

Large-Scale Food Fortification in Low- and Middle-Income Countries: A Review of Programs, Trends, Challenges, and Evidence Gaps

Osendarp SJM, Martinez H, Garrett GS, Neufeld LM, De-Regil LM, Vossenaar M, Darnton-Hill I. *Food and Nutrition Bulletin*. 2018;39:315-31.

Coverage of Large-Scale Food Fortification of Edible Oil, Wheat Flour, and Maize Flour Varies Greatly by Vehicle and Country but Is Consistently Lower among the Most Vulnerable: Results from Coverage Surveys in 8 Countries.

Aaron GJ, Friesen VM, Jungjohann S, Garrett GS, Neufeld LM, Myatt M. *Journal of Nutrition*. 2017;147:984S-94S.

Introduction

Micronutrient deficiencies, such as iron, iodine, zinc, vitamin A and folate deficiency, continue to be a public health problem in many parts of the world. Over 2 billion people are estimated to be affected by micronutrient deficiencies and experience associated negative health outcomes (1). Women of reproductive age, adolescents and young children are the most vulnerable population groups. Food fortification, biofortification, supplementation and dietary diversification/modification are among the recommended strategies to prevent micronutrient deficiencies.

The current Nutrition News for Africa summarizes a recent article published in the *Food and Nutrition Bulletin*, which had the objective to review efficacy, effectiveness, economics of food fortification, and status of and challenges faced by large-scale food fortification programs in low- and middle-income countries (2). In addition, findings from coverage surveys of large scale-food fortification programs in 8 countries published in the *Journal of Nutrition* are summarized (3).

Methods

Osendarp et al. (2) completed a literature review of English publications listed in PubMed between 2000 and 2017. They further reviewed national reports and the gray literature, targeting non-governmental organizations known to work on fortification, and followed up of citations of interest.

For the coverage surveys of 18 programs in 8 countries (Bangladesh, Côte d'Ivoire, India, Nigeria, Senegal, South Africa, Tanzania, Uganda), Aaron et al. (3) used the Fortification Assessment Coverage Toolkit (FACT) to assess fortification of wheat flour, maize flour and edible oils. FACT was developed to standardize coverage assessments and uses three indicators to evaluate coverage and vulnerability: 1) poverty, 2) poor dietary diversity, and 3) rural residence; and three measures to assess coverage: 1) consumption of the food vehicle, 2) consumption of a fortifiable vehicle, and 3) consumption of a fortified vehicle (3). The performance of individual programs were then rated as: 1) achieving overall coverage $\geq 50\%$, 2) achieving coverage of $\geq 75\%$ in at least 1 vulnerable group, and 3) achieving equity coverage for at least 1 vulnerable group.

Efficacy and effectiveness of food fortification

As reviewed by Osendarp et al (2), results from randomized controlled studies have consistently found that different food vehicles can have a beneficial effect on some micronutrients. Examples include a beneficial impact of iron fortified foods and iron fortified condiments on the prevalence of anemia and iron deficiency, of vitamin A fortified foods on vitamin A status, and of wheat flour fortification with folic acid on neural tube defects (NTDs).

Osendarp et al (2) also reviewed the effectiveness of food fortification programs, and concluded that the reduction of deficiencies in multiple micronutrients and associated adverse health consequences has been attributed to various successful national fortification programs. For example, the mandatory fortification of wheat flour with folic acid resulted in a dramatically reduced rate of NTDs in the United States and other countries. The mandatory addition of vitamin D to milk in Canada eliminated rickets among children. Salt iodization started in Switzerland and the United States and is now implemented successfully in many low and middle income countries and resulted in the reduction of the goiter prevalence globally. Vitamin A fortification of sugar has been implemented in several countries in Latin America and has led to the reduction of vitamin A deficiency. A recent review of 13 national programs concluded that the addition of iron to wheat flour resulted in a reduction of the prevalence of low ferritin in women but not in children in surveys comparing the iron status before and at least 12 months after the introduction of the fortification program (4). Rice fortification differs from other staple foods, because the grains have to be fortified directly instead of the flour. Although this was initially considered a challenge, its efficacy has been proven and programs are implemented in Japan, Costa Rica and several other countries. However, to date little is known about the effectiveness of rice fortification.

Economics of food fortification

Food fortification is frequently determined as one of the most cost-effective public health interventions to address nutritional deficiencies. The cost-effectiveness depends on the country and the micronutrient. For example, iron fortification has been estimated at 22 USD per disability adjusted life year (DALY) in East Africa and at 140 USD in Latin America (5). Similarly, the benefit-cost ratio depends on the context, and factors such as trends of the micronutrient deficiency(ies), food vehicle, and fortificant. Consistently, the benefit-cost ratio of micronutrient fortification is ranked high among other public health interventions. For example, iron fortification has a high benefit-cost ratio of 8.7:1 in countries with high burden of anemia and salt iodization has a benefit-cost ratio of approximately 30:1 (6).

