deliberately enhancing the levels of specific micronutrients, such as vitamins and minerals. In foods or condiments to boost the overall nutritional quality of the food supply. This practice aims to provide public health benefits while also posing minimal health risks. In addition to enriching staple foods with nutrients, fortification also helps to replenish micronutrient levels that may be diminished during food processing. Deficiencies in micronutrients like iron, zinc, and vitamin A are prevalent in low- and middle-income countries, possibly impairing the physical and cognitive abilities of millions. Food fortification is a cost-effective approach that has proven health, economic, and social benefits. It boosts the nutritional value of our day-to-day food supply, which is especially important in the increasingly health-conscious world of today. However, the success of fortification programs faces several technical challenges, including the need to ensure the purity of salt for effective iodization, addressing the presence of phytates and other compounds that impact the bioavailability of non-haem iron fortificants, and maintaining the appropriate storage conditions required for vitamin A-fortified foods. We conducted a survey in multiple locations, in which, we discussed how Food Fortification and Supplements contribute to health benefits with our participants. We also developed a questionnaire on Food Fortifications and Supplements Awareness Program. The participants were then guided through the questionnaires and the results were then noted down for observation. To summarise, most individuals were unaware of the importance of food fortification and supplementation in their daily lives. It should be well-established in the general world that proper supplementation and awareness helps improve overall health, reduces the risk of disease, and also maintains nutritional status.

Keywords: Micronutrient; Fortification; Nutrition; Phytates; Supplements.

1. Introduction

Oral dietary supplements (DSs) include vitamins, minerals, amino acids, energy drinks, and herbal products that are formulated as tablets, capsules, powders, or liquids. (National institute of health 2020). DS manufacturing companies claim that their products promote a healthier lifestyle by increasing physical and mental performance [1]. More than 50% of the adults in the United States use DSs, mainly to improve or maintain individual health, with vitamins being the most consumed type of DS. However, less than 25% of DSs are consumed based on the recommendations of a physician [2].

Studies have found that vitamins and minerals have several benefits, including decreasing the incidence of cancer, [3] protecting foetuses from some congenital anomalies [4] and lowering blood pressure via various physiological mechanisms [5-7]. Oral magnesium supplements can also decrease blood pressure in

hypertensive patients [8]. As 60% of the Saudi adult population is vitamin D-deficient, [9] Oral supplementation with this vitamin improves physical performance and decreases pain in individuals with osteoarthritis [10]. Furthermore, vitamin D can serve as a potential immune-modulator in COVID-19 infection due to its immune regulating function [11-12].

Athletes who have a high protein diet have a higher fatigue resistance and better muscle performance [13]. While caffeine can increase endurance and prolong training intervals [14]. Herbal supplements can be used to treat chronic liver disease, lower cholesterol levels, and increase wound-healing [15]. Food fortification, the process of adding essential micronutrients to foods, has emerged as a cost effective and sustainable strategy to address these deficiencies and improve overall health outcomes. Food fortification programs have been implemented globally targeting staple foods such as flour, salt, and cooking oil. For example, in countries like the United States and Canada, fortification of flour with folic acid has been mandated to reduce the risk of neural tube defects in newborns [16]. Similarly, salt iodization programs have been successful in addressing iodine deficiency disorders in many countries [17]. Despite the proven benefits of food fortification, its success depends on several factors, including the level of public awareness and acceptance of fortified foods.

