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Food Fortification
Global Mapping Study
2016

Technical assistance for strengthening capacities in food fortification

Developed by

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Food Fortification Global Mapping Study 2016

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Acronyms

2FAS	Food Fortification Advisory Services
ADB	Asian Development Bank
AISPA	Afghan Iodized Salt Producers Association
ASEAN	Association of Southeast Asian Nations
ASPMSA	Afdera Salt Producers Mutual Support Association
BMGF	Bill & Melinda Gates Foundation
BCC	Behavioural Change Communication
CDC	Center for Disease Control and Prevention
CGIAR	Consultative Group on International Agricultural Research
CI	Confidence Intervals
CIAT	International Centre for Tropical Agriculture
CIFF	Children Investment Fund Foundation
CIS	Commonwealth of Independent States
CLM	Cellule de Lutte Contre la Malnutrition
DALY	Disability-Adjusted Life Year
DFID	Department for International Development
EAR	Estimated Average Requirement
EC	European Commission
ECOWAS	Economic Community of West African States
EQUIP	Ensuring the Quality of Urinary Iodine Procedures
FACT	Fortification Assessment Coverage Tool
FFI	Food Fortification Initiative
FNB	Food and Nutrition Bulletin
GAIN	Global Alliance for Improved Nutrition
GMP	Good Manufacturing Practice
HACCP	Hazard Analysis and Critical Control Point
HKI	Helen Keller International
IAOM	International Association of Operative Millers
ICCIDD	International Council for Control of Iodine Deficiency Disorders
ID	Iodine Deficiency
IDD	Iodine Deficiency Disorder
IFPRI	International Food Policy Research Institute
IGN	Iodine Global Network
IRLI	International Resource Laboratories for Iodine
KAP	Knowledge, Attitudes and Practices
LMIC	Low and Middle-Income Country
M&E	Monitoring and Evaluation
MI	Micronutrient Initiative

MICS	Multiple Indicator Cluster Surveys
MIS	Management and Information System
MND	Micronutrient Deficiency
MoPH	Ministry of Public Health
MOST	USAID Micronutrient Program
MSG	Monosodium Glutamate
MT	Metric Tonne
NAS	Nutrition Advisory Services
NFA	National Fortification Alliance
NGO	Non-Governmental Organisation
NTD	Neural Tube Defects
PFS	Partners in Food Solutions
PHC	Project Healthy Children
QA/QC	Quality Assurance/Quality Control
R&D	Research and Development
RNI	Recommended Nutritional Intake
RR	Risk Ratio
SUN	Scaling Up Nutrition
UEMOA	West African Economic Monetary Union
UIC	Urinary Iodine Concentration
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
USI	Universal Salt Iodisation
VAD	Vitamin A Deficiency
VMNIS	Vitamin and Mineral Nutrition Information Service
WASH	Water, Sanitation and Hygiene
WFP	World Food Programme
WHA	World Health Assembly
WHO	World Health Organization
WIC	Women, Infants and Children
WRA	Women of Reproductive Age

Executive summary

Introduction

The European Commission (EC) is committed to supporting partner countries tackle undernutrition through evidence-based interventions. This commitment is documented in the EC's Action Plan on Nutrition adopted in 2014[1] and the underlying European Union (EU) Policy Framework on Enhancing Maternal and Child Nutrition in External Assistance that was published in 2013.[2]

Specifically, the EC Action Plan on Nutrition sets out three strategic priorities: (1) to enhance mobilisation and political commitment to nutrition; (2) to scale up actions at the country level; and (3) to contribute to the generation of knowledge for nutrition.[3] The overall objective of the Action Plan is to contribute to reducing the number of stunted children under the age of 5 years by at least 7 million by the year 2025.[4] In order to contribute to the reduction of stunting as per Sustainable Development Goal 2 – and in alignment with the Scaling Up Nutrition (SUN) '1,000 days' approach[5] and the World Health Assembly's (WHA) 2025 Global Targets on Maternal and Child Nutrition including the targets on reducing iron deficiency anaemia[6] – the EC has decided to increase its support to further development and scaling-up of food fortification, as one of the elements under the EC nutrition portfolio that contributes to reducing micronutrient deficiencies.

As a first step towards scaling up engagement and investment for food fortification, in December 2015, the EC established the Food Fortification Advisory Services (2FAS).[7] The focus of 2FAS is on strengthening institutional and technical capabilities in partner countries in relation to food fortification. This includes evidence-based policy guidance and capacity development to support the formulation of policies and programmes related to food fortification. More specifically, 2FAS provides: (1) support on identification, formulation, monitoring and evaluation of pilot projects related to food fortification. These will ensure that outcomes are sustainable, ethical, coherent with other interventions, and that the poorest and most vulnerable are benefiting; and (2) support to food fortification as a global approach, including exploiting good practices and sharing them with international partners. This comprises technical and institutional assistance, including evidence-based policy guidance and capacity development in partner countries, to support the formulation of policies and programmes related to food fortification.

2FAS has started off in 2016 with the elaboration of a common framework on Food Fortification and the undertaking of a Global Mapping exercise on food fortification (this report). The main areas of work for 2FAS across 2017 and for coming years are as follows:

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[1] EC (2014) Action Plan on Nutrition, SWD (2014) 234, 3 July, https://ec.europa.eu/europeaid/sites/devco/files/swd-action-plan-on-nutrition-234-2014_en.pdf
[2] EC (2013) Enhancing Maternal and Child Nutrition in External Assistance: An EU Policy Framework, *SWD* 72, 12 March; *SWD* (2013): 104, 27 March, http://ec.europa.eu/europeaid/documents/enhancing_maternal-child_nutrition_in_external_assistance_en.pdf
[3] EC (2014) Action Plan op. cit.
[4] This target forms about 30% of the additional reduction on top of the already downward trends in many countries that is required to achieve the WHA target of a 40% reduction worldwide.
[5] The SUN 1000 days' approach focuses on prevention of stunting through improving the quality of the women's diets during pregnancy and lactation and of young children 6–24 months of age.
[6] The WHA targets stunting, anaemia, low birth weight, wasting, overweight and exclusive breastfeeding.
[7] Landell Mills and the Global Alliance for Improved Nutrition (GAIN) comprise the consortium delivering 2FAS.

- Development and management of a (small) research portfolio on food fortification.
- Preparation of a set of country profiles on food fortification accompanied by a set of national capabilities profiles in relation to food fortification. The intention is to use these profiles as entry point for follow-up engagement for capacity development and technical support to partner countries, including public and private stakeholders. This is targeted at a selected number of countries where nutrition is a focal area in the EC development cooperation.
- Technical assistance to the EU Delegations and the EC's implementing partners on food fortification, in particular but not limited to the awarded contracts through the 2016 Call for Proposals on Inclusive and Sustainable Value Chains and Food Fortification (EuropeAid/151093/DH/ACT/Multi).

As one of the first elements of work for 2FAS, the EC commissioned a global mapping of food fortification to serve as reference documentation. The aim of the mapping is to advance understanding on the main features of food fortification including key strategic concerns, operational challenges, compliance issues, coverage, consumption trends, as well as impact on the reduction of micro-nutrients deficiencies (MNDs). This builds partially on the Global Summit on Food Fortification that was held in Arusha in September 2015.[8]

For this first edition of the document published early 2017 it was decided to focus on large-scale fortification of staple foods and condiments, and biofortification. The next version of the document will also include a section on special (fortified) products for nutrition target groups (complementary foods for young child feeding and other products) and home-level fortification.

This Global Mapping study has two main components:

a) An analysis of the overall global status and results of large-scale food fortification and biofortification. This presents an overview of the main players and programmes; key successes, challenges and gaps; monitoring and surveillance approaches and results, and some cues for future programming; and impacts on micronutrient status.
b) An analysis of each of the main vehicles for food fortification. This part combines an overview of the global approaches and achievements worldwide plus some reflections on national-level experiences with main focus on the period 2000–15.

It is anticipated that this Global Mapping on Food Fortification will help the EC, partner countries, implementing agencies and policy-makers improve programming and coordination in the nutrition and food sectors, and contribute to expanding, improving and sustaining fortification programmes. This will help ensure fortification programmes achieve public health objectives and support relevant sustainable development goals.

[8] Source: http://www.sightandlife.org/fileadmin/data/Magazine/2016/Suppl_to_1_2016/FutureFortified.pdf (accessed 30 September 2016).

Overview of key findings

This executive summary presents an overview of key findings within the 2016 Global Mapping Food Fortification Study together with some cues for future programming of support to food fortification.

1. **The spectrum of support in the area of food fortification is wide; it includes a range of interventions at different steps within the food value chain and covers a variety of micronutrients and foods. If well designed and properly implemented, the various options for food fortification can make a large contribution to improving public health outcomes.**

While not relevant in every context, especially where access to fortifiable foods is lacking or when the level of micronutrient deficiency or other concurrent morbidities warrants more targeted strategies, food fortification can be an effective tool within the broader food, nutrition, health and development agenda to address malnutrition, and in particular the issue of hidden hunger.[9] Improving micronutrient intake through food fortification programmes can lead to improved cognitive and physical development of children, work capacity of adults and economic development of nations.[10, 11, 12]

National, large-scale food fortification programming has been in place for roughly one hundred years, starting with Switzerland's salt iodisation programme, and spreading throughout more developed countries. Low and middle-income countries (LMIC) began to adopt this intervention at an accelerated pace only in the last 20 years. There has been quick scaling-up, with over 140 countries now implementing national universal salt iodisation (USI) programmes, 85 countries mandating at least one kind of cereal grain fortification with iron and folic acid, and over 40 countries mandating the fortification of edible oils, margarine and ghee with vitamin A and/or vitamin D.[13] Many other countries have also started to scale up condiment fortification, including for fish and soy sauce, bouillon cubes and other seasonings.

There is strong evidence from developed countries that food fortification is highly effective in addressing micronutrient deficiencies, especially in the case of mandatory programmes. The evidence base on health impact of food fortification in LMIC still needs to be established. (This does not apply generally to salt iodisation programming, the effectiveness of which is well documented, including in this mapping report.)

There are a handful of research initiatives under way to fill this gap, most notably the meta-analysis of impact of food fortification in LMIC completed by the Sick Kids Center for Global Health in 2015. The results of this meta-analysis were presented at the Arusha Summit on Food Fortification in September 2015 and are expected to be published in 2017. Findings include increased relevant serum micronutrient concentrations and positive impacts on functional outcomes in women and children in LMIC, including for anaemia [risk ratio (RR): 0.64 (95% CI: 0.54–0.75)], goitre [RR: 0.57 (95% CI: 0.41–0.79)], and neural tube defects [RR: 0.62 (95% CI: 0.51–0.75)].

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9 In most LMICs this primarily refers to anaemia, vitamin A deficiency and iodine deficiency. Depending on dietary patterns and main staple foods, hidden hunger, however, can also entail deficiencies for other micronutrients such as the B-complex vitamins and zinc.

10 Allen, L, B de Benoist, O Dary and R Hurrell (2006), *Guidelines on food fortification with micronutrients*, Geneva: WHO/FAO, Geneva.

11 Bhutta, ZA et al (2013) Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost?, *Lancet,* http://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736%2813%2960996-4.pdf

12 GAIN (2015) *Fortifying our Future, A Snapshot Report on Food Fortification*. Geneva: GAIN.

13 Luthringer, CL, et al. (2015) Regulatory monitoring of fortified foods: Identifying barriers and good practices. *Global Health Science and Practice* 3(3): 446–61.

In 2008, the Copenhagen Consensus on malnutrition and hunger selected food fortification as one of the 'best-buys' among 30 development interventions considered for addressing ten great challenges facing global development.[14] Food fortification, however, should not be a stand-alone intervention; rather it needs to be seen as a complement to long-term nutrition-specific and nutrition-sensitive strategies to strengthen food systems, increase nutritional diversity in people's diets, and address nutrient deficiencies through national systems.[15]

Box ES.1: Cost-effectiveness of fortifying food with folic acid, iodine and vitamin A

A number of cost comparisons have been conducted looking at fortifying foods with folic acid and the healthcare savings from preventing neural tube defects (NTDs) such as spina bifida.[16] South Africa was the first to estimate the costs of treating infants with spina bifida and reported a net savings of US$ 2.8 million (€ 2.65 million) if prevented through folic acid fortification, and a benefit:cost of 30:1.[17] Chile calculated a net savings of US$ 2.3 million (€ 2.18 million) and a benefit:cost of 8:1.[18] For iodisation of salt a benefit:cost ratio has been estimated at 30:1. Lastly, the cost-effectiveness of staple foods with vitamin A was estimated at US$ 81/disability-adjusted life years (DALY) (€ 76).[19]

2. The comparative advantage of food fortification is that it is delivered through the food system and increases the nutritional quality of existing diets and consumption patterns.

Food systems in many LMIC, often fail to sufficiently deliver foods rich in micronutrients. This can be due to issues of availability, access, affordability and utilisation.[20] Food fortification can be one of the measures to improve the quality of the diet, among other nutrition-specific and nutrition-sensitive efforts to bring about desirable changes in food consumption patterns. Using existing food delivery systems, food fortification is part of a package of evidence-based interventions that can help to prevent micronutrient malnutrition among entire populations.[21] It works when there is a clear need, a (bio)fortifiable vehicle, and good entry points for collaboration within the food production and processing chain.

Nutrients can be added to foods at different points along the value chain from production, food processing and finally to consumption. Nutrient contents can be improved through biofortification (plant breeding) or by adding nutrients to soils, fertilisers or water supplies to crops. At the processing stage (e.g. at flour mills and oil refineries) micronutrients can be effectively added to the food vehicle prior to packaging and marketing. At the household and individual levels, home-based fortification with micronutrient powders can also be applied. A summary of each type of fortification is provided in Box 2 overleaf.

Food fortification generally utilises the existing consumption patterns within a food system. In many LMICs, there is a shift to more processed and convenience foods, which among others is related to higher urbanisation levels. This facilitates the achievement of large coverage with food fortification

[14] Horton, S, H Alderman and J Rivera (2008) Copenhagen consensus 2008. Malnutrition and hunger. Copenhagen Consensus Center.
[15] 2016 Global Panel of Agriculture and Food Systems for Nutrition: Food systems and diets: Facing the challenges of the 21st century, http://glopan.org/sites/default/files/ForesightReport.pdf (accessed 7 October 2016).
[16] Children with spina bifida have varying levels of paralysis and loss of bowel and bladder control and often undergo a lifetime of surgeries and treatments, which take a toll both emotionally and financially.
[17] Sayed, A, D Bourne, R Pattinson, J Nixon and B Henderson (2008) Decline in the Prevalence of Neural Tube Defects Following Folic Acid Fortification and Its Cost-Benefit in South Africa. *Birth Defects Research* 82: 211–21.
[18] Llanos, A, E Hertrampf, F Cortes, A Pardo, S Grosse and R Uauy (2007) Cost-effectiveness of a Folic Acid Fortification Program in Chile. *Health Policy* 83: 295–303.
[19] Horton, Alderman and Rivera (2008) Copenhagen consensus, op. cit.
[20] Global Panel (2016) Facing the challenges, op. cit.
[21] Bhutta et al. (2013) *Evidence-based interventions*, op. cit.

programmes. Food fortification can be a good solution to increase the access of marginalised populations to more nutrient-rich foods, which together with continued efforts towards more diverse and balanced food systems can contribute to improvement of dietary quality. There is no evidence that food fortification of any type has led to adverse shifts in dietary patterns that result in, for example, increased prevalence of overweight and/or obesity.

Box ES.2: Types of fortification

Mandatory or large-scale fortification: this is the addition of one or more micronutrients to foods commonly consumed by the general population such as grains, salt and condiments or edible oil. It is usually mandated and regulated by the government sector, in response to evidenced micronutrient deficiencies or where a population, or sub-population, may benefit. These efforts are typically concentrated on the organised food processing sector and large- and medium-size industries.

Voluntary or market-driven fortification is when a food manufacturer takes a profit-driven initiative to add specific amounts of one or more micronutrients to processed foods, usually voluntarily, but under government regulations or standards.

Small-scale fortification: efforts to fortify among the informal or unregistered small-scale artisanal or cottage industries.

Targeted fortification is the fortification of foods aimed at specific sub-groups to increase their intake, rather than the population as a whole, of complementary foods for infants and children, emergency feeding and special school meals for children.

Biofortification is the process whereby crops are bred to increase their nutritional value.

Home-level food fortification is also known as point-of-use, micronutrient powders, such as Sprinkles©.

3. **Biofortification and large-scale fortification programmes can make a large contribution towards improving the quality of the diet for large population groups.**

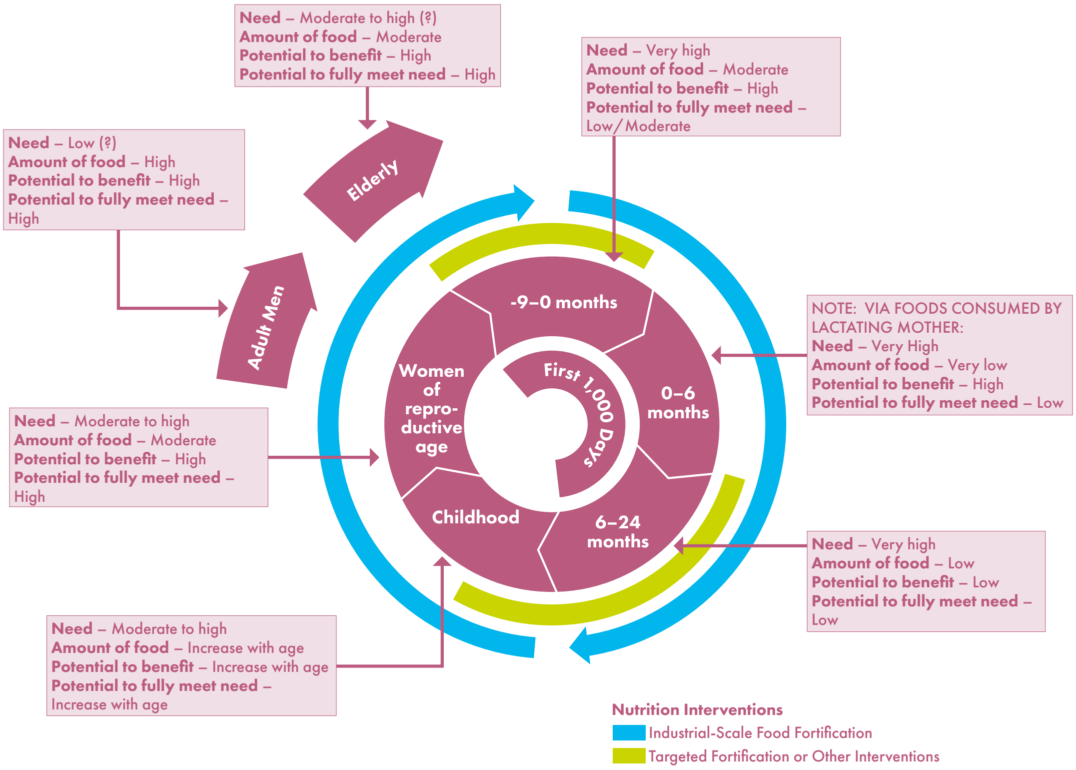
The appropriate aim of biofortification and large-scale food fortification is to shift the distribution curve of intakes at the population level rather than eliminate all deficiencies among every target group.[22] They can provide significant improvements in intakes among all population groups. This implies that these programmes can reduce the number of people within the overall population who fall in the 'deficit' category. Figure ES.1 illustrates fortification's contribution to various target groups.

Biofortification and large-scale food fortification contrast with targeted fortification or other interventions in that they can benefit various population segments through the same intervention. The relevance of such population-level interventions is first of all determined by the need for additional micronutrient intake for the population at large or one or more population segments in particular. The relevance of the programme also depends on the appropriateness of the level and type of fortificant to be added given the objectives of the programme and average per capita consumption levels of the fortified food.

The effectiveness of the intervention is determined by coverage and utilisation. The (bio)fortified-food vehicles should form part of the regular diet of the population (segment) to have any impact. In short, the (bio)fortified food vehicles need to be available, accessible, affordable and utilised, including by population groups with increased nutrition needs. Figure ES.1 describes this potential for biofortification and large-scale food fortification to benefit along the life cycle of various population groups.

[22] WHO/FAO (2006). Guidelines on Food Fortification with Micronutrients. World Health Organization/Food and Agriculture Organization of the United Nations Geneva: World Health Organization/Food and Agriculture Organization of the United Nations, 2006.

Figure ES.1: Benefits of biofortification and large-scale food fortification across the life cycle



4. **Sustainable public-private partnerships for nutrition form the basis for food fortification programmes. These partnerships should involve the government, food producers and/or processors, actors on food marketing and non-market-based delivery channels, and other actors from civil society, academia, UN and/or donors as relevant.**

One of the specific features of all types of food fortification is the important and required link between the public and private sectors as well as engagement from consumers, civil society, academia and the NGO/donor community.

Food fortification efforts require effective oversight by both the Ministry of Industry and Ministry of Health. Food control agencies also play a significant role in regulating that standards are adhered to and food safety aspects are taken good care off. In case of mandatory programmes, the government will also need to take the lead in enforcement of adherence to the standards. Biofortification programmes may have significant involvement of the Ministry of Agriculture.

National surveillance agencies, academia and even civil society groups like consumer protection agencies each have an important role to play. Thus, multi-stakeholder approaches are required to bring all relevant stakeholders to the table, so that solutions to fortified food availability, awareness and impact can be discussed and addressed holistically.

In many countries, one mechanism for addressing the multi-sectoral nature of food fortification is through the establishment of National Fortification Alliances (NFAs). These groups comprise stakeholders from a wide variety of sectors and help to coordinate and harmonise activities towards a common goal. Success factors for NFAs include shared leadership and decision-making, available budget to conduct coordination activities, and the formation of results-based short-term goals achieved through active sub-committees.[23] In other countries, other coordination mechanisms exist, such as through the SUN Movement, country-specific SUN business networks, and coalitions around a specific micronutrient (i.e. iodine or vitamin A coalitions).

In addition to national-level coordination, food fortification benefits from coordination and technical assistance from international actors, including the NGO and donor community, on good practices, priority support areas, and research gaps. Such international coordination was strengthened during the preparations for the 2015 #FutureFortified Global Summit on Food Fortification,[24] and is currently continuing in the form of a Global Fortification Technical Advisory Group.

5. Inappropriate programme design and poor compliance with standards for food fortification are major challenges that need to be addressed in order to effectively realise the potential for impact at population level through large-scale food fortification programmes.

Where large-scale food fortification programmes in LMIC have not been shown to have effective impact on micronutrient status data, it often been due to one or more of the following explanations:

- Type and concentration of fortificant added to the fortified food are inappropriate and/or not based on a good estimate of the per capita intake of the fortifiable type of the product.
- Insufficient levels of compliance with the national standards for food fortification.
- The production and/or sales levels of adequately fortified product are not sufficient to meet per capita consumption needs of the vast majority of the population.
- The efforts for social marketing of the product have been inadequate and/or the implementation period of the fortification programme too short to create enough uptake among the population.

Fortified foods are considered credence goods, since consumers cannot easily evaluate them for their quality, safety or micronutrient content against non-fortified counterparts. Therefore, mandatory legislation along with inspections, audits and enforcement through regulatory monitoring, and/or strong social behaviour change communication efforts in case of voluntary food fortification programmes are critical. Such efforts enable the consumers to better exercise their right to nutritious foods through accessing a good quality and adequately fortified product.

In addition to the need for clear legislation and a legal basis for fortification, fortified-food producers face critical challenges and capacity gaps in ensuring their products meet standards through their own quality assurance and quality control systems, and national governments face challenges in identifying and holding producers accountable to this end. This is evidenced by industry data from 15 national mandatory fortification programmes, which indicate that less than half (47%) of collected samples were compliant against relevant standards.[25] Regulation on paper is not enough to ensure fortification compliance without real incentives and strong and consistent consequences, which drive under-fortified foods out of markets.

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[23] Rehman, H et al. (2016) National Fortification Alliances (NFAs): Program guidance based on lessons learned from nine countries. Micronutrient Forum 2016 Abstract.
[24] Source: http://www.sightandlife.org/fileadmin/data/Magazine/2016/Suppl_to_1_2016/FutureFortified.pdf (accessed 30 September 2016).
[25] Luthringer et al. (2015) Regulatory monitoring op. cit.; GAIN (2016) Food fortification compliance monitoring, Internal GAIN report.

6. Monitoring and surveillance of national food fortification programmes is insufficient and needs to be strengthened at both national and global levels.

For both biofortification and large-scale food fortification programmes, achievement of impact in terms of reduction of micronutrient deficiencies requires prudent delivery, diligent monitoring for quality and safety, and consumption by a significant portion of the population over a sufficient period of time.

Effective data collection on coverage and evidence of impact by national governments or other actors is still scarce in LMIC. Routine coverage data has been collected for salt iodisation only. Very few other national programmes on food fortification systematically report coverage and quality data. There are inherent challenges to routinely collecting data on micronutrient deficiency. Similarly, data on fortified food quality, coverage and impact are scarce and challenging to collect. Data sets that are collected are often one-time information, rather than tracked over time, and not regularly assessed with data on progress of food fortification programmes to determine associations between coverage and reductions in micronutrient deficiencies at a population level.

It is because of this paucity of information that GAIN developed a Fortification Assessment Coverage Toolkit (FACT) and completed a series of FACT coverage surveys. These surveys were conducted from 2013 to 2015[26] and assessed coverage (including equity aspects) of large-scale fortification programmes including oil, wheat and maize flour in eight LMIC. They came up with specific recommendations on how to improve these programmes. It is imperative that FACT surveys are done in other countries as well.

As large-scale food fortification programming has gone to global scale, there are a number of global tracking mechanisms, usually oriented on specific micronutrients or vehicles used in food fortification programmes, see Box 3 below. Further alignment of the various global databases on micronutrient deficiencies and national food fortification programmes is required to establish a strong global information repository that can be drawn upon for global and national-level policy development and programming on food fortification.

While the Global Nutrition Report and SUN Movement have represented broad efforts to strengthen global data systems and collate the information needed to gain understanding on nutritional gaps, neither focus specifically on fortification. In addition, there is a fragmentation of food fortification-related data housed within different organisations with little consolidation. Food fortification tends to be vertically implemented based on the food vehicle being fortified and there is a range of content and presentation formats across such organisational databases, which limit comparability of findings across geographies and over time.

To address these challenges, several organisations[27] have recently agreed to improve transparent reporting and utilisation of data to assess the state of fortification globally. A working group has been established, and it is intended to launch a first iteration of a Global Repository on Food Fortification over the course of 2017. This repository will house global and national data on fortification status, including legislation and standards, quantities of production and imports, per capita consumption of fortifiable foods, quantity and proportion of adequately fortified foods, expected and assessed population coverage, and impact indicators with timing of data collection synced with status of fortification programmes. Where possible, the information will be disaggregated by various population groups and income strata.

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[26] Aaron, GJ, Friesen, VM, Garrett, GS, Neufeld, LM, Myatt, M. (2016) Coverage of large-scale food fortification of edible oil, wheat and maize flours varies greatly by vehicle and country but is consistently lower among the most vulnerable: results from coverage surveys in eight countries. *J Nutr*. Manuscript under review.

[27] GAIN, FFI, IGN, Micronutrient Forum and BMGF with inputs from WHO.

Box ES.3: Relevant nutrition and food-related databases and key reports

There are a range of databases and reports which are tracking key indicators related to nutrition, many of which are summarised below. Currently for fortification there are no commonly agreed indicators and repository where data is routinely stored. Efforts are under way to establish a Global Repository for Food Fortification in 2017.

- **WHO Global Health Observatory – Global Database on Child Growth and Malnutrition:** Compiles standardised child growth and malnutrition data from national nutritional surveys with an explicit focus on monitoring progress towards the Sustainable Development Goals
- **WHO Global Database on the Implementation of Nutrition Action (GINA):** To systematically retrieve and summarise data on vitamin and mineral status of populations globally
- **UNICEF Database on Iodized Salt:** tracks population coverage and impact of iodised salt
- **Iodine Global Network (IGN) Global Iodine Scorecard:** Tracks median urinary iodine concentration (UIC) among school-age children
- **UNICEF NutriDash:** Tracks the reach and progress of some nutrition programmes and how these efforts are affecting nutritional status
- **FFI Country Profiles and Global Progress:** Tracks the legislative status of national wheat and maize flour and rice fortification programmes, report on population status of indicators related to the impact of fortified wheat flour, maize flour, and rice
- **GAIN Fortification Assessment Coverage Tool (FACT) datasets:** For select countries, models the contribution of fortifiable and fortified foods to all population groups including target groups
- **Global Nutrition Report** (Not actually a database, but a useful annual report on global status of nutrition)
- **SUN Nutrition Tracking:** Tracks SUN countries' progress including prevalence of under-5-year-old's stunting, wasting and overweight, low birth weight, exclusive breastfeeding, anaemia in women, overweight/obesity and elevated blood glucose levels in adults.

7. Further support for food fortification from the EC can be effectively deployed along three strategic priorities within the EC Action Plan on Nutrition.

The Global Mapping Report identifies a range of ways on how the EC can help support nutrition programming through food fortification. Based on the structure of the EC Action Plan on Nutrition and its three strategic priorities, we make the following general recommendations:

- EC strategic priority 1 in nutrition – enhancing mobilisation and political commitment for nutrition – can be applied to food fortification (including biofortification) through the mobilisation of 2FAS and other EC technical assistance with the aim to support advocacy to governments. This may include for example, country-specific analysis on how to appropriately situate food fortification into national plans, policies, strategies and budgets. The EC can lead on the provision of advisory services on the type and quantity of human and financial resources required, and advocate for policy commitments to be made to ensure food fortification is delivered effectively.
- Under EC strategic priority 2 – **scale-up actions at country level** – the EC has two major entry points for engaging with food fortification and biofortification: (1) institutional strengthening and capacity development to key stakeholders; and (2) support to the EC pilot projects awarded in eight African countries in 2016 through a global Call for Proposals, and to other food fortification projects and programmes supported by the EC. For the former, the EC 2FAS will provide national-level assistance and deliver (a) country profiles on food fortification; (b) profiles on national capabilities in relation to food fortification; and (c) engage in capacity development of key national institutions

involved in building, improving and sustaining national fortification efforts. For the latter, the EC 2FAS will provide support to the pilot projects and other EC programmes and projects on food fortification to review draft project documents, prepare M&E snapshots, and provide other technical assistance as required.

- Under EC strategic priority 3 – **contribute to the generation of knowledge on nutrition** – the EC can help respond to known gaps in fortification evidence concerning the effectiveness and cost-efficiency of the various food fortification approaches in LMIC. A second area of work for which the EC is well placed is operational research on multi-sectoral approaches for food fortification within specific regional and national/local contexts in relation to the prevailing food systems (agricultural production, food processing and delivery mechanisms). This work can feed into global knowledge sharing platforms, such as the Global Nutrition Report and SUN. And third, it could be considered under this heading to support national capacity to manage data and information, to assist national government to fill gaps in evidence-based policy. For example, the EC currently supports countries by maximising the use of existing information through the use of National Information Platforms for Nutrition and this can be leveraged for improved micronutrient intervention tracking.

Table ES.1: National food fortification programmes: actors and outcomes

Actors	Outcomes
Phase 1: Problem / impact assessment (*reflective monitoring*)	
Government Nat. Alliance Support agencies	a. Regularly updated **MND prevalence data** (incl. among specific target groups) are available and used as input for design & management of FF programmes
	b. Regularly updated data on **per capita consumption of fortified/fortifiable foods (with calculation of % of RNI for key micronutrients on average coverage through consumption of these foods)** are available and used as input for goal setting and monitoring of the targeted contribution to RNIs through FF
Phase 2: Foundation building (*initiation*)	
National alliance Government Private sector Civil society Support agencies	a. **National-level agreement on existing/potential contribution of FF** through market-based and other targeted/subsidised delivery approaches, alongside other interventions on MND reduction
	b. Established and well-functioning **FF Partnerships / Alliances** that include public and private sector actors, civil society, and other key actors in the country on FF
	c. Targeted **advocacy** on FF and the potential/current role of public and private sectors to address MNDs
	d. Functioning mechanism(s) for **addressing key gaps and bottlenecks for FF programmes,** among public sector and private sector actors, and others as applicable, taking into account specific country context conditions
Phase 3: Set-Up & Launch (*adaptive planning)*	
National alliance Government Private sector Support agencies	a. **FF strategies and programme goals**, incl. (additional) MN intake targets through FF are set and accompanied by a programme **monitoring and surveillance framework** to track results over time
	b. Appropriate **FF standards and legislation** is in place, with well-functioning **auditing and inspection mechanisms** including adequately trained and equipped government staff (Food control; Health department)
	c. **SBCC strategy** is developed and in place to create acceptance and/or demand for FF
	d. **Delivery strategy** is developed for FF to reach out to the general population and/or to targeted groups (as necessary)
Private sector Support agencies	e. Management and staff levels from involved food industry agencies have **knowledge and skills on FF production/distribution/retail**
	f. **FF equipment** is procured, appropriately installed, functioning and regularly maintained
	g. **Sustainable premix procurement** channels and mechanisms are established and functioning
	h. Commercial strategy for **FF marketing & consumer education** developed and in place
	i. **Importation/production and delivery of FF are initiated** and implemented as per plan
Phase 4: Scale-up & delivery (*collaborative action*)	
Private sector Government Support agencies	a. **Internal and external QA/QC and regulatory monitoring of compliance with standards**
Private sector	b. **Importation and/or production of FF are expanded** to achieve coverage patterns as per plan
	c. **Delivery, access and coverage of FF is expanded** and sustained through market channels and appropriate promotion / marketing efforts
Government Support agencies	d. **Sustained coverage among selected population groups** through specific additional delivery mechanisms and targeted SBCC as needed
Government National alliance Civil society Support agencies	e. **FF programme quality, coverage and consumer acceptance and use is** tracked through ongoing monitoring systems as input for decision-making and for accountability purposes

Résumé

Introduction

La Commission Européenne (CE) s'est fortement engagée aux côtés des pays partenaires dans la lutte contre la malnutrition, à travers des interventions reposant sur l'analyse de données factuelles. Cet engagement s'est traduit par l'adoption en 2014[28] du Plan d'Action CE sur la Nutrition, dans le prolongement du Cadre stratégique de l'Union Européenne (UE) pour l'amélioration de la nutrition maternelle et infantile dans le contexte de l'aide extérieure, publié en 2013.[29]

Le Plan d'Action de la CE sur la Nutrition définit en particulier trois priorités: (1) renforcer la mobilisation et l'engagement politique autour des enjeux de la nutrition, (2) intensifier les actions au niveau national, et (3) contribuer à la generation de connaissances au sujet de la nutrition.[30] L'objectif global du Plan est de contribuer à réduire d'au moins sept millions, d'ici 2025,[31] le nombre d'enfants de moins de cinq ans souffrant d'un retard de croissance. Afin de contribuer au retard de croissance selon l'Objectif de Développement Durable N°2 – une démarche dans laquelle s'inscrivent également l'approche SUN[32] (Renforcement de la Nutrition) « 1000 jours » et les cibles mondiales adoptees en 2015 par l'Assemblee Mondiale de la Sante pour ameliorer la nutrition chez la mere, le nourrisson et le jeune enfant, notamment celle relative a la lute contre l'anemie, notamment celle relative à la lutte contre l'anémie[33] – la CE a récemment décidé de renforcer son soutien au développement et au renforcement de l'enrichissement alimentaire. Celui-ci constitue l'une des composantes du portefeuille « Nutrition » de la CE contribuant à lutter contre les carences en micronutriments.

L'établissement du Service de Conseil pour l'Enrichissement Alimentaire (Food Fortification Advisory Services*, 2FAS*[34]) en Décembre 2015, à l'initiative de la CE, marque la première étape de cette démarche visant à amplifier l'engagement et les investissements en faveur de l'enrichissement des aliments. L'objectif du 2FAS est de renforcer les capacités institutionnelles et techniques des pays bénéficiaires en termes d'enrichissement des aliments. Ses principaux leviers d'action consistent a fournir des conseils stratégiques bases sur des données factuelles, ainsi que de renforcer les capacités des differents acteursafin de soutenir la formulation de politiques et programmes relatifs à l'enrichissement des aliments. Le 2FAS fournit en particulier: (1) un soutien à l'identification, la formulation, le suivi et l'évaluation de projets pilotes d'enrichissement des aliments. Il s'assure notamment que les résultats sont durables, éthiques et cohérents avec d'autres interventions, et que le projet bénéficie concrètement aux populations les plus pauvres et vulnérables. (2) Un soutien à l'enrichissement alimentaire en tant qu'approche mondiale, notamment en menant des recherches

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[28] CE (2014), Plan d'Action pour la Nutrition, SWD (2014) 234, 3 Juillet
[29] CE (2013) *Améliorer la nutrition maternelle et infantile dans le cadre de l'aide extérieure: un cadre stratégique de l'UE*, SWD 72, 12 Mars, *SWD* (2013): 104, 27 Mars, http://ec.europa.eu/europeaid/documents/enhancing_maternal-child_nutrition_in_external_assistance_en.pdf
[30] CE (2014) Plan d'Action, op. cit.
[31] Cet objectif représente environ 30 % de la réduction supplémentaire, s'ajoutant à la tendance déjà à la baisse dans la plupart des pays, nécessaire pour atteindre l'objectif de l'Assemblée Mondiale de la Santé soit 40 % de baisse à l'échelle mondiale.
[32] L'approche SUN (*Scaling Up Nutrition*, Renforcement de la Nutrition) en 1000 jours cherche à prévenir les retards de croissance en améliorant la qualité du régime alimentaire des mères au cours de la grossesse et de la lactation, et la nutrition des enfants de 6 à 24 mois.
[33] Les cibles de l'AMS concernent les retards de croissance, l'anémie, l'insuffisance pondérale à la naissance, l'émaciation, le surpoids et l'allaitement exclusif.
[34] Landell Mills et GAIN (*Global Alliance for Improved Nutrition*, Alliance Mondiale pour l'Amélioration de la Nutrition) forment le consortium chargé de la mise en œuvre du 2FAS.

stratégiques et opérationnelles répondant aux déficits actuels de connaissances, et en contribuant au partage et a la mise en oeuvre des bonnes pratiques par les parties prenantes au niveau international.

Le 2FAS a débuté ses activités en 2016 avec l'élaboration d'un cadre commun sur l'enrichissement alimentaire et le lancement d'un exercice de cartographie mondiale de l'enrichissement alimentaire (le présent rapport). Les principaux axes de travail du 2FAS pour 2017 et les années à venir seront:

- Développement et gestion d'un portefeuille de recherche (de petite ampleur) sur l'enrichissement alimentaire.
- Préparation d'un ensemble de profils pays relatifs à l'enrichissement des aliments, accompagnés d'un état des lieux des capacités nationales. L'intention est d'utiliser ces profils comme point d'entrée pour la poursuite de l'engagement en faveur du développement des capacités et de l'assistance technique. Cette mission est ciblée sur un ensemble de pays où la nutrition est un enjeu central de la coopération européenne pour le développement.
- Assistance technique aux délégations de l'UE et aux partenaires de projet de la CE sur l'enrichissement des aliments, en particulier, mais non exclusivement, les titulaires des contrats passés à la suite de l'appel d'offres de 2016 « Chaînes de Valeur Inclusives et Durables et Enrichissement Alimentaire » (EuropeAid/151093/DH/ACT/Multi).

L'un des premiers projets confié par la CE au 2FAS est la réalisation d'une cartographie mondiale de l'enrichissement alimentaire, qui servira de document de référence pour les points focaux Nutrition au sein de la DEVCO C1 et des Délégations UE, mais également au-delà de la CE pour un public plus large. Cette cartographie doit permettre une meilleure compréhension des caractéristiques essentielles de l'enrichissement des aliments, y compris des principaux enjeux stratégiques, défis opérationnels et problèmes de conformité, de la couverture et des tendances de consommation. Cette démarche s'appuiera sur le travail du Sommet Mondial de l'Enrichissement Alimentaire qui s'est tenu à Arusha en Septembre 2015.[35]

Pour cette première édition du document, publiée début 2017, il a été décidé de se focaliser sur l'enrichissement a grande echelle des aliments de base et des condiments et sur le bioenrichissement. La prochaine édition envisagera également les produits spécifiques (enrichis) destinés à des groupes cibles (aliments complémentaires pour jeunes enfants et autres produits) et l'enrichissement au domicile.

Cette étude de cartographie mondiale compte deux composantes:

a) Une analyse du statut général et des résultats de l'enrichissement alimentaire à grande échelle et du bioenrichissement. Cette partie présente un aperçu des principaux acteurs et programmes, des réussites, défis et lacunes, des approches de suivi et surveillance et de leurs résultats, de l'impact constaté sur l'état nutritionnel de la population, et propose des données utiles à la planification de prochains programmes;
b) Une analyse de chacun des principaux véhicules d'enrichissement alimentaire. Cette partie combine un aperçu des approches mondiales et de leurs réalisations à l'échelle internationale, et des réflexions sur les expériences nationales principalement axées sur la période 2000-2015.

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[35] Source: http://www.sightandlife.org/fileadmin/data/Magazine/2016/Suppl_to_1_2016/FutureFortified.pdf (visité le 30 Septembre 2016).

Cet exercice de cartographie mondiale de l'enrichissement alimentaire a été pensé pour aider la CE, les agences de mise en œuvre et décideurs politiques à améliorer la programmation et coordination dans les domaines alimentaire et nutritionnel, et contribuer à l'extension, l'amélioration et la consolidation des programmes d'enrichissement des aliments. Cette démarche contribuera à s'assurer que les programmes d'enrichissement répondent bien à des objectifs de santé publique et participent utilement aux objectifs de développement durable.

Aperçu des principaux resultats

Ce résumé analytique présente un aperçu des principaux resultats de l'étude 2016 de Cartographie Mondiale de l'Enrichissement Alimentaire, complétées et les indices pour la programmation future pour soutenir l'enrichissement des aliments, qu'ils soient à l'initiative de la CE ou d'autres bailleurs.

1. **Les formes de soutien dans le domaine de l'enrichissement alimentaire recouvrent des réalités extrêmement variées: on y trouve un large éventail d'interventions à tous les niveaux de la chaîne de valeur, faisant appel à une gamme très diverse de micronutriments et vecteurs alimentaires. Si le programme est bien elabore et bien execute, il peut contribuer significativement à l'amélioration de la santé publique.**

Bien que non adapté dans certains contextes, en particulier lorsque les aliments enrichis sont difficilement accessibles ou lorsque le niveau des carences en micronutriments ou d'autres causes de morbidité demandent des stratégies plus ciblées, l'enrichissement des aliments peut être un outil efficace dans le champ plus large des programmes alimentaires, nutritionnels, de santé et de développement pour répondre à la malnutrition et notamment à l'enjeu de la faim invisible.[36] L'amélioration des apports en micronutriments par des programmes d'enrichissement des aliments se traduit potentiellement par un meilleur développement cognitif et physique des enfants, l'amélioration de la capacité de travail des adultes et un facteur stimulant le développement économique des nations.[37, 38, 39]

Des programmes nationaux d'enrichissement alimentaire à grande échelle existent depuis environ cent ans. Depuis le premier programme d'iodation du sel en Suisse, ils ont été adoptés par différents pays développés. Les pays à faible ou moyen revenu (PFMR) se sont intéressés à ces interventions à un rythme accéléré seulement au cours des vingt dernières années. Le changement d'échelle a été rapide plus de 140 pays appliquent désormais l'iodation universelle du sel (USI); 85 pays imposent au moins une forme d'enrichissement d'un produit céréalier en fer et acide folique, et 40 pays appliquent l'enrichissement des huiles alimentaires, margarines et beurres clarifiés en vitamine A et/ou D.[40] De nombreux autres pays ont entrepris de développer l'enrichissement des condiments, y compris des sauces poisson et soja, cubes de bouillon et autres assaisonnements.

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[36] Dans la plupart des pays à faible ou moyen revenu, cela fait principalement référence à l'anémie, la carence en vitamine A ou en iode. Cependant, selon les habitudes alimentaires et les aliments de base, la faim invisible peut également impliquer d'autres carences, telles que celles en vitamines du groupe B et en zinc.
[37] Allen, L, B de Benoist, O Dary et R Hurrell (2006), *Guidelines on food fortification with micronutrients*, [Lignes directrices sur l'enrichissement des aliments en micronutriments], Genève: OMS/FAO, Genève.
[38] Bhutta, ZA et al. (2013) *Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost?* [Interventions d'amélioration de la nutrition maternelle et infantile appuyées sur des données: Que peut-on faire et à quel coût ?] The Lancet. http://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736%2813%2960996-4.pdf
[39] GAIN (2015) *Fortifying our Future, A Snapshot Report on Food Fortification* [Enrichir l'avenir: Rapport de synthèse sur l'enrichissement alimentaire], Genève: GAIN.
[40] Luthringer, CL, et al. (2015) *Regulatory monitoring of fortified foods: Identifying barriers and good practices* [Suivi réglementaire des aliments enrichis: obstacles et bonnes pratiques]. *Global Health Science and Practice* 3(3): 446–61.

L'expérience des pays développés témoigne que l'enrichissement peut être une réponse hautement efficace aux carences en micronutriments, en particulier lorsque les programmes d'enrichissement sont obligatoires. Les données relatives à l'impact sur la santé de l'enrichissement alimentaire dans les pays à faible et moyen revenus restent à réunir et analyser (hormis pour l'iodation du sel, dont l'efficacité est bien documentée, y compris dans la présente cartographie).

Quelques initiatives de recherche en cours cherchent à combler cette lacune, en particulier une méta-analyse sur l'impact de l'enrichissement alimentaire dans les PFMR, réalisée par le *Sick Kids Center* (Centre pour les Enfants Malades) pour Global Health en 2015. Ses résultats ont été présentés au Sommet sur l'Enrichissement Alimentaire d'Arusha en Septembre 2015 et devraient être publiés en 2017. Les conclusions mentionnent notamment des concentrations sériques plus élevées des micronutriments concernés et un impact positif sur les résultats fonctionnels des femmes et enfants des PFMR, y compris pour l'anémie [ratio de risque – RR- 0.64 (95 % CI: 0.54–0.75)], le goitre [RR: 0.57 (95 % CI: 0.41–0.79)] et les lésions du tube neural [RR: 0.62 (95 % CI: 0.51–0.75)].

En 2008, le Consensus de Copenhague sur la malnutrition et la faim a cité l'enrichissement alimentaire comme l'une des « meilleures options » parmi 30 types d'interventions envisagées pour répondre à dix grands défis de développement à l'échelle mondiale.[41] Cependant, l'enrichissement alimentaire ne devrait pas être une intervention isolée; mais plutôt être utilisé en complément de stratégies nutritionnelles à long terme (qu'il s'agisse de stratégies spécifiques ou de la conception d'autres interventions en tenant compte de l'aspect nutritionnel) destinées à renforcer les systèmes alimentaires, promouvoir des régimes alimentaires plus diversifiés et répondre à la prévalence des apports insuffisants en micronutriments par des systèmes nationaux.[42]

Encadré ES.1: Rapport coût-efficacité de l'enrichissement des aliments en acide folique, iode et vitamine A

Différentes comparaisons de coût ont été réalisées pour mesurer l'intérêt financier de l'enrichissement alimentaire en acide folique au regard des économies pour le système de santé générées par la prévention des lésions du tube neural telles que le spina bifida.[43] L'Afrique du Sud a été le premier pays à évaluer le coût du traitement des nourrissons atteints de spina bifida. Elle a rapporté une économie nette de 2.8 millions d'US$ (2,65 millions d'€) en cas d'enrichissement préventif des aliments en acide folique, et un rapport bénéfice/coût de 30:1.[44] Le Chili a calculé une économie nette de 2,3 millions d'US$ et un rapport bénéfice/coût de 8:1.[45] Pour l'iodation du sel, le ratio bénéfice/coût a été estimé à 30:1. Enfin, le rapport coût-efficacité de l'enrichissement d'aliments de base en vitamine A a été estimé à 81 US$ (76 €) par DALY (année de vie gagnée ajustée sur l'incapacité)[46]

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[41] Horton, S, H Alderman et J Rivera (2008) Consensus de Copenhague 2008. Malnutrition et faim, Copenhagen Consensus Center (Centre du Consensus de Copenhague).
[42] 2016 Global Panel of Agriculture and Food Systems for Nutrition: Food systems and diets: Facing the challenges of the 21st century [Panel mondial de l'Agriculture et des Systèmes Alimentaires pour la Nutrition: Systèmes et régimes alimentaires, Faire face aux défis du 21e siècle], http://glopan.org/sites/default/files/ForesightReport.pdf (visité le 7 Octobre 2016).
[43] Les enfants atteints de spina bifida souffrent de paralysie à des niveaux variables et d'incontinence urinaire ou fécale; ils ont généralement besoin de chirurgies et traitements émotionnellement et financièrement lourds tout au long de leur vie.
[44] Sayed, A, D Bourne, R Pattinson, J Nixon et B Henderson (2008) *Decline in the Prevalence of Neural Tube Defects Following Folic Acid Fortification and Its Cost-Benefit in South Africa. Birth Defects Research* [Baisse de la prévalence des lésions du tube neural à la suite de l'enrichissement des aliments en acide folique et analyse coût-bénéfice en Afrique du Sud. *Recherche sur les malformations congénitales*] 82: 211–21.
[45] Llanos, A, E Hertrampf, F Cortes, A Pardo, S Grosse et R Uauy (2007) *Cost-effectiveness of a Folic Acid Fortification Program in Chile. Health Policy* [Rapport coût-efficacité d'un programme d'enrichissement des aliments en acide folique au Chili, *Politique de Santé Publique]*, 83: 295–303
[46] Horton, Alderman et Rivera (2008), Consensus de Copenhague, op. cit.

2. **L'avantage comparatif de l'enrichissement alimentaire est d'être mis en place via le système alimentaire et d'augmenter la qualité nutritionnelle des régimes et habitudes alimentaires existants.**

Les systèmes alimentaires de nombreux PFMR ne parviennent pas à fournir des aliments suffisamment riches en micronutriments. Ce constat peut s'expliquer par des problèmes de disponibilité, d'accessibilité, de coût et d'utilisation.[47] L'enrichissement alimentaire peut être une des mesures permettant d'améliorer la qualité nutritionnelle des régimes alimentaires, entre autres initiatives (visant spécifiquement la nutrition ou intégrant l'aspect nutritionnel dans leur conception) destinées à faire évoluer positivement les habitudes alimentaires. L'enrichissement des aliments, qui exploite les systèmes alimentaires existants, relève d'un ensemble d'interventions étayées par des données contribuant à prévenir la prévalence des apports insuffisants en micronutriments parmi des populations entières.[48] Cette solution fonctionne en présence d'un besoin clair, d'un véhicule adapté au (bio) enrichissement et de points d'entrée facilitant la collaboration au sein de la chaine de production et de transformation des aliments.

L'ajout de nutriments peut avoir lieu à différents points de la chaîne de valeur entre la production, la transformation et la consommation des aliments. En agriculture, la teneur de la plante en nutriments peut être augmentée par le processus de sélection/amélioration des variétés ou par l'ajout de nutriments dans les sols, l'engrais ou l'eau. Lors de la transformation (dans les minoteries ou les usines de raffinage), une adjonction de micronutriments au véhicule peut être pratiquée efficacement avant emballage et commercialisation. Au niveau individuel, les aliments peuvent être enrichis « au domicile » au moyen de micronutriments en poudre. L'encadré 2 en page suivante présente un résumé des différents types d'enrichissement.

L'enrichissement des aliments s'appuie généralement sur les habitudes de consommation existantes au sein du système alimentaire. Dans la plupart des PFMR, on assiste à une transition vers des produits alimentaires plus transformés et prêts à consommer, notamment du fait des progrès de l'urbanisation: cette évolution permet aux programmes d'enrichissement alimentaire de bénéficier d'une couverture plus large. L'enrichissement des aliments est également souvent une bonne solution pour améliorer l'accès des populations marginalisées à une alimentation plus riche en nutriments, ce qui, accompagné d'efforts constants pour diversifier et rééquilibrer les systèmes alimentaires, peut permettre d'améliorer la qualité nutritionnelle des régimes. Il n'existe pas de données tendant à suggérer que l'enrichissement alimentaire de quelque type que ce soit ait pu aboutir à une évolution néfaste des habitudes alimentaires, telles que celles contribuant à la montée de la prévalence du surpoids et/ou de l'obésité.

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[47] Global Panel (2016) *Facing the challenges,* op. cit.
[48] Bhutta et al. (2013) *Evidence-based interventions, op. cit.*

Encadré ES.2: Types d'enrichissement des aliments

L'enrichissement universel / obligatoire / à grande échelle: C'est l'ajout d'un ou plusieurs micronutriments à des aliments de consommation courante parmi la population générale, tels que les céréales, le sel, les condiments ou l'huile alimentaire. Ce type d'enrichissement est généralement rendu obligatoire et réglementé par les institutions gouvernementales, en réponse à une carence connue, où lorsque cette pratique est estimée bénéfique pour une population ou sous-population. Dans ce cas, les efforts d'enrichissement des aliments sont généralement concentrés sur le secteur agroalimentaire organisé et les grandes ou moyennes entreprises.

L'enrichissement volontaire ou commercial: C'est le fait pour un industriel de décider, pour maximiser ses ventes ou ses profits, d'ajouter une quantité spécifique d'un ou plusieurs micronutriments à des produits alimentaires transformés. Cette démarche est généralement volontaire mais encadrée par des normes ou réglementations gouvernementales.

L'enrichissement à petite échelle désigne le fait de procéder à cet enrichissement au niveau de petites entreprises artisanales ou familiales, souvent informelles.

L'enrichissement ciblé consiste à enrichir des aliments destinés à des sous-groupes spécifiques (plutôt qu'à l'ensemble de la population) afin d'augmenter leurs apports. Ce type d'enrichissement concerne notamment les aliments complémentaires pour bébés et enfants, les rations d'urgence et les repas scolaires.

Le bioenrichissement est un processus visant à cultiver des variétés offrant de meilleures qualités nutritionnelles.

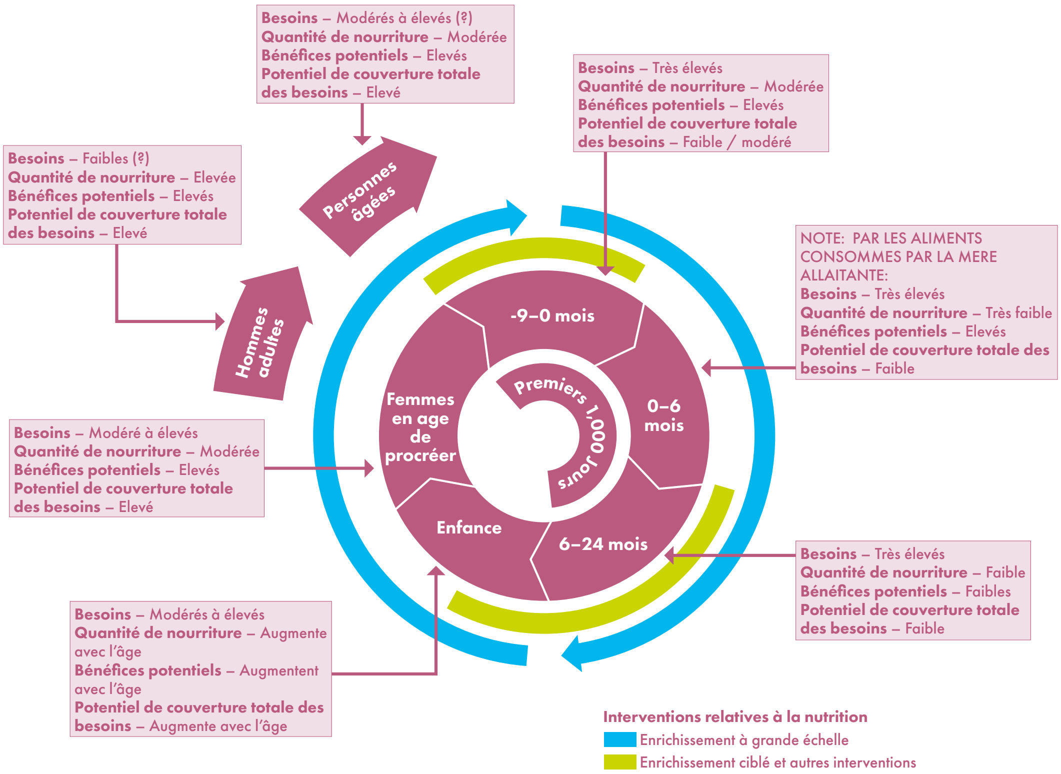
L'enrichissement au domicile (domestique) consiste à ajouter des micronutriments en poudre, de type Sprinkles© aux repas préparés à la maison.

3. Le bioenrichissement et les programmes d'enrichissement à grande échelle peuvent jouer un rôle majeur pour améliorer les apports nutritionnels de populations importantes.

L'objectif de principe du bioenrichissement et de l'enrichissement à grande échelle est d'infléchir la courbe des apports au niveau de l'ensemble de la population, pas d'éliminer systématiquement les carences au sein de chaque groupe cible.[49] Il peut en résulter une amélioration considérable de l'état nutritionnel de tous les groupes de population. Ce type de programme peut donc réduire le nombre d'individus dans la population globale considérés comme « carencés ». Le schéma ES.1 illustre la contribution de ce type d'enrichissement alimentaire aux besoins de différents groupes cibles.

[49] OMS/FAO (2006) *Guidelines on Food Fortification with Micronutrients* [Lignes directrices sur l'enrichissement des aliments en micronutriments]

Schéma ES.1: Bénéfices du bioenrichissement et de l'enrichissement à grande échelle au cours du cycle de vie



Le bioenrichissement et l'enrichissement à grande échelle se distinguent de l'enrichissement ciblé ou d'autres interventions en ce qu'ils peuvent bénéficier à plusieurs segments de population lors d'une seule et même intervention. La pertinence d'une telle intervention de niveau général est tout d'abord justifiée par un **besoin** d'apports supplémentaires en micronutriments parmi la population générale ou certains segments de population en particulier. La pertinence du programme dépend également du **choix d'un composé d'enrichissement de type et en quantité adaptés**, à déterminer en fonction des objectifs du programme et de la consommation moyenne par personne de l'aliment enrichi.

L'efficacité de l'intervention est déterminée par deux facteurs: **la couverture et l'utilisation**. Le véhicule alimentaire (bio)enrichi doit faire partie du régime alimentaire habituel de la population (ou segment) pour que le programme ait un impact. Bref, cet aliment doit être disponible, matériellement et financièrement accessible, et fréquemment utilisé, notamment par les groupes de population dont les besoins nutritionnels sont plus importants. Le schéma ES.1 décrit les bénéfices potentiels du bioenrichissement et de l'enrichissement universel tout au long du cycle de vie de différents groupes de population.

4. **L'existence de partenariats public-privé durables pour la nutrition est fondamentale pour les programmes d'enrichissement alimentaire. Ces partenariats doivent réunir le gouvernement, les producteurs et/ou transformateurs, les acteurs de la commercialisation et les canaux de distribution non commerciaux, ainsi que des acteurs de la société civile, de la recherche, et des agences ONU/bailleurs le cas échéant.**

L'une des caractéristiques commune à tous les types d'enrichissement alimentaire est l'importance et la nécessité du lien entre les secteurs public et privé, ainsi que de l'engagement de consommateurs, de la société civile, de la recherche et de la communauté des ONG/bailleurs.

Les efforts d'enrichissement alimentaires supposent une supervision effective tant par le Ministère de l'Industrie que par le Ministère de le Santé. Les organismes de contrôle des aliments ont aussi un rôle capital à jouer pour vérifier la bonne application des normes et des aspects liés à la sécurité alimentaire. Dans le cas de programmes obligatoires, le gouvernement devra agir en moteur pour le contrôle du respect de ces normes. Les programmes de bioenrichissement peuvent demander une implication significative du Ministère de l'Agriculture.

Les agences nationales de surveillance, instituts de recherche et même émanations de la société civile comme les groupements de consommateurs ont chacun un rôle important à jouer. Des approches multipartites sont donc nécessaires pour amener toutes les parties autour de la table, afin de discuter et traiter de façon globale les enjeux de disponibilité des produits enrichis, de sensibilisation et d'impact.

Dans de nombreux pays, l'établissement d'une Alliance Nationale d'Enrichissement (ANE) offre un mécanisme adapté à la nature multisectorielle de l'enrichissement alimentaire. L'Alliance réunit des parties prenantes issues de secteurs divers et aide à harmoniser et coordonner les activités vers un objectif commun. Parmi les facteurs de succès des ANE, le leadership partagé et la prise de décisions conjointes, le budget alloué à la coordination et la définition d'objectifs de résultats à court terme à travers des sous-comités actifs,[50] jouent un rôle essentiel. Dans d'autres pays, il existe d'autres mécanismes de coordination tels que le Mouvement SUN, des réseaux professionnels propres au pays, ou des coalitions formées autour d'un micronutriment spécifique (ex iode ou vitamine A).

Outre la coordination nationale, l'enrichissement des aliments est favorisé par une assistance technique coordonnée des acteurs internationaux, y compris ONG et communauté des bailleurs, sur les bonnes pratiques, domaines de soutien prioritaires et lacunes de la recherche. Cette coordination internationale a été largement consolidée lors de la préparation du Sommet Mondial *#FutureFortified* de l'Enrichissement Alimentaire,[51] et se poursuit sous forme de Groupe Mondial de Conseil Technique sur l'Enrichissement des Aliments.

5. **Des défis de taille, tels que modalités inadaptées de conception des programmes et non-respect des normes d'enrichissement, doivent être abordés afin de tirer le plein potentiel d'impact, au niveau des populations, des programmes d'enrichissement alimentaire à grande échelle.**

Lorsqu'un programme d'enrichissement alimentaire à grande échelle dans un PFMR ne démontre pas de résultats probants sur le statut nutritionnel de la population, cela peut souvent s'expliquer par un ou plusieurs facteurs parmi les suivants:

- Le type et la concentration du composé d'enrichissement étaient inadaptés et/ou basés sur une estimation erronée de la consommation par personne de l'aliment véhicule.
- Respect insuffisant des normes nationales d'enrichissement.
- La production et/ou les ventes du produit correctement enrichi ne sont pas suffisantes pour répondre aux besoins de consommation de la majorité de la population.
- Les efforts de marketing social du produit ont été insuffisants et/ou la période de mise en œuvre du programme d'enrichissement était trop courte pour permettre l'adoption du produit par la population.

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[50] Rehman, H et al. (2016) *National Fortification Alliances (NFAs): Program guidance based on lessons learned from nine countries*. [Alliances nationales pour l'Enrichissement: Orientations programme basées sur les leçons de l'expérience de neuf pays] Micronutrient Forum 2016 Abstract.
[51] Source: http://www.sightandlife.org/fileadmin/data/Magazine/2016/Suppl_to_1_2016/FutureFortified.pdf (accessed 30 September 2016).

Les aliments enrichis sont considérés comme des « achats de confiance », car les consommateurs ne sont pas en mesure d'évaluer facilement leur avantage en termes de qualité, sécurité ou contenu nutritionnel par comparaison avec le même produit non enrichi. De ce fait, une législation obligatoire assortie de contrôles, audits et mesures d'application est cruciale. Cela passe par un suivi réglementaire, accompagné d'efforts volontaristes de promotion du changement des comportements dans le cadre de programmes d'enrichissement volontaires. Ces efforts permettront aux consommateurs de mieux exercer leur droit à une alimentation nutritive, passant par l'accès à des produits de bonne qualité et correctement enrichis.

Au-delà du besoin d'une législation claire et d'une base juridique, les producteurs d'aliments enrichis font souvent face à des défis et déficits de capacités considérables pour assurer la conformité de leurs produits à travers leurs systèmes internes d'assurance qualité/contrôle qualité, et les gouvernements peinent souvent à identifier les manquements et engager la responsabilité des producteurs. C'est ce que révèle l'étude des données industrielles de 15 programmes nationaux d'enrichissement universel, qui indiquent que moins de la moitié (47 %) des échantillons prélevés étaient conformes aux normes imposées.[52] L'existence sur le papier d'une réglementation ne suffit pas à assurer le respect des normes, en l'absence de réels incitatifs et de conséquences fortes et substantielles, qui éliminent des marchés les aliments insuffisamment enrichis.

6. Le suivi et la surveillance des programmes nationaux d'enrichissement alimentaire sont insuffisants et doivent être renforcés au niveau national et mondial

Tant pour le bioenrichissement que pour les programmes d'enrichissement universel, obtenir un impact en termes de réduction des carences en micronutriments suppose une mise en œuvre prudente, un suivi diligent de la qualité et de la sécurité et la distribution du produit à une part importante de la population sur une période suffisamment longue.