Overview of current large-scale food fortification programs

In recent decades much effort was dedicated to national food fortification programs. In 2017, 75 countries (and the Punjab province in India) had mandatory legislation to fortify wheat flour, 16 countries to fortify both wheat and maize flour and 1 country to fortify maize flour with iron and folic acid (2). An additional 5 countries fortify at least half of their industrially milled wheat flour with iron and/or folic acid voluntarily. However, one of the main challenges to reach a high coverage of the

fortification program, is that many population groups consume locally produced maize meal and wheat flour. Small mills in villages and small-scale hammer mills are particularly common in Africa, where large quantities of locally produced flours remain unfortified.

Only 1% of the industrially milled rice is fortified with micronutrients. In 2017, 8 countries had mandatory rice fortification, and an additional 3 countries have large-scale voluntary rice fortification programs.

Salt iodization is mandatory in many countries and there is strong evidence of the beneficial impact on the population iodine status. While there were 110 countries considered iodine deficient in 1993, only 19 countries were considered iodine deficient in 2017 (7).

Vitamin A is added to sugar primarily in Latin American countries and to oil in African and Asian countries, although some countries fortify both sugar and oil with vitamin A. Large-scale fortification programs of edible oils are currently implemented in 50 countries, of which over half are mandatory and 8 of these programs are led by industry.

Assessment of 18 large-scale food fortification programs

Using FACT, Aaron et al (3) found that the achieved coverage ranged widely in 18 programs in 8 countries (Bangladesh, Côte d'Ivoire, India, Nigeria, Senegal, South Africa, Tanzania, Uganda) and depended on the type of food vehicle and the country. An overall program coverage of $\geq 50\%$ was achieved for wheat flour by Senegal and for maize flour by South Africa only. For edible oils, an overall program coverage of $\geq 50\%$ was achieved by three countries, namely Côte d'Ivoire, Tanzania and Uganda. Bangladesh achieved the highest consumption of fortifiable oil (88.4%). Lastly, the programs were judged based on 3 performance criteria 1) raw coverage of $\geq 50\%$, 2) $\geq 75\%$ of the proportion of vulnerable households were covered by the program, and 3) the ratio of the coverage of vulnerable households to the coverage of non-vulnerable households ≥ 1). However, only 2 programs (Côte d'Ivoire for wheat flour and South Africa for maize flour) of the 18 large-scale food fortification programs met all 3 criteria.

The main program bottlenecks were a poor choice of the food vehicle and failure to fortify a fortifiable vehicle (i.e. the food was not fortified). Aaron et al (3). highlighted the following 4 key lessons learnt: 1) the potential impact depended on the appropriate choice of the food vehicle to be fortified and on the consumed proportion of the food that was fortified, 2) the fortification program should be designed in response to the magnitude and distribution of inadequate intake and deficiency and consumption of fortifiable foods, and the food fortification program should be coordinated with other micronutrient intervention strategies, 3) effective quality control was critical and required capacity strengthening, resources, governance and political commitment, and 4) periodic reviews of the assumptions regarding dietary patterns and micronutrient deficiencies were important to ensure safe and effective programs.

Other factors known to be critical for the success of a fortification program are the multisectoral involvement that include the government, private sector, international organizations, civil society and academic groups to generate evidence, setting standards, ensure legislation and align the national

nutrition policies, ensure quality assurance and quality control (2). Developing effective monitoring systems and tools for quality control requires resources and an understanding of the different pathways that lead to effective coverage. Insufficient funding are often identified as limiting adequate quality control.

Remaining challenges of large-scale food fortification

Although large-scale food fortification programs are implemented in an increasing number of countries using different food vehicle, there is inadequate evidence regarding the impact of food fortification on public health outcomes, such as growth, cognitive development, morbidity and mortality. Thus research is needed to assess the effectiveness of programs to improve functional health outcomes of micronutrient deficiencies.

Additional issues are the accessibility and equity of food fortification programs. A common criticism is that large-scale food fortification programs may not be accessible by the one most in need. Thus, it is important to assess programs based on the “effective coverage”. While different definitions are used to assess the effectiveness of program coverage, they all have the common understanding that coverage by itself does not provide adequate information regarding the actual or potential impact of a program. For example, the coverage survey using FACT described above attempted to assess this by defining 3 performance criteria, of which the second criteria was the proportion of vulnerable households that were covered by the program, and the third criteria was the ratio of the coverage of vulnerable households to the coverage of non-vulnerable households (3). Another group working on an economic optimization model defines effective coverage as the proportion of the population that moves from deficient to sufficient micronutrient status due to the fortification program (8, 9).

NNA Editor’s Comments

Large-scale fortification programs are considered a promising strategy in regard to their cost-effectiveness and benefit-cost ratio. Indeed, the Copenhagen Consensus Center recently invited experts to conduct an extensive analyses of the benefit-cost ratio of 85 policy interventions considered promising for Haiti. Included interventions ranged from nutrition to electricity, justice, poverty alleviation and education among others; and iron fortification of wheat flour had the highest benefit-cost ratio of all reviewed interventions (10). While much progress has been achieved in implementing and scaling up food fortification programs, several challenges remain to ensure effective coverage, adequate quality control/quality assurance and assessment of impact and effectiveness.

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