Studies have shown that awareness of fortification programs among consumers and health professionals is often inadequate, leading to sub optimal consumption of fortified products [18]. The importance of supplementary awareness programs in enhancing the effectiveness of food fortification initiatives. These programs can play a crucial role in educating the public about the benefits of fortified foods, dispelling myths and misconceptions, and promoting behaviour change towards increased consumption of fortified products. Targeted awareness campaigns have been shown to significantly improve acceptance and utilization of fortified foods, leading to improved nutritional outcomes [19]. Micronutrient deficiencies continue to be a significant public health concern worldwide, particularly in low-and middle-income countries. These deficiencies, which include deficiencies in iron, iodine, Vitamin A, and zinc, can have serious health consequences, especially among vulnerable populations such as pregnant women and young children [20]. Supplementary awareness programs can play a crucial role in educating the public about the benefits of fortified foods, addressing misconceptions, and promoting behaviour change towards increased consumption of fortified products. Micronutrient deficiencies are a significant public health concern, particularly in low-and middle-income countries (LMICs), where access to diverse diets may be limited.

Iron deficiency is one of the most common micronutrient deficiencies globally and is a leading cause of anaemia. It can result in fatigue, weakness, and impaired cognitive function, particularly in children and pregnant women (WHO, 2021). Iodine Deficiency: Iodine deficiency is a leading cause of preventable intellectual disabilities worldwide. It can lead to iodine deficiency disorders (IDDs), including goitre, hypothyroidism, and cretinism. Pregnant women and young children are particularly at risk (Zimmermann et al., 2008). Vitamin A deficiency is a major cause of blindness in children and increases the risk of severe illness and death from common childhood infections. It can also impair immune function, increasing susceptibility to infections (WHO, 2009). Zinc deficiency can impair growth and development, weaken the immune system, and increase the risk of diarrhoea and respiratory infections. It is particularly harmful to pregnant women and young children (WHO, 2009).

2. Literature Review

Over the past 70 years, food fortification has significantly impacted public health in both developed and developing countries, successfully eliminating many nutritional deficiencies. According to the World Health Organization's report on global malnutrition (2000), multiple studies have demonstrated the effectiveness of food fortification in addressing micronutrient deficiencies. For instance, the current low levels of iron deficiency in the United States can largely be attributed to fortified foods. Nearly one-quarter of the iron intake in the U.S. diet comes from fortified sources, particularly flour products. (Am J Physogastric Liv Physiol. 2006; 290: G199-G203.30.)

In Canada, the fortification of flour with B vitamins began in Newfoundland in 1944. Within four years, the previously high deficiency rates, which affected nearly 20% of the population, had decreased to negligible

levels. Similarly, after the mandatory introduction of folic acid fortification in cereal-grain products in the United States, Canada, and Chile in 1998, there was a 30–70% reduction in neural tube defects in newborns.

In Europe, a comparative analysis of dietary surveys has shown that fortified foods, especially voluntarily fortified breakfast cereals in countries like France, Ireland, the United Kingdom, and Spain, have significantly increased vitamin and mineral intakes among children and adolescents. National fortification programs were also implemented in Denmark until 1987 and in Sweden until 1994.

In the developing world, the past two decades have seen a rapid expansion in the fortification of a wide range of foods, contributing to improved nutritional outcomes in these regions.

The most successful global fortification experience is the fortification of salt with iodine. Adding iodine to salt is a simple manufacturing process costing no more than 4 cents per person annually. A significant proportion of the populations in more than 110 countries have access to iodized salt. WHO. Recommended iodine levels in salt and guidelines for monitoring their adequacy and effectiveness. World Health Organization, Geneva, 1996. As of 2006, nearly two-thirds of the salt consumed in the developing world is being iodized, protecting nearly 70 million newborns each year from the threat of mental impairment caused by iodine deficiency [21]. Successful salt iodization has reduced the incidence of goitre and cretinism, prevented mental retardation and subclinical iodine deficiency disorders, and contributed to improved national productivity. (Mannar MG, Dunn JT. Salt iodization for the elimination of iodine deficiency.

Building on the success with iodization, double fortification of salt with iodine and iron is gaining ground and can be integrated with established iodization processes. Double fortified salt is currently being produced in India and has the potential to be distributed through commercial channels and public programs to reach economically weaker sections of the population in many countries. Fortification of staple foods such as flour, oils, sugar condiments, dairy products, and a range of processed foods with micronutrients is also growing (Mannar, 2006). As compiled by the Flour Fortification Initiative, more than 63 countries are fortifying all or some of their flour with iron, folic acid, and other nutrients covering 28% of the global market.