La collecte effective, par les gouvernements ou d'autres acteurs, de données permettant de documenter la couverture et l'impact, reste marginale dans les PFMR. Seule l'iodation du sel a fait l'objet d'une collecte régulière de données sur la couverture des interventions. Rares sont les autres programmes nationaux d'enrichissement à disposer de données systématiques sur la couverture et la qualité des produits. Il existe en effets de nombreux défis inhérents à la collecte régulière de données sur les carences en micronutriments. De même, les données relatives à la qualité des produits enrichis, la couverture et l'impact sont rares car difficiles à recueillir. Les ensembles de données obtenus sont souvent le reflet d'une situation à un moment précis, sans permettre la traçabilité des évolutions dans le temps, et sont trop rarement rapprochés des données retraçant l'avancement des programmes, ce qui pourrait permettre d'établir des liens entre la couverture et l'amélioration de l'état nutritionnel au niveau de la population.

Ces déficits d'information ont conduit GAIN à développer un outil d'évaluation de la couverture des programmes d'enrichissement (baptisé FACT - *Fortification Assessment Coverage Toolkit*) et effectuer une série d'études de couverture par ce moyen. Menées de 2013 à 2015[53] dans huit PFMR, ces études ont évalué la couverture (y compris au vu de considérations d'équité) de programmes d'enrichissement à grande échelle, portant notamment sur l'huile, la farine de blé et la farine de maïs. Elles ont abouti à

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[52] Luthringer et al. (2015) *Regulatory monitoring* op. cit.; GAIN (2016) *Food fortification compliance monitoring* [Suivi du respect des normes d'enrichissement alimentaire], rapport interne GAIN

[53] Aaron, GJ, Friesen, VM, Garrett, GS, Neufeld, LM, Myatt, M. (2016). La couverture des programmes d'enrichissement universel de l'huile et des farines de blé et maïs varie fortement d'un pays à l'autre, mais est généralement plus faible parmi les groupes plus vulnérables: résultats d'études de couverture dans huit pays. Manuscrit *J Nutr*. en cours d'examen.

des recommandations spécifiques sur les possibilités d'amélioration de ces programmes. Il est impératif de généraliser les études FACT à d'autres pays.

Les programmes d'enrichissement universel ayant atteint une échelle planétaire, différents mécanismes de traçabilité mondiale ont vu le jour, généralement orientés vers des micronutriments ou véhicules spécifiques (voir Encadré 3 ci-dessous). La convergence des différentes bases de données dédiées aux carences en micronutriments et programmes nationaux d'enrichissement doit être poursuivie, afin de constituer une base mondiale solide pouvant être exploitée pour les besoins de la définition de politiques mondiales ou nationales et la programmation.

Le Rapport Mondial sur la Nutrition et le Mouvement SUN représentent des efforts de grande ampleur pour renforcer les systèmes de données mondiaux et rassembler les informations nécessaires aux progrès de la compréhension des déficiences nutritionnelles, mais ni l'un ni l'autre n'envisagent spécifiquement l'enrichissement alimentaire. Par ailleurs, les données relatives à l'enrichissement des aliments sont très fragmentées, hébergées par différentes organisations avec très peu de consolidation. L'enrichissement alimentaire étant souvent mis en œuvre de façon verticale à partir du véhicule alimentaire choisi, les contenus et formats des bases de données varient drastiquement. Les données sont donc difficilement comparables dans l'espace et le temps.

Face à cette situation, différentes organisations[54] ont récemment trouvé un accord pour améliorer la transparence du reporting et de l'utilisation des données afin de dresser un état des lieux de l'enrichissement alimentaire à l'échelle mondiale. Un groupe de travail s'est constitué, avec l'intention de lancer une première version d'une Base de Données Mondiale sur l'enrichissement alimentaire courant 2017. Elle regroupera des données mondiales et nationales relatives au statut de l'enrichissement alimentaire, y compris normes et législation, quantités produites et importées, consommation par personne d'aliments vecteurs potentiels, quantité et proportion d'aliments correctement enrichis, couverture attendue et constatée par rapport à la population, et indicateurs d'impact avec leur calendrier de collecte de données, rapproché du statut des programmes d'enrichissement. Chaque fois que possible, les informations seront ventilées par groupe de population et strate de revenu.

[54] GAIN, FFI, IGN, Micronutrient Forum et BMGF avec la contribution de l'OMC

Encadré ES.3: Bases de données pertinentes et principaux rapports relatifs à la nutrition et l'alimentation

De nombreuses bases de données et rapports suivent l'évolution d'indicateurs clés liés à la nutrition, dont certaines sont présentées ci-dessous. Il n'existe actuellement pas d'indicateur consensuel ou de base de données spécifique à l'enrichissement alimentaire, qui assurerait un enregistrement régulier de ces données. Une initiative est en cours pour établir une base de données mondiales de l'enrichissement alimentaire courant 2017.

- **OMS – Observatoire mondial de la santé – Base de données mondiales sur la croissance infantile et la malnutrition:** Compile des données normalisées relatives à la croissance infantile et la malnutrition, issues d'études nutritionnelles nationales axées explicitement sur le suivi des avancées des Objectifs de Développement Durable.
- **OMS – Base de données mondiale sur la mise en œuvre des actions en faveur de la nutrition (GINA):** pour récupérer et synthétiser de façon systématique des données sur le statut en termes de vitamines et minéraux de populations à l'échelle mondiale.
- **UNICEF – Base de données sur l'iodation du sel:** Retrace la couverture et l'impact de l'iodation du sel.
- **Iodine Global Network (IGN) – Feuille de score mondiale de l'iode:** Retrace la concentration urinaire médiane en iode chez les enfants d'âge scolaire
- **UNICEF – NutriDash:** retrace la portée et les avancées de certains programmes de nutrition, et l'impact de ces efforts sur l'état nutritionnel
- **FFI – Profils pays et avancées mondiales:** retrace le statut législatif de programmes nationaux d'enrichissement du riz et des farines de blé et de maïs, et le statut des indicateurs relatifs à l'impact sur la population.
- **GAIN – Données issues de l'Outil d'évaluation de la couverture (FACT):** Pour les pays sélectionnés, modélisation de la contribution des aliments enrichis ou susceptibles de l'être à tous les groupes de population, y compris groupes cibles
- **Rapport Mondial sur la Nutrition** (pas une base de données mais un rapport annuel utile sur l'état de la nutrition à l'échelle mondiale)
- **Suivi de la Nutrition SUN:** retrace les avancées des pays SUN y compris la prévalence chez les moins de cinq ans des retards de croissance, de l'émaciation, du surpoids, de l'insuffisance pondérale à la naissance, de l'allaitement exclusif et de l'anémie chez les femmes, du surpoids/obésité et d'un taux élevé de glucose dans le sang chez les adultes.

7. L'UE pourrait poursuivre efficacement son soutien à l'enrichissement des aliments selon les trois priorités stratégiques du Plan d'Action sur la Nutrition.

La cartographie mondiale permet d'identifier différentes pistes pour un soutien de la CE aux programmes de nutrition, à travers l'enrichissement alimentaire. Dans le cadre de la structure du Plan d'Action CE sur la Nutrition et de ses trois priorités stratégiques, nous proposons les recommandations suivantes:

- Priorité stratégique CE N°1 pour la nutrition – renforcer la mobilisation et l'engagement politique en faveur de la nutrition. Elle peut s'appliquer à l'enrichissement alimentaire (y compris bioenrichissement) par la mobilisation du 2FAS et d'autres mécanismes d'assistance technique de la CE soutenant le plaidoyer auprès des gouvernements. Cet axe d'action pourra par exemple inclure une analyse spécifique par pays des pistes les plus adaptées pour intégrer l'enrichissement alimentaire aux plans nationaux, stratégies et budgets. La CE peut jouer un rôle moteur pour la fourniture de services d'assistance technique déterminant la nature et la quantité des ressources humaines et financières nécessaires, et plaider pour des engagements politiques favorisant le déploiement efficace des interventions d'enrichissement des aliments.

- Sous la priorité stratégique CE N°2 – **Amplifier les actions au niveau national** – la CE dispose de deux points d'entrée dans le domaine de l'enrichissement alimentaire et du bioenrichissement: (1) renforcement institutionnel et développement des capacités des parties prenantes; (2) soutien aux projets pilotes CE prévus dans huit pays africains et validés en 2016 à la suite d'un appel d'offre, et à d'autres projets et programmes d'enrichissement alimentaire de la CE. Au sujet du premier point, le 2FAS de la CE fournira une assistance de niveau national comprenant notamment; (a) des profils pays relatifs à l'enrichissement alimentaire; (b) un état des lieux des capacités nationales relatives à l'enrichissement alimentaire; et (c) entreprendra le développement des capacités d'institutions nationales clé impliquées dans la construction, la consolidation et la poursuite des efforts nationaux d'enrichissement alimentaire. Au sujet du second point, le 2FAS apportera son soutien aux projets pilotes et autres programmes CE relatifs à l'enrichissement alimentaire à travers l'examen critique des documents de projet, la préparation de mémos et d'autres formes d'assistance technique selon les besoins.

- Sous la priorité stratégique CE N°3 – **contribuer à la constitution de connaissances nutritionnelles –** la CE peut contribuer à combler le déficit actuel de données relatives à l'efficacité et au rapport coût-efficacité des différentes approches d'enrichissement alimentaire dans les PFMR. Un autre domaine de travail où la CE est bien placée est celui de la recherche opérationnelle sur les approches multisectorielles de l'enrichissement alimentaire, compte tenu des spécificités des contextes régionaux et nationaux/locaux, indissociables des systèmes alimentaires dominants (production agricole, transformation des produits et mécanismes de distribution). Ce travail pourrait alimenter des plateformes mondiales de partage des connaissances, telles que le Rapport Mondial sur la Nutrition et SUN. Enfin, il pourrait être envisagé sous cet axe de soutenir les capacités nationales de gestion des données et informations, afin d'aider les gouvernements partenaires à combler les lacunes de leurs politiques à partir de données factuelles. A titre d'exemple, la CE soutient actuellement les pays partenaires en optimisant l'usage des informations disponibles à travers des Plateformes Nationales d'Information sur la Nutrition: ce système pourrait servir de tremplin à un meilleur suivi des données relatives aux interventions axées sur les micronutriments.

Tableau ES.1: Programmes nationaux d'enrichissement alimentaire: acteurs et résultats

Acteurs	Résultats
Phase 1: Evaluation de la problématique et de l'impact (surveillance)	
Gouvernement Alliance nat. Agences partenaires	c. Disponibilité de données régulièrement actualisées sur la **prévalence des carences en micronutriments** (y compris au sein des groupes cibles spécifiques), et utilisation de ces données pour orienter la conception et gestion des programmes d'EA.
	d. Disponibilité de données actualisées sur la **consommation par personne d'aliments enrichis ou susceptibles de l'être (et calcul du % du RNI en micronutriments essentiels couvert par cette consommation)**; utilisation de ces données pour fixer les objectifs et assurer le suivi de la contribution des aliments enrichis au RNI.
Phase 2: Construire et renforcer les bases	
Alliance nat. Gouvernement Secteur privé Société civile Agences partenaires	e. **Accord de niveau national sur la contribution actuelle/potentielle des aliments enrichis** distribués dans le cadre de pratiques commerciales ou ciblées/subventionnées, parallèlement à d'autres interventions de lutte contre les carences en micronutriments.
	f. **Partenariats/alliances établis** et fonctionnels dans le domaine de l'enrichissement alimentaire, regroupant des acteurs publics et privés, la société civile, et d'autres parties prenantes clés
	g. **Plaidoyer** ciblé sur l'enrichissement alimentaire et le rôle actuel/potentiel des acteurs publics et privés face aux carences en micronutriments
	h. Mécanismes fonctionnels **répondant aux principales lacunes et goulots d'étranglements** des programmes d'enrichissement alimentaire, regroupant des acteurs du secteur public et privé (et d'autres le cas échéant), adaptés au contexte particulier du pays.
Phase 3: Mise en route et lancement / Planification adaptative	
Alliance nat. Gouvernement Secteur privé Agences partenaires	j. **Les stratégies et objectifs de programme**, y compris (en sus) les apports cibles par des aliments enrichis, sont fixés et s'accompagnent d'un **cadre de suivi et surveillance** mis en place par le programme pour assurer la traçabilité des résultats dans le temps
	k. Existence de **normes et d'une législation** adaptées à l'enrichissement des aliments, avec des mécanismes fonctionnels d'audit et d'inspection, sous-entendant la présence de fonctionnaires correctement formés et équipés (Services de contrôle alimentaire, Ministère de la Santé)
	l. Développement et mise en place d'une **stratégie de promotion des changements sociaux et comportementaux**, visant à sensibiliser les populations aux aliments enrichis et créer une demande
	m. Développement d'une **stratégie de distribution** pour atteindre la population générale et/ou les groupes cibles (selon les besoins).
Secteur privé Agences partenaires	n. Les équipes de direction et d'opération des agences concernées de l'industrie alimentaire disposent de compétences et capacités adaptées en termes de **production/ distribution/ vente au détail d'aliments enrichis.**
	o. **Les équipements nécessaires** à l'enrichissement des aliments ont été achetés, installés, fonctionnent et sont régulièrement entretenus.
	p. Des mécanismes et canaux établis et fonctionnels permettent **l'approvisionnement du prémélange**
	q. Développement et mise en place d'une stratégie commerciale pour **la mise sur le marché** des aliments enrichis et **la sensibilisation des consommateurs**.
	r. **L'importation/production d'aliments enrichis a été lancée** et se déroule conformément aux prévisions.

Phase 4: Amplification et déploiement (action collaborative)	
Secteur privé Gouvernement Agences partenaires	f. **Existence de mécanismes d'AQ/CQ internes et externes, et suivi réglementaire du respect des normes.**
Secteur privé	g. **Développement de l'importation et/ou production d'aliments enrichis** pour atteindre les objectifs du plan
	h. **L'accès aux aliments enrichis et la part de population couverte se développent** grâce à des canaux commerciaux et actions de promotion/marketing adaptés
Gouvernement Agences partenaires	i. **L'accès durable de certaines populations cibles aux aliments enrichis** est favorisé grâce à des mécanismes spécifiques de distribution du produit et une stratégie ciblée de promotion des changements sociaux et comportementaux.
Gouvernement Alliance nat. Société civile Agences partenaires	j. **La qualité du programme, sa couverture et la pénétration des aliments enrichis** auprès des consommateurs font l'objet d'un suivi continu, dont les données permettent d'éclairer la prise de décision et de rendre compte des résultats du programme.

Part 1

Analysis of the overall global status and results of large-scale food fortification and biofortification

1 Introduction

This chapter starts with a short description of the European Commission policy framework on nutrition, and the recent decision to scale up engagement with the food fortification sector as one of the intervention routes for addressing 'hidden hunger'. This term refers to a set of key public health problems related to micronutrients, including Iodine deficiency disorder (IDD), Vitamin A deficiency, and iron deficiency anaemia. A first task that was commissioned to the newly established Fortification Advisory Services has been to undertake a 'global mapping' of food fortification, with prime focus on industrial-scale efforts and biofortification across a range of micronutrients and vehicles. The aim is to prepare a reference document for EC nutrition focal points and beyond on the global status and national-level experiences with food fortification, firmly rooted in the set of recommendations adopted at the 2015 Arusha Future Fortified Global Summit.

1.1 Background and objectives of the mapping study

European Commission Action Plan on Nutrition

As laid out in the European Commission's (EC) Action Plan on Nutrition adopted in 2014[55] and the underlying European Union (EU) Policy Framework on Enhancing Maternal and Child Nutrition in External Assistance that was published in 2013,[56] the EC is strongly committed to supporting partner countries to tackle undernutrition. More specifically, the EC Action Plan on Nutrition sets out three strategic priorities:

a) To enhance mobilisation and political commitment to nutrition;
b) To scale up actions at country level; and
c) To contribute to the generation of knowledge for nutrition.

The EC's aim is to contribute to broader international efforts on nutrition, in particular with respect to the global targets on maternal and child nutrition that were set by the World Health Assembly (WHA) in 2012, and the Scaling Up Nutrition (SUN) movement on provision of support to national government-led initiatives and priorities to tackle malnutrition. The specific objective of the Action Plan is to contribute to reducing the number of stunted children under the age of 5 years by at least 7 million by the year 2025.[57]

As indicated in the First Progress Report on the Commission's Action Plan on Nutrition,[58] the EC will also contribute to the follow-up of the Sustainable Development Goals (SDGs). More specifically, the

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[55] EC (2014), Action Plan on Nutrition, SWD (2014) 234, 03.07.2014, https://ec.europa.eu/europeaid/sites/devco/files/swd-action-plan-on-nutrition-232–4014_en.pdf (accessed 18 February 2017).
[56] EC (2013), Enhancing Maternal and Child Nutrition in External Assistance: An EU Policy Framework, SWD (2013) 72, 12.03.2013, SWD (2013) 104, 27.03.2013, http://ec.europa.eu/europeaid/documents/enhancing_maternal-child_nutrition_in_external_assistance_en.pdf (accessed 18 February 2017).
[57] This target forms about 30% of the additional reduction on top of the already downward trends in many countries that is required to achieve the WHA target of a 40% reduction worldwide.
[58] EC (2016), First Progress Report on the Commission's Action Plan on Nutrition; July 2014 – March 2016, SWD (2016) 181 Final, 20. May 2016, http://ec.europa.eu/europeaid/sites/devco/files/swd-first-progress-report-action-plan-nutrition-2012–4016_en.dpuf (accessed 18 February 2017).

EC will support countries to adopt context-specific, feasible and robust national targets for reducing stunting, in alignment with the SDGs,[59] and accompanied by national costed action plans.

Focus on food fortification

In order to specifically address the EC's needs to contribute to reduction of stunting and to SDG2 (ref. Annex 1 for an overview of the targets under this SDG2 on food security, nutrition and sustainable agriculture)[60] – and in alignment with the SUN '1,000 days' approach[61] and the WHA 2015 Global Targets on Maternal and Child Nutrition[62] – the EC is currently consolidating its experience as input for engagement in the food fortification sector in order to further contribute to reduction of micronutrient deficiencies (see section 1.2).

Among others, this entails additional exploration of the opportunities for the EC to appropriately integrate food fortification interventions into its ongoing efforts on food security and nutrition, in particular within the programming of contributions geared towards the eradication of malnutrition and micronutrient deficiencies among vulnerable populations.

Box 1: Types of fortification

Mandatory or large-scale fortification: this is the addition of one or more micronutrients to foods commonly consumed by the general population such as grains, salt and condiments or edible oil and is usually mandated and regulated by the government sector, in response to evidenced micronutrient deficiencies or where a population, or sub-population, may benefit. These efforts are typically concentrated on the organised food processing sector and large- and medium-size industries.

Voluntary or market-driven fortification is when a food manufacturer takes a profit-driven initiative to add specific amounts of one or more micronutrients to processed foods, usually voluntarily but under government regulations or standards.

Small-scale *fortification*: efforts to fortify among the informal or unregistered small-scale artisanal or cottage industries.

Targeted fortification is the fortification of foods aimed at specific sub-groups to increase their intake, rather than the population as a whole, of complementary foods for infants and children, emergency feeding and special school meals for children.

Biofortification is the process whereby crops are bred to increase their nutritional value.

Home-level food fortification is also known as point-of-use, micronutrient powders, such as Sprinkles©.

The spectrum of support in the area of food fortification is large, with the potential to include a wide range of interventions at different steps within the value chain and to cover a variety of micronutrients. The spectrum ranges from mandatory or large-scale (industrial-scale); small-scale fortification of foods during processing; targeted, specialised fortified foods (although in the literature this is often not included under 'food fortification'); biofortification; and home-level food fortification (Box 1).

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[59] In particular SDG 2: End hunger, achieve food security and improved nutrition, and promote sustainable agriculture - See more at: https://sustainabledevelopment.un.org/?page=view&nr=164&type=230&menu=2059#sthash.iGwfTY2l.dpf

[60] EC (2014), *Action Plan on Nutrition*, *SWD* (2014) 234, 3 July 2014 https://ec.europa.eu/europeaid/sites/devco/files/swd-action-plan-on-nutrition-232–4014_en.pdf (accessed 18 February 2017).

[61] The SUN 1000 days approach focuses on prevention of stunting through improving the quality of the diets of women during pregnancy and lactation and young children 6–24 months of age.

[62] The WHA targets are comprised of stunting, anaemia, low birth weight, wasting, overweight, and exclusive breastfeeding targets.

As a first step towards scaling up engagement and investment in the food fortification sector, the EC has established the Fortification Advisory Services (2FAS). In December 2015, the EC signed a contract with the Landell Mills/Global Alliance for Improved Nutrition (GAIN) Consortium to manage this service. The 2FAS will function in close coordination with the Nutrition Advisory Services (NAS) and the Integrated Support Service on Food and Nutrition Security and Sustainable Agriculture (ISS-FANSSA), and will support the EC in two key areas of work in relation to food fortification:

a) Provision of support on identification, formulation, monitoring and evaluation of pilot projects related to food fortification, to ensure that outcomes are sustainable, ethical, coherent with other interventions, and that the poorest and most vulnerable are benefiting;
b) Provision of support to food fortification as a global approach, including exploiting and sharing of good practices with international partners. This comprises technical and institutional assistance to partner countries, including evidence-based policy guidance and capacity development, to support the formulation of policies and programmes related to food fortification.

As one of the 'start-up' activities to be undertaken in 2016, the EC commissioned the 2FAS to undertake a 'global mapping' of food fortification, which can serve as reference documentation for the EC nutrition focal points within DEVCO C1 and the EU Delegation, and also could be of interest for a wider audience beyond the EC. The Terms of Reference for this study are attached as Annex 2.

The objective of this study is '*To produce an inventory and mapping of actors and programmes dealing with food fortification worldwide, taking into account the relevant policy contexts*.' The aim is to advance understanding on the main features of food fortification including key strategic concerns, operational challenges, legal and compliance issues and production, and distribution and consumption trends. The primary focus is on national, mandated staple and condiment fortification programmes, although voluntary fortification of staples and condiments as well as biofortification is also briefly addressed.[63]

The Global Mapping Exercise has two main components:

a) Analysis of global-level status and results of industrial-scale food fortification programmes with regards to national legislation, the extent of country-level coverage achieved, and impacts on micronutrient status;
b) Analysis of national-level experiences with rolling out of the main industrial-scale food fortification programmes, focusing primarily on the period 2000–15.

The main approaches for accessing key information on food fortification have been through an extensive literature review in combination with a web-based questionnaire that was sent to a set of key actors and informants at global and regional levels in relation to food fortification.[64]

Building on the 2015 Arusha Summit on Food Fortification

This Global Mapping study closely builds on the results of the Future Fortified Global Summit that was held in Arusha in September 2015.[65] The Summit was a major milestone event within the food fortification sector, helping to align all major players around common successes, gaps and priorities

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[63] Home fortification and fortified complementary foods also form part of the overall scope of potential EC programming, but it was suggested by C1 to primarily focus the Global Mapping Exercise on large-scale food fortification. One of the reasons for this was that home fortification is the focus of a current Cochrane review.
[64] List of survey respondents attached as Annex C.
[65] Micronutrient Forum/Sight and Life/GAIN (2016), The #FutureFortified Global Summit on Food Fortification; Event Proceedings and Recommendations for Food Fortification Programme, http://www.gainhealth.org/events/future-fortified/resources/ (accessed 18 February 2017).

moving forward. Over 450 people, representing the major donors, technical assistance agencies, academic institutions, industry and government delegations from over 50 countries were brought together to identify key priority areas for further advancement of the sector (see Box 2 below, and Annex 3). The focus of the Summit was on large-scale and small-scale fortification but it also included sessions exploring the complementarity of large-scale fortification, small-scale fortification and biofortification.

Box 2: Critical areas for action summarised in the Arusha Statement on Food Fortification following the #FutureFortified Summit

First, modest but new investment is essential. Fortification is cost-effective and largely self-sustainable, costs are built into markets and typically do not require further or continuous public subsidy. Governments need to invest in technical support, oversight and compliance. The new investments are needed to build, improve and sustain fortification programmes. They are small in relation to leveraged costs, cost per beneficiary and overall returns, and tiny as a proportion of health spending. For example, it was estimated that the additional donor costs over 15 years to build, improve and sustain fortification in 25 low- and middle-income countries for multiple food vehicles would be US$ 150 million. This could effectively cover an additional billion people. Further investment in fortification would trigger significant co-investment by the private sector and motivate national governments to allocate resources.

Second, there is need for a major effort to improve oversight and enforcement of food fortification standards and regulations. Poor compliance with laws and regulation limits potential for impact and undermines effectiveness. Available data shows adequate compliance with standards as low as 50% in many contexts. Governments should improve their inspection and enforcement systems to ensure high-quality fortification and a level playing field for the producers. Effective regulatory monitoring and enforcement will notably require more robust national budget allocations.

Third, there is a need to generate more evidence to guide fortification policy and programme design to continually improve programmes and demonstrate impact. For example, there is a lack of detail of foods consumed by various target groups, limiting our understanding of potential food vehicles, use of fortified foods and quantification of the dietary gap we must address for some nutrients.

Fourth, progress requires more transparent accountability and global reporting. We support the call for a global observatory or annual report of the state of fortification.

Fifth, continuing advocacy is a high priority, and we will work together with stakeholders such as the SUN Movement and African Union to advocate for greater attention by governments.

Other core pieces of information that have provided a foundation to this study are the global databases on fortification, particularly on fortification of cereal grains (available on the Food Fortification Initiative website),[66] the Global Iodine Scorecard and Map (available on the Iodine Global Network website),[67] and the fortification of oils, condiments and sauces (tracked by GAIN). These three organisations are currently engaged in pulling the three efforts together into a ‘Global Repository on Food Fortification’, which will allow food and nutrition players access one database on the most up-to-date information and data on global large-scale food fortification programmes and efforts.

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[66] http://www.ffinetwork.org/global_progress/
[67] http://www.ign.org/scorecard.htm

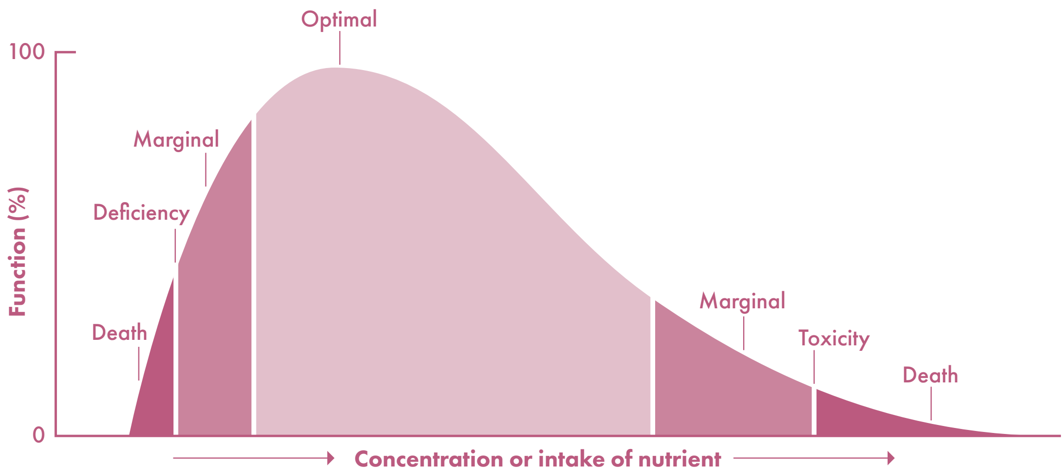
1.2 Micronutrient malnutrition: defining the problem

What are micronutrient deficiencies?

Micronutrients are essential minerals and vitamins necessary to maintain good health. These nutrition elements have to be provided by the diet on a regular basis,[68] in amounts that match the physiological requirements of the individual. The nutritional status for each micronutrient can range along a continuum from deficiency to toxic excess (see Figure 1).

Three of the primary micronutrient deficiencies (MNDs) globally are iodine deficiency disorders (IDD), vitamin A deficiency and iron deficiency anaemia. Next to these three MNDs, there also is growing attention for some other more specific nutritional deficiencies that are (still) prevalent and can lead to significant public health problems. For example, folic acid in relation to prevention of neural tube defects; a number of B-vitamins which, in case of severe deficiency, can lead to diseases such as beri-beri and pellagra; zinc; and vitamin C, D and E. Annex 4 provides more details on the main micronutrients and recommended dietary intake levels. Annex 5 presents an overview of the current micronutrient status for the EC priority countries with regards to nutrition.

Figure 1: Hypothetical micronutrient intake/status distribution (Bailey, West & Black, 2015)



The phenomenon of MNDs is also referred to as 'hidden hunger' (see Box 3 below) as it tends to receive less attention than other, more physically visible nutrition problems such as wasting and stunting. Nevertheless, MNDs are a global public health problem, with women of childbearing age and children under 5 years being at highest risk. Micronutrient deficiencies contribute to significant and often irreversible consequences along the entire life cycle, from the perinatal period through to adulthood. These consequences include increased risk of morbidity and mortality, reduced immune function and immunity against disease, poor physical and mental growth and development, poor educational attendance and attainment, and greater productivity losses. Long-term consequences of MNDs are not only seen at the individual level, but also have negative impacts on human capital and overall economic development, with intergenerational consequences.[69]

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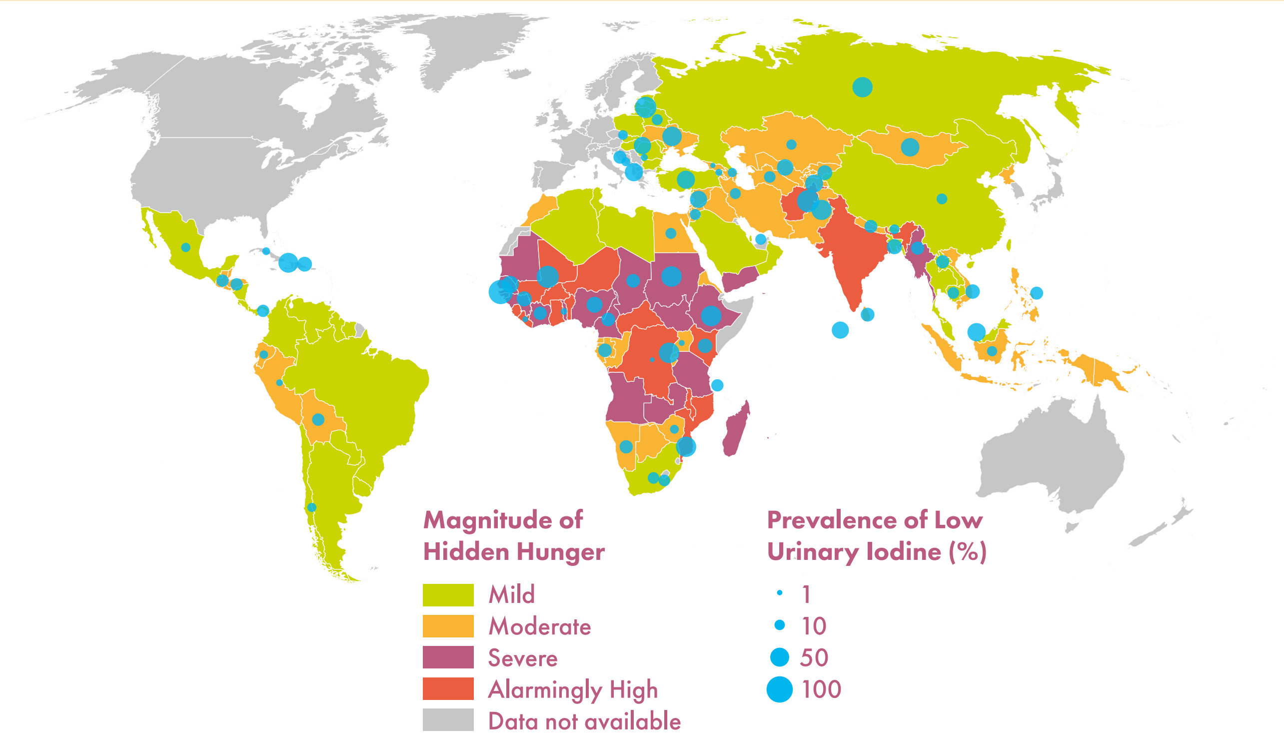
[68] Some vitamins like vitamin D and vitamin K are also produced by the body, given certain dietary or environmental conditions.
[69] Bailey RL, KP West and RE Black (2015), 'The Epidemiology of Global Micronutrient Deficiencies', *Ann Nutr Metab,* 66 (2): 22–33.

Box 3: Magnitude of hidden hunger

Deficiencies of essential vitamins and minerals (micronutrients), also called ‘hidden hunger’, and the subsequent negative consequences of these deficiencies, are significant public health problems in many areas of the world, in particular in low and middle-income country (LMIC) populations.

MNDs are highly prevalent across the world. Iron deficiency is the most common MND affecting more than 30% of the world’s population – an estimated 2 billion people. The development of 40–60% of children growing up in LMICs are at high risk due to iron deficiency in the 6–24 month age group; approximately 0.8 million (1.5%) annual deaths worldwide are attributable to iron deficiency, with a loss of about 35 million healthy life years (2.4% of global disability-adjusted life years (DALYs)). A lack of iron contributes to over 600,000 stillbirths or neonatal deaths and over 100,000 maternal deaths during pregnancy globally per year.

Vitamin A deficiency (VAD) is a primary cause of childhood morbidity and mortality in the developing world, particularly in Africa and Southeast Asia. It is the leading cause of preventable blindness in children affecting 250–500 million children worldwide, and also is common in pregnancy in LMICs (estimates ranging from 10% to 20%).



Globally, around 2 billion people are estimated to have inadequate iodine status, including as many as half of the European population and more than 500 million individuals in South-East Asia. As a result of maternal iodine deficiency, approximately 18 million newborns are estimated to be born intellectually impaired – leading to estimated intellectual losses of from 7.4 to 15 IQ points.

Folate and zinc deficiency are two other types of MND that occur in many places in the world. Due to maternal folate deficiency, some 300,000 children are estimated to be born each year with severe birth defects, including neural tube defects and spina bifida. Annually, some 1.1 million children under the age of five die due to prolonged length and increased severity of diarrheal diseases, which could have been mitigated with additional dietary zinc.

MNDs rarely happen in isolation; multiple MNDs usually occur simultaneously, mainly driven by a lack of food security and dietary diversity, alongside the impact of health and disease issues. The issue of MNDs is of particular concern in rural populations, women of reproductive age and young children, as well as in female adolescents. Overall, these issues of micronutrient malnutrition are widespread, with important health and economic consequences resulting in economic losses that are estimated to range from 2–5% of gross domestic product (GDP) in LMICs. Direct costs are estimated between US$ 20 to US$ 30 billion every year. Anaemia alone has been estimated to lead to 17% reduced lower productivity in heavy manual labour and an estimated 2.5% loss of earnings due to lower cognitive skills.

Sources: Darnton Hill, I (2016) State of the World Report: Food Fortification Synopsis Report, Micronutrient Forum 2016. Available from http://micronutrientforum.org/mn-forum-releases-synopsis-food-fortification-report/. Bailey RL, KP West & RE Black (2015), The Epidemiology of Global Micronutrient Deficiencies, *Ann Nutr Metab* 2015; 66 (suppl 2): 22–33; Yang Z & SL Huffman (2011), Review of fortified food and beverage products for pregnant and lactating women and their impact on nutritional status, *Matern Child Nutr*, 2011. 7 Suppl 3: 19–43; Thurnham DI (2013), Nutrition of adolescent girls in low- and middle-income countries, *Sight and Life*, 2013. 27: 26–37; Mi et al., (2009), Investing in the future: a united call to action on vitamin and mineral deficiencies. *Global Report 2009*, Toronto, 2009; Christianson A, CP Howson & B Modell (eds) (2006), *Global report on birth defects: The hidden toll of dying and disabled children*, March of Dimes Birth Defects Foundation, New York, 2006; Christian P et al., (2015), Nutrition and maternal, neonatal, and child health, *Semin Perinatol*, 2015. 39(5): 361–72; Zimmermann MB & K Boelaert (2015), Iodine deficiency and thyroid disorders, *Lancet Diabetes Endocrinol*, 2015. **3**(4): 286–95; Alderman H & S Horton (2007), The economics of addressing nutritional anaemia, in Kraemer K & MB Zimmermann (eds) (2007) *Nutritional anaemia, Sight and Life Press*, Basel, pp.19–36; Rowe LA & DM Dodson (2012), A knowledge-to-action approach to food fortification: guiding principles for the design of fortification programmes as a means of effectively addressing micronutrient malnutrition, *Health 2012*, 4: 904–9; Fletcher RJ, IP Bell & JP Lambert (2004), Public health aspects of food fortification: a question of balance, *Proc Nutr Soc*, 2004, 63(4): 605–14; Horton S, H Alderman & J Rivera (2008), Copenhagen Consensus 2008. Malnutrition and Hunger, Copenhagen Consensus Center, 2008; Bhutta ZA et al. (2013), Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost?, *Lancet*, 2013. 382(9890): 452–77; Horton S (1999), Options for investment in nutrition in low-income Asia, *Asian Dev Rev*, 1999, 17: 246–73; Horton S (2006), The economics of food fortification, *J Nutr,* 2006, 136(4): 1068–71.

Micronutrients within the World Health Assembly 2025 targets

One of the WHA nutrition targets is specifically focusing on one of the key micronutrient deficiencies: anaemia. The aim that has been set is ambitious: to bring anaemia rates among women of reproductive age down by 50%, which will require an average reduction of 6.1% per year.

The comprehensive WHA nutrition implementation plan comprises a set of guidelines on prevention, control and treatment of anaemia through a wide range of cost-effective strategies. An integrated and multi-sectoral approach is seen to be needed, including: a combination of efforts to improve dietary diversity; food fortification with iron, folic acid and other micronutrients; distribution of iron-containing supplements; and control of infections and malaria.[70]

Micronutrient deficiencies within the Global Nutrition Report

As indicated in the Global Nutrition Report 2016,[71] micronutrient malnutrition still remains a large-scale problem. Alongside ongoing global and national efforts to further reduce stunting and wasting rates worldwide, there is a strong and increasing focus on the prevention and control of MNDs. These efforts are focused on key nutrition target groups, such as pregnant and lactating women and young children. Another key target group in nutrition planning, including for prevention of control of MNDs, are the socioeconomically vulnerable segments of society in LMICs. However, it also remains necessary to scale up nutrition support at the national level in order to reach out to populations as a whole.[72]

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[70] WHO (20xs), Global Nutrition Targets 2025: Anaemia Policy Brief, http://apps.who.int/iris/bitstream/10665/148556/1/WHO_NMH_NHD_14.4_eng.pdf?ua=1 (accessed 18 February 2017).
[71] International Food Policy Research Institute (2016), *Global Nutrition Report 2015: From Promise to Impact, Ending Malnutrition by 2030*, Washington DC.
[72] Bailey et al. (2015), op. cit.

1.3 Structure of the report

This report contains two main parts. The first part provides an overall introduction into food fortification and biofortification. The second part then presents a set of chapters on the various forms of food fortification organised by fortified food type.

The first part starts with Chapter 2 which presents the contributions food fortification and biofortification can make alongside other interventions such as supplementation and programmatic efforts to increase dietary quality and diversity. Chapter 3 presents the available published evidence on nutrition impacts of food fortification. It also describes the current ongoing efforts to establish a consolidated evidence-based framework as core guidance and reference for refinement and further scaling-up of food fortification programmes worldwide.

Chapters 4 and 5 main focus is on large-scale food fortification programmes and biofortification, respectively. These chapters present a general overview of key aspects of these programmes in terms of main players and programmes that exist, key results that have been achieved thus far, and a listing of major success factors, challenges and gaps.

Chapter 6 provides an overview of the main monitoring and surveillance systems that exist globally in relation to micronutrient deficiencies and, more specifically, on national food fortification programmes.

Chapter 7 is a key chapter in that it presents a list of potential entry points for the EC to further scale up its engagement with food fortification and biofortification. This chapter is framed along the three Strategic Priorities in the EC Plan of Action on Nutrition. It includes topics that relate to technical assistance for establishment and strengthening of legal and regulatory frameworks, topics where (further) capacity development is needed among both government and private sector partners, and a range of potential topics for condensed pieces of research in the form of studies and trials. Finally, the chapter looks into the potential for the EC to engage with the new initiative on establishment of a Global Repository on Food Fortification.

Part 2 is comprised of four chapters (8, 9, 10 and 11) which present the main food vehicles that are currently being fortified: table salt and salt used in the food industry; vegetable fats and oils for human consumption; wheat and maize flours, and rice; and sauces and condiments and other processed foods. The main micronutrients that are provided through these fortified products are iodine (salt), vitamin A and vitamin D (fats and oils), and multiple micronutrient mixes that among others encompass iron and folate, often plus a range of B-vitamins and some other minerals (cereal products, and sauces and condiments). Each of these chapters follows the same structure, starting with an overview of the overall approaches and achievements worldwide, followed by a reflection on national experiences with this type of food fortification, and analysis of key characteristics as per the ‘enabling environment’ and the ‘value chain’ from production to consumption.

2 Fortification pathways and target groups

This chapter explains how food fortification and biofortification are positioned within the food systems approach. This is a model that combines the value chain analysis from production to consumption with analysis of the various factors that drive consumers' choices for certain foods and how these together determine peoples' diets at large. Fortification programmes are also positioned within a broader range of nutrition interventions aimed at improving quality of diets, and micronutrient intakes. It is visualised how industrial-scale food fortification can shift the distribution of population intake levels for certain micronutrients to the right. The approach in these programmes in principle is aimed at covering the population at large. It is recognised that fortification might not be enough to address deficiencies in certain key target groups along the life cycle, for which additional more specific supplementation or other programmes are still required. Another issue is that industrial-scale fortification programmes, although in principle aimed at large segments of the population, might not have good coverage among groups such as the urban poor or households in remote areas. Specific mechanisms might need to be established to stimulate supply and demand in order to create better outreach among such groups. Biofortification can be a complementary intervention to make more nutritious food available, in rural areas in particular.

2.1 Fortification within the food systems approach

Food systems approach

Food systems arise from the complex interactions of all the activities and actors involved in transforming environmental, agricultural, and manufacturing inputs into outcomes of food and nutrition security and health (Figure 2).[73, 74] Food systems have the potential to deliver adequate nutrition and food security, including availability, access, utilisation and supply stability of macro- and micronutrients. In order for fortification (including staple food fortification and biofortification) to be sustainable, it needs to be embedded within local and national/regional food systems. Today in many LMICs food systems provide large portions of populations with unvaried diets of primarily staple foods that lack essential vitamins and minerals.[75]

It is important to note that a wide range of considerations and factors affects peoples' production and consumption choices, and food systems at large. Food systems are dynamic over time, 'punctuated equilibriums' based on the interplay between sociocultural preferences, sustainable profits for farmers and the food industry, food products' availability and accessibility/affordability for consumers, health objectives (balanced diets that contain sufficient amounts of food products with positive impacts on health and nutrition, and reduced or zero amounts of products that are known to be unhealthy), and environmental concerns including efficient water use, avoidance of pollution, reduction of energy required for production, processing and distribution steps within the value chain.

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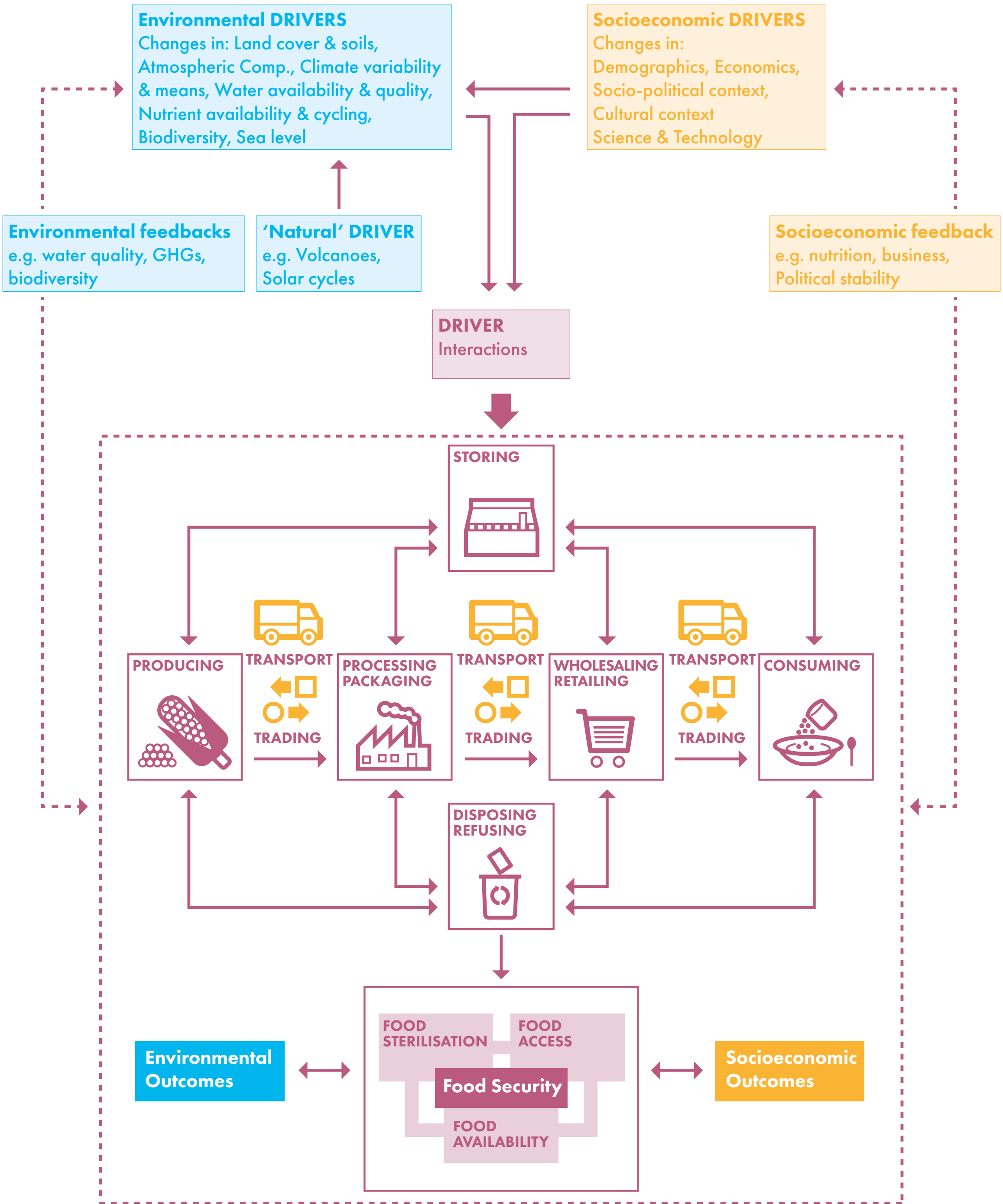
[73] Sobal J, LK Khan and C Bisogni (1998) A conceptual model of the food and nutrition system, *Soc Sci Med*, 47: 853–63.
[74] Grant M (2015) A food systems approach for food and nutrition security, *Sight and Life*, 29: 87–90.
[75] 2016 Global Panel of Agriculture and Food Systems for Nutrition: 'Food systems and diets: Facing the challenges of the 21st century', http://glopan.org/sites/default/files/ForesightReport.pdf (accessed 7 October 2016).

Figure 2: The food system map[76]



[76] Adapted from Ericksen PJ (2008) Conceptualizing Food Systems for Global Environmental Change Research. *Global Environmental Change*, 18: 232–445; Ingram J (2011) A food systems approach to researching food security and its interactions with global environmental change. *Food Security*, 3: 414–731. In Ingram J (2016) Sustainable Food Systems for a Healthy World. *Sight and Life* ,30(1): 23–83.

The food fortification model

Food fortification is part of a package of evidence-based interventions which can help to eliminate micronutrient malnutrition.[77] The Copenhagen Consensus rated food fortification as one of the most cost-effective development interventions.[78] Private sector partners from the food industry are the main actors within food fortification programmes, however, governments also have to play a large role. Governments need to invest in establishing legal frameworks for food fortification, and are responsible for monitoring of food safety and compliance with fortification standards. Governments may want to monitor overall production and product quality levels with respect to fortified foods, and regularly obtain population coverage levels. Governments evidently have to see to it that fortification programmes remain tuned in with micronutrient deficiency profiles in the country, including for specific target groups (nutritionally vulnerable groups such as pregnant and lactating women and children from 6–24 months of age, but also the more socioeconomically disadvantaged and specific geographical areas like urban slums and remote rural areas). Improving knowledge, policy and legislation, while engaging governments through targeted advocacy, can help to improve accountability and commitment to these processes.

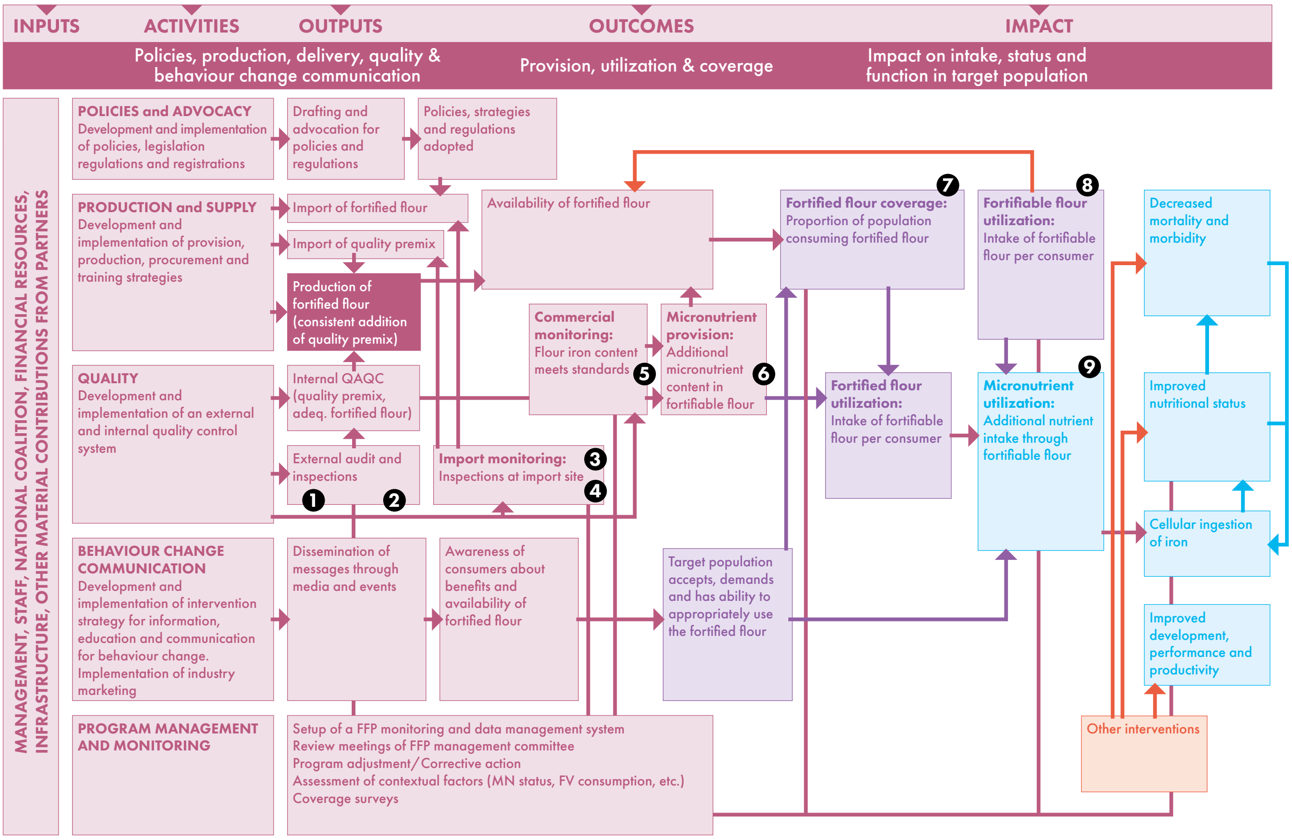
Although not always relevant, especially where access to fortified foods is lacking or when the level of micronutrient deficiency or other concurrent morbidities warrants additional complementary strategies, food fortification can be an effective tool within the broader nutrition, health and development agenda to address malnutrition – particularly the issue of hidden hunger.[79] Currently, in many LMICs, food systems provide large portions of populations with unvaried diets of primarily staple foods that lack key micronutrients. This can be due to issues of availability as well as access, affordability and utilisation. Food fortification is not a substitute for a good quality diet that supplies adequate amounts of energy, protein, fats and micronutrients required for optimal health, and it cannot alone solve all micronutrient problems. However, it can complement long-term nutrition-specific and nutrition-sensitive strategies to strengthen food systems, increase nutritional diversity in people's diets, and address nutrient deficiencies through health care systems. Food fortification plays a role in addressing micronutrient deficiencies as seen through the World Health Organization/Center for Disease Control and Prevention (WHO/CDC) impact logic model in Figure 3 below.

[77] Bhutta ZA et al. (2013) *Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost*? *The Lancet,*

[78] Hoddinott J, M Rosegrant and M Torero (2013) Hunger and malnutrition. In: B Lomborg, ed. *Global problems, Smart Solutions: Costs and benefits*. New York: Cambridge University Press and Copenhagen Consensus Center, p. 332–67.

[79] In many LMICs, this primarily refers to anaemia, vitamin A deficiency and iodine deficiency. Depending on dietary patterns and main staple foods, hidden hunger, however, can also entail deficiencies for other micronutrients like the B-complex vitamins and zinc.

Figure 3: WHO/CDC food fortification impact logic model



Adapted from © World Health Organization 2011

Food fortification should be seen as a complement to long-term nutrition-specific and nutrition-sensitive strategies to strengthen food systems, increase nutritional diversity in people's diets, and address nutrient deficiencies through national systems.[80] No country today has optimised the availability, accessibility, affordability, and utilisation of a diverse diet that meets all macro- and micronutrient needs for every person. Food fortification is therefore one strategy that is used as a stopgap measure to improve the nutritional quality of diets until such nutrition-conscious food systems are a reality for all populations. Large-scale (or mandatory) food fortification[81] has been recognised and promoted as a priority within many important public health networks, international non-governmental organisations (NGOs) and national governments, and is a key area of work that is discussed at international forums including the WHA, the SUN Movement meetings, the Micronutrient Forum, and the Global Nutrition Report.

In addition, food fortification needs to be seen as a complement to other efforts in disease prevention and management together with efforts to improve water, sanitation and hygiene (WASH). There are known interactions between nutritional status and diarrheal diseases and parasitic infections, such as

[80] Global Panel of Agriculture and Food Systems for Nutrition (2016) 'Food systems and diets: Facing the challenges of the 21st century', http://glopan.org/sites/default/files/ForesightReport.pdf (accessed 7 October 2016).
[81] This section focuses on the evidence of large-scale/mandatory/industrial-scale food fortification. This has been the fortification strategy shown through the evidence to benefit populations as a whole. Small-scale fortification among the informal sector has shown promise as a subsidised model of delivery. However, to date there is no successful example of small-scale fortification that has worked independent of external subsidy and support. Other types of food fortification, including home-fortification and targeted fortification strategies that may more adequately address the needs of specific populations will be discussed throughout where their usage would be most relevant.

helminths and malaria.[82, 83] Ensuring a higher nutritional baseline prior, during and after such infections can add to the resilience of individuals, enabling them to recover more quickly and sustain prior nutritional gains.[84] It is important to note that some of the other interventions beyond fortification may provide the requisite increases in micronutrient consumption directly, such as biofortification or supplementation. Others, however, such as WASH promotion activities and social protection activities are not likely to increase micronutrient consumption without a concurrent more direct activity. It is critical to assess the trade-offs in terms of the potential cost-effectiveness, coverage, nutritional impact, and sustainability that could be reached with each type of intervention. Often several different interventions used complementarily will maximise these trade-offs to provide the most benefit and have the broadest reach.

Overall programmatic considerations for food fortification

In general, any population group can benefit from food fortification when several main criteria are in place. It should be recognised that there are inherent challenges and differences in these criteria, which could mean that fortification may not necessarily be providing the same benefits across all populations:

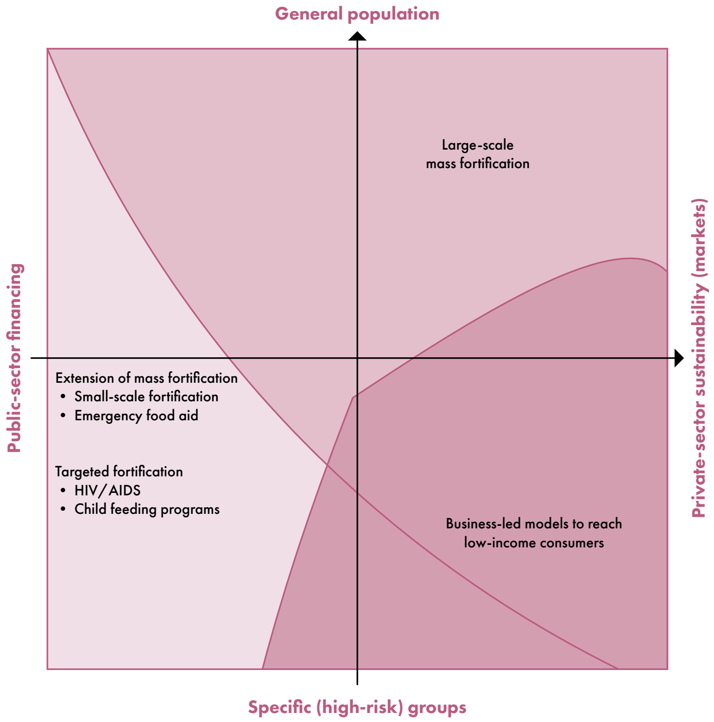
- Need: The dietary intake of key micronutrients is inadequate, as demonstrated by data on intake and/or micronutrient status.
- Coverage and utilisation: The intervention is designed to employ food vehicles consumed regularly by the population in sufficient quantity. This means that fortified-food vehicles need to be available, accessible, affordable and utilised also by populations in need.
- Appropriate fortificant at the right level: A bioavailable fortificant, added at appropriate levels given per capita consumption of fortifiable food, is used.
- Quality assurance and adherence to fortification standards: Regulatory monitoring must be effective and result in a high rate of compliance against standards and a safe food for consumption. This is easiest when fortification is mandated, but this is not a necessary condition in many contexts (see section 2.1.3).
- Long-term industry and government commitment and capacity strengthening: Important for the sustainability and institutionalisation of fortification programmes.

[82] Kung'u JK et al., (2009) Early helminth infections are inversely related to anemia, malnutrition, and malaria and are not associated with inflammation in 6- to 23-month-old Zanzibari children. *Am J Trop Med Hyg* 81(6): 1062–70.
[83] Best C et al., (2011) Can multi-micronutrient food fortification improve the micronutrient status, growth, health, and cognition of schoolchildren? A systematic review. *Nutrition Reviews* 69(4): 186–204.
[84] Christian P et al. (2015) Nutrition and maternal, neonatal, and child health. *Seminars in Perinatology* 39(5): 361–72.

Types of food fortification programmes

The range of food fortification strategies for addressing imbalances in the food system and subsequent micronutrient deficiencies are outlined in Figure 4. The vertical axis represents the extent of the population to be reached, while the horizontal axis represents the cost-recovery and sustainability potential in the initiative.[85] All of these strategies can have a role to play, depending on the given context. A detailed look at the relevant food and health systems and the causal factors for micronutrient deficiency will determine which interventions would work best and which could be sustained throughout the long term.

Figure 4: The different types of fortification



Large-scale food fortification is part of a package of evidence-based interventions, which can help to eliminate micronutrient malnutrition in many contexts.[86] Four main strategies for improving micronutrient malnutrition have been identified by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO): supplementation; disease control measures; nutrition education leading to increased diversity and quality of diets; and food fortification and biofortification.[87,88]

Each of these strategies has a role to play in eliminating micronutrient malnutrition. For maximum impact the appropriate combination of these strategies should be delivered according to context – and

[85] Adapted from R Moench-Pfanner and M Van Ameringen (2012). The Global Alliance for Improved Nutrition (GAIN): A decade of partnerships to increase access to and affordability of nutritious foods for the poor. *Food and Nutrition Bulletin*, 33(4): S373–80.
[86] Bhutta, ZA et al. (2013) Evidence-based op. cit.
[87] WHO/FAO (2006) Guidelines op. cit.
[88] In addition to FAO and WHO, other UN agencies engaged in fortification are the World Food Programme (WFP) and the United Nations Children's Fund (UNICEF). WFP has been active through its policy to provide fortified foods as part of their emergency food baskets as well as providing support to the design and implementation of fortification programmes for rice and other food commodities globally. UNICEF has been especially involved in the Universal Salt Iodization (USI) movement and in international policy and legislation.

embedded within food systems – in order to promote consumption of an adequate diet for entire populations.[89]

It is important to note that the vast majority of companies engaged in the delivery of mandated national fortification programmes are local and national medium and large food processors. Large, multinational companies have not been the main providers of fortified foods, except in a few cases (see Box 4).

Box 4: The role of large multinational corporations in food fortification and the Premix Facility

While industrial-scale food fortification has largely involved local large and medium producers, rather than multinational corporations, the latter have continued to support progress in myriad ways both as a business choice and as part of corporate social responsibility.

On the commercial side, large multinational corporations have been engaged primarily in the manufacture of micronutrient premix for fortifying staples, mainly for reasons of economies of scale, safety and quality control. When appropriate premix supply systems are in place (including transparent procurement mechanisms based on a competitive tendering process) premix suppliers are forced to compete with each other on quality and price and this helps avoid premix suppliers monopolising the supply of micronutrient fortification in a given context.

Multinational corporations have also been involved in producing fortified staple foods that are utilised in emergency food aid. This is mainly to comply with WFP policies on the provision of fortified foods and donor requirements, particularly in the US, which mandate that US-grown and manufactured commodities are added to US-donated emergency food aid. Furthermore, where high prevalence of acute malnutrition or micronutrient deficiencies occur in an emergency context, the position of the European Community Humanitarian Office (ECHO) is that micronutrient fortification of general foods is one such response option – together with facility-based or community-based therapeutic feeding for severe acute malnutrition; supplementary or complementary feeding using fortified complementary foods or ready-to-use foods; provision of micronutrient supplementation; and promotion of nutritional awareness and dietary diversity.

On the corporate social responsibility side, many multinational corporations have turned their attention to providing technical assistance to local manufacturers, sharing decades of fortification knowledge and expertise with new producers in Africa and Asia. One such entity modelling business-to-business support is Partners in Food Solutions, a consortium of General Mills, Cargill, DSM, Buhler and Hershey.

Falling in between commercial interests and corporate social responsibility, Nestlé has recently developed and marketed iron-fortified bouillon cubes (the popular Maggi brand) across Central and West Africa. These cubes were already very popular as a flavouring condiment for traditional stews and soups and now are providing the additional benefit of supporting the region’s nutrition and anaemia reduction programmes.

Transparent and systematic accountability processes must be developed to balance private commercial interests with public health interest and prevent and/or manage conflicts of interest. This can be done through existing frameworks for private sector engagement, such as the UN Standing Committee on Nutrition and the SUN Business Network.

Sources: GS Garrett, CL Luthringer and P Mkambula (2016), Improving Nutritious Food Systems by Establishing National Micronutrient Premix Supply Systems, Sight & Life Magazine, 30(1): 62–8; Guinot et al. (2012) GAIN Premix Facility: an innovative approach for improving access to quality vitamin and mineral premix in fortification initiatives, *FNB* Dec; 33(4 Suppl): S381-9.

[89] Micronutrient Forum. State of the World Report 2015: Food Fortification Synopsis Report. Available from www.micronutrientforum.org.

2.2 Population-wide coverage and specific target groups

Improving micronutrient intake through food fortification programmes with wide coverage can lead to improved cognitive and physical development of children, work capacity of adults, and economic development of nations.[90, 91, 92] Effective large-scale food fortification programmes have been shown to have a high return on investment (see Box 5).

Box 5: The economic benefits of fortification and market considerations

The economic benefits which a country experiences as a result of improving nutrition are tremendous. For example, each dollar spent on reducing chronic undernutrition has a US$ 30 payoff, according to the 2012 Copenhagen Consensus. Iron fortification yields US$ 84 for every dollar spent on reducing iron deficiency anaemia prevalence. The mental capacity that is undeveloped when children are iron deficient is never regained. That affects their academic performance and future earnings potential. Consequently, childhood anaemia is associated with a 2.5% drop in wages in adulthood. Median total losses of iron deficiency, which include both physical and cognitive losses, are US$ 16.78 per capita. These estimates of economic loss from iron deficiency do not include the social costs of maternal deaths due to iron deficiency or healthcare costs of treating infants born prematurely because their mothers were iron deficient.

Significant healthcare expenditures are averted when neural tube defects (NTDs) are prevented by fortifying foods with folic acid. The most common of these birth defects is spina bifida. Children with spina bifida have varying levels of paralysis and loss of bowel and bladder control. They often undergo a lifetime of surgery and treatment, which takes a toll both emotionally and financially. A total lifetime cost for patients with spina bifida, which includes medical care, development services and indirect costs, is estimated at US$ 620,484.

A number of cost comparisons have been conducted, looking at fortifying foods with folic acid and the healthcare savings from preventing NTD. South Africa was the first to estimate the costs of treating infants with spina bifida and reported a net savings of US$ 2.8 million. Furthermore, Chile calculated the costs of surgical treatment and rehabilitative services for a sample of children with spina bifida in one year. The results represent a net savings of US$ 2.3 million.

Sources: Hunt J (2002) Reversing Productivity Losses from Iron Deficiency: The Economic Case. *The Journal of Nutrition*, 2002 132(4), 794S–801S; Horton S and J Ross (2003) The Economics of Iron Deficiency, *Food Policy*, 2003, 28: 51–75; Y Yi, M Lindemann, A Colligs et al. (2011) Economic burden of neural tube defects and impact of prevention with folic acid: a literature review, *Eur J Pediatr* 170:1391; Sayed A et al. (2008) Decline in the Prevalence of Neural Tube Defects Following Folic Acid Fortification and Its Cost-Benefit in South Africa, *Birth Defects Research* 82 2008: 211–16; Llanos A et al. (2007) Cost-effectiveness of a Folic Acid Fortification Programme in Chile, *Health Policy* 83 2007: 295–303.

The aim of industrial-scale food fortification is to shift the distribution curve of intakes at the population level.[93] This means that food fortification can reduce the number of people within the overall population who fall in the 'deficit' category. It can provide significant improvements in intakes among all population groups, but as a stand-alone intervention cannot eliminate deficiencies among all target groups. The distribution of intakes and fortification's role is illustrated in Figure 5.

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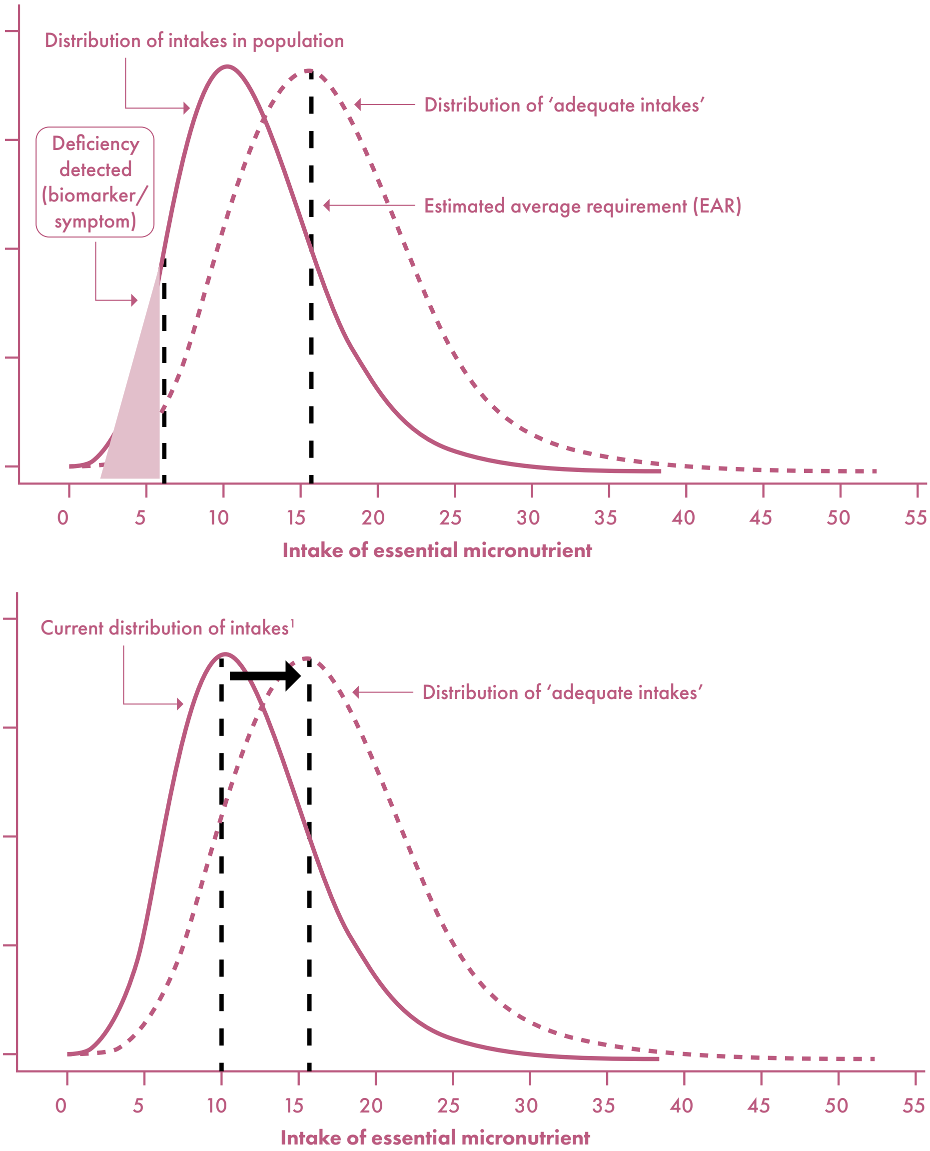
[90] Allen L, B de Benoist, O Dary and R Hurrell (2006), Guidelines on food fortification with micronutrients, WHO/FAO, Geneva, 2006.
[91] Bhutta ZA et al. (2013) op. cit.
[92] GAIN (2015), Fortifying our Future, A Snapshot Report on Food Fortification, Geneva, 2015
[93] WHO/FAO (2006). Guidelines op. cit.

Figure 5: Industrial-scale food fortification shifts distribution of intakes across entire populations[94]



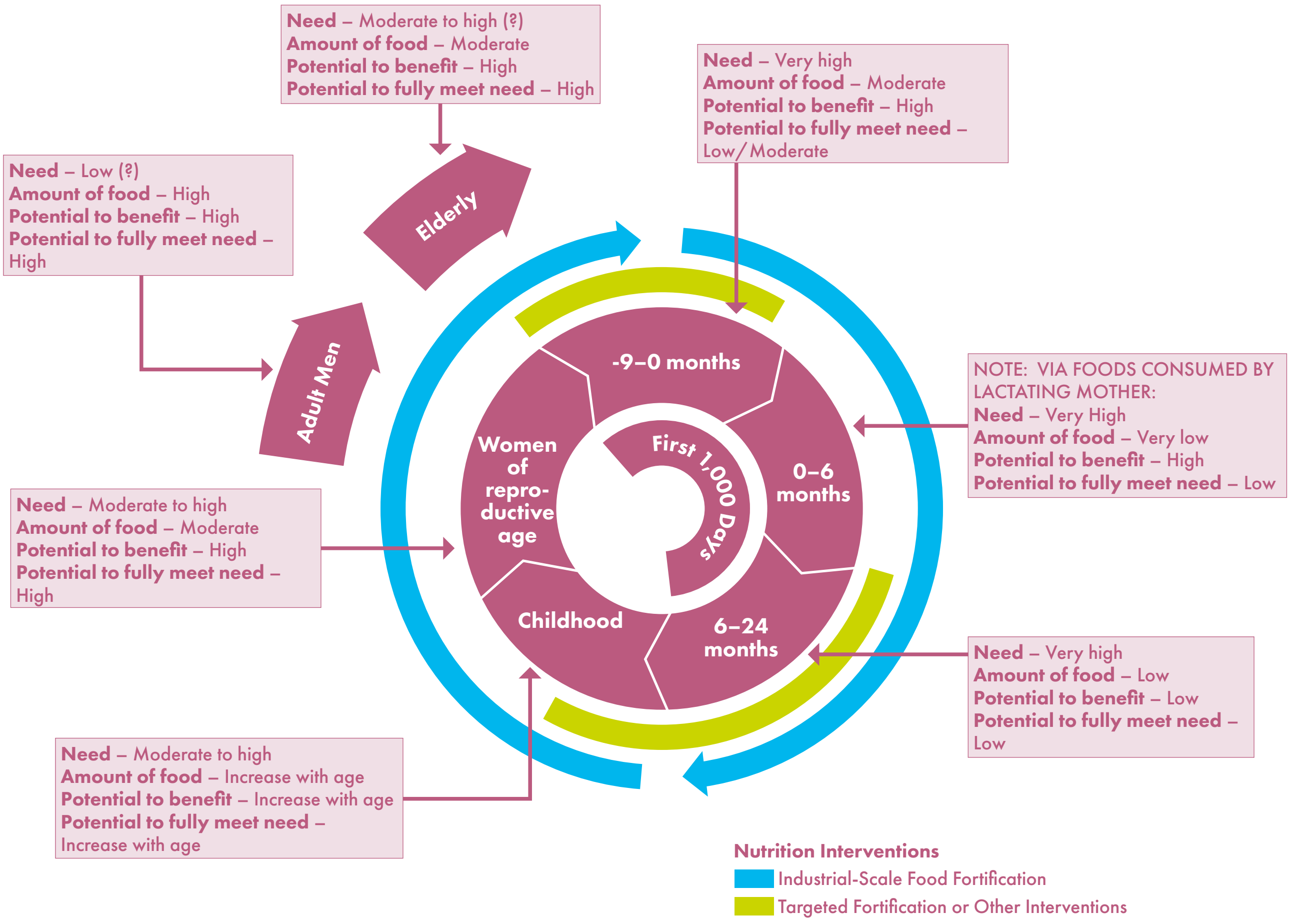
The potential of large-scale food fortification to benefit populations varies by many factors, particular gender and age. It is determined by the combination of: (1) need as defined by dietary intake of key micronutrients being inadequate, as demonstrated by data on intake and/or micronutrient status; (2) coverage and utilisation, which is defined as the intervention employing food vehicles consumed regularly by the population in sufficient quantity. This requires that fortified-food vehicles need to be available, accessible, affordable and also utilised by populations in need; and (3) appropriate fortificant added at the right level (a bioavailable fortificant, added at appropriate levels given per capita consumption of fortifiable food).

[94] This curve illustrates the fact that many people in the population will have inadequate dietary intakes of micronutrients and with food fortification you can move that curve towards more adequate intake, as long as people are consuming that food. Actual increase in intake would not be symmetrical across the population and would depend on the pattern of consumption of the fortified food and other sources of the nutrient in the diet.

Beneficiaries by age group

The benefits of food fortification for different age groups can be illustrated using the life cycle approach to nutrition programming, shown in Figure 6. Those that require the highest amounts of key micronutrients fall within the 1,000 days window, namely during pregnancy, during a period recommended for exclusive breastfeeding (children aged 0 to 6 months), and during infancy (children aged 6 to 24 months). In addition, micronutrient sufficiency just prior to pregnancy is also critical hence the need to ensure adequate intake among all women of reproductive age.

Figure 6: The life cycle approach to understanding the beneficiaries of food fortification[95]



During the 1,000 days window period, the amount of food consumed by the children themselves is quite low and thus their potential to benefit from food fortification is also low. However, a pregnant or lactating mother could consume moderate to high amounts of food and benefit significantly, passing these benefits along to her unborn child or through breastmilk. During this time period, industrial-scale fortification has a lower potential[96] to fully meet the micronutrient needs of children, providing only a basic protective level of micronutrients. Although other population-wide food-based strategies, such as dietary diversity promotion and agricultural improvements, would still not fully meet the needs of

[95] Adopted from Bartley, K. et al. (2005) A life cycle micronutrient perspective for women's health. *Am J Clin Nutr* 81: 1188S–93S.
[96] The potential to benefit would necessarily depend on the availability, access, affordability, and utilisation of safe and high-quality industrially produced fortified foods.

children themselves during this age period, targeted fortification, complementary feeding strategies and health system-based strategies would remain relevant.

However, other age groups throughout the life cycle have a much higher potential to benefit from industrial-scale food fortification alone and a higher potential to fully meet micronutrient needs. Children and adolescents increase their consumption of foods and therefore increase their benefit potential as they age. Elderly populations, even though their consumption of food may start to decrease from adulthood, also have a high benefit potential from industrial-scale food fortification.

Adolescent girls and women of reproductive age are of particular interest as this is an essential opportunity to improve micronutrient intake to fully meet needs and prevent deficiencies prior to their reproductive years and prior to pregnancy (before the first 1,000 days window of opportunity). This is critical, as micronutrient supplementation programmes may not reach these populations or may not gain full utilisation until part-way through pregnancy, if at all, due to challenging distribution logistics and behavioural change requirements for supplementation adherence. For some micronutrients such as folic acid, the window of opportunity is very short. A lack of folic acid during the first 28 days of pregnancy can lead to a higher risk of NTDs; this is often even before a woman knows she is pregnant or seeks prenatal care services to receive supplements, if they are even available and accessible. A higher baseline micronutrient status before becoming pregnant, such as that gained through industrial-scale food fortification, can help to prevent the intergenerational transmission of undernutrition and stunting, which is common in LMICs.

A set of national food fortification coverage surveys that were completed in ten countries from 2013 to September 2015 indicates that there can be good ‘effective coverage’ and potential for impact among all population groups including the vulnerable.[97] The results of these surveys indicate that considerable coverage can be achieved among specific nutrition target groups (e.g. women of reproductive age from a range of wealth groups, and young children 6–23 months of age), although it should be noted that coverage patterns vary widely between countries and the various fortified-food vehicles

Beneficiaries by socioeconomic status and geographic location

Large-scale fortification can reach significant segments of the population, especially wealthier households and those located in urban areas, through conventional market distribution systems. In countries where local diets typically rely on staple foods, such as in many LMICs, similar amounts of staple foods are consumed by each wealth quintile, with the possible exception of subsistence farmers who may consume varying amounts of staple foods, depending on what they farm. The poor in many countries may even consume larger amounts of staple foods than their wealthier counterparts, since they may not have the financial resources or market access to purchase a more diverse diet. However, staple fortification may not adequately reach poorer populations with limited or no access to sufficient financial resources to utilise local markets where fortified staple foods are available. In addition, unless all of a particular type of staple food is guaranteed to be fortified through regulatory monitoring and mandatory legislation that allows for its enforcement, there may be price differentials between fortified and non-fortified foods that could deter access and affordability to the poorest consumers. Where fortified foods are not available in local markets, efforts to work with local industries to increase the distribution of fortified foods is necessary. Where this is not possible or limited, other interventions are needed to complement fortification as part of the nutrition strategy; for example, targeted

[97] Neuffeld, L (2015) Effective Coverage: estimating potential for impact of food fortification. Plenary presentation at the 2015 Global Summit on Food Fortification, Arusha, https://www.dropbox.com/sh/3bd3zsu1wzvvuqc/AAD5M3PiVerRJe-Z2eZHL470a?dl=0&preview=Day+3_Effective+Coverage_Neufeld.pdf (accessed 30 September 2016).

supplementation programmes (micronutrients only or in form of fortified foods made available for specific target groups).

In rural areas, especially where subsistence farming is common, industrial-scale food fortification may not reach households. This could be due to issues of availability as industrial markets and distribution areas may not reach the more remote or rural areas. Indeed, the prevalence of small-scale producers of fortified foods is much higher in rural areas. This could also be due to issues of access and affordability among these typically poorer consumers. Several strategies could be useful in reaching these populations more effectively. Small-scale fortification efforts could be useful where small-scale production centres exist (see Box 6). Other food-based efforts, such as home fortification, biofortification and agricultural improvements may also provide additional benefit together with health-based efforts, such as targeted micronutrient supplementation. In addition, dietary diversity promotion efforts would always be a useful strategy, especially where diverse food products are both available and accessible.

Box 6: Small-scale food fortification

Mandated programmes usually cover only registered producers, which are medium to large industries. Industry assessments in a wide range of countries indicate that there is a trend towards consolidation of industry and that the penetration of large food producers even to rural areas is increasing, which improves the ease in ensuring quality and safety of fortified foods and improves access and availability among rural populations. Nonetheless, the informal, small-scale food processing industry for some food vehicles, particularly for maize flour and salt in Africa, continues to hold a large market share, especially in rural areas.

In 2015, UNICEF, GAIN, the Iodine Global Network (IGN) and the Micronutrient Initiative (MI) completed a review of country experiences in small-scale salt fortification, with a smaller focus on wheat, and maize fortification. The study identified settings where there are a large number of small-scale operators to better understand conditions and viable approaches under which small-scale producers may contribute towards fortification objectives.[98] The findings included that key factors influencing sustainable fortification from the small-scale sector are mandatory legislation and capacity to enforce; clarity on small-scale contribution to supply; industry consolidation or quasi-consolidation in the form of cooperatives; understanding social impact; identifying incentives, models of cooperation, business plan development, and appropriate inputs for external support; establishing minimum criteria for quality of salt; and understanding market forces and competition. However, the major finding was that market forces are not enough for small-scale iodisation and fortification to be successful; efforts to scale up and regulate this sector must be heavily subsidised by the government and/or donors and sustainability without external support remains unclear. Additional research and investment in this area, especially linking with existing technologies such as validated small-scale fortification equipment provided by the Sanku,[99] could prove useful in ensuring greater long-term and country-owned sustainability.

For poorer populations in both rural and urban areas, even where fortified foods are available, access and affordability may be lacking and informal markets may dominate. In these cases, governmental or externally subsidised social protection schemes and safety net programmes, including through cash, vouchers or fortified-food distribution may be required to enable access and affordability to the poorest (see Box 7). Although the cost to fortify that could be passed on to consumers is only a small fraction of the total cost, it is still crucial to identify various methods to continue to bring the costs down so that these do not impact the poorest. A cost analysis to identify the distribution or logistics components

[98] The yet unpublished study rolled out a standardised questionnaire looking at: (1) regulatory environment; (2) business environment/ industry structure; (3) social/cultural environment; (4) financing; (5) external support; (6) production; and (7) trade. Responses were received from Bangladesh, Ethiopia, Ghana, India, Indonesia, Pakistan, Philippines and Senegal.
[99] See also http://sanku.com/gain-officially-approves-sankus-small-scale-fortification-device/

along the value chain that contribute to these costs could also be used to determine trade-offs between using alternative food or health-based strategies to reach the poorest.

Box 7: Fortified foods as a key component to public distribution systems

Public distribution systems and social safety nets that operate through direct food distribution have been increasingly utilising fortified and other nutritious foods within their programmes to improve nutrition for the poorest and most vulnerable population groups. While these types of programmes are often used in the industrialised country context, examples of their use in LMICs have also been documented. The *Oportunidades* programme in Mexico has experienced significant success, as has the similar *Bolsa Familia* programme in Brazil.[100,101] India, as well, has started to use fortified vegetable oil, wheat flour, milk and lentils within their publicly funded programmes, such as the Public Distribution System, Integrated Child Development Services programme and the Mid-Day Meal programme at primary schools.[102]

One of the largest public distribution systems globally is school feeding, where recent lessons learned have also shown this to be efficacious in providing a nutritional impact.[103] Integrating fortified foods into school feeding programmes fills a nutritional need for school-age children and adolescents, complementing industrial-scale food fortification efforts while improving key nutrition, health, educational attainment and economic development impacts. For example, in Bangladesh, a school-based hot meal programme using locally available fortified vegetable oil and micronutrient-fortified powders was combined with nutrition-sensitive activities, including WASH, deworming and community empowerment. In Nigeria, a multi-micronutrient-fortified beverage, Nutri Sip, was provided through government-funded school nutrition programmes. This project reached 270,000 children in Nasarawa State and demand for national expansion of the programme was voiced from numerous states.[104]

2.3 The role of biofortification

Biofortification is defined as the process by which the nutritional quality of food crops is improved through (a) conventional plant breeding; (b) better agronomic practices (primarily through fertiliser application); or (c) modern biotechnology (genetic engineering) (see Box 8).[105] Biofortification is differentiated from conventional fortification in that biofortification aims to increase nutrient levels in crops during plant growth rather than during post-harvest processing of the crops. Biofortification is seen as a potentially highly effective mechanism to reach populations where supplementation and conventional fortification activities may be difficult to implement and/or have limitations.

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[100] Farfan, G et al. (2012) Oportunidades and its impact on Child Nutrition. World Bank, http://www.cedlas-er.org/sites/default/files/aux_files/farfan-paper.pdf (accessed 22 July 2016).
[101] Soares, S (2012) Bolsa Familia: A Summary of its impacts. International Policy Centre for Inclusive Growth. No 137, http://www.ipc-undp.org/pub/IPCOnePager137.pdf (accessed 22 July 2016)
[102] Personal communication with Tarun Vij, GAIN India Country Director, 27 June 2016.
[103] Drake, L et al. (ed) (2016). *Global School Feeding Sourcebook: Lessons from 14 Countries*. London: Imperial College Press.
[104] GAIN (2016) GAIN's Approach to School Nutrition Fact Sheet.
[105] The EC and its Member States are subscribing to the Codex Alimentarius food safety measures for plants derived from recombinant DNA techniques. These standards provide the framework to identify new or altered hazards present in food derived from genetically modified plants relative to the conventional counterpart. It is underlined that such assessments need to take into account the varying levels of nutrients in plants resulting from different growing conditions, bioavailability aspects for both the nutrients or undesirable substances introduced. The health, nutritional status and dietary practices of the specific population groups consuming the food also need to be considered. Ref: FAO/WHO (2009) Codex Alimentarius: Foods derived from modern biotechnology, Rome.

Box 8: Main types of biofortification

Conventional plant breeding

As plant engineering technologies are rapidly emerging, it is expected that in the near future plant researchers will be able to modify the nutritional content of a range of major and minor crops, which can improve many aspects of human and animal health and well-being. However, it is acknowledged that developing plants with improved traits involves overcoming a variety of technical, regulatory and public perception hurdles.[106]

While first-generation bio-engineered crops were primarily geared towards improving agronomic input requirements and yields, the focus for newer generations expanded to improving key 'value-added output traits' including on nutrition. The tools of biotechnology (both conventional selective breeding techniques and plant genomics[107]), are therefore used to modify qualitative aspects of food supply with the aim to adjust the level of certain nutrients in plant foods. With respect to macronutrients, this may entail improving protein quality through better amino acid balances, increasing the fibre content, changing the carbohydrate composition and changing the fatty acid composition. With respect to micronutrients, the main focus so far is on increasing vitamin A precursor levels in rice and cassava, and increasing iron levels in soybean and maize. Another area of work is the reduction of anti-nutrients, like phytate (reduces uptake of iron, calcium, zinc and other divalent mineral ions) and trypsin inhibitors in staple crops like maize and soybeans. Biotechnology is also used to reduce toxin contents in, for example, potatoes (solanine) and cassava (cyanogenic glycosides).

Better agronomic practices

Agronomic practices entail, among others, the application of mineral fertilisers, primarily those containing nitrogen, phosphorus and potassium. The premise is that, if applied at the right time, right place, in the right amount, and of the right composition, fertilisers can contribute to making agriculture in poor countries more sustainable. In order to overcome the challenges posed by the negative side effects of fertilisers, renewed research and development (R&D) efforts are currently undertaken to work out specific fertiliser application mechanisms. The aim is to increase instantaneous uptake of fertiliser by plants through identification of the best suited avenues (roots, above ground parts, seed coating) through research on phyto-physiological processes (including the diversity of mineral uptake mechanisms, their translocation and metabolism within plants). Other entry points for research on optimisation of agronomic practices are the nutrient-specific interactions between plant and soil, plant-microorganism symbiosis systems, and the options that nanotechnology can offer to increase fertiliser uptake rates.[108]

Some modelling studies have indicated that zinc-fortified rice is a cost-effective solution in South Asia.[109] The variety is expected to be relatively easily accepted by consumers. Modelling has also indicated that introduction of iron-dense beans can be expected to be highly cost-effective in Rwanda and neighbouring countries, even with lower coverage rates: around 20%. Similarly, it was found through modelling that introduction of provitamin A maize in Kenya (plus probably many East and Southern African countries) will be high cost-effective, even with lower coverage rates and major loss of provitamin A as a result of sun drying processing methods. However, in the case of the introduction of such biofortified maize in Africa it is anticipated that elaborate and perhaps prolonged nutrition information campaigns may be needed to introduce the yellow-coloured varieties to consumers.

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[106] Ref: McGloughin, MN (2010), 'Modifying agricultural crops for improved nutrition', *New Biotechnology* 27(5): 494–504.
[107] Selective breeding uses seed or germplasm for existing varieties which are naturally high in nutrients and then crossbreed these with high-yielding varieties of crops. This method is generally preferred to genetically engineering crops, as it is quicker and cheaper – and less controversial. Some genetically modified (GM) crops that are being tested comprise 'golden rice' which is developed as a potential new way to address vitamin A deficiency.
[108] Bindraban, PS, C Dimkpa, L Nagarajan et al. (2015) Revisiting fertilizers and fertilization strategies for improved nutrient uptake by plants, *Biol Fertil Soils*, 51: 899–711.
[109] And presumably also in South-East Asia.

Genetic engineering

The picture is more varied for introduction of genetically modified (GM) crops. On the one hand they might offer an immense potential for cropping and nutrition improvements, but on the other there are major public concerns as to the safety of these crops. The Copenhagen Consensus paper anticipated that the introduction of transgenic biofortified crops will remain limited in the near future, and might only take place in a few countries, including the Philippines, India and South Africa. The EC and its Member States subscribe to the Codex Alimentarius' approach on hazard identification in relation to GM plants. The EC Regulation on Genetically Modified Organisms indicates that these foods and feeds must not have adverse effect on human or animal health or on the environment; may not mislead the consumers; and may not differ from the food it is intended to replace so that is normal consumption would be nutritionally disadvantageous for the consumer.[110] This applies to any GM crop (e.g. Golden Rice)[111] but also to other research projects on how GM can contribute to increase the nutrition content (provitamin A, iron, and protein in particular) of crops like cassava, sorghum and bananas.[112]

The concerted focus on biofortification as a mechanism for contribution to micronutrient deficiencies reduction started with the Consultative Group on International Agricultural Research (CGIAR) Conference in Los Baños, Philippines, in October 1999 on 'Improving Human Nutrition Through Agriculture'.[113] Biofortification was a key topic at this meeting. A high number of presentations focused on achievements within the CGIAR Micronutrients Project which comprised a range of agronomic research projects on breeding for nutritionally improved crops. At the conference, biofortification of staple crops was positioned as a highly cost-effective though 'partial' solution that can play a role alongside other interventions such as food fortification and supplementation. It was stressed that biofortification should not replace a more holistic 'food systems approach' towards nutrition through improved dietary diversity and quality, which should be rooted in social, economic and cultural changes.

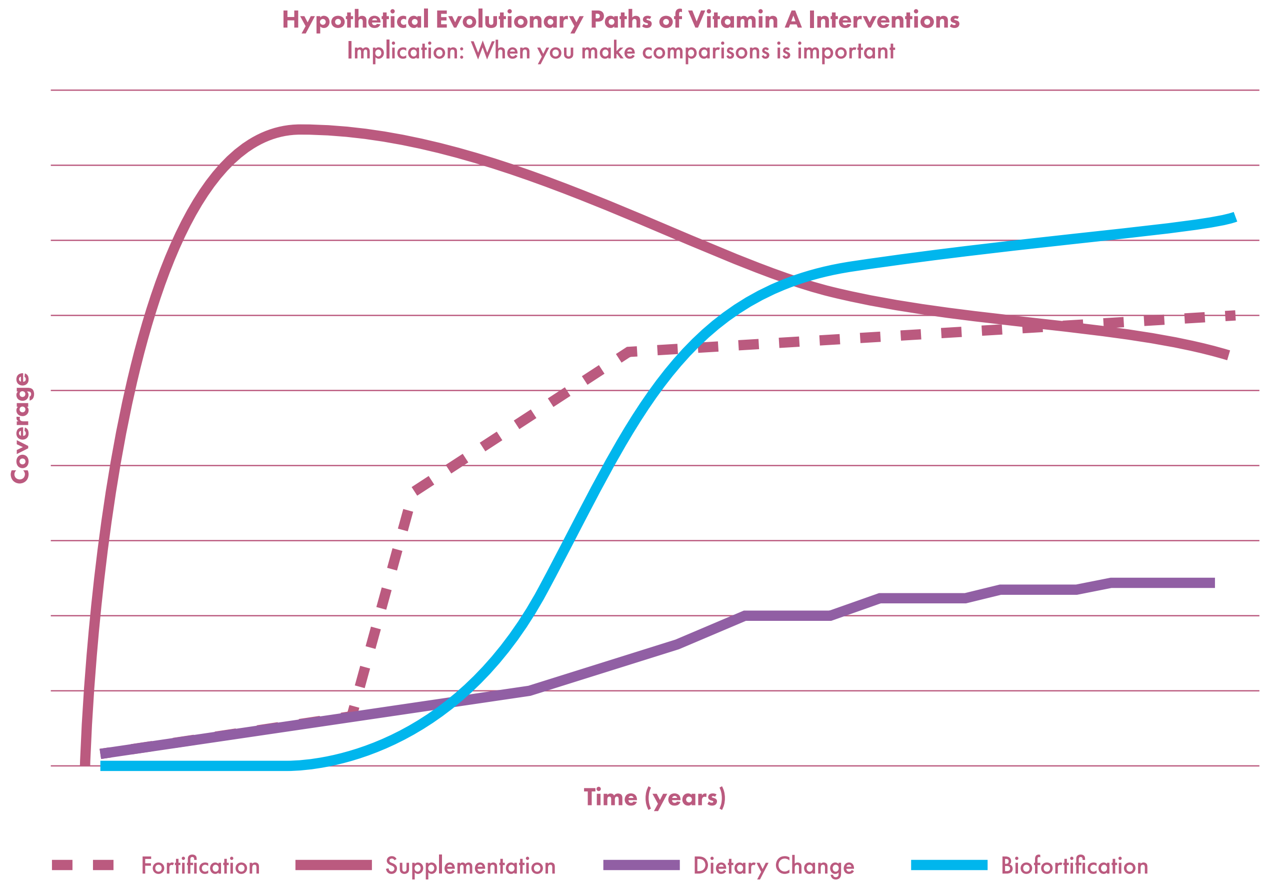
This overall line of thought was repeated in the Copenhagen Consensus Center Best Practice Paper, published in 2009,[114] on the potential contribution of biofortification to micronutrient deficiency reduction. It states that hidden hunger needs to be addressed through more than just one set of solutions or interventions to have an appreciable impact. While supplementation and food fortification are seen as the primary interventions to reduce micronutrient deficiencies, biofortification is suggested as one of the complementary interventions.[115] The paper highlights that the primary focus within biofortification is on enhancing the micronutrient content of relatively cheap staples. The main niche for biofortification is envisaged in rural areas where a large part of the crop production is consumed on-farm or locally, and where access to fortified foods[116] (usually centrally processed) and coverage of supplementation programmes through the health care system may be lower. The paper's conclusion is that biofortification is highly cost-effective even with relatively low coverage levels and corresponding impact on the magnitude of malnutrition. The main premise on which this conclusion is based is that the

[110] EC Regulation No. 1829/2003 on genetically modified food and feed; JRC (2008) Scientific and technical contribution to the development of an overall health strategy in the areas of GMOs, Luxembourg.
[111] Golden Rice is a variety produced through genetic engineering to biosynthesize beta-carotene, a precursor of vitamin A. It is named 'Golden Rice' for its yellow colour, which is due to the high beta-carotene content.
[112] This refers to the BMGF-financed biofortification projects based on genetic engineering: next to the Golden Rice project (http://www.goldenrice.org); the BioCassava project (https://www.danforthcenter.org/scientists-research/research-institutes/institute-for-international-crop-improvement/crop-improvement-projects/biocassava-plus); the African Biofortified Sorghum project (http://biosorghum.org/); and the Banana21 project (http://www.banana21.org/projects-biofortification.html).;
[113] *Food & Nutrition Bulletin* (2000) Special issue on improving human nutrition through agriculture, *FNB* 21(4): 351–571.
[114] Meenakshi, JV (2009) Best Practice Paper: New Advice from CC08; Cost-Effectiveness of Biofortification, Copenhagen Consensus Center, Copenhagen.
[115] While supplementation and fortification were ranked as #1 and #2, biofortification was ranked #5.
[116] Food fortification is most cost-effective with central processing. If fortification is undertaken in dispersed small-scale processing units (e.g. local flour mills) the programme is relatively expensive and it is more difficult to ensure compliance with fortification standards etc.

world's poor cannot afford a diverse food consumption pattern with a range of vegetables, fruits, dairy and meats, and that biofortification is an intervention that can improve their dietary quality without major changes in agro-systems and dietary patterns.

As shown in Figure 7, which is taken from the Copenhagen Consensus Center paper, biofortification programmes are expected to play a significant role in addressing vitamin A deficiency, alongside food fortification and supplementation programmes, and, to a lesser extent, programmes and projects that promote more balanced and diversified agriculture and nutrition. The interventions are complementary in order to meet needs to reduce deficiencies, in particular among vulnerable groups and poorer segments of society.[117]

The key message is that biofortification can play a major role to address micronutrient deficiencies, but that it should not be seen as a simple 'technofix' solution to the problem of hidden hunger. This message has been in some more recent reports published by Welthungerhilfe (2014) and the Global Panel on Agriculture and Food Systems for Nutrition (2016).[118, 119]



[117] See e.g. Fanzo, J et al. (2013) Diversifying Food and Diets: Using agricultural biodiversity to improve nutrition and health, *Biodiversity International*. Oxon: Earthscan.
[118] Hodge, J (2014),*Food Fortification: A 'Techno-Fix' or a Sustainable Solution to Fight Hidden Hunger?*, Deutsche Welthungerhilfe / Terre des Hommes Deutschland, Bonn.
[119] Global Panel on Agriculture and Food Systems for Nutrition (2016) *Food Systems and Diets: Facing the Challenges of the 21st Century*, London.

3 Evidence for nutrition impacts of food fortification

While there is strong evidence from developed countries that food fortification can be highly effective to address micronutrient deficiencies, especially in the case of mandatory programmes, the information base on such impacts still needs to be further established regarding low- and middle-income countries. This does not apply, however, to the Universal Salt Iodization (USI) programme, the effectiveness of which is well documented. Currently, some major research projects are under way to fill this gap. The most important one is the meta-analysis undertaken by Prof. Bhutta, results of which are expected to become available in course of 2017. It is recognised that analysis of nutrition impacts should not be limited to assessments of the prevalence of deficiencies, but also needs to extend to monitoring of the occurrence of negative side effects of fortification programmes, for example, whether there is overconsumption of certain fortified foods and what impacts that would have on health and nutrition conditions of consumers at large, or for vulnerable groups like pregnant and lactating women, young children, etc.

3.1 Reduction of micronutrient deficiencies

Nutrition outcomes of industrial-scale food fortification in industrialised countries and LMICs

The evidence of impact resulting from food fortification is strong in developed countries and growing rapidly in LMICs. Salt iodisation began in Switzerland and the United States in the early 20th century, vitamin A-fortified margarine was introduced in Denmark in 1918 and in the 1930s vitamin A-fortified milk and iron and B-complex fortified flour was introduced in a number of developed countries soon after. These fortification strategies are now common in the developed world and have contributed directly to the virtual eradication of goitre, pellagra, beriberi and rickets alongside other factors such as concurrent improvements in the availability and access to better healthcare and more diverse diets.[120, 121] There is also strong evidence in North America for significant reductions of folate-related NTDs due in part to folate-enriched flour.

The evidence of universal salt iodisation for improving iodine intakes and helping to prevent goitre and iodine deficiency in LMICs is well documented (see Chapter 8), and we are currently in an unprecedented position on the verge of being able to prevent and control iodine deficiency on a global level. Targeted efforts are now required to support the few remaining countries that are moderately to severely iodine deficient at the population level.[122]

[120] Bishai, D and R Nalubola (2002) The History of Food Fortification in the United States: Its Relevance for Current Fortification Efforts in Developing Countries, *Econ Dev Cultural Change*, 51: 35–7.
[121] Park, YK et al. (2000) Effectiveness of food fortification in the United States: the case of pellagra, *Am J Public Health*, 90(5): 727–38.
[122] Timmer, A (2012) Iodine nutrition and universal salt iodization: A landscape analysis in 2012. IDD Newsletter November, http://ign.org/newsletter/idd_nov12_iodine_nutrition_landscape_analysis.pdf (accessed 9 July 2016).

In December 2015, GAIN and the Swiss technological institute, ETH Zurich[123] completed the first multi-centre investigation of iodine status and thyroid function in all population groups in relation to the 1,000 days window. This study was completed in three countries: Croatia, China and the Philippines. The preliminary results indicate that salt iodised at a level of 25 µg/kg provides adequate iodine intake to the general population and meets the increased physiological iodine requirements in pregnant women, lactating women and breastfed infants. The iodine intake was not excessive in school children and women of reproductive age, except for children in the Philippines. The forthcoming results of the thyroid function parameters indicate normal thyroid function in all population groups. A well-functioning USI programme also supplies adequate iodine via breast milk to breastfed infants. The preliminary results similarly suggest sufficient iodine intake in 7–24 month old children. However, before this adequacy can be attributed to iodised salt, the collected information on possible other dietary iodine sources of must first be evaluated.

A meta-analysis on nutrition impacts of industrial-scale food fortification is also currently under preparation, led by Prof. Bhutta. Preliminary results are detailed in Box 9 and the full report is expected to be published in 2017.

Box 9: Meta-analysis on nutrition impacts of industrial-scale food fortification

In 2015, Prof Bhutta from the Sick Kids Center for Global Health completed a systematic review and programme analysis of industrial-scale fortification efforts for improving health outcomes in LMIC. It determines the effectiveness of large-scale fortification efforts in LMIC. Meta-analyses were performed for quantitative outcomes and results were presented as risk ratios (RR), odds ratios (OR), or standard mean differences and 95% confidence intervals (CI). Programmatic indicators were guided by the WHO/ CDC logic model for micronutrient interventions, and formed the basis of qualitative analysis.

The forthcoming results of the systematic review indicate that there are increased relevant serum micronutrient concentrations in women and children and that there is a positive impact on deficiency-related functional outcomes, including anaemia [RR: 0.64 (95% CI: 0.54, 0.75)], goitre [RR: 0.57 (95% CI: 0.41, 0.79)] and neural tube defects [RR: 0.62 (95% CI: 0.51, 0.75)]. An age-specific effect of fortification was found, with a clear gradient towards higher impact among older age groups, which potentially relates to intake and micronutrient dosage. The conclusion of the systematic review is that large-scale fortification programmes in LMICs have a positive impact, showing measurable improvements in the health status of both women and children. However, improving equal access and coverage of quality foods remains a significant gap in programme practice and knowledge.

NB: The research used mixed methods, incorporating both quantitative outcomes and a qualitative analysis of contextual factors that contribute to effective implementation of fortification programmes. All relevant published and unpublished evidence was systematically retrieved and analysed, following application of inclusion/exclusion criteria. From over 20,000 manuscripts a final selection of roughly 100 was included for analysis.

In addition to the meta-analysis referenced in Box 10, several other country-level examples of micronutrient impact can be highlighted.

- In Indonesia, a study was conducted in two districts of West Java from 2011 to 2012 to assess the effects of large-scale fortification on the vitamin A status of women and children. The results showed that fortified oil helped bring vitamin A intake closer to recommended nutrient intakes, contributing on average 26% of daily need for children aged 12 to 23 months, 38–40% among older children, and 29–35% for women. The vitamin A status of all beneficiaries

[123] ETH Zurich is a Swiss university focusing on science, technology, and pioneering effective solutions to global challenges. ETH's focus areas are world food systems, cities of the future, climate change, energy, health, risk research, information processing, new materials, and industrial processes.

improved from 2011 to 2012, as did the vitamin A content of breast milk of lactating mothers. Vitamin A deficiency dropped significantly during this time, falling from 6.5–8% to 0.6–6%.[124, 125]

- In Costa Rica, an evaluation of the impact of iron fortification revealed a significant decrease at national level in the prevalence of anaemia in children aged 1–7 years and women of reproductive age. Anaemia was reduced from 19% to 4% in children and from 18% to 10% in women. In children, iron deficiency was also reduced from 27% to 7%. As one of the earliest LMICs to implement fortification efforts, the results achieved in Costa Rica suggest significant potential for impact when programmes are adequately designed, implemented and monitored.[126]
- In Côte d'Ivoire, large-scale food fortification is considered a cost-effective approach to deliver micronutrients, and fortification of vegetable oil (vitamin A) is mandatory. In Abidjan, the capital of and largest urban community in Côte d'Ivoire, a cross-sectional survey on households with at least one child of 6–23 months was conducted to update coverage figures with adequately fortified-food vehicles, and to evaluate whether additional iron and vitamin A intake was sufficient to reduce micronutrient malnutrition. For vitamin A in oil, the additional percentage of the recommended nutrient intake was 27% and 40% for children 6–23 months and women of reproductive age, respectively. Fortification of vegetable oil was therefore providing a meaningful additional amount of vitamin A to children's diets.[127]

3.2 Food fortification's alignment with efforts to reduce non-communicable diseases and over-nutrition

With shifts in urbanisation and dietary patterns towards more processed foods, there is growing concern over the double-burden of malnutrition (under- and over-nutrition) and nutrition-related, concurrent non-communicable diseases such as diabetes, hypertension, heart disease and cancers. Food vehicles that are fortified at industrial scale because of their high consumption (including vegetable oils, salt, cereal grains and sugar) are seeing even more increases in consumption in some settings, notably among the urban poor, whose low purchasing power reduces their ability to afford a more diverse diet – when it is available – since staple foods are typically cheaper food items.

Even though this is an important concern, it must be clarified that there is no evidence to suggest that industrial-scale food fortification is the cause or a contributor of such dietary shifts. Indeed, in many countries, advertising or marketing such products as fortified is not permitted in order to remain in line with public health efforts, targeting reduction of their consumption. Thus, where such marketing is forbidden, industry does not have any justification for promoting such foods for having health benefits.

Food fortification utilises the existing consumption patterns (taking advantage of increasing consumption to better reach more marginalised populations) within a food system and improves the nutritional quality of existing diets. This is beneficial because it does not require major behaviour

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[124] Sandjaja, et al. (2015) 'Vitamin A-fortified cooking oil reduces vitamin A deficiency in infants, young children and women: Results from a programme evaluation in Indonesia', *Public Health Nutrition*, pp. 1–12.
[125] Soekirman et al., (2012) 'Fortification of Indonesian unbranded vegetable oil: Public-private initiative, from pilot to large scale', *Food and Nutrition Bulletin*, 33: S301–9.
[126] Martorell, R et al. (2015) 'Effectiveness evaluation of the food fortification program of Costa Rica: Impact on anaemia prevalence and haemoglobin concentrations in women and children', *American Journal of Clinical Nutrition*, 101(1): 210–17.
[127] Fabian, R et al. (2016) 'The potential of food fortification to add micronutrients in young children and women of reproductive age – Findings from a cross-sectional survey in Abidjan, Cote d'Ivoire', *Plos One*, July.

change communications to convince consumers to change their buying patterns or eating habits, which is a notoriously difficult task, even in industrialised countries.[128]

A separate, but related, issue is that of alignment with environmental concerns, particularly relating to the environmental degradation that can occur with large oil plantations, fields devoted to single grains and salt harvesting. Indeed, fortification efforts must take into account the needs addressing such concerns. This might entail the identification of alternative food vehicles for fortification and ensure that appropriate legislation and standards are in place, and they are flexible enough to accommodate new vehicles as consumption patterns shift.

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[128] Zamora, G and LM De-Regil (2014) Equity in access to fortified maize flour and corn meal. *Ann N Y Acad Sci*, 1312: 40–53.

4 Large-scale food fortification programmes: results, challenges and gaps

This chapter provides an overview of how food fortification programmes work in practice. After a brief overview of the main programmatic considerations within food fortification, it is explained how national governments and the local food industry are involved, and what their main roles are. The chapter also describes how a range of international partners are engaged with or provide support to these processes. Furthermore, we describe how the international coordination on these programmes is shaped, including some recent new developments aimed at increased exchange of experiences to foster harmonisation of approaches across countries. The second part of this chapter looks into key successes, challenges and gaps for food fortification programmes worldwide. Towards the end of the chapter, a more detailed overview is provided of some key challenges for food fortification programmes, as highlighted at the Arusha Summit on Food Fortification in September 2015.

4.1 Main players and programmes

National players

Over 140 countries implement national USI programmes, 85 countries mandate at least one kind of cereal grain fortification and over 40 mandate the fortification of edible oils, margarine and ghee.[129] Many other countries have also started to scale up condiment fortification. These national food fortification programmes require partnerships comprised of multi-sectoral players to deliver their intended positive health outcomes. While each country must ensure that the institutional structures, roles and responsibilities among the public and private sector are appropriate to work within the national food system, there is a common set of national players found in the majority of fortification programmes.

Government actors would include a lead ministry, which is typically the Ministry of Health or the Ministry of Industry (this ministry often includes a dedicated fortification project management unit); national or provincial/county food control authorities charged with monitoring food safety and quality; and nutrition information system/nutrition surveillance units (which are often housed within ministries of health but are sometimes positioned within a multi-sectoral nutrition coordination cell directly under the President's Office).

From the private sector, the primary players include: the food processing industry including wheat, maize and rice mills and oil and salt refineries; manufacturers and suppliers of vitamin and minerals and/or multi-micronutrient premixes;[130] private food laboratories; and retail organisations (including cooperatives where they exist). Other national players include academia and the national consumer organisations present in many countries (aimed at strengthening of the position of consumers vis-à-vis

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[129] Luthringer, CL, et al. (2015) Regulatory monitoring of fortified foods: Identifying barriers and good practices. *Global Health Science and Practice*, 3(3): 446–61.
[130] Most suppliers are located in Europe, China, India and United States.

producers and retail organisations, and at provision of information to the general public on product quality aspects).

One of the specific features of fortification programmes is the important (and required) link between the public and private sectors as well as engagement from consumers, civil society, academia and the NGO/donor community. Multi-stakeholder approaches are required to bring all relevant stakeholders to the table, so that solutions to nutrition issues can be discussed and addressed holistically. One of the mechanisms for doing this is the creation of National Fortification Alliances. Such national alliances on food fortification have been established in 16 countries, many of which are still functional after 5–15 years of operation.[131]

Box 10: Functioning of National Fortification Alliances

As stated above, because many players are involved at the national level, many countries have established fortification alliances or coordination bodies to help harmonise activities towards a common goal of preventing micronutrient deficiency through food fortification.[132] These 'National Fortification Alliances' provide neutral oversight and guidance to establish, improve and sustain food fortification programmes. Without a National Fortification Alliance (NFA), there is a risk that effective relationships between business, government, NGOs and civil society would not be systematically established under a common public health goal. Challenges such as special interests among individual sectors, budget constraints and disinterest among members are common to fortification programmes. One review found that success factors for NFAs to overcome these issues include leadership, available budget to conduct fortification coordination activities, and the formation of results-based short-term goals and active sub-committees.[133] In the early stages of programme development, NFAs are a useful mechanism for building coordination. For more mature programmes, NFAs are useful for maintaining trust between sectors and providing advice.

In addition to NFAs, many existing national coordination mechanisms help support fortification efforts on the policy level including the SUN movements, country-specific SUN business networks and iodine coalitions.

International partners

Since the early 2000s, national large-scale fortification programmes have been supported by numerous international non-governmental technical agencies, academia, donors and private sector players. The list below builds on the partner mapping completed in 2015 by the Technical Advisory Group of the Global Summit on Food Fortification.[134]

The primary **non-governmental partners** that have supported or continue to build, improve and sustain national large-scale food fortification programming since 2000 are: the Food Fortification Initiative (FFI), the Global Alliance for Improved Nutrition (GAIN), Helen Keller International (HKI), the Iodine Global Network (IGN, formerly International Council for Control of Iodine Deficiency Disorders (ICCIDD)), the International Federation for Spina Bifida and Hydrocephalus (through Smarter Futures), the Micronutrient Forum, the Micronutrient Initiative (MI), PATH, Project Healthy Children (PHC), Sight and Life, and Technoserve.

UN agencies active in fortification are: UNICEF, primarily in salt iodisation and overall advocacy; FAO, specifically on codex development and food safety; the WFP, which helps support the inclusion of

[131] These Alliances were established with the help of GAIN. Ref: H Hafeez-ur-Rehman, Building and Strengthening National Fortification Alliances: Experiences and Lessons from nine countries. (Draft report and personal communication, 25 February 2016.)
[132] Rehman, H. et al. (2016) National Fortification Alliances (NFAs): Program guidance based on lessons learned from nine countries. *Micronutrient Forum* 2016 Abstract.
[133] Ibid.
[134] For further detail, refer to 'Food fortification: Moving from knowledge to alignment to action through the formation of a Technical Advisory Group and Global Summit', http://www.karger.com/Article/PDF/448017 (accessed 17 February 2017).

fortified foods in emergency, school feeding and Cash & Voucher programmes; and WHO, which provides normative and evidence-based guidance for fortification.

Private sector partners that have provided financial or in-kind resources for fortification: DSM, BASF, Stern, UNILEVER, Buhler, Cargill, Bunge, and International Association of Operative Millers. There are, of course, multiple other private sector actors, which are involved in some way fortifying foods, but the list above concentrates on those industries which have provided specific financial or in-kind resources.[135]

Academia: Universities routinely driving research projects, monitoring and learning of fortification include CDC IMMPaCt, ETH Zurich, the Hospital for Sick Children, University of Ghent, Emory University, UC Davis, Johns Hopkins University, and Wageningen University and Research.

Financial donors, which have provided financial contributions to country fortification programmes, include bilateral donors, multilateral donors and foundations. The primary bilateral and multilateral donors have included the Government of Canada, the Government of the Netherlands, the UK Department for International Development (DFID), Irish Aid, GIZ, the United States Agency for International Development (USAID), the World Bank, the Asian Development Bank, the Inter-American Development Bank and, more recently, the European Commission. The primary foundations have included the Bill & Melinda Gates Foundation (BMGF), the Children Investment Fund Foundation (CIFF) and smaller contributions from GiveWell/Good Ventures, Goldsmith, James Percy, and Waterloo.

International coordination

The development of external donor funding for large-scale food fortification started to scale up in the early 1990s with funding made available to initiate and/or improve salt iodisation efforts in the developing world, primarily led by UNICEF, and with inputs from ICCIDD and the Iodine Network – which merged in 2014 to become the Iodine Global Network – and the International Development Research Center (now the Micronutrient Initiative).

In the early 2000s additional initiatives were established which started to unlock significant investments in staple food fortification, notably the Flour Fortification Initiative (now the FFI) and the Global Alliance for Improved Nutrition (GAIN). The latter also began supporting salt iodisation programmes in 13 countries in 2008 through the GAIN-UNICEF Universal Salt Iodisation Partnership Project. The top three donors supporting fortification since 2000 have been the BMGF, USAID and the Government of Canada with most of these resources being managed by GAIN, HKI, MI and UNICEF.

In April 2015, the Government of Tanzania, GAIN, the African Union Commission, the BMGF, USAID, UNICEF, WFP and the SUN Secretariat announced plans to co-convene the first-ever international meeting devoted to large-scale food fortification: the #FutureFortified Global Summit on Food Fortification in Tanzania, 9–11 September 2015.

The Summit helped to align international actors on the way forward. It was reported on as a success in various publications and resulted in the Arusha Summit on Food Fortification, and the post Summit discussions and actions among the majority of the international partners outlined above. Together they formed a fortification Technical Advisory Group (TAG).[136]

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[135] The SUN Business Network acts as a secretariat for private sector engagement with Sun; it is hosted by WFP and GAIN.

[136] Garrett, GS et al. (2016) 'Recommendations for food fortification programs: Technical Advisory Group report elaborating on the five recommendations from the #FutureFortified Global Summit on Food Fortification'. *Sight and Life*

The Technical Advisory Group formed three thematic working groups on regulatory monitoring, evidence and advocacy. The first working group on regulatory monitoring focused on barriers faced in countries that have adopted mandatory fortification programmes, outlined preliminary solutions with documented examples from country-specific programmes, and suggested methods for disseminating proposed practices, as well as means for tracking global compliance. The second working group on evidence identified the critical evidence gaps where timely research can enable donors, policy-makers, advocates, regulatory authorities, researchers, businesses and governments to initiate and sustain efficient, effective and equitable mandatory, large-scale fortification programmes with high potential to improve health/nutrition outcomes. The final working group on advocacy identified opportunities for the nutrition sector to advocate to national policy-makers and government officials and their influencers to implement and improve mandatory fortification programmes.

These TAG working group deliberations were published along with the Summit proceedings in a July 2016 *Sight and Life* publication. This report includes a roadmap for establishing a global food fortification repository to harmonise and streamline global databases tracking food fortification programmes and to help align international partners on priorities to establish, improve and sustain national fortification programmes.

In most of the 40 countries with nutrition as a focal area in the 11th EDF National Indicative Programme, legislation exists on food fortification, in particular for salt iodisation, but also in many cases on oil fortification with vitamin A, and on enrichment of flour with a number of micronutrients. A detailed overview is attached as Annex 6.

The primary international large-scale food fortification projects and partners have been mapped for the 40 EU priority countries for nutrition in Annex 7.

4.2 Key successes, challenges and gaps

As the experience with the various types of large-scale food fortification shows, micronutrient fortification can be a well-accepted preventive public health and nutrition intervention that provides a basic level of protection against micronutrient deficiencies. One of the respondents to the online stakeholder survey that was conducted as part of the Global Mapping study has framed it like this:

> *Fortification is done by the (food) industry and reaches the majority of urban and peri-urban consumers and all those who can access processed foods. As such it frees the hands of the government to address (the nutritional needs of) the poorest of the poor, and those not reached by fortified foods*.

While evidently fortification of condiments and more complex processed foods is a newer phenomenon, the basic concept of fortification and the addition of vitamins and minerals to commonly used food products like salt, flour and vegetable fats and oil, have a long history, dating back to the first half of the 20th century:

- ✓ Documentation of the effectiveness of food fortification started in Switzerland in the early 1900s where a decision was made to iodise salt to prevent goitre and cretinism. The approach proved to be successful and was duplicated by many other countries across the globe, especially after the WHO/UNICEF recommendation to adopt universal salt iodisation. The mandatory or

July, http://www.sightandlife.org/fileadmin/data/Magazine/2016/Suppl_to_1_2016/ FutureFortified.pdf (accessed 30 September 2016).

voluntary salt iodisation usually entails both 'table salt' and salt that is used by the food industry and for livestock consumption.

- ✓ The fortification of oils and fats with vitamin A and D started around the same time in the early 1900s, very soon after research had discovered the relation between deficiencies in the diet for these vitamins and the prevalence of xerophthalmia and rickets.

- ✓ The fortification of cereal products with iron, some of the B-vitamins, and/or some other micronutrients, started in the United States where in 1939 it became mandatory to fortify white flour and white bread. Soon afterwards, the measure was replicated in some countries in Europe, with varying numbers of micronutrients being added to different types of cereal products.

- ✓ Sugar fortification with vitamin A was established in the 1970s in a range of Latin American countries. The addition of (multiple) micronutrients to various processed foods and sauces that are aimed at enriching the flavour and appeal of meals in particular, is a more recent phenomenon, which started in the 1980s. The appeal of these types of vehicles for fortification is that they reach out to large parts of the population in South-East Asian and Western African countries, through cost-effective market-based approaches. It is not surprising therefore, that these newer types of food fortification have been scaled up rather quickly.

As a result of the literature review that was undertaken for the preparation of this Global Mapping Report, both on food fortification at large and more specifically for the different vehicles that are commonly being fortified, a listing has been prepared of the main features that underpin successful and sustainable large-scale fortification programmes, see Box 11 below:

Box 11: Key success factors and preconditions for large-scale food fortification

- There is transparent collaboration between relevant government authorities, health and nutrition experts, civil society and industrial food producers and importers. Food industry companies involved are recognised as essential partners in improving public health as they are the actual implementers of food fortification.
- There is clear legislation and appropriate national standards related to the bioavailable forms and amounts of nutrients to be added to the food vehicle(s) of choice. This applies to both mandatory and voluntary fortification programmes. In order to avoid under- or over-fortification, the standards need to be based on correct estimates of the national average per capita daily consumption levels of the food items being fortified, and need to take consumption patterns and specific needs among nutritionally vulnerable groups into account.
- National regulatory agencies (including Customs staff) have the resources, capacities and skills to monitor and enforce the food fortification standards. Regulatory agencies should identify the absolute minimum set of indicators on product quality and safety that should be monitored.
- There is regular (annual?) tracking and reporting on coverage of the population with the fortified foods, based on production data provided by the industry and estimates of sales across the primary geographic markets of the product. The impact of the intervention could be tracked in some of the areas where the population coverage of the product is shown to be close to or higher than 80% over time, instead of expending such resources in areas where impact would not be expected.
- The food industry is committed to fortification. Importers only bring foods into the countries in line with the national legislation and food fortification standards. To the extent possible and as appropriate, food producing companies are willing to invest their own resources towards purchase of needed equipment and fortificants, and, if needed, to strengthen their capacity to produce and market sufficient quantities of adequately fortified foods.
- The amounts of fortified foods available within a country are the sum of importation of such products from outside and local production. The total that is available on the market should be enough to meet

customer demands in case of voluntary programmes, and to cover total needs (>80% of total population requirements) in case of mandatory fortification.

- National industrial food producers have sufficient organisational capacities and technical skills to develop and implement the needed internal quality assurance/quality control (QA/QC) procedures and processes that are required to ensure the production and marketing of adequately fortified foods on an ongoing basis.
- Consumers are educated on the existence of fortified foods on the market, how their use can contribute to prevention of some key micronutrient deficiencies, and why a small price increase is necessary to cover additional costs. Social marketing on food fortification, possibly combined with targeted social distribution mechanisms to increase reach-out to specifically vulnerable groups, can encourage consumers to accept fortified foods. Furthermore, it is essential that consumers are regularly informed about the brands that are complying and non-complying with national fortification standards.

Within more advanced countries with well-established food industries, it is generally assumed that fortification standards are complied with; food companies are well-developed using modern technology, and implement QA/QC systems that effectively ensure the quality of the fortified foods. It is also assumed that the vast majority of the populations in such countries consume the average amounts of the fortified products (the amount that was used to determine fortification levels), on a regular basis. However, these assumptions do not equally apply to other countries whose food industries are less developed. Regrettably, assessments and studies of impact of food fortification programmes that have been published in scientific or grey literature usually do not include data on key aspects of programme implementation like the quality and population coverage of the fortified food(s) during the period when impact data were collected. Overall, where food fortification programmes have not been shown to be effective, this is typically related to one or more of the following key explanatory factors:

- The type and concentration of fortificant added to fortified food was inappropriate, and/or not based on a good estimate of the per capita intake of the '*fortifiable*' type of the product (e.g. industrially milled flour vs industrially and non-industrially milled flour).
- The quantities of adequately fortified product that were marketed are not sufficient to meet the per capita consumption needs of the vast majority of the population (nationwide or more confined sub-regions, depending on the reach-out and market penetration of fortified foods).
- The implementation period of the fortification programme has been too short to show a measurable impact on micronutrient status data.

A more detailed overview of the main successes and challenges and gaps in relation to food fortification in LMIC is provided in Tables 1 and 2 below. The overview builds on a model that has been developed by GAIN for assessment of national food fortification implementation processes (see also Annex 7):

Table 1: Key successes, challenges and gaps within the enabling environment

	Key successes	Challenges/gaps
Build/ expand	- Much of the new growth and development of legislation and standards for fortification has occurred in LMICs. - Fortification alliances, which are based on transparent partnerships between government and civil society and food industry, remain an important model to bring stakeholders together. - Advocacy efforts have brought food fortification to the forefront of national and international nutrition agendas, including SUN and the SDGs.	- Lack of information on industrial food fortification, biofortification and supplementation programme coverage and micronutrient deficiency profiles in countries, including among sub-groups of the population. - Import monitoring is often challenging when substantial quantities of unfortified staple foods enter countries through border crossings and points of entry that are not well defined and monitored. This can expose domestic producers trying to fortify to undue competition. - The shifts to more industrial environments with large-scale processing of staple foods that are happening in many countries offer new opportunities.
Improve	- Regulatory monitoring and improving the quality and safety of fortified foods was identified as a key priority area for fortification agendas globally and recognised within the Arusha Statement.	- More insight is needed into the full value chain for fortified foods production, including food safety and quality aspects (e.g. aflatoxins in cereals and pulses, and high moisture contents) and the stability of the added vitamins and minerals in fortified products during storage. - There is a lack of validated rapid test kits available for government inspection agencies (as well as fortified-food producers) to use to verify compliance with fortification standards. Similarly, government food control and testing laboratories are chronically under capacitated and under resourced.
Measure/ sustain	- Where adequate quality and high coverage of fortified foods (apparently) have been sustained over time, it has been possible to demonstrate positive impacts on micronutrient deficiency-related outcomes such as anaemia, goitre, and neural tube defects, for both developed and low and middle-income countries.	- Lack of reliable data on per capita consumption of 'fortifiable' (i.e. industrially produced) foods (e.g. flour and vegetable oil) to guide setting of appropriate national fortification standards. - A need exists to enhancing the capacity of national regulatory agencies (including Customs) to enforce food fortification standards and to adequately monitor fortification outputs and population coverage. This should build on transparent collaboration between the private and public sectors. - Limited progress on adequate integration of food fortification within holistic programming frameworks on nutrition and micronutrient deficiencies.

Table 2: Key successes, challenges and gaps within the food value chain

	Key successes	Challenges/gaps
Build/ expand	- Legislation on (mandatory) fortification of industrially produced foods is increasingly accepted and promulgated by the food industry around the world. - Establishment of a global Premix Facility, which ascertains that also small and medium enterprises can have good access to fortificants at reasonable price levels.	- In many countries, the existence of large numbers of small-scale food producers, who are not able to adequately fortify food products in economically feasible manners, is posing challenges to scaling up of food fortification programmes. This applies in particular to wheat and maize flour production where small mills are scattered across the country, supplying rural populations in many countries. - Lack of sufficiently successful strategies to encourage small-scale producers to consolidate their businesses through cooperatives and other forms of partnerships, so as to form larger enterprises that can sustainably operate. - Need to garner support of sceptics of mandatory food fortification among some groups of health professionals, consumer groups and others who may resist fortification efforts.
Improve	- Reduction of import taxes on fortificants has been shown to help increase production and quality levels of fortified foods. - Increasing levels of consumers' dependence on markets to access foods, among others as result of continuing urbanisation, in combination with the ongoing consolidation of food processing towards more industrial levels, allow that higher proportions of the population can be covered with fortified foods, including the economically disadvantaged.	- Supply chain bottlenecks and harmonisation of fortification standards need to be addressed to ensure availability and accessibility of fortified foods, incl. new vehicles, within national and regional food supply systems. - Increased consumption of processed foods provides new opportunities in terms of food fortification as part of an overall package of micronutrient malnutrition reduction measures. - More culturally appropriate communication and social marketing is still needed to encourage consumers to 'accept' consumption of adequately fortified foods as nutritionally beneficial.
Measure/ sustain	- The use of total quality systems in many countries enables greater sustainability in ensuring high-quality fortified-food production and marketing. - Inclusion of fortified foods within public distribution systems, social protection programmes, school meals programmes and emergency food aid baskets has provided platforms for reaching greater numbers of individuals, specifically poorer and rural inhabitants.	- Inability of fortified-food producers in many LMICs to ensure sustained production and marketing of sufficient quantities of adequately fortified foods over time. - As diets change and new products enter markets over time, it is necessary to ensure continued relevance of specific fortified foods. Food producers and importers depend on commercial sustainability of fortified foods! - Inevitably, food fortification programmes depend on consumers' preferences and choices. It needs to be ensured that fortified foods are appealing, accessible and affordable, particularly for more deprived households.

Challenges in ensuring impact

While there are many challenges in ensuring nutritional impact through food fortification, three key issues come to the forefront of many fortification programmes and deserve further discussion here. These are legislative challenges, regulatory monitoring challenges, and advocacy and communications challenges.