Inadequate nutrient intake results in various health and nutritional deficiencies. Proper nutrient intake is important to maintain healthy life at every stage of development. Poor mental functioning, growth disorder. High rate of infections may rise in infants due to improper nutritional supply during pregnancy. Fortification is one of the best tools to curb the mentioned issues. A cross-sectional survey was conducted in Kenya, where the level of awareness about the fortification process was analysed. Out of 100% only 28% of individuals were aware of it through radio. Individuals are not aware of the particular role of vitamin and mineral but they answered that lack of micronutrients causes various health ailments. (National Health Survey of Pakistan (NHSP). Pakistan Medical and Research Council 1996).

Malnutrition has become one of the major health problems faced by developing countries, which contributes to infant mortality, poor physical and intellectual development of children in which lowers the resistance to diseases. Throughout the developing world, malnutrition affects about 800 million people which approximately accounts for 10% of the world population. For instance, Sri Lanka Demographic and Health Survey (2006/07) highlighted that 18% of Sri Lankan children are stunted, 15% are wasted, 22% are underweight and 4% are severely underweight.

High price of commercially available fortified foods, vegetables, animal proteins and the non-availability of low-priced nutritious foods, and late introduction of supplementary foods, are mostly responsible for the observed malnourishment among children in Asia.

Fortification is the process of adding nutrients to foods in relatively small quantities to maintain or improve the dietary quality of a group, community, or population. This approach is particularly beneficial for developing weaning foods, which are typically introduced between the ages of six months and three years, a period when breastfeeding alone no longer meets the increasing nutritional needs of a child. During this critical transitional phase, there is a heightened risk of Protein-Energy Malnutrition (PEM) as children move from liquid to semi-solid or fully adult foods. To support their growing bodies, children require nutritionally balanced and calorie-dense supplementary foods, such as fortified weaning foods, in addition to breast milk

(Amankwah et al., 2009). The risk of malnutrition, growth retardation, and higher mortality rates is especially severe if abrupt weaning occurs, where the family menu is directly introduced to the infant.

In developing countries, most complementary foods are based on local staple foods, primarily cereals, and are often given to infants in the form of liquid gruel. To make these cereal-based weaning foods suitable for young children, they are typically prepared in a diluted liquid form, resulting in a larger volume but low energy and nutrient density. These cereal-based gruels are nutritionally poor, lacking essential amino acids such as threonine, lysine, and tryptophan. Additionally, the low quality of protein and high viscosity of these gruels make it difficult for children to consume enough to meet their energy and protein requirements, leading to Protein-Energy Malnutrition.

To address these nutrient deficiencies, food-based approaches, combined with nutritional education programs, can be employed as an effective strategy.

One such Strategy is blending of legumes with cereals or in other words, Fortification of legumes into solely cereal-based diets. Hence, locally available legumes: mung bean (*Vigna Radiata*) and soybean (*Glycine max*) can be used due to their high protein and iron content (Clarke et al., 2011)

Therefore, fortification of legumes with cereals may overcome the nutritional Deficiencies while improving the nutritional quality of the Cereal-based weaning foods (Banureka and Mahendran, 2009). In most developing countries, national policies do not provide the appropriate importance to food fortification.

Due to the low development of their industry sector (including food- processing industries), it is hard to reach poor people who really need fortified foods. Increased food prices remain an issue in undermining food security and livelihoods of the poor.

Despite various international aids, most fortified foods are still not accessible because they are unaffordable for vulnerable groups who often grow and process their own staple foods. Temple and Steyn (2011) demonstrated that purchasing healthier food items resulted in 69% higher daily costs. In the development of food fortification, the absence of centralized food-processing facilities is a significant constraint. Another challenge is the lack of simple and affordable technology capable of incorporating stable and bioavailable nutrients while preserving the preferred taste and appearance of foods. In developing countries, the primary obstacles to effective food fortification include limited industrial concentration and the socioeconomic conditions of large segments of the population, which prevent access to more expensive fortified foods (Bhagwat et al., 2014).

Local-scale fortification programs face several significant challenges, including the initial cost of mixing equipment, the price of the premix, maintaining high standards of quality control, and sustaining effective monitoring and distribution systems. To achieve successful food fortification, efforts must focus on enhancing food processing techniques, ensuring robust quality control and monitoring, developing reliable distribution infrastructure, securing regulatory support, and managing market dynamics to ensure low-income families have easy access to fortified foods.

The unequal accessibility to staple foods is a major barrier for impoverished populations, those at the greatest risk of micronutrient deficiencies, from benefiting from fortified foods (Wimalawansa, 2013). Therefore, it is crucial to develop techniques that utilize fortificants with a highly accessible (both financially and physically) vehicle that is already widely used by the target population. Increasingly, the goal of food fortification is shifting from merely preventing deficiencies to actively improving overall health (Dwyer et al., 2015).

3. Need of Project

The food fortification and supplementation project aims to tackle nutritional deficiencies within the population, particularly among vulnerable groups such as pregnant women, children, and the elderly. By enriching staple foods with essential vitamins, minerals, and other nutrients, these programs seek to improve overall health outcomes and reduce the risk of diseases associated with malnutrition. These efforts are crucial in enhancing food security, preventing nutrient deficiencies, and lowering the prevalence of diet-related diseases.

Various methods are employed in food fortification, including bio-fortification, where crops are bred to increase their nutritional value through conventional selective breeding or modern genetic modification, synthetic biology, such as adding probiotic bacteria to foods, and commercial or industrial fortification of common staples like flour, rice, and cooking oils.

In Pakistan, more than half of women and children suffer from inadequate levels of essential micronutrients, such as iron, folic acid, vitamin A, and vitamin D. Poor nutrition and micronutrient deficiencies during childhood have severe impacts on immunity, growth, and cognitive development. Pakistan faces significant challenges related to high rates of malnutrition, food insecurity, and limited access to diverse, nutrient-rich foods.

4. Objectives

- To improve the nutritional standard of our food intake in order to benefit the public while ensuring minimal risks to individuals' health.
- To reduce the prevalence of underweight, anaemia and iodine-deficiency disorder among under five children.
- To prevent the people who have restrictive diets or food allergies, as well as children, pregnant ladies, and older adults.
- To help maintain healthy micronutrient levels to keep bones strong, help in digestion, and prevent heart issues.

5. Plan of Work

A survey is conducted on 'Food fortification and Supplementation Awareness Program' in 'Post graduate college for women in Rajanpur', 'Vocational training institute for women', 'Women University Multan', 'Multan Public school and college', 'Government girl's higher secondary school Shorkot'. A survey-based study was done in these institutes to assess the awareness of individuals related to nutrition, food fortification and supplementation.

6. Survey Results

I conducted a survey on 'Food fortification and Supplements Awareness Program' in '**Post graduate college for women in Rajanpur**'. I gave them a proper introduction and thorough briefing about nutritional deficiencies like iron deficiency anaemia and malnutrition and how to overcome these deficiencies by choosing food and Supplements.

I gave them questionnaires and through these questionnaires I asked about their opinion about food fortification and Supplements. As expected, they have limited knowledge about food fortification and Supplementations. There are many students of different programs like BS English, BS Urdu, BS Chemistry etc. But only some students have knowledge about food fortification and Supplements and many have no knowledge. Some students don't know of any significance of nutrients and their impacts on human health. Most of students don't know and use the supplements even they need to use the supplements of calcium and iron results. Only 30% students are aware of food fortification and use supplements. Almost 40% students have no knowledge and 30% students have some knowledge but do not have proper information about food fortification and Supplements.