1. **Legislative challenges**

Mandatory fortification refers to legislation that requires all food producers and/or importers to add certain vitamins and minerals to a specific type(s) of foods. Legislation is typically complemented by a food standard, which specifies such levels of micronutrients along with any other safety and quality regulations or packaging and labelling requirements. Mandatory fortification is legally enforceable by food control authorities. On the other hand, voluntary regulation allows products to be fortified if the producer should choose to do this. Voluntary regulation is also often complemented by a standard, which provides the same information as a standard under mandatory regulation, but would only apply if a producer chooses to fortify.

In LMICs, mandatory legislation creates greater parity for industries to fortify, a term referred to as ‘levelling the playing field’. Fortified foods are considered credence goods, or goods that consumers cannot easily evaluate for their quality, safety or micronutrient content. Consumers cannot determine whether fortified foods contain the amount of micronutrients stipulated in the relevant standard because both fortified and non-fortified foods are virtually identical in their organoleptic properties. Thus, consumers must take the manufacturers’ stated claims on faith and cannot easily demand a higher-quality product. This means that consumers can be cheated into paying higher prices for claims of higher-quality products when food control agencies are not legally allowed to enforce fortification standards, as is often the case under voluntary fortification schemes. Food producers who choose not to invest in fortification or who wish to deceive consumers to cut costs can therefore drive out legitimate business. In addition, under voluntary fortification schemes, greater competition between fortified and non-fortified foods produced domestically or imported often means that the non-fortified (and often cheaper) products gain greater market share. In this way, mandatory fortification ‘levels the playing field’ by forcing all producers and importers to follow the same rules, enabling legal enforcement by food control agencies, and in the end, driving down the cost of all brands of a particular fortified-food vehicle. This also enables the consumer to better exercise their right to nutritious foods through a good quality and adequately fortified product.

Mandatory fortification has also led to sustainable health impacts.[137] A number of countries have tried to establish fortification programmes without compulsory legislation and they have failed to reach scale and impact. Mandatory legislation for salt iodisation was shown to have a greater increase in household coverage globally (from 49% to 72%) in the decade following legislation, compared with more minimal increases in countries with voluntary iodisation (40% to 49%).[138] Within 77 countries that mandate fortification of wheat flour, 90% of industrially milled flour is fortified compared to only 5% of flour where fortification is done through voluntary efforts.[139] The effects on nutritional indicators are also compelling. Mandatory folic acid fortification of flour has been associated with a marked decrease in the rates of

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[137] Bishai, D and R Nalubola (2002) The History of Food Fortification in the United States: Its Relevance for Current Fortification Efforts in Developing Countries, *Economic Development and Cultural Change*, University of Chicago Press, 51(1): 37–53, October.

[138] Horton S, Mannar V and Wesley A. (2008) Micronutrient Fortification (Iron and Salt Iodization). Copenhagen Consensus Best Practice Paper, http://www.copenhagenconsensus.com/sites/default/files/bpp_fortification.pdf (accessed 25 July 2016).

[139] Zimmerman S, et al. (2013) Mandatory policy: Most successful means of maximizing fortification’s effect on vitamin and mineral deficiency. Unpublished manuscript.

spina bifida and anencephaly.[140,141,142,143,144,145,146] In Australia, the prevalence of low serum folate was found to be 2.1% 7 months after legislation was passed to mandate fortification of wheat flour with folic acid; this is compared to 9.3% during the 15 years when fortification was allowed on a voluntary basis.[147] Similarly, mandated universal salt iodization (USI) has led to a significant decrease of iodine deficiency disorders (IDD) in the developing world and arguably IDD could be fully resolved in several LMIC as well as European countries by mandatory legislation of salt iodisation.[148,149,150]

The only documented examples of successful voluntary fortification efforts being sustainable and reaching national scale occur in countries where all of the target food vehicle is produced by four or fewer producers, or where 100% of the target food vehicle is imported and fortification processes are controlled at import sites. Voluntary fortification initiated by the private sector often has challenges in reaching target population groups at risk of nutritional deficiencies. The level of certainty that a particular fortified food will contain a pre-determined amount of a micronutrient is higher when mandated. By providing a higher level of certainty, mandatory fortification is more likely to deliver a sustained source of fortified food for consumption by the relevant population group, and, in turn, a public health benefit.[151]

Voluntary fortification may be used by a company to improve its market share or brand recognition. It is also important to note that some voluntary initiatives, namely oil fortification in India, and flour fortification in Kenya, did go to relative scale within certain sub-national regions and helped move the government and industry towards a more comprehensive and mandatory legislative framework for a public health-driven fortification programme. Kenya does mandate fortification of wheat and maize flours today and some Indian States (i.e. Rajasthan and Madhya Pradesh) mandate oil fortification and are the impetus for mandatory fortification in several other Indian States and at national level.

Mandatory standards and legislation do not alone guarantee that high-quality and adequately fortified foods are distributed and available in markets. These standards and legislative directives need to be clear and need to state the roles and responsibilities of key stakeholders throughout the process to

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140 Honein MA, LJ Paulozzi, TJ Mathews et al. (2001) Impact of folic acid fortification of the US food supply on the occurrence of neural tube defects, *JAMA*, 285: 2981–6.

141 De Wals P, F Tairou, MI Van Allen et al. (2007) Reduction in neural tube defects after folic acid fortification in Canada, *N Engl J Med*. 357: 135–42.

142 Castilla, EE, IM Orioli, JS Lopez-Camelo et al. (2003) Latin American Collaborative Study of Congenital Malformations (ECLAMC). Preliminary data on changes in neural tube defect prevalence rates after folic acid fortification in South America, *Am J Med Genet A*. 123A(2):123–8.

143 Oakley G (2009) The Scientific Basis for Eliminating Folic Acid–Preventable Spina Bifida: A Modern Miracle from Epidemiology, Ann Epidemiol 19(4): 226–30.

144 Erickson JD (2002) Folic acid and prevention of spina bifida and anencephaly. 10 years after the U.S. Public Health Service recommendation, *MMWR Recomm Rep*. 51 (RR-13): 1–3.

145 Hertrampf E, F Cortes, JD Erickson et al. (2003) Consumption of folic acid-fortified bread improves folate status in women of reproductive age in Chile. *J Nutr.* 133: 3166–9.

146 Sayed AR, D Bourne, R Pattinson et al. (2008) Decline in the prevalence of neural tube defects following folic acid fortification and its cost-benefit in South Africa. *Birth Defects Res.* 82: 211–16.

147 Brown, RD, MR Langshaw, EJ Uhr, JN Gibson and DE Joshua (2011) The impact of mandatory fortification of flour with folic acid on the blood folate levels of an Australian population. *Med J Australia*, 194(2): 65–7.

148 Iodine deficiency in Europe (2003) National reports on iodine status in West-Central European countries. First symposium of ICCIDD West-Central Europe. Goteborg, Sweden, 7 September 2002. *J Endocrinol Invest.* 26 (9 Suppl): 1–62.

149 Vejbjerg P et al. (2007) Effect of a Mandatory Iodization Program on Thyroid Gland Volume Based on Individuals' Age, Gender, and Preceding Severity of Dietary Iodine Deficiency: A Prospective, Population-Based Study, *J Clin Endocrinol Metab* 92(4): 1397–401.

150UNICEF. (2011) Universal salt iodization in Central and Eastern Europe and the Commonwealth of Independent States, http://www.slideshare.net/unicefceecis/universal-salt-iodization-in-central-and-eastern-europe-and-the-commonwealth-of-independent-states. (accessed 18 February 2017).

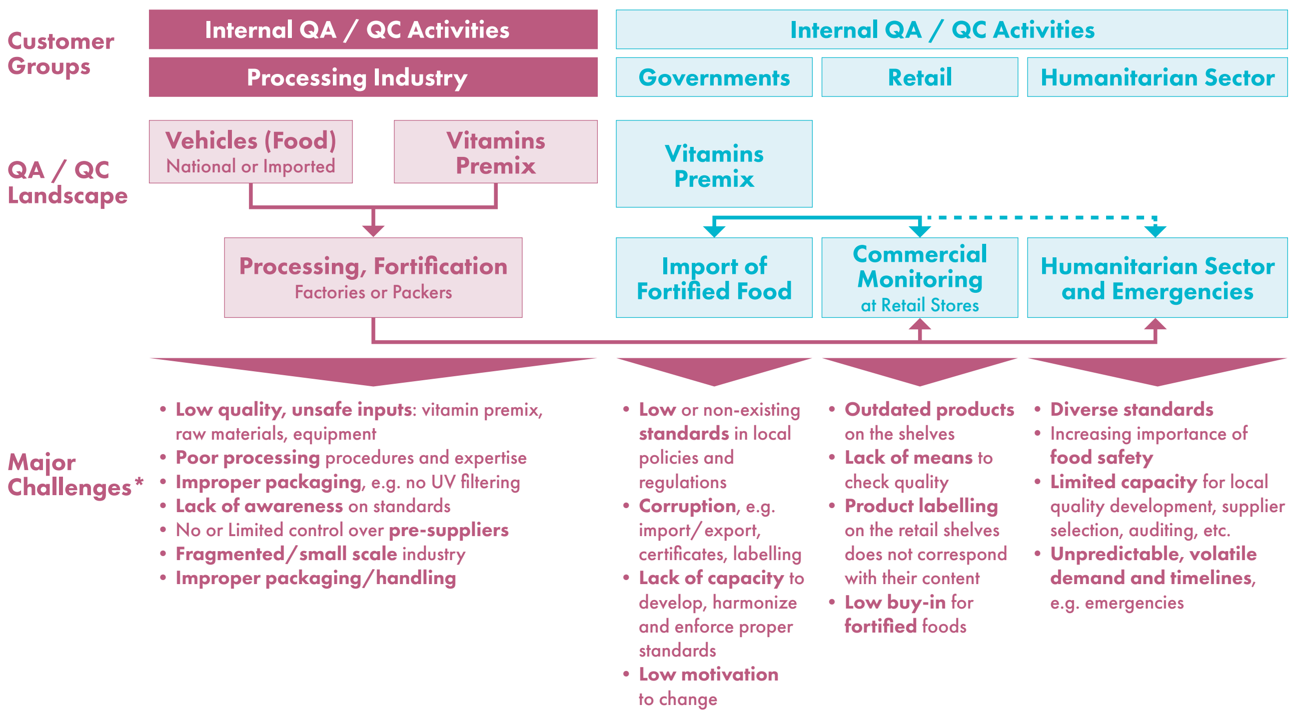
151 WHO/FAO (2006), Guidelines on FF with Micronutrients, p. 31: http://www.who.int/nutrition/publications/guide_food_fortification_micronutrients.pdf

avoid redundancies and gaps. In addition, regulatory monitoring and enforcement regimes are needed to ensure compliance of fortification programmes against standards. This is discussed as the second key challenge.

2. Regulatory monitoring challenges and the need for total quality systems

Fortified-food producers face critical challenges and capacity gaps in ensuring their products meet standards, and national governments face challenges in identifying and holding producers accountable to this end. This is evidenced by anecdotal data and self-reported industry data from 15 national mandatory fortification programmes, which indicate that less than half (47%) of collected samples were compliant against relevant standards.[152] Regulation on paper is not enough to ensure fortification compliance without real incentives and strong and consistent consequences, which drive under-fortified foods out of markets. This requires strengthening of capacity in total quality systems within industries; strengthening of capacity for inspections and laboratory testing; and prioritisation of resources from national budget allocations. Resources must be allocated strategically, focusing on essential proven elements of monitoring fortification programmes.[153] Complex legislative, regulatory and enforcement systems must be functional and sustained, despite the challenging contexts of poor governance and low human and institutional capacity where they are often required most. Elevating this problem, one of the Arusha Recommendations concluded that a major effort is needed in future to improve the quality of food fortification programmes through more coordinated regulatory monitoring mechanisms.[154] Figure 8 highlights some of the key challenges for regulatory monitoring.

Figure 8: Key challenges for regulatory monitoring[155]



[152] Luthringer, CL et al. (2015) Regulatory Monitoring op. cit.
[153] Ibid.
[154] The Arusha Statement on Food Fortification (2015), http://www.gainhealth.org/wp-content/uploads/2015/05/Arusha-Statement.pdf (accessed 10 July 2016).
[155] GAIN internal model (2016).

3. Challenges in advocacy and communications

Communication efforts on food fortification targeted towards consumers is an important component of successful fortification programmes as it ensures consumers are aware of the importance of key micronutrients and options available to them for increasing their intake. However, even more important is communication efforts targeted towards the government and private sectors, whose leadership and accountability must underpin nutrition interventions and fortification programmes more specifically. Numerous governments in LMICs have demonstrated impressive commitment and national ownership for improving nutrition. It is important that fortification programmes are regularly assessed in the context of changing dietary patterns to ensure they are effective and sustainable.

5 Biofortification programmes: results, challenges and gaps

Within this chapter, an overview is provided of the advances made with respect to biofortification research and development (R&D) and roll-out of improved seeds. The number of players is more limited in this area of work, with a prime role going to HarvestPlus, the CGIAR institutes charged with biofortification programmes through conventional breeding techniques. Several crops have been fortified, mostly staple cereals such as maize, cassava, rice, wheat and pearl millet, but also some other widely consumed lower-price range crops like beans and sweet potato. While the development of improved seeds can take a number of years, once available, roll-out is relatively swift, and across a rapidly increasing number of countries. A second theme that is briefly touched upon is the research on biofortification through genetic modification supported by the Bill & Melinda Gates Foundation (BMGF). The chapter ends with a listing of key production and consumption side issues that influence the acceptability of the improved varieties within farming systems and food systems, and an exploration of the potential role that biofortification could play to address the needs of the 1,000 days target group.

5.1 Main players and programmes

Regarding biofortification, the main focus so far has been on research for development of improved varieties through regular plant breeding and genetic modification. Various CGIAR (Consultative Group on International Agricultural Research) agencies have been involved in this. They operate in close collaboration with national Agricultural Boards and a number of agricultural research centres from western countries. Overall, the number of players and programmes has been much more limited than for large-scale food fortification. The main initiatives are the HarvestPlus biofortification programme, and a set of projects supported by the BMGF labelled the Grand Challenge #9 projects. The HarvestPlus projects are based on the use of regular breeding techniques to increase vitamin A, iron or zinc contents for various grains, root crops and legumes. The EC is engaged with one of such projects relating to biofortification of rice in Bangladesh. The projects under the Grand Challenge #9 programme on the other hand apply genetic modification to increase nutritional values of crops. The focus here is on increasing iron and vitamin A contents in some key staple food products: rice, cassava, sorghum and cooking bananas. In terms of geographical scope, the improved varieties of rice and pearl millet are developed for use in Asia, while the other cereals and the improved legumes and root crops are geared towards use in African countries. A short description of the two programmes is provided below.

The CGIAR HarvestPlus biofortification programme[156]

In 2002, the CGIAR Micronutrients Project was selected to become a pioneer CGIAR Challenge Programme focused on six crops: rice, wheat, maize, *Phaseolus* bean, cassava and sweet potato. The programme was labelled 'HarvestPlus', and in 2004 it received its first grants on biofortification research: US$ 25 million from the BMGF, and US$ 12 million from other donors. In 2012, HarvestPlus became part of the CGIAR Research Programme on Agriculture for Nutrition and Health (A4NH) which helps realise the potential of agricultural development to deliver gender-equitable health and nutritional

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[156] See: http://www.harvestplus.org/

benefits to the poor.[157] The HarvestPlus programme is coordinated by two CGIAR centres: The International Center for Tropical Agriculture (CIAT) and the International Food Policy Research Institute (IFPRI) which houses HarvestPlus' headquarters. HarvestPlus relies on a team of experts from many disciplines, including plant breeding, human nutrition, agricultural economics, marketing, social sciences and communications.

The HarvestPlus mission is to improve nutrition and public health by developing and promoting biofortified food crops that are rich in vitamins and minerals, and providing global leadership on biofortification evidence and technology. Diversification of diets is acknowledged to be a more permanent solution to micronutrient malnutrition, but as this will take decades to realise among the world's poor, the aim of HarvestPlus is to promote cultivation and consumption of biofortified crops as an effective alternative approach to reduce micronutrient deficiencies. The agency underlines three key advantages of biofortification:

1. It is sustainable as it is based on consumption of foods that people already eat.
2. It is targeted to rural areas where about 75% of the world's poor live and where access to micronutrient supplementation and marketed fortified foods may be limited.
3. It is cost-effective in the sense that a one-time external investment is enough to generate new varieties that will be available for farmers for years to come (multiplier effects).[158] This is an advantage when compared with other interventions such as micronutrient supplementation and behavioural change communications activities (e.g. infant and young child feeding and dietary diversity promotion), which have high recurrent costs.

The goal for HarvestPlus is that by 2020 15 million farming households will be growing and consuming biofortified nutritious foods, and that in total, 100 million people will have access to these foods. By 2030 this should have been scaled up to 1 billion people benefiting from biofortified nutritious foods. As the sustainability of biofortification depends on national ownership and investments, HarvestPlus has adopted a country programme approach where research on **multiple biofortified crops** is undertaken in collaboration with national agricultural research agencies. Such programmes exist in Brazil, India and China. These programmes are also aimed at creation of spill-over activities in neighbouring countries in the region. In a much wider range of countries, projects have been undertaken on improved crop varieties with increased content for a **single micronutrient** (vitamin A, iron or zinc). These projects are generally executed in close collaboration with national agricultural research institutes.

Figure 9 gives an overview of the countries where biofortified varieties have been released and those where current testing projects are being undertaken (the most recent listing of released crops as per June 2016 is attached as Annex 8). As shown in the map, so far the focus has been on biofortification with a singular micronutrient: Vitamin A, zinc, or iron. The main varieties are described in Table 3 below which provides an overview of the roll-out level for biofortified crops as reported by HarvestPlus in the Biofortification Progress Briefs published in August 2014.[159] Crop marketing has already begun and targets have been set for quick expansion for various of these crops and countries.

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[157] See: http://a4nh.cgiar.org/

[158] It is to be noted here that, similar to the high yielding varieties which formed the basis for the Green Revolution, the biofortified seeds or planting materials may be more costly to farmers than regular varieties, and their culture may require purchase of additional agricultural inputs (fertilisers, pesticides, labour) to ensure that yields will be good.

[159] HarvestPlus (2014) Biofortification Progress Briefs, August 2014.

Table 3: HarvestPlus coverage with single fortified crops: realised end 2013 and Target 2018

Crop	Improved micronutrient density achieved	Country	Achievements 2013 (No. of households)	Target 2018 (No. of households)
Africa				
Vitamin A maize	0 → 152 ppm	Zambia	10,000	500,000
		Nigeria	*(research phase)*	-
Vitamin A cassava	0 → 15 ppm	Nigeria	106,000	> 2,000,000
		DRC	25,000	750,000
		Kenya	*(research phase)*	-
Orange sweet potato (vitamin A)	2 → 32 ppm	Uganda	149,000	237,500
		Mozambique	*(research phase)*	-
Iron beans	50 → 94 ppm	Rwanda	714,000	1,200,000
		DRC	150,000	1,375,000
		Uganda	*(research phase)*	-
Asia				
Iron pearl millet	30 → 71 ppm	India	25,000	1,117,000
Zinc rice	16 → 28 ppm	Bangladesh	*(research phase)*	500,000
		India	*(research phase)*	-
Zinc wheat	25 → 37 ppm	Pakistan	*(research phase)*	250,000
		India	*(research phase)*	-
Latin America				
Iron beans	50 → 94 ppm	Mexico	*(research phase)*	-
Zinc wheat	25 → 37 ppm	Mexico	*(research phase)*	-

Through a range of research projects, HarvestPlus has been able to prove that biofortification based on selective breeding works for a variety of crops. Good results have been attained with breeding for increased micronutrient content of food staples to levels that have measurable and significant impact on human nutritional status, without reducing yields. The extra nutrients bred into the food staples are bioavailable and are absorbed by the body in sufficient amounts to meet dietary needs and consumption patterns of non-pregnant non-lactating women of childbearing age, and of young children 4–6 years of age. The amount of iron in iron beans and iron pearl millet will provide approximately 50% of the estimated average requirement (EAR). The zinc in zinc wheat and zinc rice will provide 60% of EAR. Provitamin A in vitamin A cassava and vitamin A maize will provide 50% of the EAR, while for orange sweet potatoes this is up to 100%. In their research projects, HarvestPlus has also been able to show that farmers are willing to adopt biofortified locally consumed food crop varieties and that consumers are willing to eat these more nutritious foods.[160]

[160] HarvestPlus (2016) *Biofortification: The Evidence*, Washington DC, February 2016.

Figure 9: HarvestPlus biofortified crop map – 2015

Taken from: http://www.harvestplus.org/sites/default/files/HarvestPlus_BiofortifiedCropMap_2015.pdf 8.2.

The BMGF Grand Challenge #9 on biofortification projects

In 2003, the BMGF issued a US$ 230 million grant 'The Grand Challenges in Global Health Initiative'. The initiative aims to exploit the extraordinary scientific advances in recent decades for 14 challenges in the prevention and treatment of major diseases. Under Challenge #9, the focus is on improving the micronutrient content of important staple crops through bio-engineering (genetic modification). This package consists of a set of research programmes on improved rice, cassava, sorghum and banana varieties.

The BMGF financing of bio-engineering research projects started in 2005. The total investment up to now amounts to a total of US$ 31.1 million allocated to Golden Rice, US$ 31.3 million to the BioCassava project, US$ 21.0 million to the African Biofortified Sorghum project (supplemented by US$ 4.0 million provided by the Buffett Foundation), and US$ 8.4 million to the Banana21 project. The focus in the projects primarily is on increasing the vitamin A and iron contents of the crops. While the Golden Rice project is focusing on Asia, the other three projects are targeting sub-Sahara African countries. None of the projects as of yet has reached the stage of obtaining regulatory approval and start of dissemination of the new varieties to farmers.

5.2 Key successes, challenges and gaps

Biofortification through regular plant breeding techniques has created a range of substantially more nutritious varieties, which currently are being rolled out in a rapidly increasing number of countries. Nevertheless, biofortification remains a relatively new phenomenon. As the sub-sector is being developed, there is still a wide range of unanswered questions. Currently, various ongoing research initiatives are focusing on the elaboration of possible approaches and applications for biofortified crops across the value chain from producers to consumers. Some key review papers have been published over the past years, and various consultations at international level are still ongoing processes. The main milestones in gauging the (potential) role and preconditions for roll-out and scaling-up of biofortification are briefly described in the next sections.

Copenhagen Consensus biofortification best practices paper

The first issues that were studied in the Copenhagen Consensus paper were whether crop lines can be found that have high micronutrient content and that can be bred into local varieties; and whether the nutritional efficacy of the biofortified crops can be established. The answer to these questions was positive, as evidenced by results of plant breeding research and nutrition trials. The most significant evidence was provided by studies on high-zinc rice in Bangladesh, the provitamin A rich 'golden rice' in the Philippines and orange-fleshed sweet potatoes in Uganda. Further evidence for these crops is steadily being built up.

The next set of questions around biofortification that was reviewed in the paper was that of acceptability. Will farmers and consumers accept the new varieties and make them an important part of what they produce and consume? This question was disaggregated into issues on the production side and on the consumption side:

- Agronomic aspects and agricultural extension systems: Agricultural innovations need to be disseminated to farmers to achieve a certain coverage. Improved crops can be attractive to farmers when they offer production advantages (better drought tolerance, short-maturing varieties, high-yielding varieties, new marketing opportunities, etc.)

- Organoleptic aspects: The acceptability of new varieties to consumers can be affected when a crop has a different colour[161] or taste, which may (initially) not be in line with consumer preferences. In order to ease their acceptance, it may be required to promote new varieties through intensive public health education and/or strong marketing efforts.

In the Copenhagen Consensus paper, four main types of biofortified crops were analysed, with a key crop illustrating each type. The underlying model was developed by HarvestPlus to predict the cost-effectiveness of biofortified crops (see Figure 10).[162] It takes both production and consumption aspects into account. The main determinants within the typology are whether visible traits are changed or not as a result of biofortification (costs for introduction on the market are higher in case of changes in visible traits), and whether or not there is a good agricultural outreach infrastructure that can be used to introduce the new variety.

Figure 10: HarvestPlus' typology for analysing the cost-effectiveness of biofortification

The overall picture that emerged from this analysis is that introduction of biofortified mineral-rich cereal and root crops will be relatively easier in some Asian countries as compared to Africa because of the more developed dissemination structures. For instance, in Bangladesh high coverage rates can be achieved for biofortified rice varieties as rice cultivation tends to be dominated by a few mega-varieties in which improved lines can be relatively easily back-crossed.[163] Most African countries on the other hand have relatively poor extension and seed systems infrastructures, mainly based on farmer-to-farmer exchange of seeds, using several local varieties. This can hamper quick dissemination of new varieties and might require use of subsidisation for introduction of hybrid varieties to replace traditional ones[164] (see Figure 10).[165] Within the Copenhagen Consensus Paper, it was stated that biofortification is expected to gain further ground over time. Programme costs generally should not form a major

[161] The preference in Africa is generally for white maize while nutritionally improved varieties are yellow in colour. The same applies to improved sweet potato, which has orange flesh as opposed to the whiter coloured regular sweet potato.
[162] The model is described in Meenakshi, JV (2009) Best Practice Paper: New Advice from CC08; Cost-Effectiveness of Biofortification, Copenhagen Consensus Center, Copenhagen, p. 8.
[163] Although there are exceptions with a wider range of rice varieties being grown in some countries.
[164] However, as shown by Table 3 presented within section 5.1, coverage achievements per country/continent also are dependent on efforts that are made within the project.
[165] Taken from: Africa Harvest Biotech Foundation International (2010), Africa Biofortified Sorghum Project; Five-Year Progress Report, Nairobi, p. 93.

hindrance for successful biofortification interventions because biofortification in principle requires relatively little support once the initial large research investment has been done. The relatively low levels of recurrent costs for national authorities (or the international donor community) are seen as a major advantage of biofortification when compared with supplementation interventions.

WHO technical consultation on biofortification

During the ICN2 conference it was stressed that promotion of nutrition-sensitive agriculture is a key area of work in coming years as it can provide the basis for sustainable food systems and healthy diets.[166] Obviously most of the focus here is on promotion of agriculture diversification, which entails increased attention for growing more nutritious crops, both for household consumption and as cash crops to feed (nearby) markets. Biofortification is another potential area of work under the heading of nutrition-sensitive agriculture. WHO is undertaking a technical consultation on biofortification of staple crops with vitamins and minerals and the considerations for a public health strategy.[167] The aim was to undertake a systematic review of evidence to determine the effects of staple crops biofortified with increased micronutrient content for improving vitamin and mineral status in populations, with particular emphasis on iron, vitamin A and zinc. The consultation entailed a 3-day meeting at the Sackler Institute for Nutrition Sciences in April 2016 based on a set of peer review papers on biofortification (further details provided in Annex 10).[168]

The consultation results are expected to provide an excellent international reference framework for future programming on biofortification. For instance, the review is intended to highlight the opportunities that biofortification can offer to reach out to rural remote populations and urban populations. Also, the focus will be on the relative cost levels of biofortification in comparison with industrial fortification of staple foods. Additionally, the aim is to understand whether biofortified foods are or will be accepted by consumers, especially when they have different characteristics compared to non-biofortified crops. Another area that will be looked into is the issue of potential cross-contamination of crops and the impacts the biofortification approach might have in terms of reduced biodiversity.

Cochrane review on biofortified crops

A Cochrane review is under way on the effects of biofortified crops on the vitamin and mineral status, as well as the health and cognitive function in the general population. The Protocol for this study has recently been published.[169] This review will provide key insights into the effectiveness of biofortification with respect to reducing micronutrient deficiencies, and the impacts on linear growth, wasting, cognitive functioning and work performance. Furthermore, the study looks into the existence of adverse effects and the levels of rejection of biofortified crops. The Protocol discerns the following considerations that are taken into account in the review:

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[166] At the Second International Conference on Nutrition organised by FAO and WHO in Rome, November 2014, it was stressed that the realisation of the right to adequate food in the context of national food security should be fostered through sustainable, equitable, accessible, resilient and diverse food systems. FAO/WHO (2014), Rome Declaration of Nutrition. Second International Conference of Nutrition, Rome, Italy, 19–21 November, http://www.fao.org/3/a-ml542e.pdf (accessed 23 June 2016).
FAO/WHO (2014), Framework for Action. Second International Conference of Nutrition, Rome, Italy, 19–21 November, http://www.fao.org/3/a-mm215e.pdf (accessed 23 June 2016).

[167] Ref: http://www.who.int/nutrition/callforauthors_staplecrops_biofortified_vitminarels/en/ (accessed 23 June 2016)

[168] The intention is that the set of 11 peer review papers prepared for this Technical Consultation will be shared through the Annals of the New York Academy of Science.

[169]Garcia-Casal MN, JP Peña-Rosas, H Pachon et al. (2016) Staple crops biofortified with increased micronutrient content effects on vitamin and mineral status, as well as health and cognitive function in the general population. Cochrane Database of Systematic Reviews (8) Art. No. CD012311.

- bioavailability of biofortified crops
- acceptability of biofortified crops
- economic impacts and consumer preferences
- food safety and environmental considerations
- equity and social determinants
- costs and regulations
- seeds and intellectual property

HarvestPlus: Biofortification and the 1,000 days approach

An example of the current global discussion around the use of biofortified crops is provided by the recent expert consultation organised by HarvestPlus.[170] The focus was on the potential to reach out to nutritionally vulnerable groups (the 1,000 days approach) with biofortified crops. In biofortification research the first step usually consists of establishing evidence on the efficacy. Then the project moves to effectiveness trials, crop delivery and scaling-up of the programme's stages. In the case of efficacy trials on multiple biofortified food baskets, another step is needed that precedes the other ones: to study agricultural systems and consumption patterns to determine what biofortification levels would be required in order to have impact on nutritional status. The meeting concluded that the 1,000 days window of opportunity for reduction of stunting may not be the optimal target for a programme promoting a food basket of multiple biofortified crops (see Box 12 below).[171]

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[170] HarvestPlus (2016) Feasibility of a Multiple Biofortified Food Intervention and its Potential Impact in the 1,000 Days Window of Opportunity: Proceedings of an Expert Consultation Meeting, San Diego CA, 1–2 April 2016. http://www.harvestplus.org/sandiego-consultation-proceedings (accessed 13 June 2016).

[171] It should be noted that until recently, HarvestPlus refrained from identifying specific target groups for the single biofortified crops, as there was no proof that the small increases in iron, zinc and vitamin A would have a significant impact given the increased physiological requirements for these micronutrients among young children and pregnant and lactating women. In order to build up the evidence base of single crops, efficacy trials are currently undertaken for a range of crops in India and Zambia.

Box 12: Conclusions of the HarvestPlus Expert Consultation meeting on the feasibility of a multiple biofortified food intervention and its potential impact in the 1,000 days Window of Opportunity. San Diego, 1–2 April 2016

A new development within biofortification is the aim to reach out to specific nutritionally vulnerable groups. The key question is whether a food basket of multiple biofortified foods can be a sustainable and cost-effective solution for improving the quality of dietary intakes of women during pregnancy and lactation and of young children 6–24 months of age. A HarvestPlus meeting in April 2016 concluded that the 1,000 days window of opportunity for reduction of stunting may not be the right target for a programme promoting a multiple biofortified crops food basket. The high nutritional requirements of these vulnerable groups, which require micronutrient supplementation as intake through food alone, is not enough.

- Biofortification with provitamin A is the most promising intervention for the 1,000 days target groups due to the concentration and frequency of consumption. A dose of up to 12 mg per day for women during pregnancy and lactation has shown a small but consistent impact on the vitamin A status of the mother, breast milk retinol and serum retinol up to 6 months of age. There was no effect, however, on birth outcomes or child growth. For infants/children 6–24 months of age a dose of 3 mg per day was found to have a positive effect on their vitamin A status.
- For low-dose iron the main impact that can be achieved through biofortification seems to exist in the age group 6–24 months. For this group, iron biofortified foods are associated with improved haemoglobin and serum ferritin status and reduction in anaemia prevalence. The effect exists with doses of 6–8 mg per day, or, better, 8–10 mg per day. However, although low, these doses may be difficult to achieve given the smaller amounts of food eaten by young children. Overall, supplementation was found to have a larger effect than fortification. Presumably, this is caused by the negative effect of food per se on iron absorption. No impact was found of low iron dosage on growth or morbidity outcomes (diarrhoea, fever, respiratory infections) of young children. When given during pregnancy, a low dose of iron does not seem to have any effect on birth weight or child growth, or on the child's iron status.
- While there is strong evidence that serum zinc is responsive to supplementation (daily dose of 7–10 mg for young children; up to 21 mg during pregnancy), this is not the case when the zinc is delivered as a fortificant. The explanation could be that post-absorption metabolism of zinc is different when consumed with food. While low dosage biofortification with zinc thus is not expected to have any impact on serum zinc concentrations, it may still be that there is a relation with other metabolic (and functional) indicators of zinc status.

6 Monitoring and surveillance of national food fortification programmes

This chapter presents the two key purposes of monitoring and surveillance systems that were recommended by the #FutureFortified Technical Advisory Group:[172] (1) Help guide effective implementation of (national) food fortification programmes as an essential public health intervention at national or sub-national levels over time; and (2) Provide an overview of existing global databases on national food fortification programmes and the status of development of a global repository to track the status of national food fortification programmes, as recommended at the #FutureFortified Global Summit on Food Fortification.

6.1 Basic principles and components

As illustrated in Figure 11 overleaf, the effectiveness (i.e. nutritional impact) of a food fortification programme depends on the consistent production of adequately fortified food (based on the national fortification standard) in sufficient quantities to cover the consumption needs of the vast majority (≥80%)[173] of the population (based the estimated per capita consumption of the product) in a geographic area (national or sub-national) over time. Table 4 presents examples of basic indicators of a system for food fortification programme monitoring and surveillance (definitions presented in Box 13). The primary responsibility for the marketing of adequately fortified foods lies with the national producers and importers of such foods. Thus, the necessary internal quality assurance and quality control (QA/QC) processes and procedures (e.g. Good Manufacturing Practice (GMP) and Hazard Analysis and Critical Control Point (HACCP)) must be in place within each production facility to ensure adequate fortification of the foods. Importers must procure fortified foods, based on the national fortification standards, from foreign suppliers that can assure the fortification quality of the products as ordered and provide the necessary certificates of conformity for each shipment. In turn, it is the responsibility of relevant national regulatory authorities to enforce the fortification standards through external monitoring of product quality control at the national production facilities and points of import (Box A in Figure 11).[174]

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[172]Garrett, GS et al. (2016) 'Recommendations for food fortification programs: Technical Advisory Group report elaborating on the five recommendations from the #FutureFortified Global Summit on Food Fortification. *Sight and Life*, April, http://www.sightandlife.org/fileadmin/data/Magazine/2016/Suppl_to_1_2016/ FutureFortified.pdf (accessed 30 September 2016).

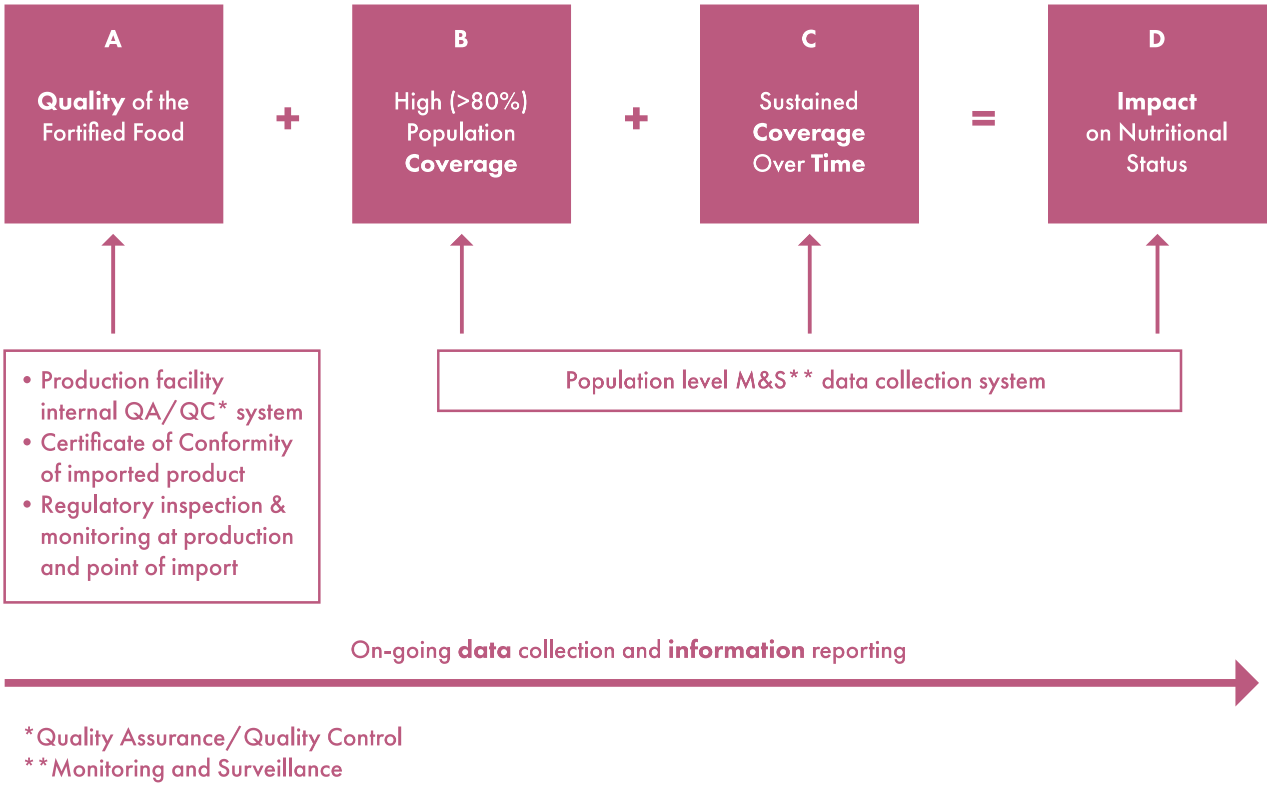
[173]Pena-Rosas, JP, et al. (2008) Chapel T. Monitoring and Evaluation in Flour Fortification Programs: Considerations for the Design and Implementation of Feasible and Effective Systems. *Nutr Reviews* (66):148–62.

[174] It is to be noted that monitoring and surveillance systems for food fortification are not suited for tracking legislation and regulatory monitoring capacity issues. Information on these important aspects needs to be obtained through other types of assessments.

Table 4: Examples of basic food fortification programme monitoring and surveillance indicators and their characteristics

Indicator	Type	Definition	Data source
Annual quantity of adequately fortified-food marketed	Output	Quantity (MT) of fortified-food marketed in geographic area per year	Fortified-food producers and importer
Annual 'expected' population coverage of adequately fortified food	Output	% of population expected to regularly access the fortified food	National regulatory agency
Prevalence of micronutrient impact indicator	Impact	% of population with target micronutrient deficiency	Sentinel health facilities where subjects are regularly assessed for the relevant micronutrient/health status indicator

Figure 11: Schematic presentation of the component of an effective food fortification programme



Source: Adapted from Parvanta I et al. (2016) FORTIMAS: An Approach for Tracking the Population Coverage and Impact of a Flour Fortification Programme, http://www.smarterfutures.net/fortimas (accessed 20 June 2016).

Box 13: Definitions of food fortification programme monitoring and surveillance

Food fortification programme monitoring:

The ongoing and systematic collection, analysis and interpretation of trend data on quality and coverage of the fortified food, and interpretation and use of the resulting information to assess how the programme is performing compared to predefined criteria.*

Food fortification programme surveillance:

The ongoing and systematic collection, analysis, and interpretation of trend data on micronutrient status of the target population with *sustained access to quality fortified food, to detect the expected (or unexpected) impact of fortification over time.***

*Adapted from: Pena-Rosas, JP et al. (2008) Nutr Reviews; 66:148–62.
**Adapted from: CDC/MMWR 2001; 50 (No. RR-13).

Once the fortification quality of the food is assured, the 'expected' population coverage of the product can be determined based on the following:

a) quantity of the fortified product marketed in a geographic area (national or sub-national);
b) estimated per capita consumption of the *fortifiable*[175] form of the product on which the national fortification standard was originally based; and
c) the population size of the geographic area.

When the 'expected' population coverage is calculated to be close to 80% or higher (see Box B in Figure 11), data on household purchases or availability of the product may be collected in the geographic area to confirm the high coverage of the adequately fortified product. Then, as indicated by Box C in Figure 11, such high population coverage must be sustained over time (at least one year) before impact on the micronutrient status of the population may be detected[176] (see Box D in Figure 11).

The main concepts to be considered in the implementation of any food fortification programme are:

a) If the quality of the fortified food, based on the required concentration of the added nutrient(s), is not assured on a sustained basis, constrained resources need not be expended to also assess its coverage or impact in the population. In other words, programmes should be 'impact assessment ready', and until that time, resources should be used to first ensure the product quality on a consistent basis.
b) If the quantity of the adequately fortified food is not sufficient to regularly meet the consumption needs of the vast majority ($\geq$80%) of the population in a geographic area, resources should be directed towards increasing the amount of such product that is accessible to the population.
c) Only after it is confirmed that the quality and quantity of the fortified food is adequate to meet the expected nutritional and dietary needs of the vast majority of the population on a regular basis, then resources may be directed towards assessing the impact of the intervention over time.

Triangulation of trend data and complementary findings on indicators of quality, population coverage and impact of the fortified food obtained through programme monitoring and surveillance, would allow

[175] Widely consumed food that is produced in facilities with minimum technological capacity to ensure its consistent fortification in an economically sustainable manner.
[176] Parvanta I et al. (2016) FORTIMAS: An Approach for Tracking the Population Coverage and Impact of a Flour Fortification Program, http://www.smarterfutures.net/fortimas (accessed 20 June 2016).

for strong inference that the intervention has been a major factor in improving the micronutrient status of the population over time, based on the preponderance of evidence.

It is also important to note that when assessing the impact of population-based nutrition interventions, especially food fortification, one must differentiate between 'initial or early impact[177] vs 'maximum impact[178] of the intervention. For example, surveillance data on increased levels of serum folate levels after the implementation of mandatory folic acid fortification of flour and cereal products in the USA led to a gradual increase in the proportion of the population with serum folate levels >20 ng/mL.[179,180] Similarly, data from NTD surveillance systems in the United States[181] and Oman[182] indicate a decreasing trend in the birth prevalence of NTDs in those countries over eight and ten year periods, respectively. In contrast, in Europe there was no folic acid fortification and the prevalence of NTD in Europe did not change between 1991 and 2011,[183] remaining high (9.1 per 10,000 births) compared to rates in the U.S. and Oman (about 3 per 10,000 births).

Furthermore, when tracking the impact of food fortification over time, it should be noted that the rate of change in the prevalence of an impact indicator will likely be more rapid in populations or sub-geographic areas of a country with a higher starting prevalence of that indicator. This is compared to the rate of change in the prevalence of the same indicator in other populations or sub-geographic areas in the country with a lower starting prevalence, provided that there is high population coverage of the quality fortified food among the different groups in the country.

It is also important to track the implementation of the food fortification programme systematically over time because unexpected and substantial changes in population coverage of fortified products can occur. For example, following the implementation of the national wheat flour fortification programme in South Africa, the market share of cake flour, which was not required to be fortified, increased from 10% to over 40% within a few years. Thus, the population coverage and consumption of fortified flour decreased, resulting in a lower impact than was expected.[184] Furthermore, data reported to the Food Fortification Initiative (FFI) on total annual production of fortified wheat flour decreased substantially in a number of countries between 2009 and 2010.[185] Therefore, continued improvement of micronutrient status after 2010 would have been unlikely in those countries where such decreases were reported.

Regrettably, the timing of most assessments, which are typically based on surveys of the impact of food fortification programmes in LMICs, rely on comparing data on specific micronutrient status indices prior to programme implementation and after a period of time of intervention implementation (often dictated by the terms of the donor funding period for the 'fortification project', rather than availability of sufficient information that impact should be detected). To date, none of those assessments have included simultaneous data on the consistent adequacy of the fortified product or its high population coverage during the entire period before the impact surveys were conducted. Only one recent publication reported on the effectiveness of fortification of multiple food vehicles on improved haemoglobin concentrations and consequent decrease in anaemia prevalence in women and children in Costa Rica

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177 Refers to a change in the prevalence of the nutritional status impact indicator one or two after the start of a well-implemented intervention.

178 Refers to a continuous change in the prevalence of the nutritional status impact over a number of years until there is a plateauing in the rate of change of the indicator.

179 Lawrence, JM et al. (1999) *Lancet* 354: 915-6.

180 Lawrence, JM et al. (2000) *NEJM* 343: 970.

181 CDC. (2015) Updated estimates of neural tube defects prevented by mandatory folic acid fortification – United States, 1995–2011. *MMWR* 64: 1–5.

182 Alasfoor, D et al. (2010) Spina bifida and birth outcome before and after fortification of flour with iron and folic acid in Oman. *East Mediter Health J.* May: 16(5): 533–8.

183 *BMJ* (2015) 351: h5949.

184 Dr Phillip Randall (2013) Consultant. Personal communication March.

185 Dr Helena Pachon (2015) Food Fortification Initiative. Personal communication August.

over a 12-year period.[186] The study utilised survey data before the start of fortification and about 12 years later. The authors reported that about 100 samples of each type of fortified food were tested annually to assess their iron fortificant content, and implied that those samples met the national iron fortification standard of Costa Rica. Furthermore, the authors indicated that one special study in 2008 found that wheat flour samples from 246 bakeries in the country contained sufficient fortificant iron. However, no data was reported on the trends on ‘expected population coverage’ of the fortified foods based on the amounts marketed, per capita consumption of the products, and the population of Costa Rica over the 12-years.

Furthermore, in countries where fortified foods are only accessible to populations in sub-national areas (e.g. in urban and peri-urban areas or selected provinces) data from nationwide surveys, which are not designed to specifically generate fortification-related statistics in those particular sub-areas, is incorrectly used to report on coverage and impact of the fortification programme.

Various approaches that have been used in some countries to assess the population coverage of fortified food and/or micronutrient status of the population at a single point-in-time include:

- Fortification Assessment Coverage Tool (FACT) survey developed and supported by GAIN[187]
- Demographic and Health Survey (DHS) developed and supported by USAID
- Multiple Cluster Indicator Survey (MICS) developed and supported by UNICEF
- Independent national nutrition/micronutrient surveys supported by various donor agencies.

The above surveys are relatively expensive to implement and none of them have thus far been implemented frequently enough in LMICs that have implemented national food fortification programmes to allow analysis of trend data on population coverage of (adequately) fortified foods and relevant micronutrient/health status of those populations. In order to adequately track the implementation and impact of food fortification programmes, countries need to design and implement appropriate and feasible monitoring and surveillance systems adapted to their settings and capacities. With funding from the Dutch Ministry of Foreign Affairs, the Smarter Futures partnership supported the development of ‘FORTIMAS: An Approach for Tracking the Population Coverage and Impact of a Flour Fortification Programme’.[188] It is believed that FORTIMAS (which was published online in 2014) is at this time the only guide that describes a feasible methodology to systematically collect, analyse, triangulate and report information based on programme monitoring data on fortified food quality and population coverage (during the time period prior to the time of assessment of impact) and surveillance data on population micronutrient/health status impact indicators over time (refer to Annex 10 for an overview of the FORTIMAS guide).

Since the online publication of the FORTIMAS guide, workshops on the methodology have been carried out in four countries with funding support of different donor agencies.[189] This guide is currently available in English and French; a Portuguese translation is forthcoming shortly, and a Russian translation may be available in the near future.

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[186] Martorell, R et al. (2015) Effectiveness evaluation of the food fortification program in Costa Rica: impact on anaemia prevalence and haemoglobin concentrations in women and children, *Am J Clin Nutr*; 101: 210–17,

[187] A peer-reviewed publication summarizing the results of ten national Fortification Assessment Coverage Tool (FACT) surveys is pending publication in the Journal of Nutrition.

[188] Parvanta I, et al. (2014) FORTIMAS: An approach for tracking the population coverage and impact of a flour fortification program. Smarter Futures. Brussels, 2014, http://www.smarterfutures.net/fortimas (accessed 1 July 2016).

[189] Countries where FORTIMAS workshops have been conducted upon request include Yemen (with EC funding support through MI), Mozambique (with Smarter Futures and Irish Aid funding support through HKI), and Georgia and Turkmenistan (with UNICEF funding support).

6.2 Global databases on micronutrient deficiencies and national food fortification programmes

There are inherent challenges to accessing and collecting data on fortified food quality, coverage and impact, especially on a regular and sustained manner so as to track trends in the relevant indicators over time. The two major challenges and their implications are discussed below. Although these challenges overlap, they are useful paradigms for understanding the data issues and working towards solutions.

a. Food fortification is a multi-dimensional and multi-sectoral public health intervention, and the information required to understand the existing situation, track progress, and overcome gaps requires data from multiple sources.

The first section of this chapter discussed the types of programme output and impact indicators needed to adequately assess the implementation reliability of food fortification programmes (with regard to sustained quality and coverage of the fortified foods) and effectiveness of such programmes in improving the micronutrient status of populations. In addition, the critical role of fortified-food producers and importers as the critical 'partners of public health' responsible for marketing adequately fortified foods, and the responsibility of national regulatory agencies to monitor and enforce fortification standards were presented. Furthermore, the need for ongoing data on selected indicators to first document fortified food quality, then population coverage of the product, before impact should or could be assessed, were described.

UNICEF, WHO, the Iodine Global Network (IGN) and the Food Fortification Initiative (FFI) maintain databases to track one or more indicators of fortified food quality and coverage, as well as micronutrient/nutritional status of populations (refer to the third section of Table 5 under the heading 'Food fortification-specific databases'). However, those databases do not provide data on adequate quality and population coverage of the fortified foods during the period before the point-in-time when the impact-related data on the micronutrient status of population is collected. Therefore, it is not possible to assess the effective implementation of the national fortification programmes by triangulating information on product quality and coverage with that on the micronutrient status of the population. In addition, the databases are typically reliant on population-based surveys that may not be specifically designed to assess the impact of the food fortification programmes, or may occur with low frequency and with substantial delays in availability of results. The Global Nutrition Report and the SUN Movement both represent broader efforts to strengthen global data systems and collate this multi-dimensional and multi-sectoral information needed to gain understanding on nutritional gaps. Both have resulted in much greater accountability in nutrition reporting and much better data and surveillance systems at national levels. Neither, however, specifically focuses on fortification, nor is able to disaggregate information on fortification from other nutrition-specific and nutrition-sensitive activities.

However, substantial amount of data is already available in, or could be readily collected through national health facilities. International guidance has recently been developed that would enable countries to utilise existing health systems data to assess the impact of food fortification programmes. For example, in collaboration with the US Centers for Disease Control and Prevention (CDCs) and the International Clearinghouse for Birth Defects Surveillance and Research based in Italy, the WHO issued guidance for tracking the birth prevalence of NTDs through maternity facilities.[190] In addition, the FORTIMAS guide was developed in 2014 to enable countries to utilise data on a minimum set of

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[190] WHO/CDC/ICBDSR (2014) *Birth Defects Surveillance: A Manual for Programme Managers.* Geneva: World Health Organization.

fortification programme impact indicators (e.g. prevalence of anaemia among women of childbearing age and birth prevalence of NTDs among newborns delivered in maternity facilities) for which data may already be available in, or could be (relatively easily) collected through, selected sentinel health facilities using non-probabilistic data collection.

b. There is significant fragmentation of food fortification-related data housed within different organisations, with little consolidation.

International donor or implementing agencies tend to only maintain data for the countries or food fortification programmes they support. In addition, there is as yet no clear guidance on the absolute minimum set of indicators on food fortification programmes to be tracked at the global level. Thus, there is a range of content and presentation formats across the existing databases, significantly limiting the types of data available and the comparability of findings across countries and regions, as well as over time (see Table 5 at the end of the chapter for details on available databases).

Furthermore, food fortification tends to be vertically implemented based on the food vehicle being fortified; organisations such as FFI and IGN have clear mandates for fortification of cereal grains and iodised salt, respectively. However, there is a glaring lack of publicly available data on the global status of other fortified products, such as vegetable oils, dairy products, soy and fish sauces, sugar, condiments such as bouillon cubes, monosodium glutamate (MSG), or seasoning packets and other processed foods. Other implementing agencies without food vehicle-specific mandates, such as GAIN, HKI and MI are likely to have large amounts of data internally on countries that each supports. However, this type of data is not readily available for assessing the global progress on food fortification, which is creating a critical gap.

To address both of these challenges, a large number of donor and implementing agencies that support food fortification programmes[191] agreed to improve transparent reporting and utilisation of data to assess the state of fortification[192] around the world. To date, a working group has been established to lead on this effort. The work started with a review of the existing databases and data sources within various implementing agencies in an effort to harmonise indicators and data collection methods for consistent tracking of the quality, coverage and impact of national fortification programmes. This exercise will culminate in the establishment of a Global Repository on Food Fortification data, a prototype of which was launched during the Micronutrient Forum in October 2016.

This global repository would house global and national data on fortification status of legislation, specific fortified-food standards, quantities of production and imports, per capita consumption of fortified foods, quantity and proportion of adequately fortified foods, expected and assessed population coverage of fortified foods, and impact indicators (with timing of data collection synced with status of the fortification programmes), disaggregated by various population groups and income strata where available. Discussions are continuing to determine a host location and technology platform, as well as to decide on whether there is a need for a fortification-specific supplement to annual global reports, such as the Global Nutrition Report.

In addition to the global repository, GAIN and Project Healthy Children have partnered to develop a global management and information system (MIS) that can be tailored and deployed for use at the national level for internal and external monitoring of fortified food quality. The MIS would collect quality

[191] Including, but not limited to, GAIN, FFI, IGN, HKI, PHC, MI, UNICEF, WFP, WHO, BMGF, and USAID.

[192] Greg S. Garrett, Rebecca Spohrer, Lynnette Neufeld, et al. (2016) Recommendations for Food Fortification Programs: Technical Advisory Group report elaborating on the five recommendations from the #FutureFortified Global Summit on Food Fortification, *Sight and Life*, http://www.sightandlife.org/fileadmin/data/Magazine/2016/Suppl_to_1_2016/FutureFortified.pdf

information at the production, import and market levels over time and disaggregated by brand and food vehicle type to better assess where bottlenecks in the value chain exist and how to best address them. The MIS would be linked to the global repository, such that aggregated quality compliance figures are regularly uploaded from national MIS to the global repository for more accountable and transparent tracking. Similar frameworks for population coverage monitoring are also being discussed with relevant stakeholders in a number of countries.

Table 5 below lists existing databases that house data on selected indicators related to population nutrition status, food supply and consumption, and specific food fortification programmes. The table is not intended to be exhaustive, but rather to be illustrative of what is available, the limitations that exist, and the key gaps that need to be filled to improve evidence-based decision-making to guide food fortification programmes around the world. Also refer to Table 2 for information on selected tools for assessment of food fortification programmes.

Box 14: Tentative list of indicators on large-scale food fortification programmes

- Partners/stakeholders
  - Donor agencies
  - Programmatic/technical supporting agencies (international and domestic, as appropriate)
  - Ministry of Industry
  - Ministry of Trade
  - Ministry of Health
  - Food Control Agency
  - Customs Agency
- Fortified/fortifiable (industrial) food producers' associations (e.g. industrial salt producers, etc.)[193]
  - Fortified/fortifiable food importers association.
- Legislation
  - Mandatory – specify the type of product (under food/condiment) to be fortified; e.g. a single grade or multiple grades of flour; table salt only or all salt used in processed foods and condiments; etc.
  - Voluntary – need to define what we mean by this term; e.g. the FFI website says, 'We use this category if at least 50% of the industrially milled wheat or maize flour or rice produced in the country is being fortified through voluntary efforts.' However, I think that we might want to make it a bit tighter to include voluntary fortification only if the product is fortified according to an international or regional standard (if the country does not have a standard).
- Estimated per capita consumption
  - Specify the per capita consumption level of the product used by the country to develop the fortification standard. For salt, probably most countries use the generally accepted consumption level of 10 g/person/day.
- Standards
  - List the country's fortification standard, including chemical composition/type (especially for iron), for each nutrient to be added to the fortified-food vehicle.
  - Indicate if it meets WHO guidance or not. For flour fortification especially, many countries that started fortification some years ago use non-bioavailable forms of iron (e.g. hydrogen reduced or atomised iron) is used; so little, if any, impact on iron status could be expected in those countries.
- 'Geographic' population coverage
  - Define the geographic area(s) of the country where the bulk of the fortified product(s) is marketed in in sufficient quantities to allow for ≥80% 'expected coverage'.
- Period of time 'expected' population coverage >80%
  - How long has≥80% expected coverage been sustained?

[193] .For wheat and maize flour fortification 'fortifiable' refers to flour milled in facility with ≥20 MT/Day production. capacity

- Timing of impact assessment
  - Was >80% population coverage sustained for at least one year before impact assessment on micronutrient status was carried out?
  - Is there an ongoing tracking and reporting system that collects and reports data on quality, population coverage and impact of fortified (food) programme, or does country primarily rely on donor funded pre-fortification survey and a follow-up survey after a defined period specified in a donor agency funding proposal?

Table 5: Overview of available global databases related to nutritional status, food supply and consumption, national food fortification programmes, and food fortification programme assessment and tracking tools.

Nutrition and micronutrient status databases				
Organisation and database	**Indicators**	**Purpose**	**Type of evidence**	**Comments**
WHO – Global Health Observatory[194] – Global Database on Child Growth and Malnutrition	% of children under five who are stunted, wasted, underweight and overweight	To compile standardised child growth and malnutrition data from national nutritional surveys with an explicit focus on monitoring progress towards the SDGs	- Nutrition status (not on micronutrients)	Surveys are not conducted on a regular basis in every country. Much of this information is inferred from regression analyses Data are not correlated to fortification programme implementation or progress
WHO – Vitamin and Mineral Nutrition Information System[195] (VMNIS)	Vitamin and mineral status of populations based on: haemoglobin, serum ferritin, serum retinol, serum and red blood cell folate, serum transferrin, urinary iodine, and C-reactive protein concentrations and prevalence of goitre and night-blindness	To systematically retrieve and summarise data on vitamin and mineral status of populations globally	- Micronutrient status	Much of the data is very old – e.g. up to 20 years old for serum retinol levels indicative of vitamin A status. Surveys are not done regularly and few tools exist for rapid assessment of micronutrient status to facilitate timely data compilation globally. The data is not directly linked to national food fortification or other micronutrient deficiency interventions

[194] More information at http://apps.who.int/gho/data/node.main.1095?lang=en
[195] More information at http://www.who.int/vmnis/en/

Nutrition and micronutrient status databases				
Organisation and database	**Indicators**	**Purpose**	**Type of evidence**	**Comments**
Global Nutrition Report[196] *Not actually a database, but a useful annual report on global status	Overview of economics and demography; child, adolescent, and adult anthropometry; micronutrient status; intervention coverage and Infant and young child feeding practices; food supply, WASH, gender and government expenditure information; policy and legislation. Country profiles show the information at national-level	To assess annual progress of UN Member States in meeting global nutrition targets established by the WHA	- Nutrition status incl. micronutrients - Causal factors	All data is taken from other sources, therefore can be dated depending on the data source The development of the Global Nutrition Report is guided by a high-level Stakeholder Group (comprised of members of governments, donor organisations, civil society, multilateral organisations, and the business sector, currently chaired by representatives from CIFF and Ethiopia MoH), written and analysed by an Independent Expert Group (currently chaired by representatives from IFPRI, Mahidol University of Thailand, and an independent consultant), and supported by a Secretariat
SUN Nutrition Tracking[197]	Country profiles of SUN members, including prevalence of under 5-year-olds stunting, wasting, and overweight, low birth weight, exclusive breastfeeding, anaemia in women, overweight/obesity and elevated blood glucose levels in adults	To evaluate and assess the institutional transformation and actions towards Scaling Up Nutrition across the four strategic objectives: expanding and sustaining an enabling political environment; prioritising and institutionalising effective actions that contribute to good nutrition; implementing effective actions aligned with Common Results; and effectively using and increasing financial resources for nutrition	- Nutrition status including some micronutrients - Causal factors - Interventions	SUN focuses on the World Health Assembly targets for Maternal, Infant, and Young Child Nutrition. The WHA tracking tool[198] is utilised as a key data source as well as the Global Nutrition Report data SUN Self-Assessments allow SUN Countries and global networks the opportunity to self-assess their progress and state of institutional transformations

[196] More information at http://globalnutritionreport.org/
[197] More information at http://scalingupnutrition.org/
[198] More information at http://www.who.int/nutrition/trackingtool/en/

Value Chain: Food supply and consumption databases				
Organisation & database	**Indicators**	**Purpose**	**Type of evidence**	**Comments**
FAO – Food Balance Sheets[199]	Quantities of foods available for human consumption in a country, food supply, nutritional and caloric content of foods	To present a comprehensive picture of the pattern of a country's food supply during a specified reference period	- Causal factors	Includes data on calorie, protein, and fat content of food only; not micronutrient content
FAO/WHO – Global Individual Food Consumption Data Tool[200] (GIFT)	Individual quantitative food consumption data and indicators in nutrition, food safety and environment	To facilitate access to the microdata and food-based indicators	- Causal factors	Currently in the pilot stage with data available for four countries; intended to be available as a global tool in 2018
Access to Nutrition Index[201] (ATNI)	Scores are compiled from a number of topics, including governance, products, accessibility, marketing, lifestyles, labelling, and engagement	To assess and rank the world's largest food manufacturers on nutrition-related commitments, practices, and performance	- Causal factors	Targets only the largest food manufacturers and does not include many located in low- and middle-income countries

Food fortification-specific databases				
Organisation and database	**Indicators**	**Purpose**	**Type of evidence**	**Comments**
UNICEF[202] – Database on Iodised Salt	% of households consuming iodised salt	To assess population coverage and impact of iodised salt	- Interventions	Lack linkages to when salt iodisation began in each country. Lack data on iodised salt industry (number of industrial producers); production capacity; quantity of iodised salt (produced and imported) marketed; geographical distribution No data on iodine status of populations

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[199] More information at http://faostat.fao.org/site/354/default.aspx
[200] More information at http://www.fao.org/fileadmin/user_upload/nutrition/docs/assessment/FAO-WHO_GIFT_Project_Brief_March2016.pdf
[201] More information at http://www.accesstonutrition.org/
[202] More information at http://data.unicef.org/nutrition/iodine.html

Food fortification-specific databases				
Organisation and database	**Indicators**	**Purpose**	**Type of evidence**	**Comments**
Iodine Global Network (IGN)[203] – Global Iodine Scorecard	Median urinary iodine concentration (UIC) among school-age children		- Nutrition status	Lack linkages to when salt iodisation began in each country Lack data on iodised salt industry (number of industrial producers); production capacity; quantity of iodised salt (produced and imported) marketed; population coverage of iodised salt and its geographical distribution across the countries. Data on UIC is collected from literature; not directly from countries
WHO – Global Database on the Implementation of Nutrition Action[204] (GINA)	Nutrition commitments made, actions taken, and programmatic lessons learned (including for fortification programmes)	To share standardised information on nutrition policies and actions	- Interventions	Not updated regularly (relies on voluntary contributions from implementing agencies) and has limited information on food fortification programmes. Opportunity exists to add more qualitative programme data and lessons learned information to complement the quantitative data of the future global repository
UNICEF – NutriDash[205]	Country-level output data, including enabling environments, implementation and reach, and monitoring of salt iodisation and home-fortification initiatives	To measure the reach and progress of nutrition programmes and how these efforts are affecting nutritional status	- Interventions	Country-level data is not publically available currently

[203] More information at http://www.ign.org/scorecard.htm
[204] More information at http://ww.who.int/nutrition/gina
[205] More information at http://www.sightandlife.org/fileadmin/data/News/2015/2_Feb/UNICEF_Global_NutriDash_report_2013.pdf

Food fortification-specific databases				
Organisation and database	**Indicators**	**Purpose**	**Type of evidence**	**Comments**
FFI – Country Profiles and Global Progress[206]	Production information (annual production, exports, number of industrial wheat and maize flour and rice mills, % product produced in industrial mills) Legislation information (status, fortification standard, % industrially milled product that is fortified) Micronutrient status (anaemia in children and women, population at risk of inadequate zinc intake, birth prevalence of NTDs)	To track the legislative status of national wheat and maize flour and rice fortification programmes, report on population status of indicators related to the impact of fortified wheat flour, maize flour, and rice	- Interventions	Production data gives no indication of geographic coverage within countries. No information on quality of fortified products based on national standards or population coverage of the products No information on whether fortification standards comply with WHO guidance Micronutrient status data is based on WHO information (can be dated) or estimated based on models and not directly relatable to the status of the cereal fortification programmes

[206] More information at http://ffinetwork.org/country_profiles/index.php

Food fortification assessment and tracking tools				
Organisation and tool	**Indicators**	**Purpose**	**Type of evidence**	**Comments**
GAIN Fortification Assessment Coverage Tool (FACT)[207]	Purchase and consumption patterns of fortifiable of fortified foods; quality of fortified foods	To provide information on dietary intake of micronutrients and whether fortification programmes are reaching target populations To model the contribution of fortifiable and fortified foods to all population groups including target groups To monitor the effective coverage of fortification programmes	- Interventions	Using a modified multi-dimensional poverty index, is able to identify specific groups with the potential to benefit from fortified foods such as those who are poor, rural or at risk of inadequate dietary intakes and thus is able to estimate potential for impact of food fortification Currently lacks modules that would more comprehensively estimate dietary intakes of micronutrients from multiple micronutrient interventions, including supplementation and biofortification

[207] More information at http://www.gainhealth.org/knowledge-centre/gains-fortification-assessment-coverage-tool-fact/

Food fortification assessment and tracking tools				
Organisation and tool	**Indicators**	**Purpose**	**Type of evidence**	**Comments**
Smarter Futures (financed by Netherlands Development Cooperation – DGIS) Flour Fortification Monitoring and Surveillance (FORTIMAS)[208]	Quantity of adequately fortified flour marketed in geographic area; expected prevalence vs. actual population coverage of fortified flour and/or flour-based staple food; consumer knowledge, attitudes and practices (KAP) related to fortified flour Prevalence of anaemia, iron deficiency, and folate sufficiency in non-pregnant women; birth prevalence of NTDs	To monitor data and triangulate findings on the quality, population coverage and impact of flour fortification programmes over time to enable inference related to fortification impacting micronutrient status of the population	- Interventions	Aims to answer the question; 'Is the micronutrient status of those who regularly consume sufficient quality fortified flour improving?' Allows for (annual) tracking trends on population coverage and impact of adequately fortified flour fortified flour in sentinel populations; is not intended to provide statistically representative findings on coverage and impact of fortified flour at any single point-in-time The methodology could be readily adapted to tracking implementation and impact of other food fortification and population-based nutrition interventions by utilising intervention specific indicator of intervention quality, population coverage and impact.