We also conducted a survey in '**Vocational training institute for women**' by giving a proper introduction and thoroughly briefing them about nutritional deficiency like iron deficiency, anaemia and malnutrition and how to overcome them by choosing food and supplements, then we asked about their opinions about food fortification and supplementation.

Current work was compiled by handing them questionnaire forms and checking all the information.

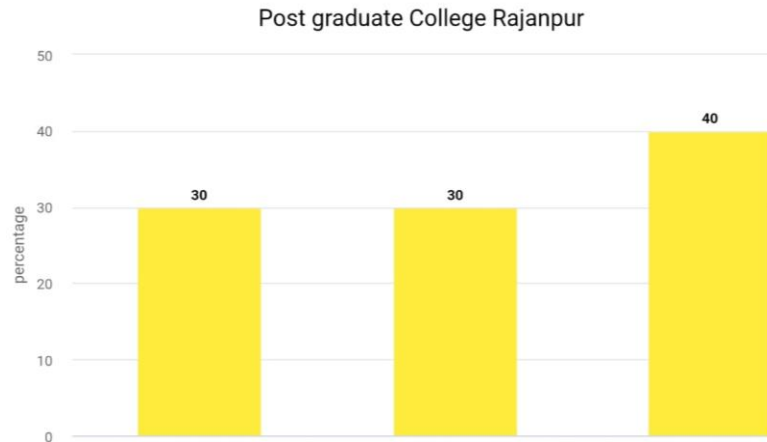


Figure 1. Graph of Post Graduate College Rajanpur

As usual, they have limited education or source of information. Most were unaware, but few girls, around 10% of them, could tell that they had read food labels on the food packaging and that they knew about the supplements. 30% of them never use supplements in their lifetime. 50% of them do not prefer to choose fortified food, they answered that they prefer to purchase the food that is less costly. They also revealed they had no source of information before this survey and around only 10% of them were knowledgeable beforehand.



Figure 2. Vocational Institute for Women

We conducted a similar survey in '**Women University Multan**'. Information was provided about food fortification and supplements, and also on their benefits and potential side effects on health. We discussed how supplements and food fortification contribute to health benefits. We then developed a questionnaire on food fortification and supplement awareness.

The aims of this survey were to see if people were aware about food fortification and supplement. We distributed a questionnaire to fill out and guided them through it.

Only 20% people were aware of food fortification and supplements, 40% were unaware, 10% didn't understand the questionnaire, and 30% had limited knowledge about the food fortification and dietary supplements.

Another survey was carried out in '**Multan Public school and college**'. A proper introduction and thorough briefing about nutritional deficiencies such as anaemia, goitre and malnutrition were given and they were informed on how to overcome these deficiencies by choosing proper food and supplement. I gave them questionnaires and through these questionnaires, I gathered their opinions.

As expected, they have a limited knowledge about food fortification and supplements. Majority of Students lacked fundamental information on the impact of nutrient and food fortification on health. Most

students were unaware of the use of supplements, even though some may be possibly requiring their use in their diets.