[208] More information at http://www.smarterfutures.net/fortimas

Food fortification assessment and tracking tools				
Organisation and tool	**Indicators**	**Purpose**	**Type of evidence**	**Comments**
FFI Flour Millers' Toolkit[209]		To offer basic information to staff of flour mills on purpose of flour fortification, and necessary technology and Qa/QC procedures for production of quality fortified flour	- Interventions	Emphasises the essential role of flour millers in efforts to improve nutritional and health status of consumers of their product FFI, GAIN and the International Grains Institute at Kansas State University in the United States has developed version 1 of an online training course for flour fortification monitoring aimed at government food control and inspection personnel. In 2016 it will be rolled out with a handful of programme managers

[209] More information at: http://ffinetwork.org/implement/toolkit.html

7 Cues for future programming of EC support to food fortification

Some key options for EC support to food fortification and biofortification are presented below, structured along the three main strategic priorities within the EC Action Plan on Nutrition. To a large extent, the points below are taken from the list with key recommendations that were developed at the Arusha Summit. Some additional action points emerged from the analysis across the various vehicles that forms a core piece within this Global Mapping Report, plus the more generic chapters on food fortification programming and monitoring models. The issues in bold are seen as core priorities suggested for the EC to consider engaging with.

7.1 SP1: Enhancing mobilisation and political commitment to food fortification and biofortification

Enhancing mobilisation and political commitment for nutrition is critical in implementing well-resourced, country-owned and sustainable projects and programmes that align with national nutrition strategies and policies. At the international level, this means support to the SUN Movement and other international efforts to ensure global and regional commitments are translated into national action. At the national level, it means support for establishing effective national nutrition and coordinating mechanisms, and ensuring that nutrition is well represented in national development policies and budgets.

The following entry points are suggested as potential areas for EC engagement within food fortification and biofortification, as part of the EC's overall commitment to nutrition. The items in bold are considered to be activities with highest priority:

- **Identification of key stakeholders of food fortification at country and regional levels, including members of National Fortification Alliances where these exist, and analysis on how to gain further buy-in and commitment to ensure high coverage and compliance with food fortification regulations. This could include support for the establishment and further institutionalisation of alliances and networks around food fortification, and analyses of the motivational factors for governments and industries to engage in food fortification.**
- Engage in advocacy to make food systems more nutritious, including, where applicable, through establishment and/or scaling-up of food fortification and/or biofortification. Advocacy efforts are needed at both international and national levels, and should target public sector partners, the food industry and civil society agencies. Such advocacy efforts need to be based on the results of food systems and consumption studies, which ideally link findings for local settings with value chains across wider geographical areas.
- Further to advocacy work, it is suggested that the EC engages in provision of technical assistance to governments on how best to include food fortification into national plans, policies, strategies and budgets, and how to advise on the type and quantity of human and financial resources, required for such food fortification programmes.

- Cost-benefit analyses to assess what the difference in costs is of doing nothing as compared to the cost of various types of fortification efforts (e.g. through the development of a 'Cost of Inaction' toolkit).

7.2 SP2: To support building, improving and sustaining food fortification and biofortification programmes within partner countries

Within the EC's pledge towards nutrition, there is considerable attention for nutrition-sensitive actions, including those at the nexus of nutrition and agriculture, rural development and food security. There is a clear focus on ensuring that national nutrition policies are realistically costed and implemented, on multi-sectoral programming and partnerships, on human and institutional/systems capacity, and on supporting effective and evidence-based programmes, in terms of implementation and measurement and surveillance.

Under this strategic priority, the EC has two major entry points for engaging with food fortification and biofortification: (1) institutional strengthening and capacity building to key stakeholders; and (2) support to the pilot projects being awarded in the Call for Proposals earlier this year. The following areas are suggested to the EC as key components that would strengthen these entry points.

- To generate evidence in specific country contexts on what the various types of food fortification, and combinations thereof, realistically can achieve in terms of quality, coverage, sustainability, and reduction of micronutrient deficiencies, at national and sub-national levels, and among specific nutrition target groups. This could encompass assessment of the contributions of biofortification, introduction of multiple micronutrient fortification, and fortification of new vehicles and special products for specific nutrition target groups, including complementary foods and micronutrient powders for home-level fortification. It also could entail research on what targeted fortification strategies or distribution models can work in the specific country context to achieve a more equitable coverage.
- Harmonisation of food fortification standards within regions to serve the dual purpose of improving nutritional status and facilitating trade of fortified foods between countries.
- Capacity strengthening across the value chain for fortified foods, including among actors on production, importation and distribution, aimed at addressing performance gaps within existing fortification programmes. Such support can consist of efforts to strengthen technical expertise in-country, but could also entail the provision of required fortification machines, testing equipment, etc. Similarly, there is a need to further build capacities in regulatory monitoring by government.
- Simplification of regulatory monitoring systems. Development of case examples of how monitoring can be streamlined and integrated into existing food standards and food safety control mechanisms, and of good practices for monitoring and ensuring timely corrective action.
- Generate evidence of key factors that underpin the sustainability of food fortification and biofortification in specific country contexts.
- Identification of key issues regarding supply and demand aspects relating to food fortification, including procurement mechanisms for multiple fortificant premixes, QA/QC systems adopted

by industry partners, effectiveness of social marketing efforts and overall behaviour change communication to low-income consumers.

7.3 SP3: Contribute to the generation of knowledge on nutrition

Contributing to the generation of knowledge on nutrition is a key issue in responding to globally identified gaps in evidence concerning the efficacy of approaches, national capacity to manage data and information, and gaps in evidence-based policy. The EC currently supports countries by maximising the use of existing information through the use of National Information Platforms for Nutrition. Another area of work is the strengthening of national capacity and establishment and strengthening of partnerships for generating data and evidence on multi-sectoral approaches. This is expected to feed into global knowledge sharing platforms, such as the Global Nutrition Report and SUN. There is also a focus on strategic investments in operational research to generate evidence about effectiveness, sustainable scale-up and efficient use of resources, especially for nutrition-sensitive activities and activities that reach the most vulnerable population groups.

The following entry points are suggested as key areas for EC's engagement with food fortification and biofortification:

- Development of techniques and capacities for simple field-level rapid testing of food products on micronutrient contents.
- Further development of methods to assess quality and coverage of food fortification and biofortification products (FACT, FORTIMAS, etc.).
- Further development and validation of biomarkers for micronutrient status, including new assessment technology that facilitates mobile nutrient status assessments based on bio-specimens of human tissue and fluids.
- Research on how national micronutrient surveillance systems (and food consumption monitoring) can be improved to provide reliable information at sub-national level, and for specific nutrition target groups.
- Support the design and establishment of a global reporting mechanism on food fortification (i.e. the Global Repository on Food Fortification), and the establishment of mechanisms to ensure that the results are shared widely and with regular frequency as key information for global and national governance, coordination, decision-making and accountability.
- Guidelines for selecting the right fortificant compounds and levels, based on highest absorption and lowest inhibitors for iron, vitamin A, zinc and others, especially when multiple food vehicles are fortified.
- Research into the connection between food fortification and food safety (e.g. aflatoxin in cereals).
- Review of the available tools and their use on estimation of national or sub-national food consumption patterns.
- Modelling techniques for understanding the contribution of fortified staple foods, biofortification and home fortification in a given context, alongside other interventions that aim to address MNDs.

Part 2

Analysis of each of the main vehicles for food fortification

8 Salt iodisation and iodised salt in processed products

SALT IODISATION	
Vehicle focus	Salt, salt in processed foods
MND focus	Iodine (up to 2 billion people worldwide affected) [potential for double fortification with iron]
Current status globally	Legislation: At least 140 countries have mandatory legislation (universal salt iodization – USI)
	Coverage: 75% of households in non-industrialised countries are using iodised salt, with substantial disparities in coverage between and within countries.
	Micronutrient status: In 2014, 25 countries were iodine deficient (mean urinary iodine concentration (UIC) <100 µg/l), and 13 have excessive iodine status (mean UIC ≥300 µg/l).
Main players	Donors: USAID, BMGF, Kiwanis International, Canada Implementers: National governments, salt producers and importers Partners: WHO, UNICEF, International Council for Control of Iodine Deficiency Disorders (ICCIDD), Iodine Global Network (IGN), GAIN, Center for Disease Control and Prevention (CDC), Micronutrient Initiative (MI)
Legislation aspects and regulatory monitoring	- IDD still mainly is dealt with as a vertical programme outside of other fortification efforts, including for regulatory monitoring. - Need for USI programme coverage monitoring among specific groups like pregnant and lactating women and children 6–24 months of age, and among specific population sub-groups; to start up targeted iodine supplementation programmes for these groups as needed to address gaps if needed. - To explore shift to double fortification of salt with iodine and iron, as this has higher impact on control of IDD. - Need for revision of USI indicator sets within national monitoring and evaluation (M&E) systems to better reflect iodine status of key target groups for IDD control (pregnant and lactating women and young children in particular)
Value chain characteristics (supply-side and demand-side)	Optimisation of results in countries with key bottlenecks in the supply chain
	Take into account the adjustment of fortification levels of table salt for the uptake of additional iodine through other processed foods (sauces and condiments)

8.1 Overall approaches and achievements worldwide

Iodine deficiency (ID) used to be a common phenomenon in many parts of the world as it is difficult to access adequate levels of iodine through diets (see the attachment in Annex 12 for further information on ID). In 1991, the World Health Assembly adopted the goal of eliminating ID disorders (IDD) as a public health problem. This was reaffirmed by the International Conference on Nutrition in 1992. In 1993, universal salt iodization (USI) was recommended by WHO and UNICEF as the main global strategy to achieve elimination of IDD.

Over the past decades, most countries have shifted to the introduction of USI as an effective, low-cost and scalable intervention for the prevention of IDD. The UNICEF 2013 Nutridash Report indicates that for the countries that provided information about salt iodisation (n=86), nearly half started during the 1990s after the World Summit for Children, while 23% of countries started iodising salt before the 1990s and 29% started after 2000.[210] In 2005, the WHA adopted a resolution committing to report every 3 years on the global IDD situation.

Box 15: Choice for salt as the vehicle for iodisation

A choice was made for salt as the preferred vehicle for iodisation as it is one of the few commodities consumed by virtually everyone and with fairly stable consumption levels throughout the year. Salt production is usually relatively centralised with few producers in limited geographical areas. Iodisation of salt is relatively easy to implement, at reasonable cost, provided that supplies of fortificants are adequate and that the market distribution channels for salt are functioning well. The addition of iodine to salt does not affect its colour, taste or odour. Moreover, it was assumed that the quality of iodised salt could be easily monitored at production, retail and household levels.

The international recommendation is that salt is fortified with iodine at a level of 15–40 ppm. This standard is based on an average salt intake of 10 g per day at the population level. Although some years ago the international recommendation on salt consumption was reduced to less than 5 g per day, there are no major concerns that the fortification levels need to be increased, especially since there is increased intake of iodised salt through processed foods and condiments (e.g. bouillon cubes which in many LMIC are commonly used as an ingredient to prepare sauces, and also bread prepared with iodised salt.)[211]

Salt iodisation might not be enough to prevent mild to moderate iron deficiency among pregnant and lactating women. In countries where USI coverage does not reach the 90% threshold, it is recommended to take additional measures through iodine supplementation[212] or iodine fortified foods targeting pregnant and lactating women and young children 7–24 months of age.[213] It is increasingly stressed within public health nutrition that iodine intake levels for young children may be inadequate after weaning from breastfeeding, as complementary foods are usually prepared without added salt.

Source: WHO (2008), Salt as a Vehicle for Fortification; Report of a WHO Expert Consultation, 21–22 March, Luxembourg, Geneva, 2008.

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[210] UNICEF (2014) Nutridash 2013: Global report on the pilot year, New York. Note: Among the countries that provided data 86% had mandatory and 4% voluntary USI, and in 10% no iodisation legislation exists.

[211] Recent research by GAIN in West Africa found that iodine shelf life in bouillon cubes was at least 6 months.

[212] Several types of oral iodine supplementation are available for public health purposes. They can be divided into low dose (daily or weekly tablets or drops for oral consumption, with WHO/UNICEF recommended daily dose of 250 µg iodine; it can also be included within multiple micronutrient supplements) or an infrequent high dose (annually or only once, as iodised oil capsules, WHO/UNICEF recommends a dose of 400 mg).

[213] WHO/UNICEF (2007) Reaching Optimal Iodine Nutrition in Pregnant and Lactating Women and Young Children, A Joint Statement.

Box 16: National IDD Control Programme cycle

The Hetzel wheel (see below) was the first global model for establishment and management of a national food fortification programme. It was established in 1994 through a collaborative effort involving WHO, UNICEF and the ICCIDD (now the IGN). As this model indicates, successful IDD control programmes should have seven elements:

a) Assessment and periodic evaluation of the situation;

b) Dissemination of findings and communication to health professionals and the public;

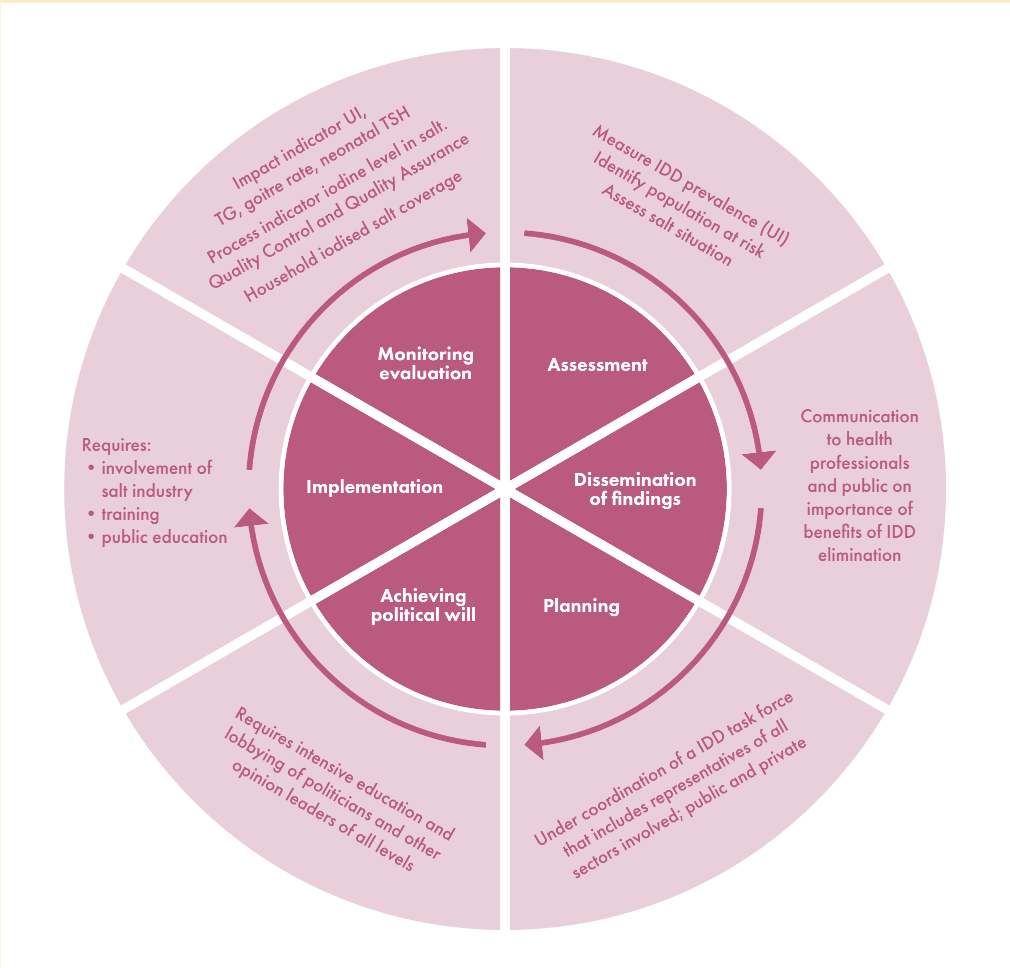
c) Planning with inclusion of the salt industry in the inter-sectoral task force on IDD, and formulation of a strategy document;

d) Achieving political will through intensive advocacy and lobbying on politicians and other opinion leaders;

e) Implementation with full involvement of the salt industry and proper mechanisms for monitoring and quality control; and

f) Monitoring and evaluation through ongoing and routine data collection including on salt iodine quality assurance and household use, and measures of programme performance.

Figure 12: The Hetzel wheel



Legislation

As shown in Figure 13 below, legislation on mandatory or voluntary salt iodisation has been established in most countries across the globe.[214] USI requires iodisation of all salt for human (food industry and household) and livestock consumption. In most countries, iodised salt, either used in the household or added to processed foods, is the primary source of iodine in the diets. However, the legislation and practical application of the use of iodised salt in processed foods varies widely from country to county, ranging from compulsory use for all food products, voluntary use for all or a restricted number of food products, no permission to use iodised salt at all, or a lack of clear legislation on the subject.[215]

Coverage

The global target for USI implementation is to reach at least 90% coverage at household level with iodised salt. However, as Figure 14 demonstrates, only a few countries have reached the target of more than 90% household coverage nationwide. According to the 2015 Global Iodine Nutrition Scorecard published by IGN, from among the 99 countries for which such data is available, 12 have achieved this target.[216,217]

[214] It is to be noted that in many European countries and also the US salt iodisation is done on a voluntary basis only, while some other countries do not have national legislation on salt iodization at all. A specific explanatory factor for the good coverage in the USA is that all table salt is produced by one company only (Morton).
[215] De Jong, J (2007) Final Report Review of Use of Iodized Salt in Processed Foods, http://www.iccidd.org/cm_data/Salt_in_processed_foods.pdf (accessed 16 February 2017).
[216] Countries with >90% household coverage with iodised salt (≥ 15 ppm) are: Armenia, Brazil, Bulgaria, China, Georgia, Kenya, Mexico, Nicaragua, Papua New Guinea, Paraguay, Sri Lanka and Tunisia.
[217] Ref. http://ign.org/cm_data/Scorecard_2015_August_26.pdf. The list of countries with insufficient iodine status includes a range of industrialised countries alongside LMICs such as Algeria, Angola, Burundi, Central African Republic, DPR Korea, Ethiopia, Gambia, Haiti, Mali, Morocco, Mozambique, South Sudan, Sudan, Ukraine and Vanuatu.

Figure 13: Countries with legislation for salt iodisation[1]

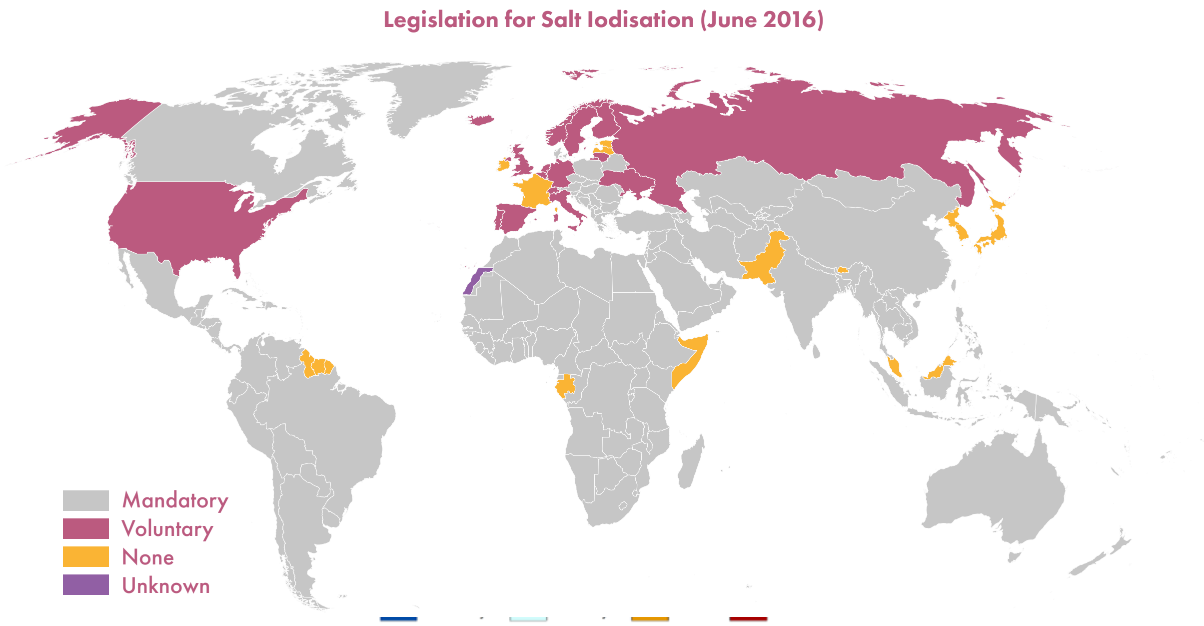
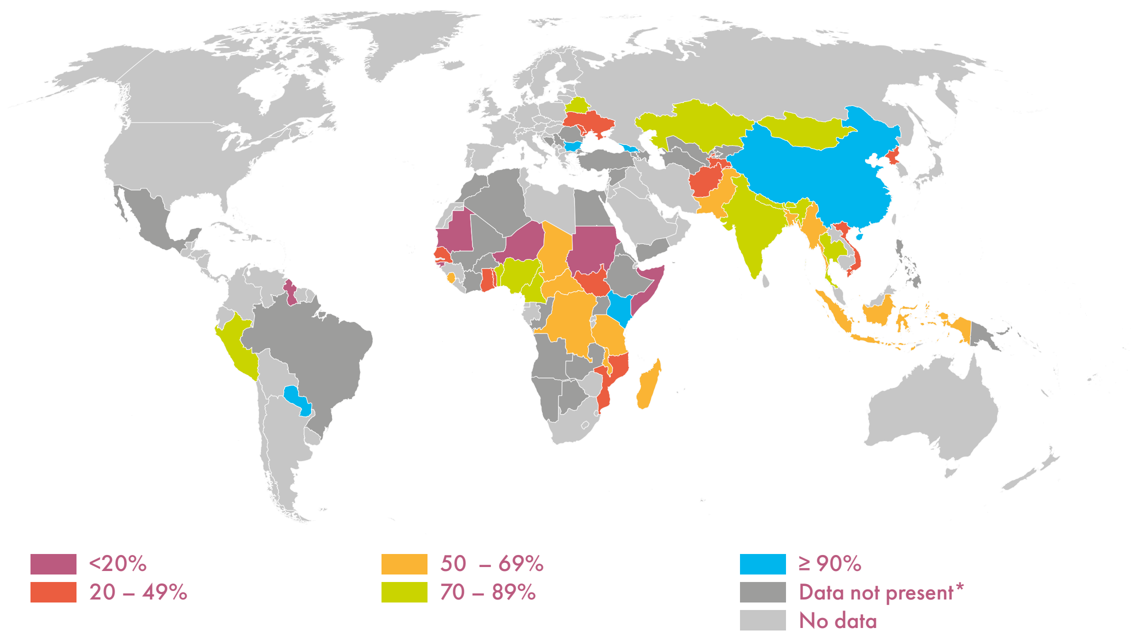
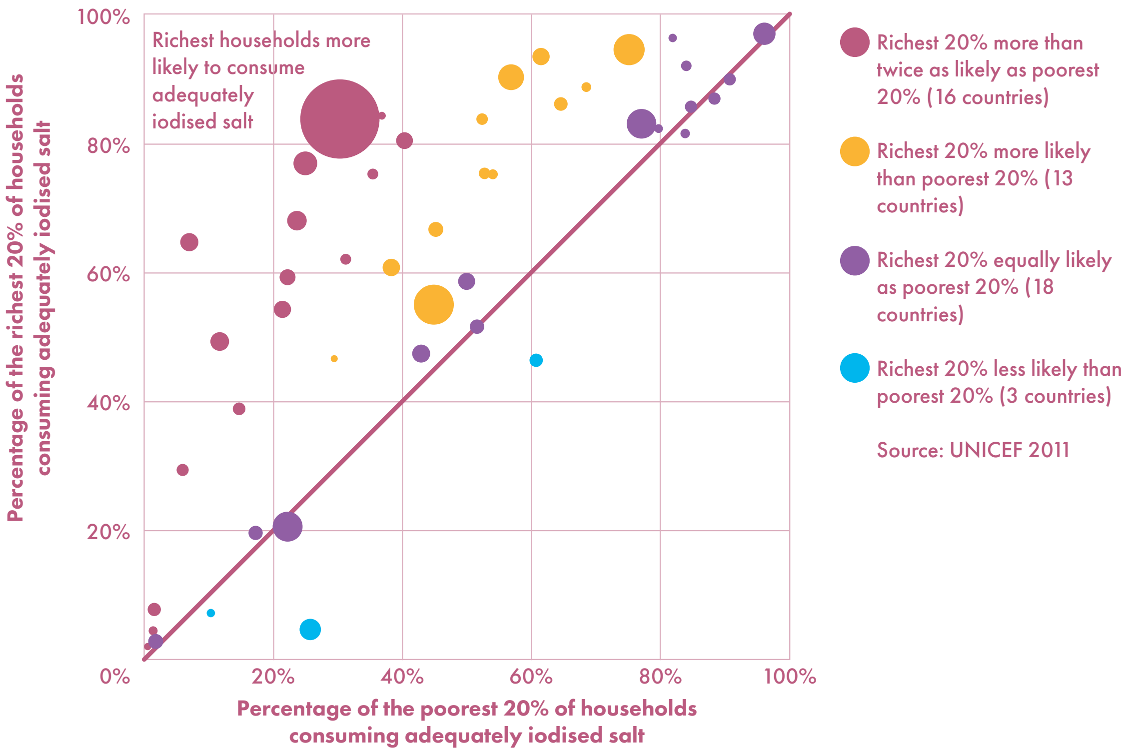


Figure 14: Percentage of households consuming adequately fortified salt 2002–9013 (n=53)



The UNICEF State of the World's Children Report for 2015 indicates that 75% of households around the globe are using iodised salt.[218] This is an improvement to the year 2000 when the global household use of iodised salt stagnated at around 70%.[219] However, national aggregate estimates mask disparities within countries. UNICEF analysis indicates that coverage of iodised salt is often better among richer households. This is, among others, due to inadequate programme reach through market channels and lack of alternative strategies to increase reach out to disadvantaged and marginalised populations (Figure 15).[220,221]

Figure 15: Use of iodised salt by households is often not equitable



Iodine deficiency trends

The WHO classification for IDD is as follows: '*severe deficiency*' when median UIC <20 µg/l; '*moderate deficiency*' when median UIC falls in the 20–49 µg/l category; '*mild deficiency*' when median UIC falls in the 50–99 µg/l bracket; '*sufficient*' when the median UIC is in the 102–099 µg/l bracket, and '*excessive*' when the median UIC ≥300 µg/l.[222] The evidence of USI for improving iodine intakes and helping prevent goitre and iodine deficiency in LMICs is well known. Tracking the impact of USI programmes is done through assessment of the population iodine status, at least every 5 years.[223] The indicator used is the median UIC, which is a measure that reflects recent iodine intake. Surveys are usually done among school-age children, since they are relatively easy to access for UIC testing.

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[218] UNICEF (2014) *State of the World's Children 2015*. New York, November.

[219] It is relevant to note here that the number of countries reporting on the household use of iodised salt increased from 90 in 2002 to 128 in 2012, and 156 in 2015.

[220] Timmer, A (2012) Iodine nutrition and universal salt iodization: a landscape analysis in 2012, IDD Newsletter, November, http://ign.org/newsletter/idd_nov12_iodine_nutrition_landscape_analysis.pdf (accessed 9 July 2016).

[221] UNICEF/IGN (2016) Technical Working Group Meeting on Research Priorities for the Monitoring of Salt Iodization Programs and Determination of Population Iodine Status, New York.

[222] Andersson, M, V Karumbunathan and MB Zimmerman (2012) Global Iodine Status in 2011 and Trends over the Past Decade, *J Nutr* 142: 744–50.

[223] Monitoring of iodine status can be done through cross-sectional surveys (independently or as part of broader nutrition surveys), or sentinel surveillance.

Figure 16: Number of iodine deficient countries in 2003, 2007, 2011 and 2014

The monitoring results published within the annual IGN Global Iodine Nutrition Scorecard reflect a growing global awareness of IDD and a tremendous success of salt iodisation programmes. There is a continuous reduction in the number of iodine deficient countries from 54 countries in 2003 to 25 in 2014 (see Figure 16).[224] For more than a decade there have been no countries in the 'severely deficient' category (with median UIC <20 µg/l). This implies that for elimination of iodine deficiency at global level, targeted efforts for establishing and scaling up USI programmes are required in a limited number of countries only, while the salt iodisation programme results in other countries need to be sustained with improvements in quality and regulatory enforcement to ensure salt is adequately iodised to standard. The 2015 Scorecard indicates that 13 countries have an excessive iodine status >300 µg/l.[225] WHO states, however, that the benefits of correcting iodine deficiency far outweigh the risks of iodine supplementation. Apart from neonates and young infants, daily iodine intakes of up to 1000 µg/day appear to be entirely safe.[226]

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[224] Data is still missing for 41 countries. Although these include only 2% of the world's population of children, they entail some countries with relatively large populations like Iraq and Congo.

[225] An excessive iodine status was found to exist in Armenia, Benin, Brazil, Colombia, Costa Rica, Georgia, Honduras, Paraguay, Qatar, Solomon Islands, Somalia, Uganda and Uruguay.

[226] This does not apply to patients with thyroiditis (higher intakes can induce hypothyroidism), patients with autonomous thyroid nodules (sudden and excessive increments of iodine supply can induce hyperthyroidism), genetically susceptible individuals (iodine excess can trigger thyroid autoimmunity, and patients with thyroid cancer. Source: WHO (2007), Vitamin and Mineral Requirements in Human Nutrition, Geneva.

Box 17: The EQUIP and IRLI programmes

The CDC supports external quality control of laboratories performing UIC analysis. The 'Ensuring the Quality of Urinary Iodine Procedures' (EQUIP) programme was established in 2001. Its aim is to support good laboratory practice and contribute to producing reliable urinary iodine results around the world through a system of external quality assurance testing. During the first five rounds of EQUIP, a total of 41 laboratories from 26 countries across all continents have participated. Three times per year, unknown specimens are issued to the participating laboratories with the request to analyse these samples in duplicate on three different days. Feedback is provided to the laboratories regarding the level of accuracy achieved. This has led to improved performance as a group, and considerable improvements for several laboratories that ordered new equipment or arranged for additional training.

At an international workshop on ID control in Bangkok in 2001, it was decided to establish the International Resource Laboratories for Iodine (IRLI) Network. Twelve of the laboratories participating in EQUIP were selected to the IRLI Network to serve as external monitor for other laboratories in their region that provide clinical and salt production data for ID control monitoring. The IRLI laboratories represent all WHO regions, and are supported by CDC, ICCIDD, MI, UNICEF and WHO. EQUIP is assisting the network through continued external quality assurance, collaboration on development of standards of operation, and training and assistance as needed.

Source: Caldwell, KL et al. (2005), 'EQUIP: a worldwide programme to ensure the quality of urinary iodine procedures', *Accred Qual Assur* 10: 356–61.

8.2 Considerations and reflections on national experiences

A recent landscape analysis on USI implementation[227] distinguishes four groups of countries with particular characteristics and needs (further illustrated by the country cases in Boxes 18 to 21):[228]

a) Countries with scaled-up programmes that already have achieved optimal iodine status where the focus needs to be on consolidation, programme adjustments and sustaining the achievements through maintaining periodic oversight, regular renewing of the commitment, programme adaptations in response to national context changes if any, and ensuring optimal programme reach for the disadvantaged and marginalised population (Box 18)..

b) Countries in scale-up phase where the focus is on improving the quality of iodised salt in key areas and market segments, expansion of the iodisation capacity to salt producers not iodising their product, and expansion of the use of iodised salt by the processed food industry. In these countries there often is a need to improve commitment through targeted advocacy and communication efforts that address key challenges within the value chain from salt producers up to the household level, increased collaboration among all stakeholders, as well as through better regulatory monitoring and enforcement of locally produced salt and imported salt. A particular challenge is to find ways to reach disadvantaged groups through market channels or alternative strategies (i.e. subsidies or public distribution systems) (Box 19).

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[227] Timmer, A (2012), 'Iodine nutrition and universal salt iodization: a landscape analysis in 2012', IDD Newsletter, November 2012.
[228] The case descriptions are based on the following sources: GAIN / UNICEF (2016), GAIN-UNICEF USI Partnership Project Final Report; Annex 2: Country Reports, Geneva/New York (Ethiopia and Sudan); Van der Haar, F, G Gerasimov, V Qahoush Tyler and A Timmer (2011) Universal salt iodization in the Central and Eastern Europe, Commonwealth of Independent States (CEE/CIS) Region during the decade 2000–09: Experiences, achievements and lessons learned, *FNB* 32 (4) (suppl); Gerasimov, G and F van der Haar (2015) Strengthening IDD prevention in Eastern Europe and Central Asia', *IDD Newsletter* November; Afghanistan Ministry of Public Health, Strategy on USI Revolving Fund in Afghanistan, 2013–15.
Begin, F and K Codling (2013) Iodized salt legislation in South and East Asia and the Pacific; an overview, *IDD Newsletter* May; ICCIDD South Asia Region (2014) Iodized Salt Coverage Jumps in Afghanistan, Iodine Nutrition improves significantly, *IDD News*, 12(3) September.

c) Countries without any policies or plans to scale up and achieve USI even though the iodine status of the population is not optimal. In these countries, there is a need to create more understanding and awareness among key gatekeepers about the function of USI to correct iodine deficiency, and to strengthen capacities to implement USI. This could be done, for example, through organisation of visits and evidence from other countries with successful USI programmes (Box 20).

d) Fragile states where the enabling environment is not conducive for USI due to the political-economical setting or where, because of weak governance, high levels of vulnerability and natural disasters, USI is not (fully) implemented. Iodine nutrition has low priority, and strategies to reduce IDD, if existent, may be weakening. The main aim in these settings is to encourage stronger commitment by all stakeholders and to increase the capacity to implement salt iodisation or temporary alternative strategies to help improve the iodine status of target population groups with available resources (Box 21).

Box 18: Countries with scaled-up programmes: Armenia, Azerbaijan and Georgia

Enabling environment: In the 1950s, the former Soviet Union began successful salt iodisation efforts. When the USSR was dissolved in 1991, however, salt iodisation was marked by the use of ageing technologies and stagnant QA practices. Iodisation programmes fragmented and collapsed in most countries within the Commonwealth of Independent States (CIS), and IDD started to resurge. From 2000 onwards, USI strategies were strengthened in nearly all CIS countries. The 2001 Minsk agreement set a common CIS standard of 40 + 15 mg iodine/kg salt and established mutual collaboration in promoting iodised salt trade and quality. By 2005, all three countries had mandatory salt iodisation that encompassed both consumer salt and the food industry. This was achieved with strong technical assistance from UNICEF, including engagement of UNICEF Goodwill Ambassador Anatoly Karpov in advocacy on USI legislation and the development of a USI monitoring framework, ref. http://ceecis.org/iodine.html), and support by Kiwanis International and USAID. Compliance monitoring in Armenia is done at the Avan production site, and through monitoring of the use of iodised salt at the level of the food industry and at household level. In Azerbaijan the Independent Consumers Union (a national NGO) is monitoring the supply of iodised salt at selected market outlets, alongside periodic household coverage monitoring. No data exists on the use of iodised salt in the food industry. In Georgia, the inspection system is less clear, but use of iodised salt in the food industry is reported. A small survey in 2007 found the food industry mostly to be compliant. Current efforts in the CIS countries focus on drafting of national-level ‘USI Sustainability Road Maps’.

Supply-side: The salt iodisation laws are well enacted in Armenia where the local company Avan produces all salt supplies. In Georgia, where the bulk of salt is imported from Ukraine, enactment highly improved after the change of government in 2005 when marketing of non-iodised salt was banned. In Azerbaijan, cottage salt companies emerged in the 1990s that supplied about half of national needs while the rest was imported from Turkey and Ukraine, mostly as iodised salt. In 2010, a large salt factory (Azersun) began operation with the capacity to fully cover domestic consumption needs for iodised salt.

Demand-side: In 2000, household coverage of iodised salt was 80% in Armenia, 40% in Azerbaijan and only 10% in Georgia. In Georgia and Azerbaijan, immediate needs were addressed in 1999/2000 through distribution of iodised oil capsules to children and pregnant and lactating women in the goitre-affected regions. In Armenia, national logos are used for fortified salt. Azerbaijan has implemented various consumer campaigns on iodised salt, and the topic was inserted in the primary school curriculum. In Georgia, no systematic communication campaigns took place, but social mobilisation has been conducted from 2005 onwards by the local NGO SOCO. A current topic is alignment of salt iodisation and salt intake reduction. The USI coverage target and population iodine nutrition adequacy was reached in 2006 in Armenia (97% household coverage; median UIC 313 µg/l) and in 2005 in Georgia (91% household coverage; median UIC 321 µg/l). In Azerbaijan a population coverage of 77% of households has been achieved, and a median UIC was 204 µg/l (2009).

Box 19: Country in scaling-up phase: Ethiopia

Enabling environment: Because of the Ethiopia-Eritrea war, the supply line of iodised salt from Eritrean sea salt producers to Ethiopia has been cut since 1998. Household coverage of iodised salt plummeted, with median UIC among school-age children only being 24.5 µg/l. Under the USI Partnership (2009–16, also refer to Annex 11), GAIN and UNICEF in collaboration with MI provided support on the drafting of legislation and revised salt iodisation standards, which were implemented in February 2011. The capacity of regulatory agencies was strengthened in partnership with the Ethiopia Food, Medicine, and Health Care Administration and Control Authority, including reporting protocols, better inspection capacity in production regions, and larger laboratory capacity for titration analysis as part of the national iodised salt tracking system.

Supply-side: The USI Partnership project also worked on building capacity of industry through the Afdera Salt Producers Mutual Support Association (ASPMSA). Standard operating procedures and quality control protocols were developed, training was done on use of iodisation equipment, and a KIO3 revolving fund and supply system were established in collaboration with the Pharmaceutical Fund and Supply Agency and ASPMSA. As a first step towards establishment of a national iodisation facility (CIF) that reduces the challenges of industry fragmentation, the project supplied some mechanised iodisation machines with capacity to provide 24% of national iodised salt needs.

Demand-side: A multi-channel public education approach was developed through broadcast and print media and social mobilisation via road shows and health workers with a main focus on Afar and Gambella – the salt production areas – and covering both producers and consumers. A USI coverage survey in 2014 showed major improvements in household access – 93% household coverage for iodised salt overall and 43% for adequately iodised salt. The 2015 national survey showed a median UIC among school children of 105.6 µg/l, which is classified as sufficient.

Box 20: Country where USI is not yet implemented: Sudan

Enabling environment: Although Sudan adopted USI in 1994, IDD remained a major problem (median UIC 9.8 µg/l; 1997). Under the USI Partnership (2013–16) UNICEF supported the reactivation of the National Micronutrient Alliance, with greater focus on production of iodised salt (goals were set to achieve 50% coverage by 2015 and 100% by 2017). UNICEF supported development of draft regulations, and mandatory regulations now exist in ten states (from five in 2013). National QA/QC monitoring guidelines were developed but not used due to lack of motivation among regulatory bodies.

Supply-side: Building capacity of industry was done through sensitisation and training events, provision of iodisation machines to 18 medium-scale salt plants (all in Red Sea State). The approach is to gradually withdraw subsidised KIO3 and ensure tax-free status for its importation. Supply levels of iodised salt briefly rose to 55% but then declined to 20% within a year. As only four of the supplied iodisation machines were in use, a shift was made to support the only large-scale salt factory in Sudan (GIAD Industrial Group) through donation of an iodisation machine and technical assistance. This factory should initiate iodised salt production in the near future.

Demand-side: Social **mobilisation activities were undertaken in 18 states (June 2013–June 2014). However, the National Iodised Salt** Behaviour Change Communication (BCC) **campaign was delayed as a consistent supply of iodised salt had not** been established. So far, household coverage of iodised salt has remained very low (7.5%, 2014).

Box 21: Fragile states: the case of Afghanistan

Enabling environment: The concept of a national salt iodisation programme was introduced in Afghanistan in 2002 through a number of meetings with government authorities and small-scale (1–2 MT/day) salt producers. While various Asian countries mandate salt iodisation through their Food Acts or Food Standards (integrated within routine food control systems), USI is a vertical programme in Afghanistan with a stand-alone legislative framework. The regulation on iodising salt for human and animal consumption was issued under existing laws (not the Food Act) and was notified in 2011. There is a ban on importation of raw rock salt and only packaged iodised salt is allowed to be imported. The regulation mandates an iodisation level of 30–50 ppm at the production level, 30–50 ppm at the market level, and >15 ppm at household level. Compliance monitoring is done by the Ministry of Public Health (MoPH): The Public Nutrition Department the quality of iodised salt at production facilities, and the Department for Quality Control of Drugs and Food monitors the quality of iodised salt at retailer level. In 2014, IGN signalled a need to simplify reporting tools, and to strengthen data sharing and use for decision-making. In recent years, the Afghan government has renewed its commitment to the elimination of IDD. As part of the National Food Fortification Project (2010–15) supported by the Khalifa Foundation (KBZF), GAIN and UNICEF have assisted the MoPH and the Afghan Iodized Salt Producers Association (AISPA; 31 members) to establish a new strategy for supporting iodisation by the local raw salt industry. In December 2013, a high-level meeting on the USI programme in Afghanistan was organised with the objective to ensure ongoing commitment of all stakeholders towards a sustainable USI programme. Another element was to support MoPH in its efforts on legislation to alleviate import duties and tax on the imported fortificant. Support was provided to AISPA to set up a representation office in Kabul. Support was also given to develop a quality control and quality assurance (QA/QC) manual to be used by the AISPA member salt producers, which includes standard operating procedures. Other activities under the heading of QA/QC were a review by GAIN of the salt production processes being applied by AISPA members for lake salt extraction, support from GAIN to a government-funded training of salt production employees, and the distribution of rapid testing kits to wholesalers and retailers, especially in rural areas.

Supply-side: Small salt producers have been encouraged to form business partnerships and shift to larger-scale salt production technology. Iodisation equipment was purchased from Iran with UNICEF financial support. The first iodised salt factory (Ayenda-i-Darakhshan, or ‘Bright Future’) was established in Kabul in 2003. In total, 29 iodised salt production plants have been established, all with a 3–8 MT/h production capacity. However, in Afghanistan USI has been hampered by lack of technical expertise among salt producers and sub-optimal capacity among the enforcement agencies. Despite the ban, there are large influxes of non-iodised salt from neighbouring countries. As procurement of potassium iodate largely depended on donors, GAIN introduced a revolving procurement fund for potassium iodate (KIO_3) to be managed by AISPA. The fund includes mechanisms for appropriate cost-recovery, forecasting demand and distribution, and is designed to transform a donation-based system into a financially viable business model. The fund started on 1 January 2014 with a seed stock of 4.7 MT of KIO_3, which was provided by GAIN in partnership with MI. This amount is about 60% of annual requirement if 100% of all salt for human consumption in Afghanistan is iodised. The production of iodised salt has increased from 4,000 MT in 2003 to 118,000 MT in 2012; still well below maximum production capacities and total domestic needs for humans and animals (estimated at 160,000 MT).

Demand-side: The USI regulation prescribes consumer education on USI, including on the specific packaging and labelling. The aim of the national salt iodisation programme was to achieve USI by 2015. The National Food Fortification Project has increased the coverage with USI which by 2015 was estimated to be around 7 million people. Household coverage of iodised salt was reported to have increased from 28% to 66%. This contrasts, however, with the information from the 2010/11 MICS survey which indicates a coverage level of 20% only. Since the start of the USI programme, significant improvements have been seen in iodine deficiency rates. As shown by the data of the Afghanistan National Nutrition Surveys in 2004 and 2010, the prevalence of UIC of <100 µg/L decreased from 72% to 30% among children and from 75% to 41% among women of reproductive age (WRA).

8.2.1 Enabling environment characteristics

Need to move towards more integrated programming

Within the food fortification sector specifically and the food and nutrition sector more broadly, it needs to be taken into account that there is a global-level shift away from vertical programmes and emphasis on integrated programming. This implies there is a need to embed iodine programme in micronutrient and nutrition strategies and plans. Furthermore, USI needs to be more firmly linked to the '1,000 days approach' advocated by the SUN Movement.[229]

For instance, there is a need to harmonise interventions on iodine supplementation for pregnant and lactating women with USI programme coverage results and patterns. While USI is seen as the most cost-effective, feasible and sustainable approach for ID control, it is recognised that vulnerable groups, such as pregnant and breastfeeding women and infants, may need to be targeted with additional iodine supplementation through community clinics. It is currently under review whether to extend iodine supplementation to all WRA in areas where large proportions of the population do not have access to iodised salt.[230]

Further study is required regarding the integration of ID control with programmes for control of other micronutrient deficiencies. This is because micronutrient deficiencies can interact with iodine nutrition and thyroid function. For instance, it has been shown that provision of iron together with iodine results in greater improvements in thyroid function and volume than by providing iodine alone. These insights formed the basis for trials with double-fortified salt, which indeed indicated significant additional impacts in comparison with the regular iodised salt. Similar metabolic interaction might exist between iodine and vitamin A (either when given alone or in combination with iodised salt), but the evidence for that is still relatively weak. There is even less evidence on the interaction between iodine and zinc metabolism. Despite numerous studies, no correlation has been proved with selenium.[231]

Need for revision of indicator sets within national M&E systems

There is a need for adaptation of the set of indicators used for coverage and impact monitoring:

- Currently, regulatory monitoring is done at the point of production and distribution while it may also be needed to monitor fortification levels of table salt at community levels (beyond the five-yearly surveys).
- Most of the national iodised salt coverage surveys are based on the use of rapid test kits, which are able to detect the presence of iodine in salt but are not suitable for quantitatively measuring actual iodine content. The results of such surveys thus do not reflect the proportion of salt that is adequately fortified, which in fact is the key indicator to be monitored if the M&E system aims to provide information for operational planning and decision-making.
- No test kits are yet available for measuring the presence of iodine in processed foods, and so other methods are required to determine the total iodine consumption from the diet.

[229] In this respect it is interesting that in a recent meta-analysis a correlation was found to exist between the absence of iodised salt in the household and childhood stunting, underweight and low birth weight, even when adjustments were done in relation to various confounding factors Source: Kraemer M, R Kupka, SV Subramanian and S Vollmer (2016) Association between household unavailability of iodized salt and child growth: evidence from 89 demographic and health surveys, *Am J Clin Nutr* 104-1093-100.
[230] A Cochrane Review is being prepared to assess the effects and safety of iodine supplementation in women before or during pregnancy and in the postpartum period for optimal maternal and child outcomes and to inform policy-making towards achievement of the WHA 2012 global targets. Source: De-Regil, LM et al. (2015) Iodine supplementation for women during the preconception, pregnancy and postpartum period, *Cochrane Database of Systematic Review* 6, Art. No. CD011761.
[231] Hess, SY (2015) The impact of common micronutrient deficiencies on iodine and thyroid metabolism: the evidence from human studies', *Best Practice & Research Clin Endocr & Metab* 24: 117–32.

- There is a growing need to monitor excess iodine intakes as well as deficiency. This should be done through total dietary assessments of iodine intake to determine the various sources of dietary iodine and the food items that contribute to excessive intake apart from iodised salt.
- Though the median UIC in school-age children serves well as a proxy for the overall population, it may mask deficiency among significant sub-groups of the population who are at a higher risk. This refers in particular to pregnant women.[232, 233] It can also apply to other population sub-groups that might not be reached by USI programmes and are at risk of ID.
- It is advocated by some experts to shift to IDD monitoring through assessment of the serum level of Tg[234] (thyroglobulin, a precursor of the thyroid hormone T3) as a measure of thyroid function (and thus reflect iodine intakes over a period of months or years). Use of such assays would require collection of blood samples and more advanced laboratory testing. For assessment of USI coverage, it would still be needed to continue collection of data on the UIC indicator as this directly reflects recent iodine intake.[235] Determination of serum concentrations of the thyroid hormones (T4 and T3) directly is not recommended for monitoring, as these tests are cumbersome, expensive and less sensitive.

8.2.2 Value chain characteristics (supply-side and demand-side)

Need for optimisation of results in countries with key bottlenecks in the supply chain

In order to further scale up production levels of iodised salt (and thus increase market shares), a shift is required to more differentiated analysis of context-specific bottlenecks in iodised salt supply chains as applicable per country setting. UNICEF has recently developed a new tool to identify specific supply-side targets for salt producers, which is based on specific analysis per value chain segment (from large-scale producers to small-scale importers). The tool is further explained in Box 22 below.

The issue is that successes in establishing USI programmes over the past decades have primarily depended on engaging larger-scale and mechanised salt producers of higher-quality refined salt. These industries usually responded well to the mix of support for the establishment of USI. Iodised salt is typically sold through more modern and commercial market outlets. In particular the more urban and affluent consumers have good access to iodised salt.

It is now needed to close the remaining gap through a more intensive focus on traditional markets, lower quality salt, and more rural and lower-income consumers. Obviously, it is more difficult to reach homogeneity and iodine retention through the distribution chain. Producers are mostly small and medium-scale enterprises facing a range of difficulties to integrate iodisation into their production processes and business models. In some countries like Ethiopia e.g. efforts are underway to consolidate the salt production sector through joining small-scale salt producers in cooperatives and introduce centralised iodisation facilities to benefit from economies of scale.[236] A concomitant issue is that local government officials have significant discretion in implementing national mandates, and tend to be weaker in more remote parts of the country. At the demand-side the context is also different, with less affluent and more rural consumers who tend to purchase more traditional, inexpensive and unrefined salt.

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[232] For pregnant women, the median in the population should be within the range 150–249 µg/l.
[233] Zimmermann MB (2011) The role of iodine in human growth and development, *Seminars in Cell & Developmental Biology* 22: 645–52.
[234] The Dry Blood Spot Tg reference range for iodine-sufficient school-age children is 4–40 µg/l.
[235] Zimmermann, MB, I Aeberli, M Andersson et al. (2013) Thyroglobulin is a sensitive measure of both deficient and excess iodine intakes in children and indicates no adverse effects on thyroid function in the UIC range of 100–299 µg/L: A UNICEF/ICCIDD Study Group Report. *J Clin Endocrinol Metab* 98: 0000-0000.
[236] IFPRI (2016) Global Nutrition Report: From Promise to Impact; Ending Malnutrition by 2030, Washington DC, p. 56.

Box 22: UNICEF's tool for setting supply-side targets

A newly developed UNICEF tool on setting supply-side targets provides a step-by-step guide to define a set of national context-specific targets focused on two indicators: (a) metric tonnes of adequately iodised salt produced by various supply segments; and (b) proportion of the national edible salt supply that is adequately iodised.

The tool consists of six Excel worksheets. It discerns a set of actions for three (iodised) salt quality categories within a total of five different supply segments (ranging from larger-scale capacity to small import enterprises) aimed at reaching three different objectives (sustaining or improving coverage with adequately iodised salt, or expansion of salt iodisation to salt producers who do not currently iodise).

Source: UNICEF (2015), Managing Universal Salt Iodisation Communications (MUSIC): A Tool for Setting Supply-Side Targets for Universal Salt Iodisation programmes, New York, April 2015.

Need for adaptation of USI programmes due to changes in consumption patterns

A need exists to incorporate policy changes with regard to salt consumption within USI programmes. The WHO salt reduction policy reaffirmed that USI is the recommended strategy to control IDD.[237] However, a need was identified to make salt iodisation and salt reduction programmes congruent.[238] It is underlined that iodisation of salt should never be used to promote salt intake to the public. As salt intakes may increasingly vary between countries, it is recommended that national authorities should regularly reassess average salt level intakes, and to adjust fortification levels accordingly.[239]

Another aspect that prompts adaptation of USI programming is the trend towards increased consumption of processed foods. This trend is often observed in industrialised countries but is seen to be expanding worldwide. This raises concerns because in many cases the legislation for iodised salt is either unclear on usage within the food industry or does not require the usage of iodised salt in processed foods. While USI programming and monitoring has continued to focus mainly on iodised salt purchased and consumed within households (table salt and cooking salt), it is obvious that promotion of the use of iodised salt by the food industry may provide opportunities to increase iodine consumption in lower- and middle-income countries as well.[240] Some interesting studies have been undertaken in recent years on how this could be shaped (see Box 23 and Box 24 below).

[237] Average salt consumption of the adult population should be reduced to < 5 g/day.
[238] WHO (2008) Salt as a Vehicle for Fortification; Report of a WHO Expert Consultation, 21–22 March, Luxembourg, Geneva.
[239] The recommendation to fortify at a level of 20–40 ppm is based on the assumption that average salt intakes amount to 10 g/day at the population level.
[240] For instance, in Senegal it was found that bouillon nowadays is an important source of dietary iodine intake. No major losses occur during shelf life (13.6% for bouillon cubes, and 0.8% for powder sachets), and the iodine was well retained in the broth (with cooking times of up to an hour) and in rice cooked in broth. Source: Spohrer, R et al. (2015) Estimation of population iodine intake from iodized salt consumed through bouillon seasoning in Senegal, *Ann. NY Acad Sci* 1357: 43–52, http://onlinelibrary.wiley.com/doi/10.1111/nyas.12963/epdf (accessed 5 July 2016).

Box 23: Use of salt in processed foods

In 2010, a study commissioned by the Micronutrient Initiative was undertaken covering 39 countries to assess opportunities for increasing iodine intake by promoting the use of iodised salt in processed foods. This included a review of consumption of discretionary salt (table salt) and processed food consumption patterns among various socioeconomic groups; preparing an inventory of the main suppliers of these processed foods; and an assessment of the (iodised) salt content of these foods. Frequent consumption of packaged, prepared ('Western style') foods was only found, however, among the higher income groups and in more urban areas, which are not the main target groups for ID reduction. Still, bread and cheese are widely consumed processed foods in many developing countries and are potentially good vehicles for iodisation.

Source: Davis Ohlhorst S, M Slavin, JM Bhide and B Bugusu (2012) 'Use of Iodised Salt in Processed Foods in Select Countries around the World and the Role of Food Processors', *Comprehensive Reviews in Food Science and Food Safety* 11: 233–84.

Box 24: Dried salted fish with iodised salt in the Philippines

In 2012, GAIN undertook a study to estimate the potential contribution of certain processed foods to micronutrient intake in South-East Asia if they are made with fortified ingredients. The study looked into the potential contribution of the use of iodised salt in various processed foods in the Philippines. It was found that dried salted fish is popular in rural and coastal areas and a very appropriate vehicle for iodisation. Preparation of the dried salted fish with iodised salt can provide at least 65% of the iodine required nutrition intake for women of reproductive age and more than 100% of that for children 1–6 years of age. It would require some formal changes in order to enact mandatory fortification of dried salted fish. The production of vacuum-packed sachets of salted dried fish is an emerging enterprise that is undertaken by non-licensed manufacturers. These are not monitored by the Food and Drug Administration (FDA) of the Philippines as the Act Promoting Salt Iodization Nationwide (ASIN) law only requires licensed food processors to use iodised salt.

Source: Spohrer, R et al. (2013) 'The growing importance of staple foods and condiments used as ingredients in the food industry and implications for large-scale food fortification programmes in Southeast Asia', *FNB* 34(2) (supplement): S50–61.

9 Fortification of vegetable oils and fats

VEGETABLE OILS AND FATS	
Vehicle focus	Vegetable oils and margarine
MND focus	Vitamin A, Vitamin D
Current status globally	Legislation: 49 countries legislate vegetable oils/fats fortification at a mandatory level. An additional ten countries allow voluntary fortification. One country is currently planning mandatory legislation Coverage: Global data is not available and therefore global coverage cannot be estimated. In 12 GAIN-supported countries, 245.7 million people are currently being reached with added vitamin A intakes Micronutrient status: Vitamin D deficiency data are largely non-existent. Vitamin A deficiency data is extremely dated, but most international authorities, including WHO, agree that there is poor vitamin A status in low- and middle-income countries
Main players	Donors: Bill & Melinda Gates Foundation (BMGF), USAID, Netherlands Development Cooperation Implementers: National governments; oil producers, refiners and importers Partners: GAIN, MI, HKI
Enabling environment characteristics	Emphasis on import monitoring as a critical control point Harmonised regional standards can play a strong role in supporting regional trade Government support and incentives for industry voluntarily fortifying can expand the reach of fortified products Alignment with efforts to reduce consumption of fats and oils
Value chain characteristics (supply and demand-side)	Quality of oil plays a role in the stability and retention of vitamin A Two major global suppliers of vegetable oils, Indonesia and Malaysia can have an impact on fortified oil consumption Diversion of vegetable oils to biodiesel production Trend towards consumption of red palm oil and efforts to reduce palm oil production

9.1 Overall approaches and achievements worldwide

The fortification of oils and fats began in the early 1900s in response to high levels of xerophthalmia and rickets, then understood to be linked to deficient intakes of vitamin A and vitamin D. As vitamin A and D are both fat-soluble, the choice was made to introduce fortification of fats and oils with these vitamins. This was done with the intention to increase the amount of vitamins A and D within regular food consumption patterns, as well as to make vegetable-based fats and oils nutritionally equivalent to their animal-based counterparts (e.g. butter and animal-based ghee).

The impact of such fortification dates back to the 1910s.[241] In 1917, Denmark introduced margarine fortified with vitamin A. Cases of xerophthalmia had been virtually eliminated within just one year.[242] In

[241] Arnaud Laillou et al. (2013) Vitamin A-fortified vegetable oil exported from Malaysia and Indonesia can significantly contribute to vitamin A intake worldwide, *Food and Nutrition Bulletin*, 34: S72–80.

Newfoundland, a similar vitamin A-fortified margarine was introduced in 1944 and contributed to reduce the percentage of subjects with a serum retinol level below 20 μg/dL (vitamin A deficiency threshold) from 48% to 2% after 4 years. More recently, the introduction of shelf-stable vitamin A-fortified margarine in the Philippines was found to decrease the baseline prevalence of children with low serum retinol from 25.6% to 10.1% after 6 months.[243] Likewise, in West Java, Indonesia, the introduction of fortified vegetable oil decreased the prevalence of vitamin A deficiency from 5–18% to 0.5–6% in both women and children.[244]

Similarly, fortification with vitamin D had drastic impacts on reducing deficiency of this vitamin. During the early 1900s, industrialisation in Europe and North America led to reduced reliance on family agriculture and less exposure to sunlight. Over 80% of children in these areas were estimated to have suffered from rickets. By the 1930s, it was noticed that where there was significant consumption of cod liver oil, naturally high in vitamin D, rickets was nearly eliminated, leading to vitamin D fortification of margarine and milk and a recommendation to consume ‘a daily spoonful of cod liver oil during winter months’, which continued into the 1970s.[245]

Since the early 2000s, vitamin A fortification of oils and fats has been recognised as a successful and low-cost strategy, particularly for LMICs where supply chains for vitamin A supplements are difficult and expensive to sustain.[246] Dual fortification with vitamins A and D has also been recognised as an important strategy, particularly in countries where it is culturally appropriate to wear covering styles of dress and where urbanisation and industrialisation is decreasing the amount of time people spend outdoors. Fortification is also recognised as a useful strategy to ensure women of reproductive age begin pregnancy with a good nutritional status; it is difficult to entirely correct a vitamin A deficiency with prenatal supplementation.

Fats and oils are ideal food vehicles for delivering vitamins A and D. First, they are a major dietary component and widely consumed globally across all socioeconomic groups. Negligible differences in access to and consumption of vegetable oil were seen between high and low-income population segments. In addition, oils and fats are also consumed by children in greater amounts than other typically fortified staple foods.[247]

Second, since vitamins A and D (as well as vitamins E and K) are fat-soluble, fats are also required for maximum absorption by the human body.[248] Thus, fortifying liquid fats and oils is ideal as the vitamins can be easily and uniformly distributed as well as delivered to the body along with a fat source to improve absorption. While more research needs to be done in this area, studies have shown that even increased dietary diversity to include consumption of fruits and vegetables high in vitamin A may not

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[242] Jack Bagriansky and Peter Ranum (1998) *Vitamin A Fortification of P.L. 480 Vegetable Oil*. Washington, DC: SUSTAIN.
[243] Florentino S Solon, Liza E Sanchez-Fermin and Lorena S Wambangco (2000) Strengths and weaknesses of the food fortification programme for the elimination of vitamin A deficiency in the Philippines, *Food and Nutrition Bulletin*, 21: 239–46.
[244] Sandjaja, et al. (2015) Vitamin A-fortified cooking oil reduces vitamin A deficiency in infants, young children and women: Results from a programme evaluation in Indonesia, *Public Health Nutrition*, pp. 1–12.
[245] Michael F Holick (2010) The Vitamin D Deficiency Pandemic: A Forgotten Hormone Important for Health’, *Public Health Reviews*, 32: 267–83.
[246] Omar Dary and Jose O Mora (2002) Food fortification to reduce vitamin A deficiency: International vitamin A consultative group recommendations, *The Journal of Nutrition*, 132: 2927S-2933S; Soekirman, et al. (2012) Fortification of Indonesian unbranded vegetable oil: Public-private initiative, from pilot to large scale, *Food and Nutrition Bulletin*, 33: S301–9.
[247] John L Fiedler and Barbara Macdonald (2009) A strategic approach to the unfinished fortification agenda: Feasibility, costs, and cost-effectiveness analysis of fortification programs in 48 countries, *Food and Nutrition Bulletin*, 30: 283–316.
[248] Karin H. van het Hof, et al (2000) Dietary factors that affect the bioavailability of carotenoids, *The Journal of Nutrition*, 130: 503–6; P. Jayarajan, Vinodini Reddy and M. Mohanram (2013) Effect of dietary fat on absorption of β carotene from green leafy vegetables in children. *Indian Journal of Medical Research*, 137: 53–6.

alone improve vitamin A status without also consuming sources of dietary fats (plant or animal based) in tandem.[249] In addition, vitamin A tends to undergo rapid oxidation, leading to changes in smell, taste and colour, and even to rancidity. Oils and fats, especially those that contain antioxidants (a fairly routine practice for higher-quality vegetable oils), provide a good matrix that can better stabilise vitamin A and delay its degradation better than flours or other food vehicles. It must be noted, however, that even for higher-quality vegetable oils, vitamin A losses of 6% are typically seen after one frying, while repeated frying at high temperatures could result in the degradation of over 60% of the vitamin A content.[250]

Third, the oil and fats processing sector is often very centralised, unlike other food vehicles. The fewer production sites that exist, the easier it is to monitor and enforce quality and safety parameters. The exception to this generalised notion is that in many countries there exist 'repackers', who package bulk quantities of edible oil into smaller and often unbranded and unlabelled bottles for sale. This issue can be remedied through ensuring that the major producers and importers who would sell in bulk to repackers are indeed fortifying. Oils and fats also require more chemical processing from their raw form, thus it is more likely that production facilities have more mechanised equipment and technical capacity which would facilitate an easy introduction to fortification.

Last, vitamin A is relatively inexpensive, leading to high returns on investment for fortification. Fortification costs only US$ 1.70–2.00 per metric tonne of vegetable oil, which is the equivalent of 0.3–0.4% of the purchase price or US$ 0.012 per person annually.[251] The benefit-cost ratio to fortify vegetable oil has been estimated at 50:1 or US$ 16–22 per DALY[252] averted.[253]

In the longer term, food fortification with vitamin A might offer an alternative strategy to replace (part of) the vitamin A supplementation programmes.[254] Periodic vitamin A supplementation is widely practised as a preventive public health nutrition intervention targeted at pregnant women and children 6–59 months of age.[255] In countries with high prevalence rates, coverage can also extend to primary school children; for example, alongside periodic deworming campaigns. Albeit effective, supplementation remains a costly intervention, and in some developing countries difficult to achieve with regularity due to inadequate supply and distribution channels.

Current global status: legislation

Forty-nine countries currently mandate the fortification of vegetable oils or fats (margarine). All of these national programmes include vitamin A and 20 of them also include vitamin D in their standards. An additional ten countries voluntarily allow fortification of vegetable oils or fats, all including vitamin A and six including vitamin D. Furthermore, one country (Ethiopia) is currently in the planning stages to enact

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[249] S. de Pee, CE West, JGAJ Hautvast, Muhilal and D Karyadi (1995) Lack of improvement in vitamin A status with increased consumption of dark-green leafy vegetables, *The Lancet*, 346: 75–81.

[250] JP Rowe, LV Ogden, OA Pike, FM Steele and ML Dunn. (2009) Effect of end-user preparation methods on vitamin content of fortified humanitarian food-aid commodities.' *Journal of Food Composition and Analysis*, 22: 33–7.

[251] Omar Dary and Jose O Mora (2002) Food fortification to reduce vitamin A deficiency: International vitamin A consultative group recommendations, *The Journal of Nutrition*, 132: 2927S–33S; Soekirman et al. (2012) Fortification of Indonesian unbranded vegetable oil: Public-private initiative, from pilot to large scale, *Food Nutr Bull*, 33: S301–9.

[252] The DALY is a measure of overall disease burden, expressed as the number of years lost due to ill-health, disability, or early death.

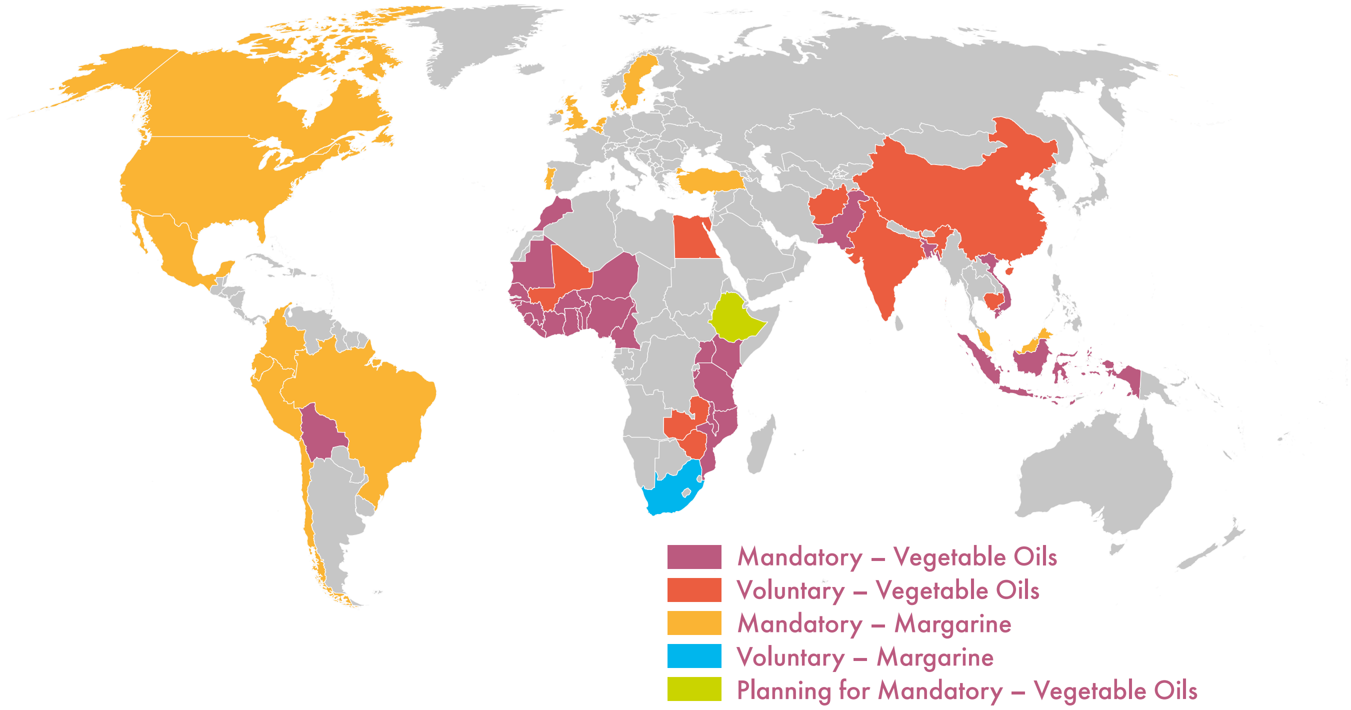
[253] Ronald Ross Watson, Joe K Gerald and Victor R Preedy, eds (2011) *Nutrients, Dietary supplements, and nutriceuticals: Cost analysis versus clinical benefits*. New York: Springer.

[254] Amanda C Palmer and Keith P West (2010) A quarter of a century of progress to prevent vitamin A deficiency through supplementation, *Food Reviews International*, 26: 270–301.

[255] WHO (2011) *Guideline: Vitamin A supplementation in infants and children 6–59 months of age*, Geneva: WHO; WHO (2011) *Guideline: Vitamin A supplementation in pregnant women*, Geneva: WHO.

mandatory fortification of vegetable oils with vitamin A. It is yet unclear whether this country will also include fortification of vitamin D. (see Figure 17).

Figure 17: Map of countries regulating the fortification of vegetable oils or fats[256]



Current global status: coverage

There are no published estimates of the total global reach or effective coverage of edible oils to date. However, it is known that in 12 countries supported by GAIN from 2007–13, vitamin A-fortified oil is currently reaching 245.7 million people. In addition, it is estimated that around 55 million people are currently being reached with vitamin A-fortified oil in eight West African countries (see Box 25).

Several studies have also shown that fortified oils and fats can contribute positively towards the recommended daily intake of vitamin A. In West Java, Indonesia, fortified oil was found to contribute to 34% of daily nutritional requirements for vitamin A for under 2-year-old children and 42–50% for women.[257] In Senegal, it was determined that 73% of WRA consume fortifiable oil (oil that is industrially produced with the potential to easily fortify at scale) on a weekly basis and 72% of WRA get at least 10% of their vitamin A recommended nutrient intake from oil. Similar studies in Rajasthan, India, Abidjan and Côte d'Ivoire have found that fortified vegetable oils can contribute 20–35% of WRA's daily vitamin A requirements.[258]

Current global status: micronutrient deficiencies

Children under five and WRA are most at risk of vitamin A deficiency and are most affected by its consequences. Since 2005,[259] the WHO estimated that 190 million preschool-aged children and 19.1

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[256] GAIN (2016) internal data.
[257] Sandjaja et al. (2015) Vitamin A-fortified cooking oil reduces vitamin A deficiency in infants, young children and women: Results from a programme evaluation in Indonesia, *Public Health Nutrition,* pp. 1–12.
[258] GAIN FACT results, 2015–16.
[259] Note that this data is over 20 years old, which presents a major challenge for quantifying and monitoring vitamin A deficiency at a global level. Individual implementation agencies and national governments may have more up-to-date information on vitamin A deficiency, but this information is not currently compiled or available at a global scale.

million pregnant women are affected.[260] It is a significant public health problem in over half the countries worldwide, and is especially prevalent in Africa and South and South-East Asia – particularly among rural populations, WRA and preschool children.

Vitamin D deficiency data is largely non-existent at any level (national or global), but is estimated to be widespread, especially among women, where diets do not contain significant animal-based products, where individuals spend most of their day indoors due to cultural factors or changes in working dynamics, and where individuals have limited sun exposure because of climatic constraints or cultural dress habits.[261]

9.2 Considerations and reflections on national experiences

9.2.1 Enabling environment characteristics

Emphasis on import monitoring as a critical control point

Many countries do not produce their own oilseeds and rely on crude or refined vegetable oil imports to meet demand. Indeed, nearly 25% of the global vegetable oil production is centred on two countries: Malaysia and Indonesia (see also section 9.2.2 and Box 27 below). To ensure the full impact of fortified oils and fats, legislation must cover standards and monitoring guidelines not only for domestic production and refining, but also for imports. If the countries from where most of the oil is imported do not routinely fortify, governments should consider incentivising the establishment of fortification facilities near key import locations so that imported oil can be fortified prior to its distribution domestically.

Harmonised regional standards support regional trade

Mandatory fortification is seen as the gold standard type of legislation to ensure equity within industry and that significant price differences do not exist within markets between fortified products and their non-fortified counterparts. Since the bulk of vegetable oils are traded, it is critical that regional standards are in place and each participating country aspires towards mandatory fortification to limit competition, either domestically or through imports, of non-fortified products. Harmonised regional standards are being met within the Economic Community of West African States (ECOWAS) states (see Box 25 below), East Africa's East African Community states, and Asia's Association of Southeast Asian Nations (ASEAN) states, though there continues to be opportunities to increase the number of countries following such standards, and to advocate for mandatory fortification.

[260] WHO (2009) Global Prevalence of Vitamin A Deficiency in Populations at Risk 1995–2005, Global Database on Vitamin A Deficiency. Geneva: WHO.
[261] Michael F Holick (2007) Vitamin D Deficiency, *New England Journal of Medicine*, 357: 266–81.

Box 25: West Africa regional oil fortification

Starting in the early/mid-2000s, Helen Keller International, with the support of GAIN and the Micronutrient Initiative brokered a strategic negotiation to support local oil industries to add value to their products through fortification with vitamin A and compete over non-fortified imported products. This began the regional *Tache d'Huile* initiative, which was designed to correct and prevent vitamin A deficiencies and reduce child mortality: in sub-Saharan Africa, control of vitamin A deficiency is estimated to prevent more than 600,000 child deaths annually. In the West African region, 54% of preschool-age children and 13% of pregnant women are vitamin A deficient or have night-blindness, respectively. All countries in the region enjoy a highly centralised vegetable oil industry, with their populations consuming more than 5g of vegetable oil daily, making this a promising region for successful and sustainable fortification programmes.

National and regional fortification alliances were created with stakeholders from the public, private, civil society and NGO sectors. These stakeholders advocated for large-scale fortification, supported industrial evaluations to assess technical capacity, and built public-private partnerships to develop standards, regulations and social marketing practices. These multi-stakeholder alliances facilitated efforts to coordinate partners, engage consumers, and to mobilise the political and private sectors' will to fortify. They continue to have an important role in ensuring effectiveness and sustainability.

In 2006, Mali became the first country in the region to pass a mandatory fortification decree for vegetable oil. This was closely followed by Côte d'Ivoire and Senegal. Since 2012, all eight member countries of the Professional Association of Cooking Oil Industries of the West African Economic and Monetary Union (AIFO-UEMOA)[†] fortify their vegetable oil. This has since spread to all 15 countries of the ECOWAS reaching an estimated 70–75% of the population in these countries through fortified, domestic supplies; 25–30% of the cooking oil demand is still met through imports from outside of the region and largely remains unfortified.

This regional initiative achieved a great deal in a short period of time and provided many lessons learned that have been applied to similar regional efforts worldwide. In Mali, for instance, five oil refineries were involved in domestic fortification; by the project's end they had produced over 39,000 MT in total. An unexpected drop in cottonseed production led to the need for alternative sources of vegetable oil, including sunflower oil and a greater reliance on imports. By the end of the project, 90% of the vegetable oil consumed was imported, nearly all from Côte d'Ivoire. This strengthened the argument for having a regional strategy, as this imported oil was already fortified. The imported brand, Dinor, became the most popular, known by 92% of women questioned, higher than any domestic brands.

In Côte d'Ivoire, three refineries were involved in domestic fortification and over 206,000 MT were marketed by 2011, covering 89% of the domestic market and providing an important source for imported oil throughout the region. One of the key success factors was the mandatory decree that also allowed for tax breaks on equipment and fortificant. This significantly improved the enabling environment and encouraged fortification by the private sector. Another lesson learned was the importance of understanding the geopolitical situation and responding to it. In 2009, a market survey found relatively low levels of adequately fortified oil on a national level, but upon further investigation, it was found that in the South, 81% of oil was adequately fortified while only 12% was adequately fortified in the North. Due to the political situation, borders in the North were poorly controlled and cheaper brands of unfortified oil from neighbouring countries had easily penetrated the markets. Government authorities responded to this information by promoting the use of new quality control devices, such as the iCheck CHROMA, specifically in these poorly controlled areas, which allowed for more rapid analysis and helped to curb the import of non-fortified oil.

In Senegal, two oil refineries were involved, producing over 65,000 MT by 2011 (around 46% of the market). From the start, the Cellule de Lutte Contre la Malnutrition (CLM) was established within the Prime Minister's Office, providing support for nutrition initiatives at the highest level of the health agenda. CLM strengthened accountability and facilitated decentralisation of results and management. Other government ministries provided support to procurement of equipment and fortificant, which helped to offset initial costs and facilitate enrolment of industries. The 2009 mandatory decree also clearly stipulated the roles and responsibilities of government entities, including the various ministries involved, which contributed to overall coordination.

Industry was involved from the start and actively developed QA/QC protocols.

Overall, this regional initiative benefitted from a bottom-up approach through ensuring UEMOA Commission ownership of the process. The UEMOA Commission focused their attention on advocacy with industry partners that already considered fortification as part of their corporate social responsibility and understood that the value addition of vitamin A gave them a competitive advantage. This paved the way for other industrial producers to join the effort throughout the region on a voluntary basis while pushing for mandatory legislation to level the playing field, including for imports. An understanding of regional trade dynamics also was a key success factor, as it paved the way for regionally harmonised standards and regulations that facilitated growth of industry, encouraged trade and market expansion, increased reach and consumption, and supported advocacy for mandatory fortification. This served as the foundation for future industry and a very easy adoption of regional mandatory wheat flour fortification shortly after. In addition, a harmonised regional fortification logo, see Annex 13 was established for branding, which has led to improved consumer recognition and demand.

† AIFO-UEMOA consists of Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo. All AIFO-UEMOA countries participate in ECOWAS, plus Cape Verde, The Gambia, Ghana, Guinea, Liberia, Nigeria and Sierra Leone

Source: Mawuli Sablah et al., 'Thriving public-private partnership to fortify cooking oil in the West African Economic and Monetary Union (UEMOA) to control vitamin A deficiency: Faire Tache d'Huile en Afrique de l'Ouest', *Food and Nutrition Bulletin*, 33 (2012): S310–20.

Government incentives for voluntary fortification

Much of the fortified vegetable oil production began through the voluntary efforts of one or more large corporations. When governments provide incentives for industry to fortify, through positive recognition of good corporate social responsibility, tax exemption for premix or fortification equipment, or exclusive registration or marketing rights, it encourages other producers to join in this effort and makes it easier to eventually justify mandatory fortification. This is most feasible through the use of government-regulated seals or logos that identify fortified products, such as the *Sangkap Pinoy* seal in the Philippines (see Box 26 below). This model has been especially successful in India, where the programmatic and nutritional success of voluntarily fortified vegetable oil in Rajasthan has prompted requests from other Indian States to their respective oil industries to scale up fortification in an effort to push for national mandatory fortification.

Box 26: Oil fortification in the Philippines

The Philippines has a significant prevalence of vitamin A deficiency, particularly among preschool children. Especially for rural populations and households in the lowest income quartile, the average daily intake of vitamin A is only sufficient to meet 65–75% of the recommended dietary allowance. In addition, over half of mothers have low levels of retinol content in their breastmilk, which can be a risk factor of vitamin A deficiency for the breastfeeding child.

During the 1990s, the Philippines embarked on a national nutrition strategy to combat vitamin A deficiency that included food fortification, among several other interventions. Both margarine and cooking oils were fortified with vitamin A under this strategy. Star brand margarine was first fortified in 1992 via a decision by its manufacturer, Proctor & Gamble, Philippines, to improve nutrition status among the population. At the time, margarine was consumed by 94% of the population and a controlled field trial among 3–6-year-old children showed significant increase in mean serum retinol levels after the introduction of fortification. This success prompted the manufacture of a micro-sized package of fortified margarine, designed to allow lower-income groups to afford the product. The success also prompted the use of the new *Sangkap Pinoy* seal, a stamp or recognition from the Department of Health of a properly fortified, high-quality food product. Margarine was one of the first three products to carry this seal upon its launch in 1996.

In 1997, the San Pablo Manufacturing Corporation, producer of Minola cooking oil, developed, tested and adopted the technology to fortify cooking oil with vitamin A. Cooking oil is also frequently consumed by Filipinos, ranking third in a list of most commonly consumed food items. Fortified cooking oil is now commercially available throughout the country and carries the *Sangkap Pinoy* seal.

The Philippines' case had several unique factors that contributed to its success and also posed challenges for sustainability. First, it was supported by the government at the executive and legislative levels. Five-year strategic plans were developed for food fortification and a multi-stakeholder food fortification task force (National Fortification Alliance) coordinated efforts. The *Sangkap Pinoy* seal continues to encourage food producers to market high-quality, fortified products and increases awareness of nutrition among the general public. This programme provides a mechanism for the government to support the private sector and serves as foundation for the public-private partnership. Very few producers are involved in the manufacture of vegetable oil and margarine, and even in the absence of mandatory legislation, producers are willing and able to fortify and sustain the effort.

One of the key challenges in the fortification programme is that there are no clear policies regarding acceptable food items that can receive the *Sangkap Pinoy* seal, the conduct of food consumption surveys to define fortification levels in food products, or the sharing of fortification technology and research results. Of particular interest is the fact that the *Sangkap Pinoy* seal encourages the fortification of any food product and current legislation also includes the food industry in its fortification regulations (i.e. the manufacture of processed foods can and should use fortified staple foods such as oil and margarine in their processing). While this is advanced in comparison with other countries, and provides an opportunity to reach more people through a diversity of fortified products, there has not been a limit placed on fortification of such processed foods, resulting in their proliferation in the market. Without protocols for measuring intakes of key vitamins through consumption surveys, there is potential for consuming too much of a particular vitamin or mineral. Moreover, the *Sangkap Pinoy* seal in some cases has been misused; for example, using the seal on less nutrient-dense foods or non-fortified foods as a way to raise the product's profile among consumers as a good, nutritious choice, even when this may not reflect the actual nutritious content.

Source: Florentino S Solon, Liza E Sanchez-Fermin and Lorena S Wambangco (2000) 'Strengths and weaknesses of the food fortification programme for the elimination of vitamin A deficiency in the Philippines', *Food and Nutrition Bulletin*, 21: 239–46.

9.2.2 Value chain characteristics (supply and demand-side)

Quality of vegetable oil is related to stability and retention of vitamin A

Similar to many other fortified staple foods, profit margins on cooking oil are very modest and it is assumed that producers will not absorb the extra cost of fortification, but will rather pass this on to consumers by raising the market price. For oils and fats, fortification with vitamin A costs around US$ 0.004 per litre, which is only around 1% of the market price of oil. This is lower than most of the other food vehicles. Also similar to other food vehicles, control systems are difficult and costly to put in place unless the industry is sufficiently centralised. In some countries, such as Indonesia, most of the cooking oil purchased by consumers is in loose form, resold as unbranded and unlabelled in smaller packages from a bulk purchase. In these cases, fortification will be nearly impossible to control unless it is implemented at the factory level.[262]

Vitamin A is a very unstable molecule, therefore the types of additives and the quality of the oil need to be considered to ensure the quality of the added vitamin A and the shelf-life of the fortified oil remains reasonable for most consumers.[263] For vegetable oils that are not adequately refined to remove

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[262] Arnaud Laillou et al. (2013) Vitamin A-fortified vegetable oil exported from Malaysia and Indonesia can significantly contribute to vitamin A intake worldwide, *Food and Nutrition Bulletin*, 34: S72–80.
[263] To be noted that high levels of peroxide in raw oil can adversely affect the stability of vitamin A while also carrying negative health effects such as increasing the risk of cancers. Peroxide levels in edible oil can be reduced or eliminated

peroxides, which have been seen in several LMICs, vitamin A degradation occurs faster for higher levels of initial peroxide levels in the cooking oil.[264] Even during controlled storage, without exposure to light or oxygen, peroxide levels increase in cooking oils over time: within 3 months for oil containing an initially small level of peroxide. Vitamin A losses increase as peroxide levels increase.

Even for oil that has been refined to reduce or eliminate peroxide, vitamin A stability is negatively affected with exposure to light, oxygen (through open containers), and high temperatures – climactic and storage conditions that are often present in developing countries.[265] After only 6 months, oil stored in direct sunlight in open containers had lost most of the vitamin A activity and had become too unstable for consumption. Sealed containers can typically retain up to 100% vitamin A and vitamin D content after 5 months.[266]

Two major global players can have an impact on fortified oil consumption

A unique characteristic of the global vegetable oil industry is that it is largely based on imports. Most countries do not produce enough oilseeds or manufacture enough vegetable oil to satisfy domestic demand. In addition, with the growing trend towards convenience foods and processed foods, there is a growing demand for vegetable oils. To satisfy demand, most countries must import either the raw oilseeds to process and refine into vegetable oil or, more commonly, import refined vegetable oil directly. Two countries, Malaysia and Indonesia, each produce over 18 million MT of vegetable oil annually (nearly one-quarter of global production) and export the majority of this production to nearly every country in the world (see Box 27). Working with vegetable oil producers, refiners and exporters in these countries could have a large impact on global nutritional status.

Box 27: Potential impact of oil fortification in Malaysia and Indonesia for export

Indonesia and Malaysia each produce over 18 million MT of vegetable oil annually, amounting to 23.7% of the global production. Both countries export refined vegetable oil to most countries, especially in Africa and Asia, providing a huge potential to reach hundreds of millions of consumers with fortified oil. Indonesia is the largest producer of vegetable oil and the second largest exporter, exporting around 6–8 million MT annually (35–45% of total production). Of this, nearly 30% was sent to China and 20% to South Asia (Pakistan, India and Bangladesh); another 6% was exported to neighbouring South-East Asian countries (Vietnam, Philippines, Myanmar and Cambodia). Malaysia is the second largest producer and largest exporter of vegetable oil, exporting over 14 million MT annually (around 80% of total production). Nearly half of Malaysia's exports go to China, Pakistan, India, Bangladesh, Vietnam, Egypt, Philippines and Myanmar. Some 53% of Malaysia's exports go to Islamic countries, where Malaysia has created a niche market and a network of re-exporters, particularly in the United Arab Emirates, to accommodate growing demand. In both countries, smallholder farmers of oil crops should be considered as part of this value chain and supported to sell their produce to the larger refineries or centralised fortification facilities for greater control over the fortification process.

Studies and models have shown that ensuring all vegetable oil for domestic consumption and export from these two countries could have a significant impact across Africa and Asia, regions with the highest

in high-quality refining processes. Fortification of low-quality vegetable oils containing high peroxide levels may indeed carry enough health risk to outweigh the benefit of added vitamin A, although more research is needed in this area to understand such linkages more fully.

264 Nuri Andarwulan et al. (2014) Quality of vegetable oil prior to fortification is an important criteria to achieve a health impact, *Nutrients*, 6: 5051–60; Arnaud Laillou et al. (2012) Vegetable oil of poor quality is limiting the success of fortification with vitamin A in Egypt, *Food and Nutrition Bulletin*, 33: 186–93.

265 Chan Theary et al. (2013) Fish sauce, soy sauce, and vegetable oil fortification in Cambodia: Where do we stand to date?, *Food and Nutrition Bulletin*, 34: S62–71.

266 Rebecca Spohrer et al. (2013) The growing importance of staple foods and condiments used as ingredients in the food industry and implications for large-scale food fortification programs in Southeast Asia, *Food and Nutrition Bulletin*, 34: S50–61.

prevalence of vitamin A deficiency. Domestically produced vegetable oil in Indonesia has been shown to reach 94% of Indonesian households, contributing to estimated average requirements (EAR) for vitamin A of 54% for women and 51–57% for children under five. Fortification for export in both countries could contribute to 19% EAR for Ethiopian women, 31% EAR for Bangladeshi children and 47% EAR for Bangladeshi women, 18% EAR for Cambodian women, 79% for Afghan women and 78% for Egyptian women.

In Indonesia, six oil refineries have the technical capacity to fortify and currently control 70–80% of the domestic cooking oil market. These private sector entities already support moving forward with mandatory fortification and are committed to fortify. The Indonesian government has also started the process of developing national regulations and draft legislation.

In Malaysia, the situation is somewhat different. Vitamin A deficiencies occur at low rates nationally and current data suggest that these are confined to certain population groups, mainly in rural areas, and are continuously decreasing. For this reason, neither industry nor the government is particularly interested in voluntarily fortifying or making fortification mandatory, as it will not have significant national impact on vitamin A status. This means that it will likely require importing countries to join together to demand fortified exports from Malaysia, or have their own fortification facilities add vitamin A after import. Malaysian exports have been growing strongly over the past decade, by an average of 7% annually, most of which are refined oils. However, unrefined oils are increasingly exported to Malaysian-established refineries in countries such as China, Pakistan, India and Bangladesh, where they are given a special allowance to export a significant quota without export duty.

The importance of regional harmonisation of standards is also evident in this example. In 2015, the ASEAN region has eliminated import duties on all products within this ASEAN free trade zone. Many countries within this region, including Cambodia and Laos rely solely on vegetable oil imports, as they have no local production. In order to impact the nutrition of these countries through fortified imports, these countries must agree on standards and common protocols for monitoring.

Sources: Arnaud Laillou et al. (2013) 'Vitamin A-fortified vegetable oil exported from Malaysia and Indonesia can significantly contribute to vitamin A intake worldwide', *Food and Nutrition Bulletin*, 34: S72–80; Soekirman et al. (2012) 'Fortification of Indonesian unbranded vegetable oil: Public-private initiative, from pilot to large scale', *Food and Nutrition Bulletin*, 33: S301–9.

Diversion of vegetable oils to biodiesel production

While demand for vegetable oils is increasing, demand for refined oil for biodiesel fuels is simultaneously growing. The biodiesel market is an attractive growth opportunity, particularly for Malaysian refiners who have less of an interest in the nutritional benefits, leading to reduced availability and increased cost of refined oil for foods. This will also reduce the potential of refiners to focus resources towards fortification for export as the biodiesel market can be more lucrative. This is a critical area where additional research efforts would benefit knowledge and understanding of the various value chains and alternative uses for vegetable oils.

Trend towards consumption of red palm oil

It must be noted that there is a trend towards greater consumption of red palm oil in some regions, in West Africa in particular. Red palm oil is naturally rich in vitamin A and is highly efficacious in improving vitamin A status among population at risk of Vitamin A deficiency.[267] There is a small but growing concern that overconsumption of vitamin A in these regions may become a problem for certain population groups who are consuming red palm oil in addition to other products fortified with vitamin A.

[267] Rice AL and JB Burns (2010) Moving from Efficacy to Effectiveness: Red Palm Oil's Role in Preventing Vitamin A Deficiency, *J Am College of Nutr*, 29(3) 302S–313S.

10 Fortification of wheat and maize flours and rice

FLOUR AND CEREAL	
Vehicle focus	Wheat flour, maize flour and rice
	Unique characteristics: Fortification levels vary based on per capita consumption and extraction rate for wheat and maize flour; three different technologies available for rice fortification depending on local preparation/cooking practices
MND focus	Iron, zinc, folate, vitamin B12, other B-vitamins, (and vitamin A)
Current status globally	Legislation: 85, 16 and 6 countries mandate wheat flour, maize flour and rice fortification, respectively
	Coverage: Percentages fortified globally: 28% of wheat flour, 58% of maize flour and 0.8% of rice
	Micronutrient status: Reductions in prevalence of anaemia and neural tube defects have been documented
Main players	Donors: USAID, BMGF, ADB, DFID, CIDA, CDC, USAID, EU, Dutch Ministry of Foreign Affairs Implementers: National flour and rice millers, importers and governments Partners: FFI, Smarter Futures, GAIN, MI, HKI, UNICEF, WFP, FAO, SPRING, Project Healthy Children
Enabling environment characteristics	Legislatively mandated fortification; 2009 WHO consensus statement on wheat and maize flour fortification; 2012 WHO Consultation 'Technical Considerations for Rice Fortification in Public Health'; FFI ' Millers' Toolkit' for wheat and maize flour millers; 2014 Smarter Futures' guide for monitoring and surveillance of flour fortification programmes (FORTIMAS); capacity of national producers, importers and regulatory monitoring agencies to assure that adequately fortified products are consistently marketed
	Current national industrial flour and rice production and importation capacity may not cover the entire country's population consumption needs, but primarily reach certain large sub-geographic areas
Value chain	Enabling access to fortified flour and rice to areas outside of current market coverage and/or disadvantaged populations; potential increases in market share of flour grade(s) not mandated to be fortified over time

Wheat, maize (or corn) and rice represent close to 95% of all the cereals consumed around the world.[268] Wheat is consumed in Central Asia, Middle East, South and North America and Europe; rice is the primary cereal consumed across Asia, and maize is a staple in Southern and Eastern Africa and

[268] FAO (2012) FAOSTAT, Food Supply, http://faostat.fao.org/site/345/default.aspx (accessed 15 July 2016).

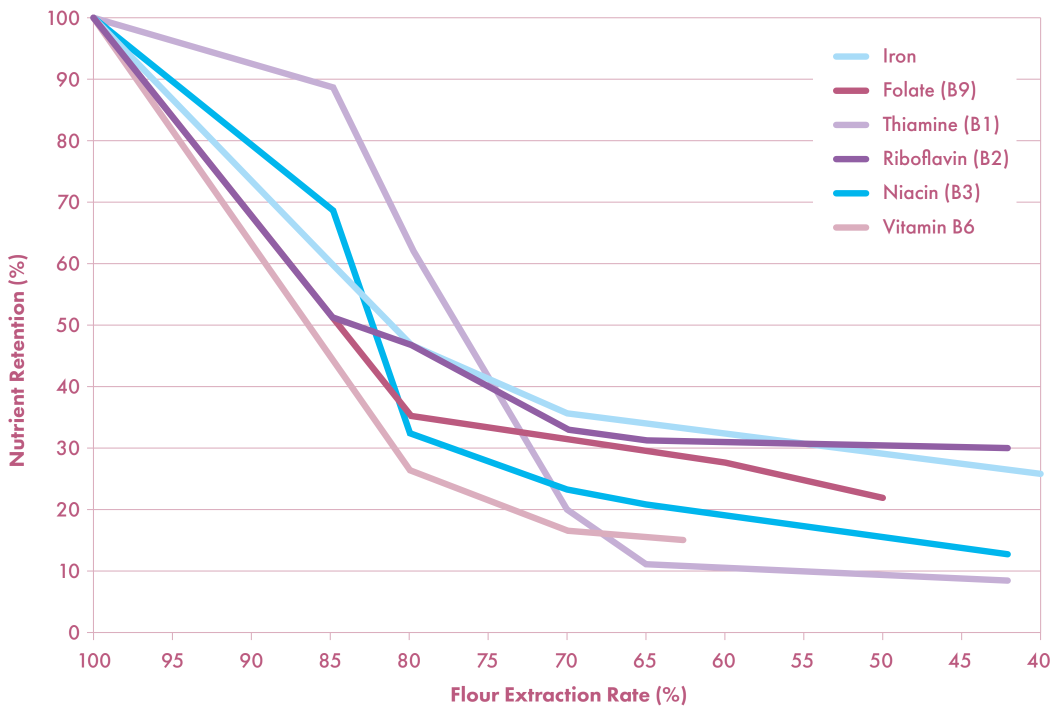
Central America.[269] Whole grain flours and brown (unpolished) rice contain various vitamins and minerals needed for human health (see Table 6) within their outer shell. However, modern roller milling processes remove much of the bran and germ of the grains of these cereals, along with their naturally occurring vitamin and mineral content (Figure 18). Therefore, regular consumption of industrially milled wheat and corn flours and polished rice as staple foods contributes to vitamin and mineral deficiencies, particularly when a varied diet is not accessible to the entire population. In fact, a Dutch physician – Dr Christiaan Eijkman – found that beriberi (deficiency of thiamine, or vitamin B1) was found to be due to consumption of polished rice.[270] In addition, some B-vitamin deficiencies were quite common in the United States in the first half of the 20th century because of widespread consumption of industrially milled white flour;[271] and in the early 1900s, Beriberi was reported among Norwegian merchant sailors on long voyages after the replacement of dark rye bread with white bread in the sailors' food.[272]

Table 6: Potential symptoms and outcomes of deficiencies of micronutrients lost during milling of cereal grains

Micronutrient	Potential symptoms/outcomes of deficiency
Iron	Microcytic anaemia, compromised immune system, increased lead absorption (if exposed to this toxic element), irreversibly impaired cognition (in young children), lethargy and reduced work capacity in adults, increased risk of premature and/or low birth weight babies (in pregnancy), maternal death during childbirth (when severe deficiency)
Folate (vitamin B9)	Macrocytic anaemia, lethargy and weakness, neural tube defects affected foetuses and births (when insufficient maternal folate status during first 28 days of pregnancy)
Thiamine (vitamin B1)	Fatigue, irritability, sleep irritability, loss of recent memory, muscle cramps, tachycardia, anorexia, constipation, beriberi (when severe deficiency)
Riboflavin (vitamin B2)	Fatigue and weakness, cracks and sores around corners of the mouth, swollen magenta-coloured tongue, sensitivity to light, impaired nervous system
Niacin (vitamin B3)	Indigestion, vomiting, depression, pellagra (when severe deficiency)

[269] Ranum, P et al. (2014) Global maize production, utilization, and consumption. *Ann NY Acad Sci*; 1312:105–1212.
[270] Christiaan Eijkman, Beriberi and vitamin B1, https://www.nobelprize.org/educational/medicine/vitamin_b1/eijkman.html (accessed 20 July 2016).
[271] Wilder, RM (1956) A brief history of the enrichment of flour and bread, *JAMA*; 162: 1539–41, http://jama.jamanetwork.com/article.aspx?articleid=319273 (accessed 16 June 2016).
[272] Macpherson, C (1966) The first recognition of beriberi in Canada, *Canad. Med. Ass. J*. 95: 278–9.

Figure 18: Graphic example of nutrient losses due to milling of wheat



Adapted from 'Wheat in Human Nutrition' by W.R. Aykroyd and Joyce Doughty
Food and Agriculture Organization of the United Nations, Rome, 1970.

While protective against deficiencies of some B-vitamins, regular consumption of whole grain (or high extraction) forms of these cereals may contribute to deficiencies of minerals such as iron, zinc and calcium, because the phytic acid (phytate) present in the husk of the grains inhibits absorption of those minerals from the diet. A study in some villages in Iran in the late 1960s, found that although diets contained over 44 mg of iron per day (substantially higher than the recommended dietary allowance of 18 mg for women of childbearing age), there was still a high prevalence of anaemia among children and women. The researchers attributed the high prevalence of (iron deficiency) anaemia to the high daily consumption of unleavened whole wheat bread, with high phytate content, which inhibited absorption of dietary iron.[273, 274]

With the understanding of the role of white (low extraction) flour in contributing to micronutrient deficiencies in the United States, the Council on Foods and Nutrition of the American Medical Association advocated for the 'restorative addition' (enrichment) of thiamine, riboflavin, niacin, iron and calcium in white flour and white bread in 1939. This was followed by the British government requiring the fortification of white flour with thiamine in 1940, and a government order in Denmark in 1953 called for addition of thiamine, riboflavin and iron to white flour, farina and semolina.[275]

Nowadays, effective and sustainable fortification of flour and rice is technologically and economically feasible through large-scale production by industrial processing plants. Leading cereal scientists and milling experts from the public and private sectors have agreed that production of adequately fortified wheat and maize flour is only economically feasible in mills with a production capacity of more than 20

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[273] Haghshenass, M et al. (1972) Iron-deficiency anaemia in an Iranian population associated with high intakes of iron. *Am Jour Clin Nutr*; 25: 1143–6.
[274] Tannic acid in tea also retards dietary iron absorption. Thus, fortification of flour and rice with bioavailable forms of iron would help to increase the overall amount of iron the people's diets.
[275] Wilder, RM (1956) A brief history of the enrichment of flour and bread, *JAMA*; 162: 1539–41, http://jama.jamanetwork.com/article.aspx?articleid=319273 (accessed 16 June 2016).

MT/day.[276] A similar capacity is also needed for a rice production facility, to consistently assure the fortification quality of the product through the mixing of fortified rice kernels with regular rice in the production chain.[277]

10.1 Overall achievements worldwide

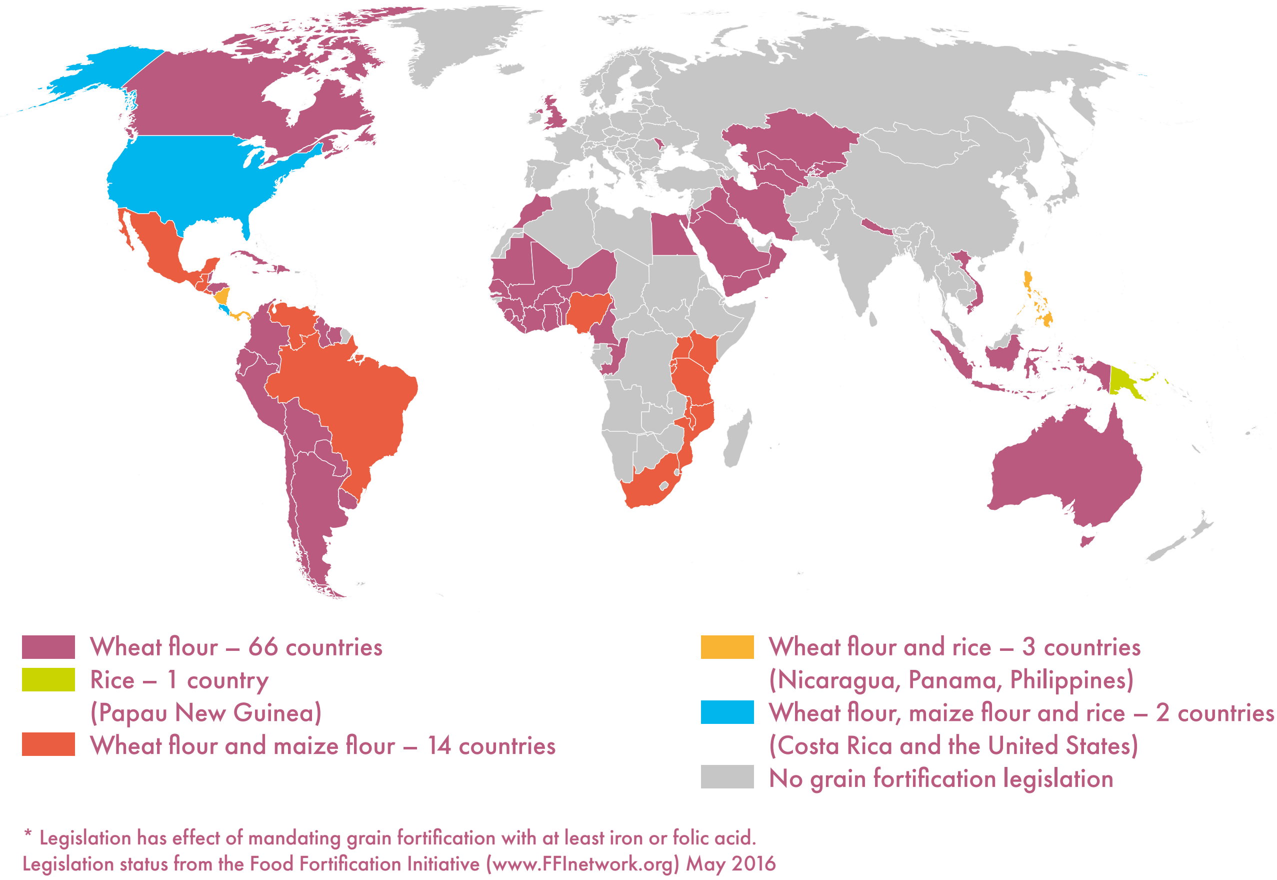
A. Legislation on fortification of wheat and maize flours and rice

Figure 19 overleaf illustrates the distribution of countries around the world that mandate fortification of wheat and maize flours and/or rice. A compilation of data reported by the FFI indicates that, as of May 2016, 85 countries have legislation requiring fortification of industrially milled wheat flour. This is a sign of substantial progress over the last decade; in 2007, only 54 countries had issued such legislation.[278] In addition, 16 countries now require fortification of industrially milled maize flour, while six require fortification of industrially produced rice. The figure also demonstrates that fortification of wheat flour is more widespread around the globe, while maize flour fortification occurs in a number of Central and South American and sub-Sarah African countries where this product has historically been a major staple food. Fortified rice is currently mandatory in fewer countries, notably the United States, Costa Rica, Nicaragua, Panama, Philippines and Papua New Guinea, even though it is a staple food for nearly half of the world's population.

In addition, the FFI reports that currently nine countries (Afghanistan, DRC, Gambia, Kiribati, Lesotho, Namibia, Qatar, Swaziland and United Arab Emirates – UAE) voluntarily fortify at least half of their industrially milled wheat flour; Lesotho, Namibia and Nicaragua do so for maize flour, while voluntary large-scale fortification of rice is occurring Brazil, Colombia and Dominican Republic.[279]

[276] FFI. Second Technical Workshop on Wheat Flour Fortification: Practical Recommendations for National Application, http://www.ffinetwork.org/plan/documents/AtlantaSummary.pdf (accessed 26 June 2016).
[277] Personal communication. Mr. Quentin Johnson, flour and rice milling expert of the Food Fortification Initiative (July 2016).
[278] CDC/MMWR (2008). Trends in wheat-flour fortification with folic acid and iron – worldwide, 2004 and 2007. 57: 8–10, http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5701a4.htm (accessed 24 June 2016).
[279] FFI. Global progress, http://www.ffinetwork.org/global_progress/index.php (accessed 20 July 2016).

Figure 19: Global status of industrially milled flour and rice fortification legislation – May 2016



Source: http://www.ffinetwork.org/global_progress/index.php.

B. Population coverage of fortified product

Table 7 shows the proportion of industrially produced wheat flour and rice worldwide that is fortified. Although about 85 countries now require fortification of wheat flour, the distribution of those countries varies greatly by region (Figure 19), and some of the most populous countries (e.g. China, India, Pakistan, Bangladesh) do not yet mandate any cereal food fortification. Thus, although substantially higher than the proportion of 18% achieved in 2004,[280] globally only 28% of industrially milled flour is currently being fortified. Many countries in the Americas, much of West Africa, a substantial part of Middle East and Central Asia, as well as Australia, Indonesia, Philippines and Vietnam, and Nepal mandate wheat flour fortification.

[280] CDC (2008) Trends in wheat-flour fortification with folic acid and iron – worldwide, 2004 and 2007. *MMWR*; 57: 8–10, 11 January, http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5701a4.htm (accessed 24 June 2016).

Table 7: Global progress on fortification of industrially produced wheat and maize flours and rice

Progress indictor	2014	2015
Proportion of industrially milled wheat flour worldwide that is fortified	29.9%	28.1%
Proportion of industrially milled maize flour worldwide that is fortified	47.7%	58.0%
Proportion of industrially milled rice worldwide that is fortified	0.8%	0.8%

Source: FFI (2016). 2015 Year in Review. Atlanta, USA, http://www.ffinetwork.org/about/stay_informed/releases/2015Review.html (accessed 14 July 2016).

The worldwide proportion of fortified industrially milled maize flour is much higher, currently standing at 58%. This is primarily because nearly all of the cornflour-consuming countries of Central and South America have been fortifying it for many years, and fortification of industrially milled maize flour has more recently been initiated in sub-Sahara Africa (Figure 14).

Although Costa Rica and the United States have been fortifying rice for a number of years, and new approaches have been developed for effective fortification of rice (see section 10.2.2. and Annex 13), the bulk of consumers of this grain are in Asia where rice fortification is not yet being implemented at national scale, except in Papua New Guinea (see Figure 19). In 2015 only 0.8% of industrially milled rice produced worldwide was reportedly fortified (Table 7).

C. Impact on micronutrient status

Wheat and maize flour fortification

Although a number of vitamins and minerals are recommended to be added to fortified wheat and corn flours (see Annex 13), most countries currently fortifying these products are doing so with at least iron and folic acid.[281] Therefore, much of the recent focus on assessing the nutritional and public health impact of such fortification programmes has been on documenting the impact of iron and folic acid fortification.

An important factor that has limited the effectiveness of national flour fortification programmes in reducing anaemia due to iron deficiency is that most countries have been either using non-bioavailable forms of iron fortificant and/or adding too little of bioavailable iron fortificants based on the average per capita intake of industrially milled flour.[282] A meta-analysis was recently conducted on the impact of national wheat flour fortification programmes, alone or in combination with maize flour fortification, with the addition of at least iron, folic acid, vitamin A or vitamin B12, using the WHO's VMNIS database. The key finding was that each year of sustained flour fortification was associated with a 2.4% reduction in the odds of anaemia prevalence in non-pregnant women of childbearing age.[283] An important factor was that most of the flour fortification programmes in the countries included in the study met the WHO recommendations (see Annex 13) related to the type and concentration of iron to be added to flour.

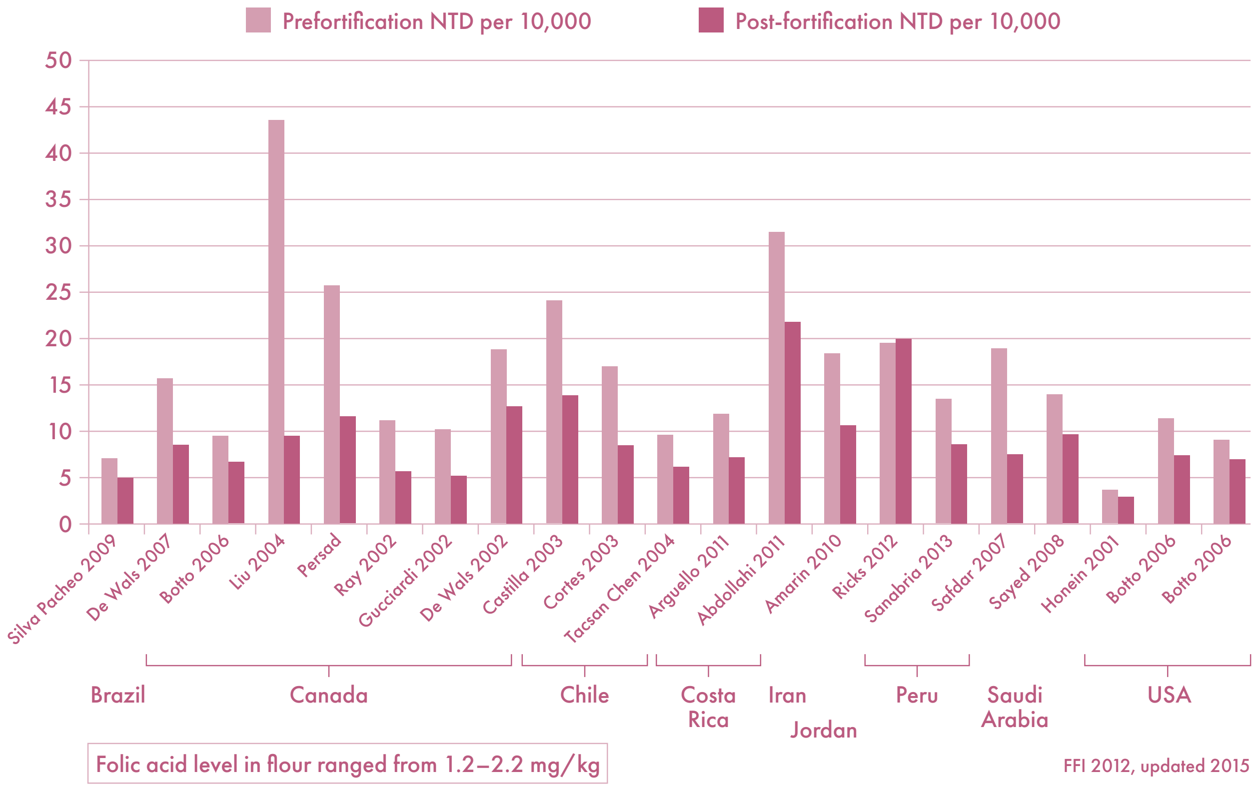
The possible impact of the national wheat flour fortification programmes with folic acid on increasing the folate status of populations and decreasing the birth prevalence of NTDs have been documented in a number of countries. For example, in Chile, the mean serum folate concentration in women of childbearing age increased from 9.7 nmol/l before fortification to 37.2 nmol/l after fortification was

[281] FFI. Global progress. Atlanta, USA, http://www.ffinetwork.org/global_progress/index.php (accessed 26 June 2016).
[282] Hurrell, R, et al. (2010) Revised recommendation for iron fortification of wheat flour and an evaluation of the expected impact of current national wheat flour fortification programmes. *FNB* 31 (1 suppl): S7–S21.
[283] Barkley, SB et al. (2015). Anaemia prevalence may be reduced among countries that fortify flour. *Br J Nutr* 114: 265–73.

implemented,[284] while in the United States, the prevalence of low serum folate (<3 nmol/l) was reduced from 21% in the pre-fortification period to <1% (virtual elimination) in the post-fortification period.[285]

The first country to fortify flour with folic acid was Oman, which started the programme in 1996. The annual birth prevalence of spina bifida in that country dramatically decreased from a range of 23–40/10,000 births in the early 1990s to about 3/10,000 births in 2006[286] following the start of mandatory flour fortification in 1996. Substantial reductions of 25–50% in the birth prevalence of NTDs have also been documented after folic acid fortification of flour in Canada, Chile, Costa Rica and the United States.[287] Figure 20 presents a summary of findings on the impact of flour fortification with folic acid on birth prevalence of birth defects in countries in different regions of the world.

Figure 20: Reduction in birth prevalence of neural tube defects post-flour fortification with folic acid across various countries



Source: FFI (http://www.ffinetwork.org/)

Although concerns have been raised about possible adverse effects of increased folic acid intake (e.g. on cancer risk), the findings of such associational studies have been countered by other studies and experts. A meeting that included researchers in folic acid nutrition as well as other public health and nutrition scientists and flour fortification specialists convened in 2008[288] concluded that folic acid fortification of flour is safe and effective when implemented based on the guidelines recommended at that event. Therefore, the WHO accepted the recommendation of that expert meeting and issued a

[284] Hertrampf, E et al. (2003) Consumption of folic acid-fortified bread improves folate status in women of reproductive age in Chile. *J Nutr* 133: 3166–9.
[285] CDC (2010) CDC Grand Rounds: Additional opportunities to prevent neural tube defects with folic acid fortification. *MMWR* 59:980–4, 13 August.
[286] Alasfoor, D et al. (2010) Spina bifida and birth outcome before and after fortification of flour with iron and folic acid in Oman. *EMHJ* 16:533–8.
[287] Berry, RJ et al. (2010) Fortification of flour with folic acid. *FNB* 31(Suppl 1): S22–35.
[288] Stone Mountain Conference reference.

consensus statement[289] on fortification of industrial flour in 2009 (which is the most current guidance on the subject).

Rice fortification

Similarly, a number of micronutrients have recently been recommended for addition to rice (see Annex 13). However, only a relatively small number of countries have fortified rice (see section 6.2) and currently there are only a few reports on the impact of those programmes:

- A recent publication on available evidence for large-scale rice fortification, only report four studies on the effectiveness of fortified rice:[290]
- A study in the Philippines in the late 1940s reported a substantial reduction in the prevalence of beriberi (due to thiamine deficiency); no laboratory measures of micronutrient status were reported.
- Another study the Philippines, using iron-fortified rice reported higher haemoglobin levels and reduced prevalence of anaemia among children, but not mothers, after the intervention.
- A study in Thailand (1971–75) distributed fortified rice to children of different age groups. No differences were found in haemoglobin (or haematocrit) levels of the children receiving or not receiving the rice. It was conjectured that the prevalence of widespread caloric insufficiency among the study populations might have affected the results.
- A more recent study in Costa Rica in 2011 reported an additional decline in birth prevalence of NTDs with the fortification of rice and milk with folic acid, after the initial decrease in NTDs following folic acid fortification of flour.

D. Global-level entities with specific mandate to support flour and rice fortification

Food Fortification Initiative (FFI)

The FFI was formally established as the Flour Fortification Initiative in 2003 being ‘a network of partners working together to make fortification standard practice in industrial mills’. In May 2003 the Board of Directors of the International Association of Operative Millers (IAOM) passed a resolution in support of flour fortification around the world. By June of that year, the IAOM as well as the Australian Wheat Board, US Wheat Associates, American Ingredients Company, the Wheat Foods Council, Cargill, GAIN, Micronutrient Initiative, UNICEF and Fleishman Hillard public relations agency, among others, joined the FFI network in support of flour fortification.[291]

With the development of technically feasible and financially sustainable technology and methods, the FFI expanded its mandate to also include advocacy and support for fortification of rice, which is generally not eaten as flour. Thus, the partnership’s name was changed to Food Fortification Initiative in 2014,[292] and its mission slightly modified; that is, ‘to advocate for and support fortification of industrially milled cereal grains by collaborating with multi-sector partners.[293, 294]

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289 WHO consensus statement.
290 De Pee S. Overview of evidence and recommendations for effective large-scale rice fortification. In WFP and Sight and Life; Scaling up Rice Fortification in Asia. Sight and Life, Basel, Switzerland. https://issuu.com/sight_and_life/docs/sal_wfp_suppl (accessed 3 July 2016).
291 http://www.cdcfoundation.org/sites/default/files/upload/image/10YearPressRelease.pdf (accessed 20 June 2016).
292 http://www.ffinetwork.org/about/History.html (accessed 20 June 2016).
293 http://www.ffinetwork.org/about/index.html (accessed 18 June 2016).
294 The most current list of FFI partners includes 93 entities representing public, private and civic sectors organisations from around the world, http://www.ffinetwork.org/about/partners.html An executive management team representing leaders from across those sectors provides strategic direction to the FFI partnership.

A particularly important contribution of FFI is that it tracks and reports on progress of wheat and maize flour and rice fortification at national and global levels on an annual basis. In addition, FFI has supported the development of practical tools, such as:

a) A 'Millers Toolkit'[295] to help train the relevant personnel of flour mills on appropriate fortification processes and procedures so as to ensure the production of a quality fortified product that meets national and/or international standards.
b) A 'Cost-Benefit Analysis Modelling Tool',[296] which can be used by countries to project the potential 'cost of doing nothing' vs. the economic benefit returns of fortification to reduce the burden of micronutrient deficiencies.

Smarter Futures

Smarter Futures is a public-private-civic partnership, composed of FFI, Helen Keller International (HKI), the International Federation of Spina Bifida and Hydrocephalus (IF), the Ministry of Foreign Affairs of the Netherlands and AkzoNobel that supports partnerships of flour millers, governments, vitamin and mineral suppliers, international organisations and academic institutions to make fortification of wheat and maize flours a reality in Africa. Essentially, Smarter Futures is the 'Africa arm' of FFI.[297] Specifically, Smarter Futures supports capacity development of flour millers, government food control personnel and other stakeholders regarding quality and effective fortification of wheat and maize flour with vitamins and minerals through meetings, workshops and development relevant tools. The members of the partnership support these efforts through direct funding or in-kind contributions.[298]

Smarter Futures has also supported development of resources that countries can use to advocate for and track the progress of their flour fortification programmes:

a) The 'Fortify Grains to Prevent Neural Tube Defects in Africa Advocacy Toolkit', http://www.smarterfutures.net/wp-content/uploads/2013/12/spina_version-grains-small-size.pdf. The toolkit may be used to help generate political and other needed support fortification of flour with folic acid to debilitating birth defect such as spina bifida and anencephaly.
b) 'FORTIMAS: An Approach for Tracking the Population Coverage and Impact of a Flour Fortification Programme' (http://www.smarterfutures.net/fortimas). This guide, based on sentinel data collection methodology, offers feasible approaches for countries to document trends in the effectiveness of a flour fortification programme over time in populations documented to regularly consume adequately fortified flour. The approach can also be used for tracking other population-based food and/or nutrition interventions, provided that the appropriate indicators of intervention quality, coverage and impact are substituted for those related to fortified flour.

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295 http://www.ffinetwork.org/implement/toolkit.html (accessed 20 June 2016).
296 http://www.ffinetwork.org/about/calendar/2013/CostBenefit2013.html (accessed 25 June 2016).
297 Brief overview of Smarter Futures. Anna Verster, Senior Advisor on flour fortification at IF (personal communication, 25 June 2016).
298 http://www.smarterfutures.net/ (accessed 18 June 2016).

10.2 Considerations and reflections on national experiences

10.2.1 Enabling environment characteristics

Fortification legislation vs fortification standards

As described in Chapter 1, to be optimally effective and sustainable as a public health intervention, fortification of widely consumed (industrially produced) staple foods must be mandated by legislation. This helps to 'level the playing field' by eliminating the reason for producers and importers to charge a higher price for a fortified staple food compared to a non-fortified version of the same product. In addition, mandatory fortification of one or more specified foods helps to prevent unsubstantiated health claims being made by marketers of unfortified versions of the product(s). Furthermore, because food fortification is intended to protect target populations against various micronutrient deficiencies and alleviate MND prevalence, sufficient production of adequately fortified foods and their high population coverage must be assured and sustained indefinitely.

Two very important documents that will support countries to initiate effective flour and rice fortification programmes, as well as help countries with older programmes to potentially improve their interventions, are the 2009 WHO guidelines[299] on fortification of wheat and maize flour, and the recommendations of the 2012 WHO consultation on rice fortification using fortified rice kernels[300] (see Annex 13). The key features of the flour fortification guidelines are that levels for five micronutrients are defined based on the extraction level (low and high) of the *fortifiable* (i.e. industrially milled) flour and its average per capita consumption. The recommendations on rice fortification define levels for eight micronutrients based on the average per capita consumption of the cereal. In addition, the acceptable forms of bioavailable iron fortificants that could be added to each food vehicle are specified in the respective documents.

Regional harmonisation of fortification standards

Regional or bilateral harmonisation of food fortification standards would help to streamline exportation and importation of mandatorily fortified foods among trading nations. However, to also be successful as a public health intervention, strong commitment is required by producers and importers of the fortified food(s) to abide by their national laws and manufacture and import fortified foods that meet the fortification standards. In addition, strong commitment of the relevant national governments is required to monitor and enforce the fortification regulations and standards.

Various levels of regional agreements on food fortification have been achieved. For example, the ECOWAS Assembly of Health Ministers passed a resolution in 2006 calling for food fortification throughout West Africa.[301] Now 14 of 15 countries in the region have mandatory legislation on wheat flour fortification (see Figure 19) and harmonised fortification standards and logos.[302] Also, 13 industrial

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299 WHO/FAO/UNICEF/GAIN/MI/FFI (2009) Recommendations on wheat and maize flour fortification. Meeting Report: Interim Consensus Statement. Geneva, http://www.who.int/nutrition/publications/micronutrients/wheat_maize_fort.pdf (accessed 28 June 2016),

300 De Pee, S (2014). Proposing nutrients and nutrient levels of rice fortification. *Ann. N.Y. Acad. Sci.*; 1324: 55–66.

301 Sablah, M et al. (2013). Food fortification in Africa: Progress to date and priorities moving forward. *Sight and Life*; 27 (3): 18–24.

302 'Public-private partnership in support of food fortification in West Africa'. Presentation by Fred Grant, Regional Nutrition Advisor, HKI, Africa Regional Office. Smarter Futures Africa Network Meeting, 3 Dec. 2014, Cape Town, S. Africa, http://ffinetwork.org/about/calendar/2014/documents/CT_PartnershipsWestAfica.pdf (accessed 17 July 2016).

wheat flour millers of francophone West Africa (AIM-UEMOA) have committed to fight micronutrient deficiencies by fortifying flour.[303]

In the Central Asia Republics and Kazakhstan, a number of donor and technical agencies have supported flour fortification efforts since the late 1990s, including efforts to harmonise regional flour fortification standards.[304] Kazakhstan is the largest producer and exporter of industrially milled wheat flour within that region. Yet, although fortification of wheat flour is mandatory in the country, Kazakh flour mills typically fortify only 20% of flour for their domestic markets,[305] and primarily export unfortified flour to countries in the region. Such exports of unfortified flour by Kazakh mills can negatively impact the population coverage and the impact of fortified flour in the importing countries. An example is Uzbekistan, where the law on mandatory flour fortification does not apply to imported flour (see Box 28).

National legislation on wheat or rice fortification vs actual population coverage of fortified products

Because effective and economically sustainable fortification of wheat and maize flours and rice is currently only feasible through the large-scale (industrial) production of these foods, the market distribution and accessibility of the products should be considered within a national public nutrition policy context. For example, in some LMICs like Afghanistan, Bangladesh, Ethiopia and Mozambique, the market coverage of fortified varieties of cereals is not nationwide as populations of most rural communities consume those cereals as processed by small-scale community-based mills (which are currently not suitable for consistently assuring fortification quality in a cost-efficient manner). Therefore, only populations within the sub-geographic areas in those countries where the 'fortifiable' food is and/or will be widely marketed and accessible would nutritionally benefit from fortification programmes. Thus, a national survey using a single sampling stratum would not be an appropriate approach to assess the impact of sub-regionally accessible fortified flour or rice. In addition, alternative strategies (e.g. supplementation) to meet the micronutrient needs of rural populations not covered by the fortification programme would have to be implemented based on local capacities. At the same time, it should be understood that the production capacity of the industrial flour and rice milling sectors in most LMICs is growing. Thus, over time, the population coverage of industrially produced fortified flour and rice is expected to increase.

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[303] Bluthner, A and L Vierck (2009) Setting standards for business & development: How legal frameworks can support market-based nutrition partnerships. *EFFL*; issue 2:104–18.

[304] USAID and GAIN. Regional fortification in the Central Asian Republics: Lesson learned. 27 January 2015. http://www.gainhealth.org/wp-content/uploads/2014/07/Summary-of-Lessons-Learned-in-the-Central-Asia-Republics-ENG1.pdf (accessed 17 June 2016).

[305] McKee, D (2013) Kazakhstan wheat flour fortification: Rapid assessment. GAIN consultant; date of mission: 17–21 October, http://www.gainhealth.org/wp-content/uploads/2014/07/Kazakhstan-Flour-Fortification-Report-McKee-2013.pdf (accessed 15 July 2016).

Box 28: Lessons learned from the Uzbekistan national wheat flour fortification programme

Fortification efforts have focused on first grade flour having an extraction rate of 75%, which is produced mainly by industrial mills overseen by UzDonMakhsulot (a large state-run milling agency), and some private mills. Although the flour is reportedly consumed by 61% of the population nationally, its coverage is likely much higher among urban populations, because rural households consume bread made from non-fortified flour milled by small-scale millers. From 2001 to 2004, the fortification programme was supported by the Asian Development Bank (ADB) and engaged only 14 mills in six provinces; the KAP Komplex No. 1 premix produced in Kazakhstan was used. From 2004 to 2008, the fortification efforts were expanded to an additional 34 mills in the country with the support of GAIN and World Bank, including support for a premix financing mechanism.