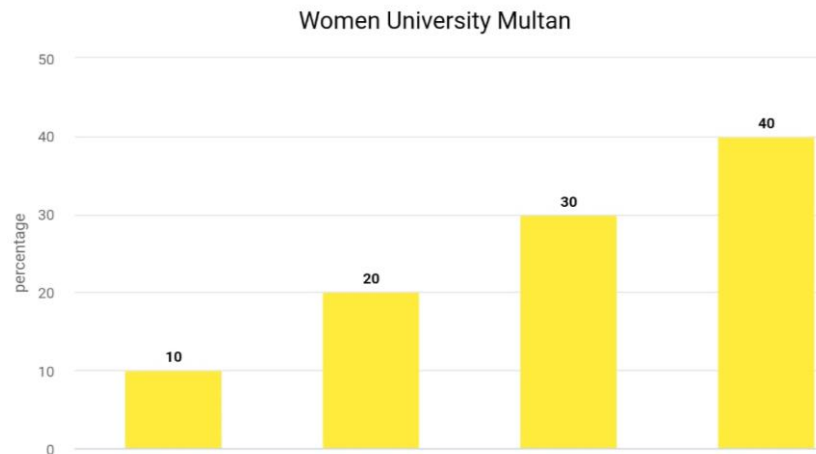


Figure 3. Graph of Women University Multan

Only 35% students are aware with food fortification and use of supplements. Almost 50% student have no knowledge about this and 15% student have some knowledge but not have a proper information about food fortification and supplement.

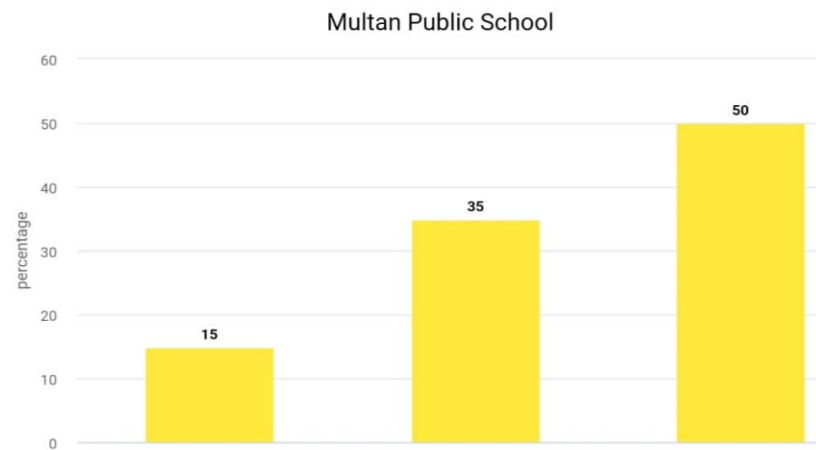


Figure 4. Graph of Multan Public School

An identical survey occurred in '**Government girl's higher secondary school Shorkot**', I gave them a proper introduction and thoroughly briefing about the nutritional deficiencies like iron deficiency anaemia and malnutrition and how to overcome these deficiencies by choosing food fortification and Supplements. I give them questionnaires and through these questionnaires I ask about their thoughts on food fortification and Supplements.

As expected, they have limited knowledge about food fortification and Supplementations. There are many students of different programs like BS English, BS Urdu, and BS Chemistry etc. But only a sharp minority of students have knowledge about food fortification and Supplements. Students were uninformed on the usage of nutrients and supplements. Most students did not use supplements and were unaware of the fact that they need to use supplements of calcium and iron.

Only 25% of students are aware of food fortification and use supplements. Almost 40% of students had no knowledge about this and 35% students have some knowledge.

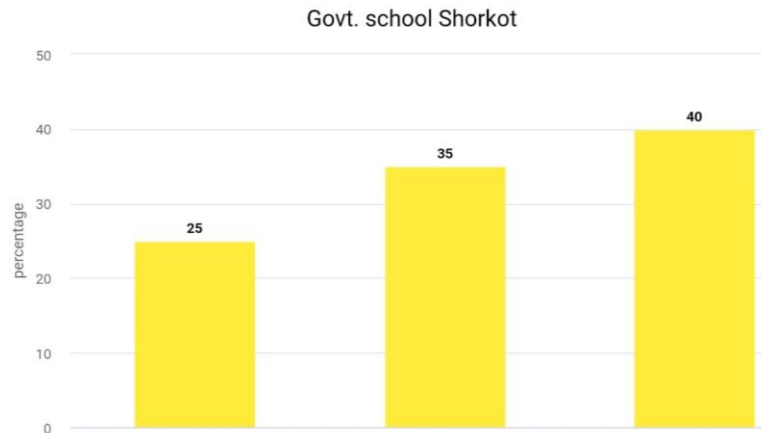


Figure 5. Graph of Govt. School Shorkot

7. Recommendations

• **Prioritization:**

Identify the most prevalent micronutrient deficiencies in your target population. Focus fortification efforts on addressing these specific deficiencies (e.g., iron deficiency anaemia by fortifying staple foods with iron).