A Presidential Decree issued in 2005 officially supported flour fortification, and allowed for funding UzDonMakhsulot to cover the cost of fortification. That Decree was renewed in 2009, and in 2011 legislation for mandatory fortification was passed that required both UzDonMakhsulot and private mills to fortify first grade flour. However, the law did not require the importation of fortified flour. Thus, increases in wheat production in Kazakhstan led to increased imports of unfortified flour from that country into Uzbekistan. In addition, the UzDonMakhsulot mills relied on an inefficient system of wheat procurement from domestic farm cooperatives and domestic farms that produced wheat based on targets set by the government. Yet, although domestic farmers had the option to sell extra wheat production to UzDonMakhsulot mills at a fixed price, the farmers opted to sell the extra wheat to private mills at higher prices. Those factors led to large fluctuations in the production of domestic fortified flour, and even though the production of fortified flour may have been close to the planned targets, the actual market share and population coverage of fortified flour likely varied greatly over time, which may have affected the level of impact on micronutrient status of the population.†

Since there is no systematic and ongoing monitoring of coverage and impact of fortified flour in Uzbekistan, it is not possible to adequately track the quality, coverage and impact of the flour fortification programme in the country and be able to use the information to maximise its effectiveness.

†Source: Wirth, JP et al. (2012). Lessons learned from national food fortification projects: Experiences from Morocco, Uzbekistan and Vietnam. *FNB*, 33(4) (suppl.): S281–S292.

Monitoring and surveillance

Even when national legislation mandates the fortification of wheat and maize flour and rice, domestic producers must implement the necessary QA/QC processes to ensure a consistent production of adequately fortified product. Domestic importers must also take responsibility to only procure and market fortified products and produce the necessary certificates of conformity for their imports. In addition, the relevant national authorities must regularly enforce the fortification standards through appropriate regulatory monitoring protocols and procedures. In addition, the relevant authorities should publish the results of their regulatory monitoring findings. An assessment carried out by the FFI in 2015 among the 84 countries that mandate fortification of wheat flour, maize flour, and/or rice, found that many countries have not yet developed official documentation of their regulatory monitoring rules and operating procedures, and even larger proportions of them still need to publish their findings on the compliance monitoring of the products as well as assessments (Table 8). Because none of the 84 countries have implemented feasible ongoing surveillance systems to track the impact of their fortification programmes, and most of them likely depend on donor agency funding support to carry out even a one-time follow-up population survey as an assessment of the impact of their programmes, the majority of the countries have not completed impact studies (see last row of Table 8).

Table 8: Proportion of countries, which reported on selected programme monitoring components related to fortification of wheat and maize flour and rice

Monitoring component	Wheat	Maize	Rice
Rules and operating procedures for external monitoring of fortification at mill level by national authorities are stipulated in a document	78%	77%	50%
Rules and operating procedures for commercial monitoring of fortification at retail level by national authorities are stipulated in a document	62%	69%	25%
Rules and operating procedures for verification of fortification at import level by national authorities are stipulated in a document	67%	80%	50%
A national report on the status of fortification monitoring and compliance has been compiled in the last 5 years	35%	31%	25%
An impact evaluation of the fortification programme has been completed	29%	23%	0%

Source: FFI (2016). 2015 Year in Review. Atlanta, USA, http://www.ffinetwork.org/about/stay_informed/publications/documents/2015_FFI_Review.pdf (accessed 14 July 2016).

The FFI has developed the 'Millers' Toolkit'[306] as a training resource on internal QA/QC processes for milling personnel responsible for production of fortified wheat or maize flour. In addition, FFI, in collaboration with the International Grains Institute at Kansas State University in the United States, is developing an online training course for flour fortification monitoring aimed at government food control and inspection personnel. This course is expected to be available in the latter part of 2016.[307] The FFI recently developed a rapid, low-cost and easy-to-use qualitative assay for programmatic and regulatory monitoring to identify fortified rice in field settings.[308]

The effectiveness of a flour fortification programmes depends on the production of adequately fortified flour in sufficient quantities to reach the vast majority of the population in a geographic area consistently over time (Figure 21). Regrettably, many countries still do not adequately monitor or enforce food fortification standards and regulations. This is due to a variety of factors, especially lack of funding and adequate technical capacity. In addition, countries do not integrate data on sustained product quality and population coverage during the follow-up period, after which the population impact their fortification programmes are assessed (see Table 8).

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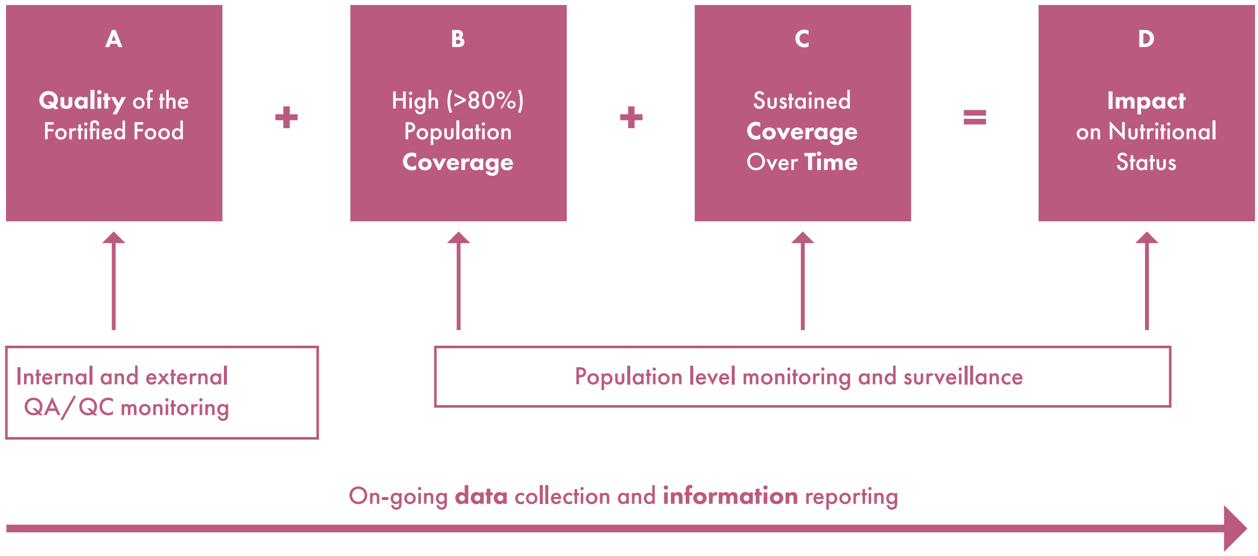
306 http://www.ffinetwork.org/implement/toolkit.html (accessed 20 June 2016).
307 FFI (2016) *2015 Year in Review*. Atlanta, USA, http://www.ffinetwork.org/about/stay_informed/releases/2015Review.html (accessed 14 July 2016).
308 FFI (2015) http://ffinetwork.org/implement/documents/QualitativeRiceAssay.pdf (accessed 17 July 2016).

Figure 21: Schematic presentation of the components of an effective food fortification programme



Adapted from Parvanta I et al., FORTIMAS: An Approach for Tracking the Population Coverage and Impact of a Flour Fortification Progamme, http://www.smarterfutures.net/fortimas (accessed 20 June 2016)

The Smarter Futures partnership recently supported the development of 'FORTIMAS: An Approach for Tracking the Population Coverage and Impact of a Flour Fortification Programme'[309] – published online in 2014. Currently, this is the only published guide that describes a feasible methodology to systematically report data on monitoring fortified product quality and population coverage and surveillance of related micronutrient status indicators over time. To date workshops on the methodology have been carried out in four countries with funding support of different donor agencies (Yemen with EC funding support through MI, Mozambique through HKI, and Georgia and Turkmenistan with UNICEF support).

Box 29: Nigeria: a case study of poor compliance with national food fortification regulations

A nationwide survey was conducted to determine the levels of vitamin A and iron in wheat and maize flours (as well as in sugar and vegetable oils and some flour-based processed foods) as a means to assess compliance with the Nigerian Industrial Standard for those fortified products. Product samples were collected from production facilities and markets in all 36 states of the country. The proportion of products found to comply with the national standards was only 12–33% for vitamin A content, and 1–21% for iron content.

The study concluded that the non-compliance was primarily due to under-addition of fortificant premix at the production facilities due to technological or other factors, and that regulatory monitoring was inadequate or ineffective. Thus, Nigerian consumers are not enabled to regularly consume adequately fortified wheat and maize flours, and the envisaged public health impact of the food fortification programme in Nigeria will not be achieved.

Source: Ogunmoyela, OA et al. (2013). A Critical Evaluation of Survey Results of Vitamin A and Fe Levels in the Mandatory Fortified Food Vehicles and Some Selected Processed Foods in Nigeria. *NIFOJ*; 31:52–62.

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[309] Parvanta, I, et al. (2014) FORTIMAS: An approach for tracking the population coverage and impact of a flour fortification programme. Smarter Futures. Brussels, http://www.smarterfutures.net/fortimas (accessed 1 July 2016).

10.2.2 Value chain characteristics (supply and demand-side)

Technologically, fortification of wheat and maize flours is a relatively simple process of mixing a defined amount of premix powder (mix of one or more vitamins and minerals) with a specified amount of flour (also a powder) before the final product is packaged and marketed. The recommended approach for fortification of rice involves the addition of specially produced fortified rice kernels at specific ratios (1:100 or 1:200) to regular rice.[310, 311, 312] (see Annex 13). The fortified rice kernels are produced through coating or extrusion methods. Coating technology allows for adding micronutrient premix to rice kernels in a liquid fortificant mix together with waxes and gums to 'fix' the micronutrient layer or layers to the rice grains. The coated rice is then dried to yield fortified kernels.[313] Extrusion technology allows for production of fortified rice kernels by combining water and a fortificant premix with rice flour (usually made by grinding lower value and non-contaminated broken rice) to form a dough. The dough is then passed through an extruder to produce fortified rice kernels (that otherwise resemble ordinary rice). One extra advantage of rice kernels produced using extrusion technology is that broken or other rice discarded during processing can be reused to produce the rice dough for making the fortified kernels. In addition, in settings where rice is either washed prior to preparation or cooked in extra water, which is discarded, the use of extruded fortified kernels would still allow for consumers to benefit from fortification. Rice kernels produced with coating technology are better to use in settings where excess cooking water is not discarded when cooking rice.

Cost of flour fortification

The cost of fortifying flour is quite small compared to the overall production costs of the products as well as the larger market fluctuations due to size of harvest and availability of the grains. The capital costs to start flour fortification can vary substantially depending on the type of equipment needed. Assuming a wheat or maize with a rated capacity greater than 50 metric tonnes of wheat ground per 24-hour period, a volumetric manual operation feeder can cost from US$ 3,000 to US$ 10,000, while an automatic feeder with linked microprocessor control can cost from US$ 15,000 to US$ 35,000. The vitamins and minerals included in the premix also affect the cost of flour fortification. Several studies estimate that the cost to fortify flour with iron alone is between US$ 0.05 and US$ 0.07 per person per year. The added cost of including other nutrients such as folic acid is minimal once the equipment and procedures for fortification are in place in a flour mill. The incremental increase in retail cost of fortified flour is negligible. For 1 kg of flour, the increase may be about US$ 0.00063, or 0.16% of the current retail price.[314]

In most countries, flour millers incur the costs of buying premix and pass these costs to customers. Depending on the vitamins and minerals used, the price increase for bakers is as little as US$ 0.10 per 50 kg of flour, and for consumers it is as little as US$ 0.10 per loaf of bread or 0.01 per 5 kg of flour. However, in some countries, such as Jordan, Iran and Iraq, the governments pay for the premix to be added to flour as an investment in the health of their populations.[315]

[310] USAID/A2Z/AED/IFT (2008) Rice fortification in developing countries: A critical review of the technical and economic stability. A2Z Project. Washington DC, April.
[311] De, Pee, S (2014) op. cit.
[312] Steiger, G et al. (2014) Fortification of rice: technologies and nutrients. *Ann. N.Y. Acad. Sci*. 1324: 29–39.
[313] Montgomery, S et al. Technology for rice fortification. In Scaling up Rice Fortification in Asia. *Sight and Life*. https://issuu.com/sight_and_life/docs/sal_wfp_suppl (accessed 7 July 2016).
[314] FFI. Who pays for fortification? http://www.ffinetwork.org/about/faq/faq_finance.html (accessed 3 July 2016).
[315] http://www.ffinetwork.org/implement/toolkit.htm

Cost of rice fortification

A review of the technical and economic feasibility of rice fortification reported that 'independent of the fortification formula and the fortification process, it is estimated that rice-premixes have a production cost of about US$ 1/kg, and commercial prices around US$ 2/kg. Rice-premixes are usually designed to be diluted 1:100 to 1:200, and they represent around 90 percent of the total fortification cost. Consequently, the cost of rice fortification is estimated between US$ 10/MT and US$ 20/MT. This means that the cost of fortified rice would be US$ 0.36–0.73 or US$ 1.09–2.18 more per year than the cost of unfortified rice for consumers with usual rice intakes of 100 or 300 g/day, respectively'.[316]

When the costs are passed on to the consumer, the incremental increase in retail cost of fortified rice is very low: for 1 kg of fortified rice, it may be around 1.5–3% of current retail price (US$ 8–16 per 10 kg of rice). An alternative perspective on the cost of rice fortification is to consider that to fortify 1 MT of rice will cost about US$ 15, and, for instance, the cost of providing a child with nutrient-rich fortified rice as a component of a daily school meal for an entire year is about US$ 0.40.[317]

Consumer trends

Historically, fortification of flour was initiated in some countries in the Americas and Western Europe towards the middle of the 20th century to restore the natural vitamin and mineral content of the cereal which are lost during milling). Based on that approach, only low extraction or white flour has been typically fortified since the high extraction or whole grain varieties of flour would contain most of their original micronutrient composition. However, most health and nutritional guidelines now promote the consumption of wholegrain cereals to help prevent some chronic diseases (e.g. by helping to improve bowl movement and gastrointestinal health, and improve cardiovascular health by helping lower cholesterol levels). Thus, there has been a growing trend in the consumption of wholegrain flour products, especially in western countries.

Although the consumption of wholegrain (or high extraction) flour (and brown or unpolished rice) helps to reduce chronic diseases, it is also well known that the phytic acid present in the bran of such foods inhibits the absorption of the natural iron contained within those products. Furthermore, such whole grain foods do not contain sufficient amounts of folate to help protect foetuses against NTDs. Thus, replacing fortified white flour in the diet with unfortified wholegrain flour might lead to inadequate iron and folate status of consumers. Fortunately, sodium-iron EDTA[318] is now available as a form of fortificant that allows good absorption of added iron from fortified wholegrain cereals, and folic acid added to such fortified cereals is also readily absorbable.

The recommendation therefore to fortify high extraction (whole grain) flour with iron and folic acid was first issued in 2004.[319] That recommendation was affirmed at a follow-up technical workshop in 2008,[320] and is included in the current WHO guidance on wheat and maize flour fortification issued in 2009.[321]

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316 USAID/A2Z/AED/IFT (2008) Rice fortification in developing countries: A critical review of the technical and economic stability. A2Z Project. Washington DC, April.
317 FFI, How much does it cost to fortify? http://www.ffinetwork.org/about/faq/faq_finance.html (accessed 3 July 2016).
318 Ethylenediaminetetraacetic acid
319 FFI (2004) Wheat flour fortification: Current Knowledge and practical considerations. Summary report of an international technical workshop, 1–3 December, Cuernavaca, Mexico. http://www.ffinetwork.org/plan/documents/CuernavacaSummary.pdf (accessed 26 June 2016).
320 FFI. Second Technical Workshop on Wheat Flour Fortification: Practical Recommendations for National Application. http://www.ffinetwork.org/plan/documents/AtlantaSummary.pdf (accessed 26 June 2016)
321 WHO, FAO, UNICEF, GAIN, MI and FFI (2009) Recommendations on wheat and maize flour fortification. Meeting Report: Interim Consensus Statement. Geneva, World Health Organization, http://www.who.int/nutrition/publications/micronutrients/wheat_maize_fort.pdf (accessed 28 June 2016).

Because the flour and rice industries change their production practices based on significant consumer preference for different variety of cereals, it is essential that legislation on fortification of these cereals be flexible enough to allow for adjustments if significant change in the consumer market occurs; e.g. if there is increasing demand for wholegrain flour products or other varieties of flour, the fortification legislation will have to be adapted as necessary (see Box 30 for an example from South Africa).

Box 30: South Africa case study: shift in consumer preferences towards unfortified cake flour

In South Africa, the original regulations on wheat flour fortification excluded cake flour, a low extraction refined flour, since it represented a small (10–15%) share of national flour market in 2002 and was not consumed by low-income populations. However, the flour market changed substantially over time and by 2013, the market share for cake flour had grown to 40–50%. Furthermore, it was reported that cake flour was increasingly used in foods purchased by low-income consumers, the population group at higher risk for micronutrient deficiency.

Although the flour milling industry in South Africa is cautious about requiring fortification of cake flour in a revised mandate, citing concerns over potential for adverse sensory changes, as well as the financial resources needed by them to procure and install additional micro-feeders to the production lines for cake flour at the mills. Nevertheless, there is growing consensus among the stakeholders of the flour fortification programme towards recommending that cake flour be added to the list of food vehicles that must be fortified.

Source: UNICEF, FFI (2014) Monitoring of flour fortification: The case of South Africa. New York, USA, http://www.ffinetwork.org/monitor/Documents/SouthAfricaCS.pdf

Social marketing and behavioural change communication

The purpose of social marketing and behavioural change communication components of mandatory flour and rice fortification programmes is to encourage consumers to accept the (mandatorily) fortified products, as opposed to promoting the use of a fortified product in place of an unfortified variant of the same product (as would be the case in a voluntary food fortification programme). A useful tool for informing the population about a fortified flour and/or rice programme is to develop a locally appropriate 'fortified food' logo that would appear on the packages, containers and sacks of various fortified foods. Refer to Annex 11 for a few examples of such logos.

Public distribution approaches

A comparative analysis (based on prices in mid-September 2008)[322] showed that the approximate cost to grow 1 MT of wheat was US$ 268 while the cost to buy 1 MT of wheat was US$ 312, the cost to fortify 1 MT of wheat flour was only US$ 1.50–3.00 (depending on the combination of micronutrients to be added). Therefore, in the vast majority of cases, the incremental cost of the fortified cereal would be passed on directly to the consumer.

However, in cases of populations with restricted access to consumer markets (e.g. people at remote locations or internally displaced or refugee populations housed in camps), or very low-income citizens who would still be significantly affected by the small increase in the price of fortified flour or rice, fully and/or partially subsidised systems would be needed to enable those groups to regularly access the staple foods. For low-income populations with access to food markets, it may be more sustainable in the long-term if some type of conditional cash transfer method using vouchers or other subsidised approaches is developed that would enable the target consumers to access the fortified product(s) through their local markets, instead of having to rely on (often inefficient) public distribution systems. Furthermore, the overall cost of the subsidised market-based delivery system would be expected to be

[322] FFI. http://www.ffinetwork.org

less for the government because it would rely on the established logistics and delivery networks of the markets that could more efficiently enable the target consumer to access the fortified cereal product(s).

Such a publicly supported, but market-based fortified flour or rice distribution system could also help increase the markets for the products to other consumers in the geographic areas who are not dependent on government subsidies. For example, in the United States the government-supported Special Supplemental Nutrition Programme for Women, Infants and Children (WIC)[323] enables low-income programme beneficiaries to purchase specific micronutrient-fortified foods in their local market using government issued vouchers or debit cards. Since the inception of the WIC Programme in 1972, there has been a dramatic increase in the number of micronutrient-fortified foods in the market that are authorised by that programme.[324] If necessary, such an approach to enable very low-income consumers to regularly access subsidised fortified flour and/or rice through their local markets (instead of public distribution of the foods to the very needy) could be adapted in LMICs starting with urban and peri-urban areas where markets are usually well-developed, and expanded to rural areas over time.

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[323] USDA/FNS. The Special Supplemental Nutrition Progamme for Women, Infants and Children, http://www.fns.usda.gov/wic/women-infants-and-children-wic (accessed 17 July 2016)

[324] Parvanta, I and Knowles, J (2004) Practical considerations for improving micronutrient status in the first two years of life, in Pettifor, JM and S Zlotkin (eds) *Micronutrient Deficiencies during the Weaning Period and the First Years of Life*, Nestlé Nutrition Workshop Series, Vol. 54, Vevey, Switzerland: Nestlé.

11 Fortification of sauces, condiments and other processed foods

SAUCES, CONDIMENTS and OTHER PROCESSED FOODS	
Vehicle focus	Soy and fish sauces, curry paste, sugar, bouillon cubes, flavoured salts, MSG, seasoning powders
MND focus	Primarily iron, iodine, and vitamin A; other micronutrients depending on the food vehicle
Current status globally	Legislation: 12–15 countries allow voluntary fortification of one or more condiments/sauces Coverage: Global data is not available. Micronutrient status: See other chapters
Main players	Donors: BMGF, USAID, Netherlands Development Cooperation Implementers: National governments; producers, refiners, and importers Partners: GAIN, MI, HKI, UNICEF previously involved in sugar fortification in Central America, but nothing recent
Enabling environment characteristics	Challenges in monitoring multiple food vehicles with varying levels of micronutrients Advocacy and private sector engagement under voluntary fortification schemes
Supply-side characteristics	Selecting the right vehicle/micronutrient combination
Demand-side characteristics	Opportunities within a shift towards processed foods

11.1 Overall approaches and achievements worldwide

A large number of sauces, condiments, sugar, spices and other processed foods have been increasingly fortified over the past 20–30 years, particularly in South-East Asia and West Africa. These condiments and sauces include soy and fish sauces, curry paste, bouillon cubes, flavoured salts, monosodium glutamate (MSG) and other seasoning powders. Countries introduced the fortification of these ‘food vehicles’ to reach a large proportion of the population in situations where staple foods were deemed less appropriate conveyors.[325] In many regions, condiments and sauces are part of the daily diet, and they are largely inexpensive and accessible. Consumption is relatively constant across age and socioeconomic groups. Another advantage is that these vehicles are often centrally processed.

The first such product to be fortified was sugar with vitamin A in the 1970s in several Latin American countries. In these countries, other typical vehicles for vitamin A, such as dairy products, wheat flour or

[325] In other words, other staple foods typically fortified were consumed in very small amounts, their quality was inadequate, they were not widely distributed, or they were not consumed by rural or lower income populations.

vegetable oils, were not consumed in sufficient quantities to achieve any significant nutritional impact through fortification. However, sugar was consumed in much larger quantities and by all ages and socioeconomic groups; furthermore sugar processing is highly centralised in this region.

In South-East and East Asia, fish sauce and soy sauce are the most popular seasonings and added to a variety of foods during household meal preparation. These ingredients are typically fortified with vitamin A, iron, iodine and/or zinc. They benefit from being in liquid form, having a strong flavour and dark in colour, and normally being blended in with prepared meals, which masks the potential organoleptic changes that can occur with those nutrients. Intakes of soy and fish sauce are increasing as populations alter their consumption patterns both towards a diet higher in processed foods.

Bouillon cubes and seasoning powders have also become popular, highly marketed, and low-cost seasonings globally, especially with the rise of instant noodles or rice. With limited technical capacity, these powders can be fortified with multiple micronutrient premix, especially as they are often added to soups or liquid matrices which better ensure uniform mixing. Such powders can be used with or without added flavouring or seasoning elements for home fortification or addition to infant complementary foods – a strategy that has been proposed for improving micronutrient intake in young children who may not consume sufficient quantities of other fortified staple foods.[326]

Key linkages exist with ensuring universal salt iodisation, particularly for the processed food industry. Each of the products mentioned above (except for sugar) requires the use of salt during the manufacturing process, which can be a simple way of increasing iodine intakes through these vehicles if iodised salt is used (also see Chapter 4). In addition, the consumption of such condiments and seasonings often reduces and replaces consumption of salt alone as a seasoning.

While the fortification of condiments and sauces can be technologically simpler than fortification of other staple foods, the same considerations continue to apply. The addition of micronutrients can affect the overall quality of the finished product, including sensory characteristics, shelf-life, particle size, and micronutrient interactions within the food matrix.[327] These would all be affected by climactic and storage conditions in each locality that such products are manufactured, distributed and consumed.

Current global status: legislation

Cambodia is the only country to have mandated fortification of fish and soy sauces with iron. A dozen countries allow voluntary fortification of one or more condiments or sauces (see Figure 22). Overall, this is a highly untapped vehicle for delivering key micronutrients, such as iron, iodine, zinc, and vitamin A, to populations. However, there are inherent challenges that need to be addressed in monitoring and tracking dietary consumption of key micronutrients when there are multiple food vehicles all being voluntarily fortified together. It is important to set fortification levels based on the consumption of all foods that may be contributors to a particular micronutrient intake to avoid excess intakes.

Most of these voluntarily fortified condiments and sauces programmes were led by the private sector. Despite advocacy efforts, it remains difficult to bring additional producers of these vehicles to fortify without relevant legislation.

Around 20–30 countries, particularly in Latin America and sub-Saharan Africa, also have mandatory or voluntary fortification of sugar with vitamin A. However this information is not currently tracked globally.

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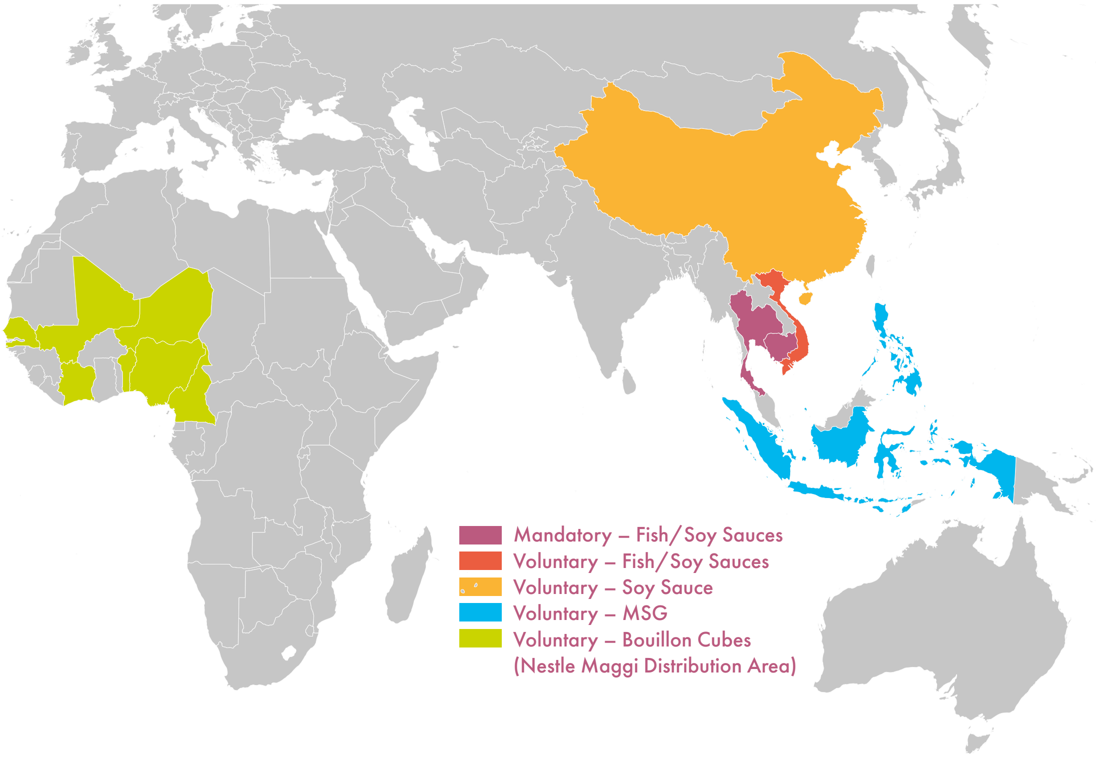
[326] Rebecca Spohrer et al. (2015) Estimation of population iodine intake from iodized salt consumed through bouillon seasoning in Senegal, *Ann NY Acad Sci*, 1357: 43–52.
[327] Elvira Gonzalez de Mejia et al. (2015) Industrial processing of condiments and seasonings and its implications for micronutrient fortification, *Ann NY Acad Sci*, 1357: 8–28.

Figure 22: Map of countries regulating the fortification of various condiments and sauces[328]



Current global status: coverage

There are no published estimates of the total global reach or effective coverage of fortified condiments and sauces beyond individual case studies and trials within individual countries or communities. Fortified condiments and sauces are difficult to track due to the lack of focus on any one food vehicle or micronutrient disorder. For example, there could be a role for the Iodine Global Network to monitor iodine consumption through fish or soy sauces and seasoning powders that fortify with iodine directly or utilise iodised salt in their preparation.

11.2 Considerations and reflections on national experiences

11.2.1 Enabling environment characteristics

Challenges in monitoring multiple food vehicles with varying levels of micronutrients

As with staple foods, under paradigms of mandatory fortification, significant technical assistance for industry level QA/QC and government level regulatory monitoring is needed to ensure products are adequately fortified according to the relevant standard. However, since only a handful of sugar fortification programmes and no condiments/sauces programmes are under mandatory legislation, there is an inherent challenge in monitoring and enforcing standards. Whether the food vehicle in question is under mandatory or voluntary legislation, it is critical to ensure good working relationships between the government and the private sector to bolster monitoring efforts and promote an enabling environment for success. Box 31 highlights an example from Central America that showcases this effort.

[328] GAIN internal data (2016). Some additional source information is within the figure.

Box 31: Vitamin A-fortified sugar in Central America

In the 1970s, the Institute of Nutrition of Central America and Panama, affiliated with the Pan-American Health Organization, developed appropriate technology, promoted legislation and established national programmes in Guatemala, Honduras and El Salvador to fortify sugar with vitamin A. This was done with financial support from the USAID Micronutrient Programme (MOST). Sugar was chosen as the food vehicle because of its high and stable daily consumption, especially among target groups, and industry consolidation. As one of the initial experiences in fortifying a solid granule, versus the liquid matrices for oils and fats, new technology was developed, including the use of a gelatine-based beadlet to bind vitamin A to sugar crystals through a layer of vegetable oil to promote stability and avoid segregation. Mandatory fortification legislation was decreed in each of the countries for both domestic and industrial use. It was also forbidden to declare that the product contained added vitamin A to avoid promoting higher sugar consumption.

Evaluations from each of the countries showed that this programme had great success against objectives of improving vitamin A intake. In Guatemala, vitamin A intake tripled as a result of the programme and the prevalence of vitamin A deficiency decreased from 22% to 5% in only one year. In both El Salvador and Guatemala, 95% of households were identified as consuming sugar and over 75% of samples were found to be adequately fortified. In these two countries, fortified sugar contributes 45–180% of the vitamin A recommended daily intake; sugar is the main dietary source of vitamin A, including the source of half of the vitamin A intake for children between 2 and 5 years old. In Honduras, the programme was started and stopped several times during the 1970s and 1980s but by 1993 had achieved 80% household coverage with over 65% of sugar samples being adequately fortified.

Added costs are very reasonable: less than US$ 10 per MT or around US$ 0.30 per person annually to fortify, even taking into account that vitamin A needed for dry matrices can be up to four times more expensive and less stable than oily forms.

Several lessons have been documented through this project and form the basis for much of our modern understanding of what works in fortification programmes. A key success factor in the Central American sugar experience was the fact that the private sector was highly consolidated, better organised and more responsive to advocacy efforts by nutrition experts. The Central American sugar industries are some of the most active in the economy and produce sufficient product to meet domestic demand. This programme also demonstrated the importance of multi-stakeholder fortification alliance structures to ensure commitment and sustainability from both public and private sectors. Also critical were the continuous efforts in QA/QC within the private sector and government monitoring through food control systems, in addition to a supportive and collaborative attitude between the government and the industry. The industry assumes responsibility for production of a high-quality product. Since sugar is also a widely traded commodity within the region, this programme demonstrated the importance of regional harmonisation of standards and legislation to satisfy free trade agreements.

Source: Jose O Mora et al., 'Vitamin A sugar fortification in Central America: Experience and lessons learned', *MOST, The USAID Micronutrient Programme*, 2000.

Advocacy and private sector engagement under voluntary fortification schemes

For condiments and sauces under voluntary fortification schemes, social marketing and advocacy efforts are needed to convince the private sector of the benefits and added value fortification can provide as well as to convince consumers to demand and purchase such products in the market. This is especially the case when attempting to increase the number of producers who fortify or when the political environment drastically changes (see Box 32).

Box 32: Fortification of fish and soy sauce in Cambodia and Vietnam

Cambodia and Vietnam both suffer from high levels of micronutrient deficiency with Cambodia having the highest prevalence within South-East Asia. As per the 2014 Demographic Health Survey, 55.5% of children under five suffer from anaemia in Cambodia and 45% of women of reproductive age; 30% of anaemia cases are attributable to iron deficiency. In Vietnam, the 2000 Nutrition Risk Factor Survey identified slightly lower levels of anaemia – 34% in preschool children and 25% prevalence in women of reproductive age. In both countries, 80–90% of their populations consume fish and soy sauces regularly, which contributes between 3.2–12.7% of recommended dietary intake for iron.

The two countries have implemented fish and soy sauce fortification with iron quite differently. In Vietnam, the initial project from 2005–08, supported by GAIN, the World Bank and the Vietnam National Institute of Nutrition and funded by BMGF, planned to recruit 30 state-run fish sauce manufacturers. However, when the industry was privatised early in the project, only ten of the newly privatised manufacturers were willing to invest in fortification without the guaranteed return on investment that the state-run manufacturing system would have provided. These ten manufacturers accounted for less than 5% of the national fish sauce production, which drove advocacy for mandatory legislation. Although this has yet to be achieved, fortification of fish sauce has gained traction among both government and the private sector. From 2000 to 2008, consumption increased by 14% and continues to increase today. During this time period, however, increases in many other potentially fortifiable food vehicles increased much more; consumption of seasoning powders increased by 106%. This led to a push to incorporate fortification of soy sauce, vegetable oil and seasoning powders to reach larger populations with micronutrients. GAIN continued to provide financial and technical support until 2014. The key lesson learned throughout the Vietnam experience was to remain flexible and adaptable to changing circumstances and changing consumer habits while considering the integration of several potential food vehicles for fortification as part of a national nutrition strategy. Despite low coverage of fortified fish sauce, the demonstration of efficacy and effectiveness were useful advocacy tools that led to expansion of fortification programmes throughout the country.

In contrast, the Cambodian experience, another GAIN-supported project with funding from BMGF between 2011 and 2015, has reached widespread coverage and high quality in a short period of time. Currently around 90% of fish and soy sauce produced in Cambodia is industrially processed and therefore fortifiable. Production has drastically increased over the past 5 years, increasing five-fold between 2013 and 2014 alone. Political commitment is strong following the success of salt iodisation and the Ministry of Industry and Mines has taken ownership of the process and is working towards mandatory fortification. Over 40 manufacturers are fortifying these sauces, but many, especially larger producers, are reluctant to fortify without mandatory legislation in place. Between 2012 and 2014, 74% of samples complied with regulations for iron content and the Cambodian standard allows for a wide range of iron content (from 230–460 mg/L) enabling fortified products from other countries to enter the market freely. A recent knowledge, actions and practice study found that Cambodians had a positive perception of fortified sauces and even the added cost of fortified sauces was widely recognised as affordable.

Despite high political commitment, capacity for law enforcement, quality control and systems of monitoring are weak. This is a key priority area to ensure that both locally produced and imported sauces are adequately fortified. In addition, if Cambodia expects compliance to improve, the weak industry motivation, especially among large producers, is something that will have to be overcome by greater engagement throughout the transition to mandatory fortification.

Sources: Arnaud Laillou et al., 'Beyond effectiveness – The adversities of implementing a fortification progamme. A case study on the quality of iron fortification of fish and soy sauce in Cambodia', *Nutrients*, 8 (2016). Chan Theary et al., 'Fish sauce, soy sauce, and vegetable oil fortification in Cambodia: Where do we stand to date?', *Food and Nutrition Bulletin*, 34 (2013): S62–71. James P Wirth et al., 'Lessons learned from national food fortification projects: Experiences from Morocco, Uzbekistan and Vietnam', *Food and Nutrition Bulletin*, 33 (2012): S281–92.

11.2.2 Value chain characteristics (supply and demand-side)

Selecting the right vehicle/micronutrient combination

The greatest supply-side issues have been in ensuring the sensory properties of fortified condiments and sauces match their non-fortified counterparts.[329] Various studies have been conducted to assess the effects of vitamin A, iron, zinc and other vitamins and minerals on the organoleptic properties of the final product, and they have all revealed that sensory changes are a common issue globally.

For iron compounds, the most common challenge is to balance bioavailability with achieving desired sensory properties and cost. The most bioavailable iron compound, NaFeEDTA, is also the only iron compound that does not cause precipitates in fish sauce, but its cost can be prohibitive as it can contribute as much as 8% to the overall product price. Ferrous sulphate is more cost-effective with good bioavailability, but it tends to oxidise and change the sensory properties of the final product. It has, however, been found that adding citric acid to fish sauce can successfully stabilise ferrous sulphate, which may offer a less expensive alternative. Ferrous fumarate is also a lower cost alternative with good bioavailability that has successfully been used to fortify fish sauce, soy sauce and curry powders. Several other iron compounds exist and have been used to fortify fish and soy sauces, such as ferric phosphate, ferric orthophosphate and ferric pyrophosphate. These have a much lower iron bioavailability, but are significantly cheaper and have fewer negative effects on product stability and organoleptic characteristics.

For vitamin A and zinc it is also difficult to maintain the stability and sensory properties, and these vitamins have far fewer molecular options than iron. Zinc also tends to affect sensory properties and has not typically been used in fortification of sauces and condiments, except for the multi-micronutrient fortification of seasoning powders.

A key success factor in maintaining sensory properties and stability of the vitamins and the final product is to add any vitamins and nutrients during the last steps of manufacturing. Thermal treatment, irradiation, oxidation, light exposure, moisture and oxygen exposure can easily cause degradation of vitamins and lead to unacceptable sensory changes in the final product. In addition, the climactic conditions and realities of supply chain, distribution and storage methods must be considered when choosing the types of nutrients to fortify with as well as the types of packaging materials that should be used. These food technology difficulties are highlighted in Box 33 below.

Box 33: MSG fortification in the Philippines and Indonesia

MSG (Monosodium Glutamate) is a highly popular flavouring agent and preservative used widely throughout South-East and East Asia in a variety of processed foods, condiments, sauces and seasonings. MSG is a good vehicle for delivery of vitamin A in this region as it is so widely consumed. In the Philippines, 98% of households consume MSG at least once per week, including children in the households, and consumption varies little with socioeconomic status. Its production is highly centralised. In the Philippines, MSG is produced by only two manufacturers, with one controlling 90% of the market.

The efficacy of vitamin A fortification of MSG has been demonstrated in the Philippines and in Indonesia. In these countries, fortified MSG was able to supply all the recommended dietary intake of vitamin A. When compared with vitamin A supplementation and biofortification interventions available at the time, MSG fortification was more closely linked to significant increases in mean serum retinol levels among children.

Like most foods fortified with vitamin A, cost and stability were the two major issues faced in the Philippines and Indonesia. The cost to fortify a solid or granular matrix with vitamin A is much higher than using a liquid

[329] Elvira Gonzalez de Mejia et al. (2015) op. cit.

matrix, such as cooking oil. For MSG, the addition of vitamin A costs US $575/MT, which is the equivalent of 11.5% of the retail cost. This is due to the high amount of vitamin A that needs to be added to make an impact on vitamin A status based on the MSG consumption amounts. This is significantly higher than for other vehicles and without mandatory legislation in place, fortified MSG has a hard time competing with non-fortified MSG without subsidy or price stabilisation. In Indonesia, MSG sachets were reduced from 2.4g to 2g to avoid raising the purchasing price. However, consumers recognised this change and still preferred the non-fortified product.

The second challenge relates to the stability of vitamin A and its effect on the sensory properties of the final MSG. Vitamin A tended to cause discoloration of the typically pure white colour of MSG and it separated from MSG crystals when exposed to moisture and oxygen, prevalent in the humid climates of the Philippines and Indonesia. In small sachets, these organoleptic changes were not easily noticeable, but were unacceptable in larger packages. Indonesia tried to overcome these technical difficulties, first by pulverising MSG to preserve the white colour (which was later determined to interfere with the hermetic seals of sachets), and later by reducing vitamin A levels to provide only 50% of the recommended intake. In contrast, the Philippines discontinued fortification of MSG despite its public health impact and consumer acceptability. A key lesson learned through these projects was the need for field testing of newer fortified products such as MSG. The large differences in humidity throughout both countries led to varying effects on the degradation of vitamin A and the discoloration of the final MSG, some more acceptable to consumers than others. This will have significant implications for the types of processing that can be used (i.e. pulverising) and the types and sizes of packages.

Note: While there continues to be ongoing discussion around MSG as a possible carcinogen, several international authorities on food safety – including the US Food and Drug Administration, American Medical Association, USA National Academy of Sciences, Federation of American Societies for Experimental Biology, Joint FAO/WHO Expert Committee on Food Additives, and the Scientific Committee for Food of the European Commission – have all confirmed that MSG is safe for general consumption and is not considered carcinogenic. There are some studies that suggest that very high consumption of MSG could be of potential concern, but these findings are limited and far from conclusive.

Sources: Patricia A Murphy, 'History of technology development for vitamin A fortification of foods in developing countries', *FAO Technical Consultation on Food Fortification: Technology and Quality Control*, 1995. Florentino S Solon, Liza E Sanchez-Fermin and Lorena S Wambangco, 'Strengths and weaknesses of the food fortification programme for the elimination of vitamin A deficiency in the Philippines', *Food and Nutrition Bulletin*, 21 (2000): 239–46.

Dietary patterns increasingly include processed foods

Legislation and regulations for sauces, condiments and processed foods should consider including provisions for the use of iodised salt, fortified vegetable oils and fortified grains in their manufacture, especially if this will help to ensure coverage among target groups. However, careful consideration of the total dietary consumption of key micronutrients is needed to ensure the risk of overdose is minimised. In addition, processed foods should be considered holistically as part of the food system. For some micronutrients, this means that fortified processed foods are utilised as complementary to the main staple foods and should not contain a significant proportion of the recommended daily allowance, in that eating a variety of these foods in addition to other staple foods will combine to provide 100% of an individual's micronutrient needs. In other cases, such as iodine, it is more critical to think of both iodised salt and processed foods that use iodised salt in their manufacture as the sole provider of iodine in the diet.

With shifts towards urbanisation, increasing incomes and changes in employment trends, diets, including in LMICs, contain greater proportions of processed and convenience foods. This means that there is a significant increase in the number of potential processed food vehicles that can be fortified directly or indirectly through the usage of fortified staples in their manufacture (such as flours, vegetable oils, salt or other condiments/sauces). This opportunity is highlighted in Box 34.

Box 34: Opportunities in fortification of processed foods

Particularly in Southeast Asia, the food industry is rapidly transforming to reflect economic growth, infrastructure development, increased trade and foreign investment, and rising consumer incomes. This is seen especially in the rise of centralised food systems and processed food consumption and the rise in supermarket sales – growing by 30–40% per year in China and growing over 65% in Vietnam between 2000 and 2006. As of 2013, nearly 85% of organised retailers' food sales globally are processed or semi-processed foods. This presents an opportunity to provide additional nutrients to consumers through direct fortification of processed foods and via indirect fortification through the use of fortified flour, vegetable oil and salt during manufacture, especially in South-East Asia where consumption of industrially processed wheat flour is quite low and fortification of rice has not yet gained traction at a large scale. In addition, the majority of wheat flour processed in this region goes to the food manufacturing industry; up to 90% of wheat flour in Indonesia is diverted to the manufacture of proceed foods, including 50% for fresh and instant noodles.

In a 2013 study of the potential contribution of processed foods to intakes of iodine, vitamin A and iron, it was found that processed foods such as sweet ham, fish paste, dried salted fish, biscuits and instant noodles can provide significant nutrient contributions, even for young children. Salted fish made with iodised salt can provide 107–141% of the iodine recommended nutritional intake (RNI) for 1–6-year-old children; biscuits containing fortified vegetable oil can provide up to 18% of the vitamin A RNI for 4–6-year-old children; and instant noodles made with fortified wheat flour can provide up to 45–50% of the iron RNI for 4–6-year-old children. Similarly high nutrient contributions were seen in women of reproductive age.

Instant noodles are an especially attractive option for delivering key micronutrients. In Indonesia, two producers (Indofood and Wing) own 85% of the instant noodle market, with them becoming one of the cheapest staple foods available, even replacing rice among the poorest who can no longer easily afford it. Over 75% of the Indonesian population consumes instant noodles on a weekly basis and yearly consumption is over 100 packs per person. Consumption of instant noodles in China is even higher and the trend is gaining traction throughout South-East Asia, especially among the poorest consumers.

Instant noodles are unique in that there are many options for fortification of a wide range of micronutrients, including vitamin A, iodine, iron and folic acid, and few technical barriers exist in doing so. Instant noodles can be made with fortified wheat flour and/or fried in fortified vegetable oil (the noodles retain about 20% of the oil from frying). The oil and flavouring sachet that comes with the noodle pack can also be fortified with multiple micronutrients.

Processed foods provide an opportunity for reaching the growing urban poor and middle-income populations. Within industrialised countries, inclusion of fortified ingredients in processed foods has been recognised as a key way to overcome stagnation of fortification progress as diets change and fewer staple foods are consumed directly. As diets change towards consumption of more processed foods, behavioural change communications to promote healthy, diversified diets will continue to be highly relevant as a complementary strategy.

Sources: Arnaud Laillou et al. (2013) 'Vitamin A-fortified vegetable oil exported from Malaysia and Indonesia can significantly contribute to vitamin A intake worldwide', *Food and Nutrition Bulletin*, 34: S72–80; Rebecca Spohrer et al. (2013) 'The growing importance of staple foods and condiments used as ingredients in the food industry and implications for large-scale food fortification programmes in Southeast Asia', *Food and Nutrition Bulletin*, 34: S50–61; MV Capanzana et al. (2005) 'Effects of iodised salt on the quality of selected processed food products', *Food and Nutrition Research Institute*, Bicutan, Taguig City, Philippines.

Annexes

Annex 1: SDG2 on food security, nutrition and sustainable agriculture

The following targets have been set for Goal 2:[330]

2.1
By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round

2.2
By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons

2.3
By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment

2.4
By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality

2.5
By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilisation of genetic resources and associated traditional knowledge, as internationally agreed

2.a
Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries

2.b
Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round

2.c
Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility

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[330] Source: https://sustainabledevelopment.un.org/sdg2

Annex 2: Terms of reference

TERMS OF REFERENCE

Global Mapping Exercise

Revised July 2016

I BACKGROUND

The EC is strongly committed to support partner countries to tackle undernutrition, with three strategic priorities: (a) enhance mobilisation and political commitment to nutrition; (b) to scale up actions at country level; and (c) to contribute to generation of knowledge for nutrition.[331] In the EC Action Plan of Nutrition (2014) this is further operationalised, in alignment with the Scaling Up Nutrition (SUN) '1,000 days' approach (focus on prevention of stunting through improving the quality of the diets of women during pregnancy and lactation and young children 6–24 months of age),[332] and the World Health Assembly's (WHA) 2015 Global Targets on Maternal and Child Nutrition (which comprises stunting, anaemia, low birth weight, wasting, overweight, and exclusive breastfeeding targets).[333]

The EC recently decided to provide support to further development and scaling-up of food fortification as one of the elements under the EC nutrition portfolio. This support is aimed at contributing to the eradication of undernutrition among vulnerable populations by enhancing resilience through food fortification. The addition of essential vitamins and minerals to widely marketed processed food commodities is widely accepted at global levels as a key strategy to reduce micronutrient deficiencies.[334] The micronutrients that are commonly added in case of post-harvest grain fortification are iron and folic acid (vitamin B11), while vitamin B1, B2, and B3 are also often added. WHO recommends to also add vitamin B12 and Zinc (in some cases also vitamin A). Other widely fortified-food vehicles are salt containing iodine, and vegetable oil with added vitamin A.

In many countries, large-scale food fortification started when laws were passed on mandatory universal salt iodization (USI). Currently, over 140 countries have legal frameworks on USI, but effective coverage varies widely from country to country. Also, laws in 85[335] countries require mandatory fortification of various types of cereal grain products, and in many of these countries such fortification efforts have been rapidly scaled up. National programmes on in-home fortification of infant complementary foods are being implemented in 10 countries, while in 32 countries there are sub-national programmes.[336]

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[331] EC (2013) Enhancing Maternal and Child Nutrition in External Assistance: An EU Policy Framework, *SWD* 72, 12 March; and *SWD* 104, 27 March, http://ec.europa.eu/europeaid/documents/enhancing_maternal-child_nutrition_in_external_assistance_en.pdf
[332] Increasingly the SUN approach also encompasses a focus on adolescent girls, in order to ensure they are in good nutrition before they get pregnant.
[333] EC (2014) Action Plan on Nutrition, *SWD* 234, 3 July, https://ec.europa.eu/europeaid/sites/devco/files/swd-action-plan-on-nutrition-234-2014_en.pdf
[334] In many LMICs this primarily refers to anaemia, vitamin A deficiency and iodine deficiency. But depending on the dietary patterns and main staple foods, hidden hunger can also entail deficiencies for other micronutrients like the B-vitamins and zinc.
[335] Ref. http://www.ffinetwork.org/global_progress/index.php
[336] Ref. http://www.hftag.org/

Food fortification is rated to be cost-effective and sustainable. It can lead to substantial improvement in micronutrient status of populations over time, which could in turn lead to improved cognitive and physical development of children, work capacity of adults, and economic development of nations (FAO/WHO, 2006;[337] The 2012 Copenhagen Consensus, 2012;[338] 2013 Lancet series on nutrition,[339] GAIN Snapshot Report, 2015).[340] An overview is currently under preparation of existing evidence on impact of food fortification on micronutrient status in vulnerable populations which will be published in summer 2016.[341]

In order to strengthen the institutional and technical capacities of partner countries related to food fortification, the EC has recently established the Fortification Advisory Services (FAS).[342] One of the first activities to be taken up by the FAS is a mapping exercise on key learning related to food fortification efforts around the globe. This document provides the Terms of Reference for this activity.

II DESCRIPTION OF THE ASSIGNMENT

Objectives and scope of work

The objective for the Global Mapping Exercise is as follows:

> *To produce an inventory and mapping of actors and programmes dealing with food fortification worldwide, taking into account the relevant policy contexts.*

The primary focus of the mapping exercise will be on industrial-scale programmes for fortification of commonly eaten foods. A second component that has been added to the exercise is to cover biofortification projects.

The Global Mapping Exercise will consist of the following elements:

1) Review of the global and national policy contexts relevant for food fortification, including preparation of a listing of countries with the food fortification legislation status in relation to the main food vehicles for fortification: salt, flour, edible oil, and sauces and condiments, and the micronutrient status.

2) Preparation of an overview of the main publicly accessible databases for tracking the status of food fortification programmes around the world, including a review of the indicators they contain.

3) Overview of the main programmes on food fortification within the period 2000–2015, with primary focus on large-scale food fortification programmes:
   - National legal context in relation to food fortification (mandatory or voluntary)

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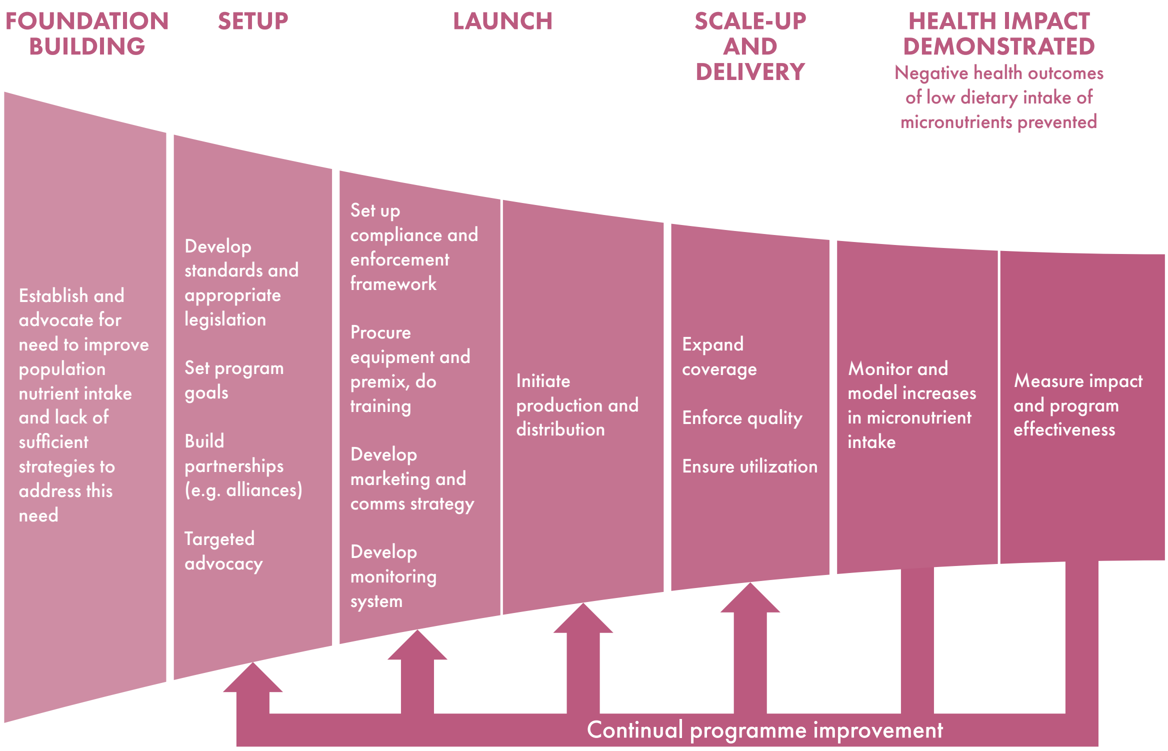
337 Allen L, B de Benoist, O Dary and R Hurrell (2006) op. cit.
338 Third Copenhagen Consensus Outcome Document (2012), http://www.copenhagenconsensus.com/sites/default/files/outcome_document_updated_1105.pdf
339 Bhutta ZA, et al. (2013) op. cit.
340 GAIN (2015) Fortifying our Future, A Snapshot Report on Food Fortification, Geneva.
341 This refers to the meta-analysis currently being undertaken by Dr Bhutta which analyses 70 studies on the nutrition impacts of food fortification which were selected from over 1000 manuscripts based on a strict set of scientific criteria.
342 Within the ToR for the FAS, there are two levels of work: (a) support to generation of and exchanging knowledge and fostering innovation with respect to food fortification at global level; and (b) support to country-level programmes on food fortification that will generate further evidence on the comparative advantages of food fortification in terms of effectiveness to reduce key micronutrient deficiencies among the most vulnerable and key population segments in need, and generate data on cost-efficiency aspects.

- Key actors involved (Governments; food producers, importers and retailers; international technical organisations and NGOs; donor agencies; academia; private sector; and consumer groups[343])
- (Reconstruct) Key strategic choices (intervention strategies for food fortification to address key MNDs)[344]
- Essential conditions and key success factors for implementation
- Operational challenges (incl. capacity issues) and sustainability aspects
- Performance (amounts of fortified food produced; achieved population coverage over time)[345]

4) Identification of best practices and key lessons for future programming through analysis of the main implementation set-ups[346] (including through public-private partnerships) in the field of food fortification. The figure below provides the National Food Fortification Impact Model that GAIN uses to visualise the key steps in food fortification implementation from planning until measurement of impacts.

Figure A2.1: Key steps in food fortification implementation



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343 It is suggested to identify key actors on food fortification worldwide through looking at the composition of the National Food Fortification Alliances for a selected number of countries.
344 Most of this information probably will have to come from the interviews with key actors (including national-level actors; see our suggestion under the methodology section), complemented where possible with information from literature resources, including national-level documentation on nutrition strategies and action plans.
345 GAIN has done some work on modelling of population coverage using existing information from MOI and MOH records, FACT and other assessments. Such information exists for a limited number of country programmes only.
346 This could entail a reconstruction of key process steps toward implementation for a number of selected food fortification programmes: (a) policy and advocacy; (b) production, supply, and marketing/distribution; (c) quality assurance/quality control (QAQC) by food producers; (d) regulatory monitoring by the public sector; to (e) communications across the entire food fortification supply chain and to the population on the reasons for fortifying foods.

Proposed methodology

The information which will form the basis of the inventory and mapping will be gathered through a combination of data collection methods, which will be undertaken in the following proposed sequence:

a) Initial literature searches on food fortification based on a list of key documents suggested by GAIN.

b) Undertake an extensive literature research on the web, based on a set of key words on food fortification, including application of the snowballing method based on the literature references within the documentation obtained (Appendix A provides an overview of key study topics in relation to food fortification as suggested during the First Global Summit on Food Fortification in Arusha, September 2015). Results will be presented in the form of a desk report.

c) Carry out Skype/telephone interviews with representatives of selected key actors on food fortification at global level. A listing of potential agencies to be contacted is attached as Appendix B.

d) Further literature search based on suggestions from the key actors interviewed, and for further enrichment of the information base for the Global Mapping Exercise as deemed appropriate.

e) Analysis of findings and production of a draft final and final report; Draft results will be presented to DEVCO C1 at a half-day meeting.

f) The dissemination plan for the Global Mapping results will be developed after this meeting, in full coordination with DEVCO C1.

III REPORTS

Deliverables and dissemination

The core result of the Global Mapping Exercise will be a narrative report that presents the results of the inventory and mapping on food fortification worldwide. A desk report will be produced at the end of step b) of the proposed methodology. A draft final and final report will be prepared at the end of the information gathering and analysis process steps listed above (step e). The main report will be 50 to 70 pages, supplemented with annexes.

The precise dissemination plan on the formats in which the results will be presented and the communication channels that will be used for sharing these deliverables of the Global Mapping Exercise will be developed in close collaboration with DEVCO C1. This will be done towards the end of the process, upon completion of the data collection and analysis steps. As a minimum, the Global Mapping Exercise should result in producing a final report including a short executive summary. This could be complemented by a brief on the results of the Global Mapping on Food Fortification (max. 4 pages) for wider sharing.

It is envisaged that the results of the Global Mapping Exercise will be shared with a range of audiences:

- Within EC (DEVCO C1 and beyond, Heads of Cooperation within the EU Delegation which have taken up nutrition as a focal area);
- With the key actors (including food producers and importers) on food fortification worldwide consulted in the course of the exercise (publishing of a summary in a range of nutrition and food fortification-related bulletins and newsletters, including industry publications like *World Grain*, *Nutra-Ingredients*, etc.);

- With a more general audience of nutrition and food security professionals (posting on the Cap4Dev website, the GAIN website, and other nutrition-oriented platforms).

IV INPUT REQUIREMENTS and TIMEFRAME

The FAS Team Leader (KE1) will lead the overall implementation of the exercise. The total time investment as currently envisaged is indicated in the table below.

The work will be undertaken by members of the FAS Core Team (KE1 and KE2) and some GAIN staff members (non-key experts) who are well placed to lead and/or contribute to various parts of the Global Mapping Exercise.

Overall, the core desk work on the Global Mapping will be undertaken from late April until mid-July 2016. A round of interviews with key stakeholders is scheduled for end July to early September. The draft and final report will be prepared in the period September to mid-October. A meeting for presentation of the results to DEVCO C1 will be scheduled for mid-October. The dissemination of the results is scheduled for the period from end October onwards.

The table below presents the activities and actors for each of the process steps within the Global Mapping Exercise, together with a proposed allocation of working days and timeframe for the implementation of the study:

Table A2.1: Proposed time budget for the Global Mapping

Step	Activity	No. of days			Period
		FAS (KE1)	FAS (KE2)	GAIN	
1.	Review of policy contexts on food fortification and listing of countries with mandatory, voluntary and public distribution systems (per food vehicle)	4	2	5	Mid-May – early June 2016
2.	Description of available databases on food fortification worldwide	-	2	4	Mid-May – early July 2016
3.	Literature review for development of an overview of the main food fortification programmes worldwide, with short description of key characteristics and results achieved thus far	12	12	8	Mid-May – early July 2016
4.	Production of the first draft chapters based on the desk review	5	4	4	Early July – Mid-July 2016
5a.	2-day team meeting to finalise report structure, jointly review draft chapters produced thus far, and jointly decide on the approaches for the interview round and further work planning	3	3	3	Mid-July 2016
5b.	Production of a draft desk report	7	4	4	Interim outputs: 3rd week July 2016
6.	Interviews with key actors on food fortification (HQ levels) on key strategic choices, process steps during implementation, operational challenges and sustainability aspects	5	5	5	End July – early Sept 2016
7a.	2-day team meeting to jointly analyse key findings (Part 1 and Part 2 in particular), and for joint revision of the more advanced draft chapters	3	2	2	Mid-Aug 2016
7b.	Production of the final draft and final report	4	3	2	End Sept/mid-Oct 2016
7c.	1-Day Meeting with C1 to present draft results	3	3	3	Mid-Oct 2016
8.	Development of a dissemination plan	1	-	-	Oct–Nov 2016
9.	Preparation of a brief or other products for wider sharing of the results of the Global Mapping Exercise	3	1	1	Oct–Nov 2016
	Total	**50**	**41**	**41**	

Appendix A: Global Summit on Food Fortification – key issues in relation to food fortification

During the First Global Summit on Food Fortification, organised by GAIN in Arusha in September 2015, GAIN presented a number of issues that need attention in order to ensure that long-term impacts will be sustained through continued food fortification programmes. These are further detailed in the Arusha Statement on Food Fortification:[347]

- Gaining better understanding of the dietary trends and gaps that exist in the various countries and specific contexts. This includes monitoring the changes in consumption patterns towards more processed, ready-to-eat, and animal-source foods. These changes occur in a considerable number of low- and middle-income countries as a result of income growth, urbanisation trends, and the rapid transformation of the food industry towards increasingly commercial and consolidated supply, marketing and retail systems.

- Filling critical gaps in programming and evidence in order to be able to expand food fortification to new countries and to other food vehicles beyond salt, edible oil and cereals,[348] as well as to improve and sustain existing fortification efforts. This includes leveraging the opportunities for food fortification that the shift towards more industrial environments and large-scale processing of staple foods is offering.

- Addressing performance gaps in existing fortification programmes, like the Universal Salt Iodization (USI) programme, and in wheat flour fortification programmes where folic acid is added to prevent neural tube defects and iron deficiency in order to reduce anaemia prevalence. This requires improved legislation, regulations and enforcement regimes, and measures to raise overall compliance with fortification standards. Furthermore, there is a need to improve capacity for quality assurance and quality control (QA/QC) at industry level.

- Generate further evidence that can guide fortification policy and programme design. This includes quantification of the dietary gaps for specific target groups, comparative analysis across programming options to combat micronutrient deficiencies, and assessment of the potential of new food fortification vehicles. It also entails further development and testing of tools to monitor fortification coverage, and, for example, innovative tests for rapid assessment of micronutrient content in samples of fortified food.

- Ensure continued food fortification leadership and accountability in public and private sectors. With donor and government investment to track population needs and enforce programme standards, alongside private sector commitment, fortification efforts can be expanded and scaled up to substantially reduce vitamin and mineral deficiency disorders around the world.

[347] Arusha Statement on Food Fortification (2015) published by the Global Summit on Food Fortification co-hosts (GAIN and Government of Tanzania), http://www.gainhealth.org/wp-content/uploads/2015/05/Arusha-Statement.pdf (accessed on 17 April 2016).
[348] Condiments and seasonings, e.g. are vehicles for food fortification that currently are being piloted in various countries.