• **Legislation and Standards:**

Establish clear national legislation and standards for food fortification. This ensures consistent fortification levels and quality control across food products.

• **Fortification Levels:**

Set scientifically-based fortification levels based on dietary needs and potential risks of overconsumption. Regularly review and update these levels as necessary.

• **Monitoring and Evaluation:**

Implement robust monitoring and evaluation systems to track the impact of fortification programs. This allows for adjustments to ensure effectiveness and address any unintended consequences.

• **Industry Collaboration:**

Promote collaboration between government agencies, food manufacturers, and public health institutions. This fosters knowledge sharing, innovation, and the development of cost-effective fortification strategies.

• **Targeted Supplementation:**

Targeted supplementation programs should prioritize high-risk groups like pregnant women, young children, and individuals with specific deficiencies identified through health checks.

• **Cost-Effectiveness:**

Select cost-effective, high-quality supplements based on evidence-based guidelines. Consider local production to increase affordability and accessibility.

• **Delivery Channels:**

Establish efficient distribution channels to ensure supplements reach target populations. This could involve collaborating with healthcare providers, community health workers, and NGOs.

• **Education and Counselling:**

Provide clear information and counselling on proper supplement use, dosage, and potential interactions with medications.

• **Sustainability:**

Develop long-term sustainable funding models for supplementation programs to avoid disruptions in essential services.

- **Public Education Campaigns:**

Launch targeted public education campaigns about the importance of micronutrients and the benefits of fortified foods and supplements for improved health and well-being. Utilize multiple communication channels like television, radio, social media, and community outreach programs.

- **Information on Food Labels:**

Mandate clear and easy-to-understand information on food labels regarding fortification content. This empowers consumers to make informed choices about the nutritional value of their food.

- **Community Engagement:**

Engage with community leaders, influencers, and local organizations to promote awareness and acceptance of fortified foods and supplements. Empower communities to advocate for continued fortification programs.

- **Partnerships:**

Collaborate with civil society organizations, schools, and healthcare providers to integrate information on micronutrient deficiencies and solutions into existing programs.

- **Success Stories:**

Share success stories and positive impacts of fortification and supplementation programs to build public confidence and support.

8. Conclusion

The current research in 2024 underscores the critical importance of food fortification and supplementary awareness programs in addressing nutritional deficiencies and improving public health outcomes.

Studies have consistently shown that fortifying foods with essential micronutrients can effectively reduce the prevalence of deficiencies, particularly in vulnerable populations such as pregnant women and children. According to the data which is find from survey 40% people including pregnant woman don't even know about the fortification and supplements and 10% are illiterate can't read labels and other information. Only the remaining 30% read the labels and were aware about food fortification and supplement awareness program. 20% have limited knowledge.

Additionally, awareness programs play a crucial role in educating individuals about the benefits of fortified foods and supplements, leading to increased acceptance and consumption. The integration of these strategies into public health policies and programs is essential for achieving sustainable improvements in nutrition and health.

9. Future Research Direction

Future research should focus on enhancing the effectiveness and sustainability of food fortification and supplementation programs through innovative approaches. Behavioural change communication strategies should be further explored to promote optimal nutrition practices at the community level.

Additionally, more studies are needed to understand the long-term impact of these interventions on health outcomes, as well as to identify novel approaches to address emerging challenges in maternal and child nutrition. By addressing these gaps, we can pave the way for more targeted and impactful interventions to improve maternal and child nutrition globally.

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