Appendix B: Key actors in relation to food fortification

Agency		Location
NGO, foundations and technical institutes		
MN Forum	Micronutrient Forum	Ottawa, Canada (hosted by MI),
IGN	Iodine Global Network	Ottawa, Canada
FFI	Food Fortification Initiative	Atlanta GA, USA
Sight and Life		Basel, Switzerland (hosted by DSM)
Smarter Futures		Amsterdam, NL / Atlanta GA, USA
MI	Micronutrient Initiative	Ottawa, Canada
GAIN	Global Alliance for Improved Nutrition	Geneva, Switzerland / London, UK
ETH Zurich	Eidgenössische Technische Hochschule	Zurich, Switzerland
ACF	Action Contre la Faim	Paris, France
SCF	Save the Children Fund	London, UK
WHH	Welt Hunger Hilfe	Bonn, Germany
CIFF	Children's Investment Fund Foundation	London, UK
HKI	Helen Keller International	New York NY, USA
PATH	Progam for Appropriate Technology in Health	Seattle WA, USA / Washington DC
PHC	Project Healthy Children	Cambridge MA, USA
PSI	Population Services International	Washington DC, USA
SPRING	SPRING-Nutrition	Arlington VA, USA (hosted by JSI)
FHI360/FANTA	Family Health International	Durham NC, USA / Washington DC
PFS	Partners in Food Solutions/TechnoServe Alliance	Minneapolis MN, USA
IMMPaCT	International Micronutrient Malnutrition Prevention and Control	Atlanta GA, USA
Private sector (large-scale food fortification/regional farmers' organisations)		
DSM		Heerlen, NL
Akzo Nobel		Amsterdam, NL
Unilever		Rotterdam, NL / Leatherhead, UK
Unga Millers		Nairobi, Kenya
Buhler		Uzwil, Switzerland
Cargill	Biotechnology Development Center	Minneapolis MN, USA / Vilvoorde, Belgium

Agency		Location
IAOM	International Association of Operational Millers	Lenexa KS, USA
US Wheat Associates		Arlington VA, USA
Interflour Group		Singapore (mills in Malaysia, Vietnam, Indonesia and Turkey)
EAFF	East Africa Farmers Federation	Nairobi, Kenya
CAPAD	Confédération des Associations des Producteurs Agricoles pour le Développement	Bujumbura, Burundi
SACAU	Southern African Confederation of Agricultural Unions	Pretoria, South Africa
Technical institutes involved in biofortification research		
IFPRI	International Food Policy Research Institute	Washington DC, USA
HarvestPlus		Cali, Colombia (at CIAT) / Washington DC, USA (at IFPRI)
IRRI	International Rice Research Institute	Los Baños, Philippines
CIP	International Potato Center	Lima, Peru
UN agencies		
WHO	World Health Organization	Geneva, Switzerland
WFP	World Food Programme	Rome, Italy
FAO	Food and Agricultural Organization	Rome, Italy
UNICEF	United Nations Children Fund	New York NY, USA
IFAD	International Fund for Agricultural Development	Rome, Italy
Donor agencies/governments/inter-governmental agencies		
SUN	Scaling Up Nutrition Movement Secretariat	Geneva, Switzerland
WB	World Bank	Washington DC, USA
ADB	Asian Development Bank	Manila
AfDB	African Development Bank	Abidjan, Ivory Coast
AU	African Union	Addis Ababa, Ethiopia
NEPAD	New Partnership for Africa's Development	Midrand, RSA
ECOWAS	Economic Community of West African States	Abuja, Nigeria
EC	European Commission	Brussels, Belgium
USAID	United States Agency for International Development	Washington DC, USA

Agency		Location
DFATD	Department of Foreign Affairs, Trade and Development, Canada	Ottawa, Canada
DFID	Department for International Development, United Kingdom	London, UK
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit	Bonn, Germany
DGIS	Ministry of Foreign Affairs of The Netherlands	The Hague, NL
IA	Irish Aid	Dublin, Ireland
BMGF	Bill & Melinda Gates Foundation	Seattle WA, USA

Mailing list for the survey monkey questionnaire

Agency	Topic	Person	Position
Smarter Futures	Grains QA/QC, Africa	Anna Verster	Project Coordinator
East African Farmers Association (EAFF)	Biofortification; value chain issues for grains	Philip Kiriro Stephen Muchiri	
HarvestPlus	Biofortification	Peg Willingham	Head of Advocacy and Policy
UNICEF	Salt	Roland Kupka	Sr. Advisor Micronutrients
Iodine Global Network (IGN)	Salt	Jonathan Gorstein	Executive Director
DSM	Premix	Anthony Hehir	Director Nutrition Improvement Programme
GAIN	(all topics)	Greg Garrett, Lynnette Neufeld, Arnold Timmer	
WFP – ODB (Bangkok RO)	Rice	Rizwan Yusufali	Sr. Food Fortification Specialist
FAO – RAF (Africa RO)	Food systems	Mohamed Ag Bendech	Senior Nutrition Officer
SUN Business Network	Private Sector Engagement	Jonathan Tench	Manager SUN Global Business Network
Unga Millers	East Africa Wheat Miller	Nick Hutchinson	Member Board of Directors
HKI – West Africa Regional Office	West Africa/Regional Oil/Flour	Fred Grant	Regional Nutrition Advisor
USAID	Donor	Omar Dary	Sr. Nutrition Advisor
Micronutrient Initiative (MI)	(all topics)	Noor Khan	Sr. Technical Advisor for Nutrition in Food Systems

Agency	Topic	Person	Position
WHO – EMRO	Fortification Standards	(*seek contact through JP Penas-Rosas WHO HQ*)	
Salt or Oil Producer	Private Sector Engagement	(*seek contact through IGN, Penjani, Ravi)*	
Partners in Food Solutions (PFS)	B2B TA QA/QC	Jeff Dykstra Brent Wibberley Jonathan Thomas	CEO PFS Director of PFS programmes Chief of Party Solutions for African Food Enterprises
International Association of Operative Millers (IAOM)	Miller Association – Private sector engagement	(*seek contact through FFI*)	

Annex 3: Arusha list of research priorities and research questions

The #FutureFortified Global Summit on Food Fortification[349] which took place in September, 2015 helped to create a sectorwide consensus on evidence gaps, delivery models and pathways for fortification. It provided evidence that food fortification can improve, and has indeed improved, the dietary intakes of essential nutrients for those living in rural and urban poor areas. It forged a renewed vision for the scale-up of fortification globally, where essential conditions for potential success and sustainability are met.

The Arusha Statement on Food Fortification outlined five key recommendations as critical action points for all stakeholders in food fortification to consider:

Summit recommendation 1: Generate new investment in the sector

Modest but new investment is essential. Fortification is cost-effective and largely self-sustainable. Costs are built into markets and typically do not require further or continuous public subsidy. Governments need to invest in technical support, oversight and compliance.

Summit recommendation 2: Improve oversight and enforcement of fortification

There is a need for a major effort to improve oversight and enforcement of food fortification standards and regulations. Poor compliance with laws and regulations limits potential for impact and undermines effectiveness. Available data shows adequate compliance with standards in as low as 50% in many contexts. Governments should improve their inspection and enforcement systems to ensure high-quality fortification and a level playing field for the producers. Effective regulatory monitoring and enforcement will notably require more robust national budget allocations.

Three priority areas emerged:

- Simplifying the process of compliance data collection for inspectors
- Identifying motivating factors for government to ensure compliance
- Identifying and putting in place enablers for industry to comply with established regulatory frameworks

Summit recommendation 3: Generate more evidence to guide fortification

There is a need to generate more evidence to guide fortification policy and programme design, to continually improve programmes and demonstrate impact. For example, there is a lack of detail of foods consumed by various target groups, limiting our understanding of potential food vehicles, use of fortified foods and quantification of the dietary gap that we must address for some nutrients.

Five priority areas for research were identified:

- Measuring the magnitude and distribution of the health problem
- Understanding the diverse causes of the problem
- Developing solutions or interventions

[349] The #FutureFortified Global Summit on Food Fortification; Event Proceedings and Recommendations for Food Fortification Programs, http://projecthealthychildren.org/wp-content/uploads/2016/07/TAG-FutureFortified-Supplement-2016.pdf

- Implementing or delivering solutions and monitoring progress
- Evaluating impact

Summit recommendation 4: Increase accountability and global reporting

Progress requires more transparent accountability and global reporting. We support the call for a global observatory or annual report of the state of fortification.

Suggested actions:

- Create a working group to define key indicators including method of collection
- Determine what financial and human resources are needed to start up and sustain a global repository
- Recommend a host location for the system
- Determine the final use of the global reporting system as that will largely determine which technology platform can be used. A database that is only used by Technical Advisory Group members to pull data and create reports, for example, is very different from a system for country fortification partners to enter monitoring data
- Identify what is already being collected, including the World Health Organization's Vitamin and Mineral Nutrition Information System *VMNIS), UNICEF's Multiple Indicator Cluster Surveys (MICS), and NutriDash system, Demographics and Health Surveys, and IGN, GAIN and FFI data on fortification of specific food vehicles
- Determine if information identified above will be incorporated into the global reporting system or if it will be linked as an external resource
- Ensure consistency in the technical side of the database including coding countries and defining geographic regions
- Build a global reporting system, or amend an existing system, to accommodate the above findings
- Train individuals from Technical Advisory Group entities and partners in how to use the global reporting system to add data and retrieve reports
- Maintain global reporting system with accurate information
- Use data form the global reporting system for advocacy with key stakeholders and donor appeals.

Summit recommendation 5: Continue to advocate at the global and country level

Continuing advocacy is a high priority, and we will work together with stakeholders such as the SUN Movement and African Union to advocate for greater attention by governments.

Five ways are proposed to advocate for fortification with one clear voice:

- Form a high-level champions groups to share messages about the economic benefits of well-implemented and monitored mandatory fortification programmes
- Highlight cost-benefit messages through Technical Advisory Group entities' communications channels as evidence that the global community is unanimous in this effort
- Support country leaders in the suggested actions for the four channels described in this report. Country will want data specific to their setting
- Appeal to policy-makers' deeper values whenever possible, such as a sense of self-respect and accomplishment. As the cost of fortification is immediate but the benefits are long-term, appeal to the policy-makers' desire to leave a legacy for future generations
- Increase involvement in the International Coalition on Advocating Nutrition (ICAN) to mainstream fortification as a nutrition intervention and to uniformly share the message about economic benefit.

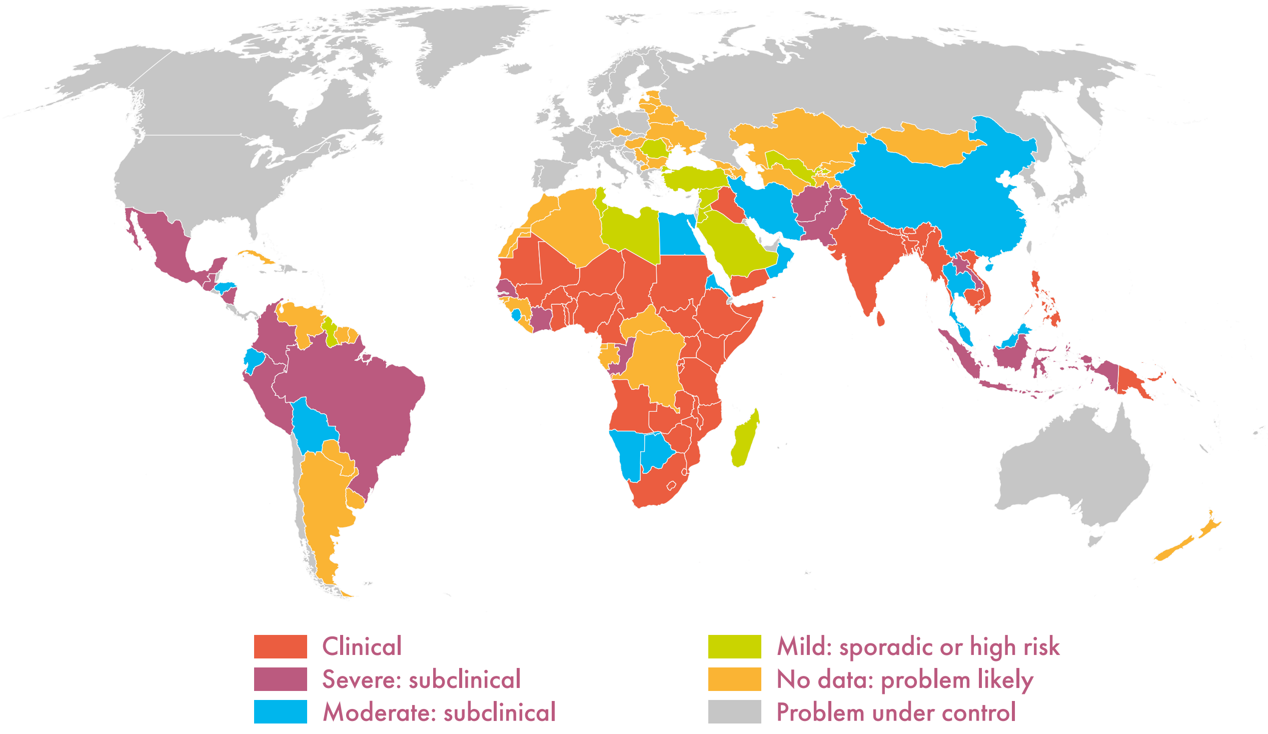
Annex 4: Background on key micronutrients

Vitamin A

Vitamin A is essential for healthy eyes, growth and immune function. Its deficiency is the leading cause of acquired blindness in children and contributes significantly to morbidity and mortality from common childhood infections. Vitamin A deficiency is a significant public health problem in over half of all countries globally and is especially prevalent in Africa and Southeast Asia. Figure A4.1 depicts the countries categorised by the extent of vitamin A deficiency.[350] Note that this data is over 20 years old, which presents a major challenge for quantifying and monitoring vitamin A deficiency at the global level.

Children under five and women of reproductive age are most at risk of vitamin A deficiency; approximately 190 million preschool-aged children and 19.1 million pregnant women are estimated to be affected.[351] It is estimated that the risk of childhood mortality can be reduced by 23% from provision of vitamin A where deficiency is widespread.[352] The WHO recommended daily intakes for vitamin A are listed in Table A4.1. Though fortification of selected foods, including complementary foods, are starting to be implemented in more countries, currently the primary intervention to reduce the burden of paediatric vitamin A deficiency is the distribution of high dose vitamin A capsules to children under 5 years old every 6 months.

Figure A4.1: Countries categorised by the degree of public health importance of vitamin A deficiency



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[350] WHO (1996) XVII IVACG Meeting Guatemala, WHO..
[351] WHO (2009) Global Prevalence of Vitamin A Deficiency in Populations at Risk 1995–2005, Geneva.
[352] Bagriansky, J and P Ranum (1998) Vitamin A Fortification of PL 480 Vegetable Oil, SUSTAIN, Washington, DC.

Table A4.1: Recommended daily intakes for vitamin A for selected population groups.[353]

Population group	Recommended daily intake (IU/day)
Infants: 0–1 years	1167
Children: 1–6 years	1333
Women of reproductive age: 16–45 years	2000
Lactating women	2833

Vitamin D

Vitamin D is essential for calcium absorption and bone health, modulation of cell growth, and the neuromuscular and immune system. Its deficiency can result in a softening of the bones, including impeded bone growth in children leading to rickets, and bone fragility and osteomalacia in adults, particularly the elderly. Low levels of vitamin D in pregnancy are associated with gestational diabetes, pre-eclampsia during pregnancy and delivery of low birth weight babies, as well as increased risk of viral and bacterial infections, including HIV, influenza and tuberculosis.[354] Vitamin D is also produced in the body through exposure to sunlight. Darker skinned populations living in the northern hemispheres with longer winters, and peoples not adequately exposed to sunlight due to cultural habits (e.g. clothing that inhibits sun exposure) are at higher risk of vitamin D deficiency, especially if they do not regularly consume the limited dietary sources of the nutrient, such as meat, dairy, fish and eggs. The current recommended levels of intake of vitamin D are listed in Table A4.2.

Table A4.2: Recommended nutrient intakes for vitamin D for selected population groups.[355]

Population group	Recommended nutrient intake (µg /day)
Infants through adolescents 0–18 years	5
Adults: 19–50 51–65 65+	5 10 15
Pregnant women	5
Adults over age 71	5

Folate

Folate (or vitamin B9) functions as a coenzyme in the metabolism of nucleic and amino acids. Folate deficiency may result in megaloblastic anaemia, and inadequate folate status during the first 28 days of pregnancy is a risk factor for the development of neural tube defects (NTD) such as spina bifida and anencephaly in the foetus. Therefore, an essential public health objective is to help ensure that women enter pregnancy with an optimal folate status. To reduce the risk of NTD, women of childbearing age should take 400 mg of folic acid (the synthetic and more bioavailable form of the vitamin) daily, in addition to food folate from a varied diet.[356]

Although most countries require that all pregnant women receive a folic acid supplement (which also contains iron with or without additional micronutrients), supplementation does not prevent NTD cases, because the vast majority of women are not aware of being pregnant well past the 28 day window when

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353 WHO (2009) Global Prevalence, op. cit.
354 Holick, MF (2007) Vitamin D Deficiency*, New Engl J of Med* 357: 266–81.
355 WHO/FAO (2004) Vitamin and mineral requirement in human nutrition. 2nd edition. Geneva: WHO.
356 IOM. (2006) Folate in *Dietary Reference Intakes: The Essential Guide to Nutrient Requirements*. Washington, DC: National Academy Press, http://www.nap.edu/catalog/11537.htm (accessed 21 July 2016).

the neural tube of the foetus is already formed, before they are tested to confirm pregnancy. Also, in many LMICs, large proportions of pregnant women either seek antenatal care in the 2nd or 3rd trimesters of pregnancy or none at all. In developed countries, women who plan to become pregnant may seek appropriate medical care and receive folic acid supplements in the 'preconception' period; on the other hand, large proportions of pregnancies in those countries are also unplanned, and antenatal intake of folic acid supplements are delayed and not effective to prevent NTD. Fortification of commonly consumed staple foods with folic acid has been confirmed to substantially reduce the birth prevalence of NTD in a number of developed and LMICs, and is recommended by the WHO as an effective public health intervention.

Table A4.3: Recommended nutrient intakes for folic acid (as dietary folate equivalents) for selected population groups.[357]

Population group	Recommended nutrient intake (μg /day)
Infants: 0–12 months	80
Children: 1–3 years	150
Adults: 19–65 years	400
Pregnant women	600
Adults over age 71	500

B-complex vitamins (other than folate)

Thiamine, or vitamin B1, was the first of the B-complex vitamins to be identified as an essential vitamin. Other members of this group of water-soluble vitamins are riboflavin (vitamin B2), niacin (vitamin B3), pantothenic acid (vitamin B5), pyridoxine (vitamin B6), biotin (vitamin B7), and vitamin B12. Generally, these vitamins help the body to get or make energy from the calorie-containing food consumed.[358] They are also essential in the production of red blood cells. Dietary sources of B-complex vitamins include fish, poultry, meat, eggs, dairy products, leafy green vegetables, beans and peas. In countries where flour, rice and/or other cereals are fortified with B-complex vitamins, those staple foods are also important sources of these essential micronutrients, especially among the low-income populations who may not have sufficient and regular access to the higher priced natural sources of the vitamins.

Table A4.4: Recommended nutrient intakes for B-complex vitamins for selected population groups.[359]

Population group	Vit. B1	Vit. B2	Vit. B3*	Vit. B5	Vit. B6	Vit. B7	Vit. B12
Infants: 0–6 months 7–12 months	 0.2 0.3	 0.3 0.4	 2 4	 1.7	 0.1 0.3	 5 6	 0.4 0.7
Children: 1–3 yrs.	 0.5	 0.5	 6	 1.8	 0.5	 8	 0.9
Adults: 19+ years (females) 19+ years (males)	1.1 1.2	1.1 1.3	14 16	5.0 5.0	1.3** 1.3**	30 30	2.4 2.4
Pregnant women	1.4	1.4	18	6.0	1.9	30	2.6
Lactating women	1.5	1.6	17	7.0	2.0	35	2.8

*In mgNEs (niacin equivalents)/day **For adults 19–50 years

[357] WHO/FAO (2004) op. cit.
[358] MedlinPlus (2015) B Vitamins. NIH/U.S. National Library of Medicine. Bethesda, MD. 13 July, https://medlineplus.gov/bvitamins.html (accessed 22 July 2016).
[359] WHO/FAO (2004) op. cit.

Iodine

Iodine is a micronutrient necessary for the production of thyroid hormones that are needed for the regulation of various enzymes and metabolic processes including protein synthesis. Deficiency of iodine results in the development of goitre, an enlargement of the thyroid gland, and is also the most prevalent cause of preventable brain damage,[360] especially in the unborn foetus. Therefore, ensuring adequate iodine intake of pregnant women is essential to protecting the brain development and cognitive capacity of the next generation. Severe iodine deficiency during pregnancy can result in cretinism,[361] a condition of severely stunted physical and cognitive development.

It is now commonly understood that much of the upper layers of soil on earth became depleted of iodine towards the end of the last ice age when the receding ice carried the iodine in the soil with it to the oceans. Even in current times, the soil of river valleys and hills continue to be very low in iodine content due to the soil erosion that occurs with heavy rains and flooding. Thus, plants and livestock raised on iodine-depleted soil have low iodine content and are not adequate sources of dietary iodine for humans. Iodine-rich natural food sources include seaweed, shellfish and saltwater fish. However, the least expensive source of dietary iodine is artificially iodised salt; iodisation of salt accounts for less than 5% of the retail price of salt in most countries.[362]

Iodine deficiency[363]

Trials in Papua New Guinea and western China in the early 20th century showed that goitre could be prevented through iodine supplementation. It was concluded that food items that are produced in these areas do not contain adequate amounts of iodine. For ensuring proper iodine intakes of individuals it was therefore found to be essential to supplement with iodine capsules or to fortify food item(s).

Although the mineral iodine is widely present in the earth's environment overall, the soils are depleted of iodide in geographical areas with leaching from glaciations, flooding and erosion. Crops and livestock products in these regions are low in iodine content, and goitre (enlargement of the thyroid gland) used to be endemic, with highly adverse effects on growth and development. Another causal factor in relation to goitre is that the diet in some parts of the world contains 'goitrogenic factors' which have negative impacts on iodine status because of inhibited uptake of iodine by the thyroid gland. This refers to an overload of thiocyanate in the diet: for example, when poorly detoxified cassava forms the main staple; where there is a high consumption of walnuts; and as a result of bacterial and chemical water pollutants. The effect of cassava in exacerbating goitre and cretinism may be corrected by increasing the intake of iodine.

The human body contains 15–20 mg of iodine of which almost 80% is in the thyroid gland. Iodine is necessary for the production of two thyroid hormones (thyroxine – T4 and triiodothyronine – T3) which are essential for the development of the brain and overall nervous system. Iodine deficiency (ID) during pregnancy and first 2–3 years of life affects the T4 and T3 levels in the blood which leads to irreversible change through impaired development of the brain and central nervous system. In iodine deficiency, the serum T4 is typically lower and the serum T3 higher than in normal populations. Serum TSH[364] rises when serum T4 concentrations are low, and falls when they are high.

Moderate to severe ID during pregnancy increases the rates of spontaneous abortions, leading to reduced birth weights and increased infant mortality rates. In its most extreme forms, ID during pregnancy leads to 'cretinism', either in the neurological form (the most common) with mental retardation, defects of hearing and

[360] WHO (2016) Micronutrient deficiencies: Iodine deficiency disorders. Geneva: WHO, http://www.who.int/nutrition/topics/idd/en/ (accessed 21 July 2016).
[361] IOM. (2006) Iodine, op. cit.
[362] Mannar, VMG and JT Dunn (1995) Salt iodization for the elimination of iodine deficiency. ICCIDD, http://ign.org/cm_data/1995_WHO_Salt_iodization_for_the_elimination_of_IDD.pdf (accessed 21 July, 2016)
[363] Large parts of this section are based on: WHO/UNICEF/ICCIDD (2007), Assessment of iodine deficiency disorders and monitoring their elimination; a guide for programme managers, Geneva: WHO.
[364] Thyroid-stimulating hormone.

speech, squint, and spasticity of the lower limbs, or the myxoedematous form marked by dwarfism and myxoedema. ID during childhood reduces somatic growth and affects cognitive and motor function development, and contributes to a reduction of learning ability, with a loss on average of 13 IQ points.

The recommendations from WHO on dietary iodine intake are 90 µg per day for children 0–5 years old, 120 µg per day for children 6–12 years of age, 150 µg per day for adolescents and adults, and an increased requirement of 250 µg per day for pregnant and lactating women. Such intakes should result in a median urinary iodine excretion of 100–200 µg/l in adolescents and adults, and 150–250 µg/l for pregnant women. It is generally assumed that in countries with long-standing deficiency iodine intake should not exceed 500 µg per day (180 µg per day for children younger than 2 years old).

The classification for levels of iodine deficiency at population level is based on measurement of UIC among school-age children: a level <20 µg/l indicates severe ID; 20–49 µg/l moderate ID; and 50–99 µg/l mild ID. In case of an UIC ≥300 µg/l the iodine intake is excessive and there is risk of adverse health consequences.

Table A4.5: Recommended daily intakes for iodine for selected population groups[365]

Population group	Recommended daily intake (µg/day)
Infants and children 0–59 months	90
Children 6–12 months	120
Adolescents and adults	150
Pregnant women	200
Lactating women	200

Iron

Iron is an essential component of haemoglobin, which transfers oxygen from the lungs to tissues throughout the body.[366] Iron is also a component of myoglobin, a protein needed to provide oxygen to muscles, and is also necessary for growth, development, cellular function, and synthesis of some hormones and connective tissue.[367] Although it is the second most abundant metal in the earth's crust, dietary deficiency of iron is the most common cause of anaemia worldwide.[368] It is naturally present in many foods and may also be added to some fortified foods. Dietary iron comes in two forms: haeme and non-haeme. Meat, fish and poultry contain both forms of iron, while plants and fortified foods contain non-haeme iron only. The absorption of non-haeme iron is inhibited by plant phytates and tannins, while ascorbic acid increases its absorption.

The risk of iron deficiency is high among children <24 months of age and pregnant women, because of increased needs for the nutrient during those periods of rapid tissue growth. Non-pregnant women of childbearing age are also at increased risk of iron deficiency due to high losses of the nutrient with menstrual blood. Therefore, these population groups would especially benefit from the consumption of good food sources of iron, including fortified foods.

Iron overload is a risk among individuals with genetically acquired hemochromatosis due to their lack of natural control of iron absorption at the intestinal level. However, the prevention and control of iron overload disease in such individuals requires early screening and diagnosis of the condition and periodic phlebotomy and chelation therapy, to reduce their body iron levels, along with recommendations to reduce vitamin C intake, avoid iron-containing dietary supplements and limit

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365 WHO/FAO (2004) op cit.
366 Wessling-Resnick, M (2014) Iron, in Ross, AC, B Caballero, RJ Cousins, KL Tucker, RG Ziegler (eds) *Modern Nutrition in Health and Disease*. 11th edn. Baltimore, MD: Lippincott Williams & Wilkins, pp. 176–88.
367 NIH (2016) Iron: Dietary supplement fact sheet (for health professionals). Updated 11 February 2016. https://ods.od.nih.gov/factsheets/Iron-HealthProfessional/ (accessed 21 July 2016).
368 Iron absorption. Revised 11 January 2001. Boston: Harvard University, http://sickle.bwh.harvard.edu/iron_absorption.html (accessed 21 July, 2016).

alcohol intake.[369] Another group at risk of iron overload disease is individuals with genetically acquired transfusion dependent hemoglobinopathy (e.g. thalassemia major). To prevent complication of iron overload in such patients, the medical treatment of thalassemia also includes intake of medicinal chelating agents to remove excess iron from the required and frequent blood transfusions.[370]

Table A4.6: Recommended dietary allowance for iron for selected population groups[371]

Population group	Recommended dietary allowance (mg/day)
Infants: 7–12 months	11
Children: 1–3 years	7
Women: 19–30 years	18
Pregnant women	27
Lactating women	9

Zinc

Similar to iron, zinc is an essential micronutrient that is naturally present in some foods and added to various fortified foods. It may also be consumed as a dietary supplement, and is required for many components of cellular metabolism.[372] Zinc is also needed for the catalytic activity of nearly 100 enzymes[373] and it also has a role in immune function, and wound healing, as well as other functions (e.g. sense of taste and smell). Due to its role in immune function, zinc supplementation is a component of oral rehydration therapy in patients suffering from diarrhoea.[374] It is also necessary during periods of growth, such as pregnancy, childhood and adolescence. Because there is no storage system of zinc, this nutrient has to be consumed regularly to order to maintain its needed levels in the human body.

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[369] NIH/NHLBI (2011) How is hemochromatosis treated? 1February. Bethesda, MD, USA, http://www.nhlbi.nih.gov/health/health-topics/topics/hemo/treatment (accessed 21 July 2016).

[370] Porter, J et al. (2014) Iron overload and chelation, in Cappellini, MD, et al. eds. *Guidelines for the Management of Transfusion Dependent Thalassaemia (TDT)*. 3rd edn. Nicosia (CY): Thalassaemia International Federation, http://www.ncbi.nlm.nih.gov/books/NBK269373/ (accessed 21 July 2016).

[371] IOM (2006) Iron, in *Dietary Reference Intakes: The Essential Guide to Nutrient Requirements*. Washington, DC: National Academy Press, http://www.nap.edu/catalog/11537.htm (accessed 21 July 2016).

[372] NIH (2016) Zinc: Fact sheet for health professionals. Updated 11 February 2016, https://ods.od.nih.gov/factsheets/Iron-HealthProfessional/ (accessed 21 July 2016).

[373] IOM/FNB (2001) *Dietary reference intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese,* molybdenum*, nickel, silicon, vanadium, and zinc*. Washington, DC: National Academy Press.

[374] WHO/eLENA (2016) Zinc supplementation in the management of diarrhea. Geneva: WHO, http://www.who.int/elena/titles/bbc/zinc_diarrhoea/en/ (accessed 22 July 2016).

Oysters contain a higher amount of zinc per serving than any other food. However, in general good dietary sources of iron, such as meat and poultry, beans, nuts and whole grains, are also good source of zinc. Furthermore, like iron the bioavailability of zinc from animal foods is higher than from plant sources, and dietary phytates inhibit its absorption. The WHO recommends the addition of zinc to fortified wheat and maize flours[375], while similar fortification of polished rice is also recommended.[376]

Table A4.7: Recommended dietary allowance for zinc for selected population groups.[377]

Population group	Recommended dietary allowance (mg/day)
Infants: 7–12 months	3
Children: 1–3 years	3
Women: 19–30 years	8

[375] WHO, FAO, UNICEF, GAIN, MI, & FFI. (2009) Recommendations on wheat and maize flour fortification. Meeting Report: Interim Consensus Statement. Geneva: World Health Organization. http://www.who.int/nutrition/publications/micronutrients/wheat_maize_fort.pdf (accessed 28 June 2016).
[376] De Pee, S (2014). Proposing nutrients and nutrient levels of rice fortification. *Ann. N.Y. Acad. Sci*. 1324: 55–66.
[377] NIH. (2016) Zinc: Fact sheet for health professionals. Updated 11 February 2016, https://ods.od.nih.gov/factsheets/Iron-HealthProfessional/ (accessed 21 July 2016).

Annex 5: Micronutrients status 42 countries

Region	Country	Iron				Folic acid		Iodine		Vitamin A				Zinc	
		Anaemia in WRA (non-pregnant) (% with Hg <120 g/L)	Data year	Anaemia in children <5 (% with Hg <110 g/L)	Data year	Birth preva-lence of NTDs (per 10,000 births)	Data year	Median UIC (ug/L)	Data year	VAD in pregnant women (% with Serum Retinol <0.70 umol/L)	Data year	VAD in children <5 (% with Serum Retinol <0.70 umol/L)	Data year	Population at risk of inadequate zinc intake (%)	Data year
Asia/ Pacific	Afghanistan	31%	2011	44%	2011	20	2012	171	2013	16.0%	Est 1995–2005	64.5%	Est 1995–2005	20.2%	2012
	Bangladesh	43%	2011	56%	2011	47	2012	163	2005	23.7%	1998	21.7%	1998	29.7%	2012
	Cambodia	43%	2011	55%	2011	19	2012	236	2011	16.5%	Est 1995–2005	22.3%	2000	16.4%	2012
	Lao PDR	31%	2011	42%	2011	19	2012	103	2013	16.6%	Est 1995–2005	44.7%	2000	14.8%	2012
	Myanmar	30%	2011	40%	2011	7	2012	124	2006	18.0%	Est 1995–2005	36.7%	Est 1995–2005	19.5%	2012
	Nepal	36%	2011	51%	2011	47	2012	193	2007	31.5%	1998	32.3%	1998	23.7%	2012
	Pakistan	51%	2011	61%	2011	20	2012	124	2011	10.0%	2001	12.5%	2001	20.4%	2012
	Sri Lanka	26%	2011	36%	2011	20	2012	153	2005	22.7%	Est 1995–2005	35.3%	1996	45.7%	2012
	Timor-Leste	22%	2011	45%	2011	5	2012			15.4%	Est 1995–2005	45.8%	Est 1995–2005	16.9%	2012
East/ Southern Africa	Burundi	20%	2011	47%	2011	13	2012	70	2005	12.2%	Est 1995–2005	27.9%	2005	38.0%	2012
	Ethiopia	19%	2011	50%	2011	22	2012	25	2005	13.2%	Est 1995–2005	46.1%	1997	11.0%	2012
	Kenya	24%	2011	46%	2011	13	2012	118	2004	17.3%	Est 1995–2005	84.4%	1999	25.3%	2012
	Madagascar	32%	2011	50%	2011	13	2012			13.8%	Est 1995–2005	42.1%	2000	16.0%	2012
	Malawi	28%	2011	66%	2011	13	2012	175	2009	13.7%	Est 1995–2005	59.2%	2001	40.6%	2012
	Mozambique	44%	2011	66%	2011	13	2012	97	2012	14.3%	2002	68.8%	2002	31.4%	2012
	Rwanda	17%	2011	38%	2011	13	2012	298	1996	6.2%	1996	6.4%	1996	34.9%	2012
	Somalia	42%	2011	57%	2011	22	2012	417	2009	18.8%	Est 1995–	61.7%	Est 1995–	24.5%	2012

Region	Country	Iron				Folic acid		Iodine		Vitamin A				Zinc	
		Anaemia in WRA (non-pregnant) (% with Hg <120 g/L)	Data year	Anaemia in children <5 (% with Hg <110 g/L)	Data year	Birth prevalence of NTDs (per 10,000 births)	Data year	Median UIC (ug/L)	Data year	VAD in pregnant women (% with Serum Retinol <0.70 umol/L)	Data year	VAD in children <5 (% with Serum Retinol <0.70 umol/L)	Data year	Population at risk of inadequate zinc intake (%)	Data year
											2005		2005		
	Sudan	31%	2011	59%	2011	22	2012	66	2006	16.1%	Est 1995–2005	27.8%	Est 1995–2005	7.4%	2012
	Tanzania	38%	2011	61%	2011	13	2012	204	2004	14.8%	Est 1995–2005	24.2%	1997	34.1%	2012
	Uganda	26%	2011	56%	2011	13	2012	464	2005	23.3%	2001	27.9%	2001	20.5%	2012
	Zambia	28%	2011	59%	2011	23	2012	245	1999	20.0%	1999	35.8%	1999	48.4%	2012
	Zimbabwe	28%	2011	58%	2011	13	2012	245	2011	14.0%	Est 1995–2005	54.1%	2003	44.9%	2012
Latin America	Cuba	23%	2011	34%	2011	8	2012	176	2012	2.3%	Est 1995–2005	3.6%	2000	20.2%	2012
	Guatemala	25%	2011	47%	2011	22.8	2012	144	2005	1.1%	Est 1995–2005	15.8%	1995	29.8%	2012
	Haiti	36%	2011	62%	2011	18	2012	39	2012	2.0%	Est 1995–2005	32.0%	2005	34.9%	2012
	Honduras	18%	2011	39%	2011	24.3	2012	356	2005	1.5%	Est 1995–2005	13.8%	1996	22.5%	2012
Middle East	Yemen	38%	2011	59%	2011	12	2012	173	1998	15.8%	Est 1995–2005	27.0%	Est 1995–2005	23.4%	2012
West/ Central Africa	Angola	44%	2011	52%	2011	20	2012	29	2006	15.0%	Est 1995–2005	34.3%	1999	24.4%	2012
	Benin	48%	2011	65%	2011	27	2012	318	2011	18.0%	Est 1995–2005	70.7%	1999	17.9%	2012
	Burkina Faso	48%	2011	86%	2011	27	2012	114	1999	16.7%	Est 1995–2005	54.3%	Est 1995–2005	39.4%	2012
	Cameroon	41%	2011	63%	2011	20	2012	190	2002	17.9%	Est 1995–2005	38.8%	2000	33.8%	2012
	Chad	46%	2011	74%	2011	20	2012	213	2003	17.1%	Est 1995–2005	50.1%	Est 1995–2005	34.5%	2012
	Côte d'Ivoire	48%	2011	75%	2011	27	2012	203	2004	19.0%	Est 1995–2005	57.3%	1996	33.4%	2012
	Dem. Rep. Congo	49%	2011	67%	2011	20	2012	249	2007	16.1%	Est 1995–2005	61.1%	1999	54.3%	2012
	Gambia	48%	2011	65%	2011	27.1	2012	42	1999	34.0%	1999	64.0%	1999	34.9%	2012

Region	Country	Iron				Folic acid		Iodine		Vitamin A				Zinc	
		Anaemia in WRA (non-pregnant) (% with Hg <120 g/L)	Data year	Anaemia in children <5 (% with Hg <110 g/L)	Data year	Birth preva-lence of NTDs (per 10,000 births)	Data year	Median UIC (ug/L)	Data year	VAD in pregnant women (% with Serum Retinol <0.70 umol/L)	Data year	VAD in children <5 (% with Serum Retinol <0.70 umol/L)	Data year	Population at risk of inadequate zinc intake (%)	Data year
	Guinea-Bissau	44%	2011	71%	2011	27	2012			18.0%	Est 1995–2005	54.7%	Est 1995–2005	27.1%	2012
	Mali	56%	2011	80%	2011	27	2012	69	2005	16.7%	Est 1995–2005	58.6%	Est 1995–2005	22.3%	2012
	Mauritania	38%	2011	71%	2011	27	2012	179	2012	17.1%	Est 1995–2005	47.7%	Est 1995–2005	9.6%	2012
	Niger	45%	2011	76%	2011	27	2012	270	1998	14.7%	Est 1995–2005	67.0%	Est 1995–2005	16.9%	2012
	Nigeria	47%	2011	71%	2011	27	2012	130	2005	1.7%	2001	29.5%	2001	20.6%	2012
	Senegal	57%	2011	79%	2011	27	2012	104	2010	19.4%	Est 1995–2005	37.0%	Est 1995–2005	24.6%	2012
	Sierra Leone	45%	2011	74%	2011	27	2012	158	2003	17.6%	Est 1995–2005	74.8%	Est 1995–2005	27.2%	2012
	Cut off values:	40, 20, 5		40, 20, 5		40, 20, 10		300, 100, 50, 20		20, 10, 2		20, 10, 2		40, 20, 10	
							blue = excessive								

Annex 6: Food fortification legislation 42 countries

Region	Country	Salt		Vegetable oil		Wheat flour		Maize flour		Rice		Condiments/ sauces/other			Sources
		Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Product	Standards	
Asia/ Pacific	Afghanistan	M	KIO3 - 30-50 ppm	V	Vit. A - 7.2-10.8 ppm Vit. D - 0.06-0.09 ppm	V	NaFeEDTA - 12-18 ppm Zinc - 30 ppm Folic Acid - 1 ppm B12 - 0.008 ppm								Afghanistan Standards - UNICEF Report (Salt 2015) AS 475 (Oil 2014) AS? (Wheat 2013)
	Bangladesh	M 1989	KIO3 - 45-50 ppm	M 2015	Vit. A - 15-30 ppm					P					UNICEF Report (Salt 2015) Bangladesh Regulation (Oil 2015)
	Cambodia	M 2003	KIO3 - 50-60 ppm	V	Vit. A - 18 ppm					P		M 2015	Fish sauce	NaFeEDTA - 230-460 ppm Ferrous Sulphate - 230-460 ppm	IGN Newsletter (Salt 2013) Theary FNB (Oil 2013) NCN 48 (Fish/Soy Sauce 2012)
												M 2015	Soy sauce	NaFeEDTA - 230-460 ppm Ferrous Sulphate - 230-460 ppm	
	Lao PDR	M 1995	KIO3 - 40-60 ppm												UNICEF Report (Salt 2015)
	Myanmar	M	KIO3 - 40-60 ppm												UNICEF Report (Salt 2015)
	Nepal	M 1999	KIO3 - 50 ppm			M	Electrolytic Iron - 60 ppm Folic Acid - 1.5 ppm Vit. A - 1 ppm								UNICEF Report (Salt 2015) Gazette 11 (Wheat 2011)

Region	Country	Salt		Vegetable oil		Wheat flour		Maize flour		Rice		Condiments/ sauces/other			Sources
		Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Product	Standards	
	Pakistan	L	KIO3 - 30 ppm	M	Vit. A - 8.9-10.9 ppm	L	NaFeEDTA - 20 ppm Folic Acid - 1.3 ppm								Global Standards Review (Salt 2014) Punjab Decree (Wheat 2014) PS 2858 (Oil 2003)
	Sri Lanka	M 1995	KIO3 - 15-30 ppm												UNICEF Report (Salt 2015)
	Timor-Leste														
East/ South-ern Africa	**Burundi**	M 1992	KIO3 - 30-60 ppm	V 2015	Vit. A - 20-40 ppm	M	NaFeEDTA - 20-40 ppm Fer. Fumarate - 30-50 ppm Zinc - 60-116 ppm Folic Acid - 1.1-3.2 ppm B12 - 0.01-0.029 ppm Niacin - 30-90 ppm Riboflavin - 3.3-9.6 ppm Thiamin - 4.6-14.2 ppm Vit. A - 0.5-1.4 ppm	M	NaFeEDTA - 10-30 ppm Zinc - 33-65 ppm Folic Acid - 0.6-1.7 ppm B12 - 0.007-0.022 ppm Niacin - 14.9-43.4 ppm Riboflavin - 2.0-5.8 ppm Thiamin - 3.0-9.4 ppm Vit. A - 0.5-1.4 ppm	P		V	Sugar	Vit A. - 2-15 ppm	East Africa Standard - DEAS 35 (Salt 2011) DEAS 767 (Wheat 2011) DEAS 768 (Maize 2011) DEAS 769 (Oil 2011) DEAS 770 (Sugar 2011)
	Ethiopia	M 2011	KIO3 - 60-80 ppm	P		P									Ethiopian Standards Agency - ES 298 (Salt 2012)
	Kenya	M 2009	KIO3 - 30-60 ppm	M 2013	Vit. A - 20-40 ppm	M 2013	NaFeEDTA - 20-40 ppm Fer. Fumarate - 30-50 ppm Zinc - 60-116 ppm Folic Acid - 1.1-3.2 ppm B12 - 0.01-0.029 ppm Niacin - 30-90 ppm Riboflavin - 3.3-9.6 ppm	M 2013	NaFeEDTA - 10-30 ppm Zinc - 33-65 ppm Folic Acid - 0.6-1.7 ppm B12 - 0.007-0.022 ppm Niacin - 14.9-43.4 ppm			V 2013	Sugar	Vit A. - 2-15 ppm	East Africa Standard - DEAS 35 (Salt 2011) DEAS 767 (Wheat 2011) DEAS 768 (Maize 2011) DEAS 769 (Oil 2011) DEAS 770 (Sugar 2011)

Region	Country	Salt		Vegetable oil		Wheat flour		Maize flour		Rice		Condiments/ sauces/other			Sources
		Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Product	Standards	
							Thiamin - 4.6-14.2 ppm Vit. A - 0.5-1.4 ppm		Riboflavin - 2.0-5.8 ppm Thiamin - 3.0-9.4 ppm Vit. A - 0.5-1.4 ppm						
	Madagascar	M 1995	KIO3 - 50 ppm												Global Standards Review (Salt 2014)
	Malawi	M 1995	KIO3 - 80-100 ppm	M 2015	Vit. A - 30-40 ppm	M 2015	NaFeEDTA - 27-51 ppm Zinc - 60-116 ppm Folic Acid - 1.3-3.3 ppm B12 - 0.011-0.029 ppm Niacin - 33-87 ppm Riboflavin - 3.6-9.6 ppm Thiamin - 5.4-14.2 ppm Vit. A - 0.6-1.4 ppm	M 2015	NaFeEDTA - 21-41 ppm Zinc - 33-65 ppm Folic Acid - 0.7-1.7 ppm B12 - 0.008-0.022 ppm Niacin - 16.6-43.4 ppm Riboflavin - 2.2-5.8 ppm Thiamin - 3.6-9.4 ppm Vit. A - 0.6-1.4 ppm			M 2015	Sugar	Vit. A - 8-22 ppm	Malawi Bureau of Standards - Iodisation of Salt Act 52-02 (Salt 1998) MS 30 (Wheat 2011) MS 32 (Maize 1998) MS 51 (Oil 2011) MS 202 (White Sugar 2013) MS 209 (Raw Sugar 2013)
	Mozambique	M 2016	KIO3 - 40-80 ppm	M 2016	Vit. A - 15-43 ppm Vit. D - 0.15-1 ppm	M 2016	NaFeEDTA - 20-140 ppm Zinc - 30-269 ppm Folic Acid - 2-6 ppm B12 - 0.02 ppm Niacin - 45-210 ppm Riboflavin - 4 ppm	M 2016	NaFeEDTA - 20-117 ppm Zinc - 20-225 ppm Folic Acid - 2-5 ppm B12 - 0.02 ppm Niacin - 45-175 ppm Riboflavin -			M 2016	Sugar	Vit. A - 10-30 ppm	Catalogo de Normas Mocambicanas - NM 5 (Maize 2012) NM 7 (Wheat 2012) NM 9 (Salt 2012) NM 110 (Sugar 2012) NM 425 (Oil 2012)

Region	Country	Salt		Vegetable oil		Wheat flour		Maize flour		Rice		Condiments/ sauces/other			Sources
		Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Product	Standards	
							Thiamin - 5 ppm Vit. A - 2-18 ppm		4 ppm Thiamin - 5 ppm Vit. A - 1-15 ppm						
	Rwanda	M 1991	KIO3 - 30-60 ppm	M 2014	Vit. A - 20-40 ppm	M 2014	NaFeEDTA - 20-40 ppm Fer. Fumarate - 30-50 ppm Zinc - 60-116 ppm Folic Acid - 1.1-3.2 ppm B12 - 0.01-0.029 ppm Niacin - 30-90 ppm Riboflavin - 3.3-9.6 ppm Thiamin - 4.6-14.2 ppm Vit. A - 0.5-1.4 ppm	M 2014	NaFeEDTA - 10-30 ppm Zinc - 33-65 ppm Folic Acid - 0.6-1.7 ppm B12 - 0.007-0.022 ppm Niacin - 14.9-43.4 ppm Riboflavin - 2.0-5.8 ppm Thiamin - 3.0-9.4 ppm Vit. A - 0.5-1.4 ppm			M 2014	Sugar	Vit A. - 2-15 ppm	East Africa Standard - DEAS 35 (Salt 2011) DEAS 767 (Wheat 2011) DEAS 768 (Maize 2011) DEAS 769 (Oil 2011) DEAS 770 (Sugar 2011)
	Somalia														
	Sudan	M 2003	KIO3 - 25-35 ppm			V	Ferrous Sulphate - 40 ppm Folic Acid - 1.5 ppm								Global Standards Review (Salt 2003) ? (Wheat)

Region	Country	Salt		Vegetable oil		Wheat flour		Maize flour		Rice		Condiments/ sauces/other			Sources
		Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Product	Standards	
	Tanzania	M 1995	KIO3 - 30-60 ppm	M 2012	Vit. A - 20-40 ppm	M 2012	NaFeEDTA - 20-40 ppm Fer. Fumarate - 30-50 ppm Zinc - 60-116 ppm Folic Acid - 1.1-3.2 ppm B12 - 0.01-0.029 ppm Niacin - 30-90 ppm Riboflavin - 3.3-9.6 ppm Thiamin - 4.6-14.2 ppm Vit. A - 0.5-1.4 ppm	M 2012	NaFeEDTA - 10-30 ppm Zinc - 33-65 ppm Folic Acid - 0.6-1.7 ppm B12 - 0.007-0.022 ppm Niacin - 14.9-43.4 ppm Riboflavin - 2.0-5.8 ppm Thiamin - 3.0-9.4 ppm Vit. A - 0.5-1.4 ppm			V 2012	Sugar	Vit A. - 2-15 ppm	East Africa Standard - DEAS 35 (Salt 2011) DEAS 767 (Wheat 2011) DEAS 768 (Maize 2011) DEAS 769 (Oil 2011) DEAS 770 (Sugar 2011)
	Uganda	M 1994	KIO3 - 30-60 ppm	M 2013	Vit. A - 20-40 ppm	M 2013	NaFeEDTA - 20-40 ppm Fer. Fumarate - 30-50 ppm Zinc - 60-116 ppm Folic Acid - 1.1-3.2 ppm B12 - 0.01-0.029 ppm Niacin - 30-90 ppm Riboflavin - 3.3-9.6 ppm Thiamin - 4.6-14.2 ppm Vit. A - 0.5-1.4 ppm	M 2013	NaFeEDTA - 10-30 ppm Zinc - 33-65 ppm Folic Acid - 0.6-1.7 ppm B12 - 0.007-0.022 ppm Niacin - 14.9-43.4 ppm Riboflavin - 2.0-5.8 ppm Thiamin - 3.0-9.4 ppm Vit. A - 0.5-1.4 ppm			V	Sugar	Vit A. - 2-15 ppm	East Africa Standard - DEAS 35 (Salt 2011) DEAS 767 (Wheat 2011) DEAS 768 (Maize 2011) DEAS 769 (Oil 2011) DEAS 770 (Sugar 2011)

Region	Country	Salt		Vegetable oil		Wheat flour		Maize flour		Rice		Condiments/ sauces/other			Sources
		Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Product	Standards	
	Zambia	M 1994	KIO3 - 50 ppm	V 1998		V 1998		V 1998				M 1998	Sugar		Zambia Bureau of Standards - Food and Drug Act (Salt 1994) ZS 234 (Oil 2005) ? (Sugar)
	Zimbabwe	M 1993		V		V		V				V	Sugar		Standards Association of Zimbabwe - ZWS 532 (Salt 1997)
Latin America	Cuba	M 1999	KIO3 - 18-23 ppm			M	Fer. Sulphate - 45-65 ppm Folic Acid - 1.8-1.9 ppm B12 - 0.004 ppm Niacin - 45-46 ppm Riboflavin - 6-7 ppm Thiamin - 5-6 ppm								Norma Cubana - Global Standards Review (Salt 2014) NC 877 (Wheat 2012)
	Guatemala	M 1993	KIO3 - 20-60 ppm	M		M	Ferrous Fumarate - 55 ppm Folic Acid - 1.8 ppm Niacin - 55 ppm Riboflavin - 4.2 ppm Thiamin - 6.2 ppm	M	Unspecified Iron - 38.2 ppm Zinc - 33 ppm Folic Acid - 1.64 ppm B12 - 0.0051 ppm Niacin - 46 ppm Riboflavin - 3.7 ppm Thiamin - 4.7 ppm			M	Sugar	Vit A. - 13-17 ppm	Acuerdo Gubernativo 29-2004 (Salt 2004) ? (Oil) RTCA 67.01.15:07 (Wheat 2007) Acuerdo Guvernativo Numero 298-2015 (Maize 2015) NGO 34 034 (Sugar 1987)
	Haiti					M	Unsp. Iron - 29-46 ppm Niacin - 35-65 ppm Riboflavin - 2.7-4.8 ppm Thiamin - 4.4-7.7 ppm								FFI Website (Wheat 2016)

Region	Country	Salt		Vegetable oil		Wheat flour		Maize flour		Rice		Condiments/ sauces/other			Sources
		Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Product	Standards	
	Honduras	M 1971	KIO3 - 50-100 ppm	M	Vit. A - 10.5 ppm Vit. D - 0.0375 ppm	M	Ferrous Fumarate - 55 ppm Folic Acid - 1.8 ppm Niacin - 55 ppm Riboflavin - 4.2 ppm Thiamin - 6.2 ppm					M 1976	Sugar		Global Standards Review (Salt 2014) SAFO Report (Oil) RTCA 67.01.15:07 (Wheat 2007)
Middle East	Yemen	M 1996	KIO3 - 40 ppm			M	Iron - 30 ppm Folic Acid - 1.8 ppm Niacin - 55 ppm Riboflavin - 4.2 ppm Thiamin - 6.2 ppm Vit. D - 0.014 ppm								Gulf Cooperation Concil - Global Standards Review (Salt 2014) GSO 194 (Wheat 2006)
West/ Central Africa	Angola	M 1996	KIO3 - 36 ppm												Global Standards Review (Salt 2014)
	Benin	M 1994	KIO3 - 20-40 ppm	M 2008	Vit. A - 11-24 ppm	M 2008	Ferrous Fumarate - 60 ppm Zinc - 55 ppm Folic Acid - 2.6 ppm B12 - 0.02 ppm Niacin - 36.18 ppm Riboflavin - 2.79 ppm Thiamin - 2.79 ppm					V	Bouillon Cubes	Iron Fortified by Nestlé	Global Standards Review (Salt 2014) West Africa Harmonised Standards (Oil 2014) FFI Website (Wheat 2016) ? (Bouillon)
	Burkina Faso	M 2003	KIO3 - 50-80 ppm	M	Vit. A - 11-24 ppm	M	Ferrous Fumarate - 60 ppm Zinc - 55 ppm Folic Acid - 2.6 ppm B12 - 0.02 ppm Niacin - 36.18								Global Standards Review (Salt 2014) West Africa Harmonised Standards (Oil 2014) FFI Website (Wheat 2016)

Region	Country	Salt		Vegetable oil		Wheat flour		Maize flour		Rice		Condiments/ sauces/other			Sources
		Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Product	Standards	
							ppm Riboflavin - 2.79 ppm Thiamin - 2.79 ppm								
	Cameroon	M 1995		M 2012		M 2012	Ferrous Fumarate - 60 ppm Zinc - 55 ppm Folic Acid - 2.6 ppm B12 - 0.02 ppm Niacin - 36.18 ppm Riboflavin - 2.79 ppm Thiamin - 2.79 ppm					V	Bouillon Cubes	Iron Fortified by Nestlé	? (Salt) ? (Oil) FFI Website (Wheat 2016) ? (Bouillon)
	Chad	M 1994	KIO3 - 83-135 ppm												Decree 94-499 (Salt)
	Côte d'Ivoire	M 1994	KIO3 - 84-135 ppm	M 2007	Vit. A - 11-24 ppm	M 2007	Ferrous Fumarate - 60 ppm Zinc - 55 ppm Folic Acid - 2.6 ppm B12 - 0.02 ppm Niacin - 36.18 ppm Riboflavin - 2.79 ppm Thiamin - 2.79 ppm					V	Bouillon Cubes	Iron Fortified by Nestlé	NI 336 (Salt 2001) West Africa Harmonised Standards (Oil 2014) FFI Website (Wheat 2016) ? (Bouillon)
	Dem. Rep. Congo	M 1993	KIO3 - 80-100 ppm			V	Ferrous Sulphate - 45 ppm Folic Acid - 1.5 ppm								Global Standards Review (Salt 2014) FFI Website (Wheat 2016)
	Gambia					V	Ferrous Fumarate - 60 ppm								FFI Website (Wheat 2016)

Region	Country	Salt		Vegetable oil		Wheat flour		Maize flour		Rice		Condiments/ sauces/other			Sources
		Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Product	Standards	
							Folic Acid - 2.6 ppm								
	Guinea-Bissau	M 1995	KIO3 - 100 ppm	M	Vit. A - 11-24 ppm	M	Ferrous Fumarate - 60 ppm Zinc - 55 ppm Folic Acid - 2.6 ppm B12 - 0.02 ppm Niacin - 36.18 ppm Riboflavin - 2.79 ppm Thiamin - 2.79 ppm								Global Standards Review (Salt 2014) West Africa Harmonised Standards (Oil 2014) FFI Website (Wheat 2016)
	Mali	M	KIO3 - 50 ppm	V 2007	Vit. A - 11-24 ppm	M 2007	Ferrous Fumarate - 60 ppm Zinc - 55 ppm Folic Acid - 2.6 ppm B12 - 0.02 ppm Niacin - 36.18 ppm Riboflavin - 2.79 ppm Thiamin - 2.79 ppm	M 2007				V	Bouillon Cubes	Iron Fortified by Nestlé	Global Standards Review (Salt 2014) West Africa Harmonised Standards (Oil 2014) FFI Website (Wheat 2016) ? (Bouillon)
	Mauritania	M		M 2010		M 2010	Ferrous Fumarate - 60 ppm Zinc - 55 ppm Folic Acid - 2.6 ppm B12 - 0.02 ppm Niacin - 36.18 ppm Riboflavin - 2.79 ppm Thiamin - 2.79 ppm								? (Salt) ? (Oil) FFI Website (Wheat 2016)

Region	Country	Salt		Vegetable oil		Wheat flour		Maize flour		Rice		Condiments/ sauces/other			Sources
		Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Product	Standards	
	Niger	M 2004	KIO3 - 80-100 ppm	M	Vit. A - 11-24 ppm	M	Ferrous Fumarate - 60 ppm Zinc - 55 ppm Folic Acid - 2.6 ppm B12 - 0.02 ppm Niacin - 36.18 ppm Riboflavin - 2.79 ppm Thiamin - 2.79 ppm	V				V	Bouillon Cubes	Iron Fortified by Nestlé	Global Standards Review (Salt 2014) West Africa Harmonised Standards (Oil 2014) FFI Website (Wheat 2016) ? (Maize) ? (Bouillon)
	Nigeria	M 1994	KIO3 - 84.3 ppm	M 2002	Margarine: Vit. A - 7.8-9.9 ppm Vit. D - 0.7-0.825 ppm Oils: Vit. A - 6 ppm	M 2002	NaFeEDTA - 40 ppm Zinc - 50 ppm Folic Acid - 2.6 ppm B12 - 0.02 ppm Niacin - 45 ppm Riboflavin - 5 ppm Thiamin - 6 ppm Vit. A - 2 ppm	M 2002	NaFeEDTA - 40 ppm Zinc - 50 ppm Folic Acid - 2.6 ppm B12 - 0.02 ppm Niacin - 45 ppm Riboflavin - 5 ppm Thiamin - 6 ppm Vit. A - 2 ppm			V M 2002	Bouillon Cubes Sugar	Iron Fortified by Nestlé Vit. A - 7.5 ppm	Nigerian Industrial Standard - Global Standards Review (Salt 1994) NIS 230, NIS 289, NIS 243, and NIS 387-394 (Oil 2000) NIS 121 and NIS 396 (Flour 2010) NIS 718 and NIS 723 (Maize 2010) ? (Bouillon) NIS 90, NIS 383, and NIS 438 (Sugar 2000)
	Senegal	M 2000	KIO3 - 80-100 ppm	M 2009	Vit. A - 11-24 ppm	M 2009	Ferrous Fumarate - 60 ppm Zinc - 55 ppm Folic Acid - 2.6 ppm B12 - 0.02 ppm Niacin - 36.18 ppm Riboflavin - 2.79 ppm Thiamin - 2.79 ppm					V	Bouillon Cubes	Iron Fortified by Nestlé	Global Standards Review (Salt 2014) West Africa Harmonised Standards (Oil 2014) FFI Website (Wheat 2016) ? (Bouillon)

Region	Country	Salt		Vegetable oil		Wheat flour		Maize flour		Rice		Condiments/ sauces/other			Sources
		Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Standards	Leg.	Product	Standards	
	Sierra Leone	M 2010	KIO3 - 100 ppm	M	Vit. A - 17.4-22.6 ppm	M	Unsp. Iron - 58.8 ppm Zinc - 28.3 ppm Folic Acid - 2.08 ppm B12 - 0.01 ppm Niacin - 59 ppm Riboflavin - 4.5 ppm Thiamin - 8.4 ppm Vit. A - 2 ppm					M	Sugar	Vit. A - 8-22 ppm	Sierra Leone Standard - SLS 30 (Salt 2010) SLS 41 (Oil 2010) SLS 39 (Wheat 2010) SLS 3 (Sugar 2010)
		M	Mandatory												
		V	Voluntary												
		P	Planning												
		L	Localised (Mandatory in Some States Only)												

Annex 7: Food fortification implementation processes, key support projects and status of advancement in the 42 countries

An approach being used to implement sustainable and impactful national fortification programmes is shown in Figure A7.1 below. This approach indicates the three key stages of the progression of national programmes, which influence the type of intervention and set of activities required to maximise impacts. While there is no 'hard criteria' to determine when countries progress between these stages, rules of thumb are also indicated:[378]

1. *Build/expand.* During this stage, the appropriate food vehicles and fortificants for fortification are chosen, legislation and standards are developed, fortification alliances are established, and advocacy is designed and targeted to bring key stakeholders on board. At this stage, less than half of the fortifiable food vehicle is being adequately fortified according to the relevant standard.

2. *Improve*. During this stage, fortification has already started, but targeted technical inputs are required to strengthen capacity at industry level for QA/QC and increased production volumes and at government level to improve the quality and consistency of inspections, enforcement, and testing. Monitoring information systems and frameworks are put in place to ensure quality improvements are institutionalised. At this stage, between 50–79% of the fortifiable food vehicle is adequately fortified.

3. *Measure impact/sustain progress*. During this stage, gains in coverage and quality are sustained over time through targeted training and advocacy inputs, while the programme effectiveness and impact on micronutrient status is measured. Results feedback to activities within the first two stages for targeted expansion and to improvements that may need to happen based on shifts in consumption patterns, production and import patterns, or changes to the enabling environment. At this stage, 80% or more of the fortifiable food vehicle is adequately fortified.

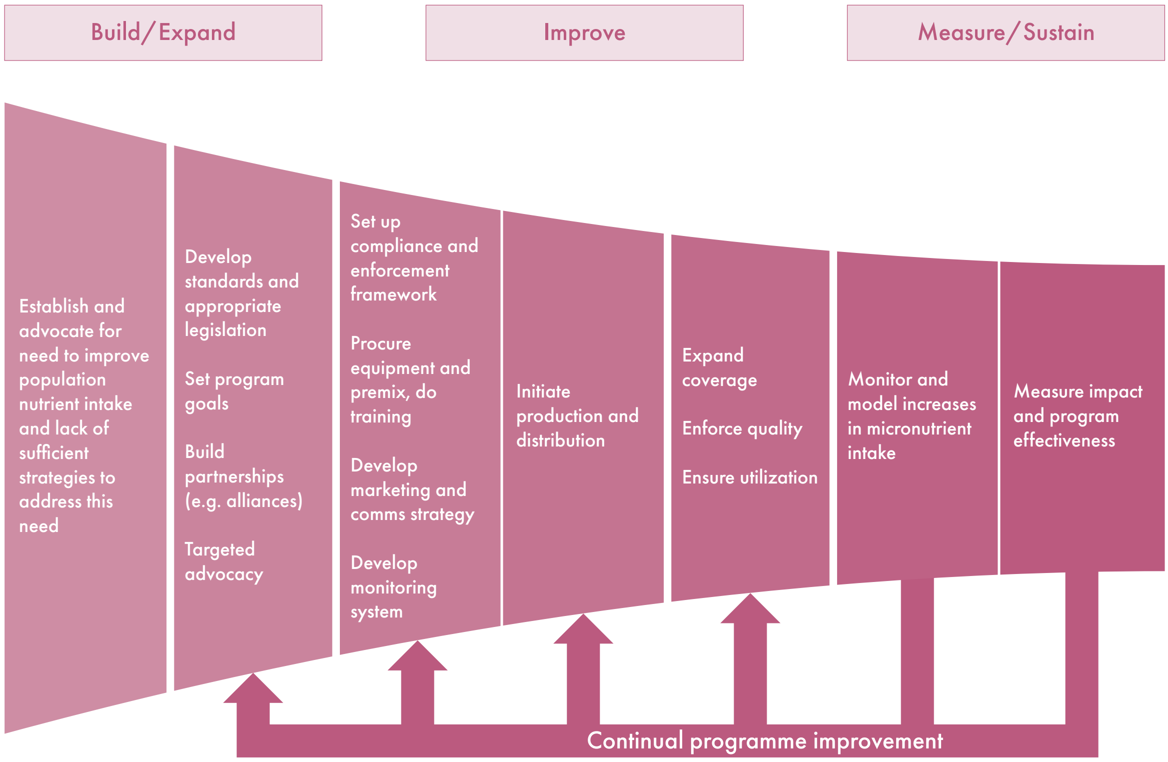
Based on current data availability and the criteria laid out above, each of the EC priority countries has been categorised as being in the *build*, *improve*, or *sustain* stages for each relevant food vehicle (see Table A7.1). Note that blank cells in the table indicate that a particular food vehicle is not likely relevant to the country in question, primarily owing to it not being commonly consumed in quantities relevant for industrial-scale fortification (i.e. at least 10g/capita/day for vegetable oil and at least 75g/capita/day for grains). This is not an indication of where new fortification programmes should be supported, but only an indication of vehicle relevance and potential consideration upon looking at several other important

[378] For more information on definitions and criteria for each programming stage, refer to Garrett, GS et al. (2016) Recommendations for food fortification programs: Technical Advisory Group report elaborating on the five recommendations from the #FutureFortified Global Summit on Food Fortification. *Sight and Life* July, http://www.sightandlife.org/fileadmin/data/Magazine/2016/Suppl_to_1_2016/ FutureFortified.pdf (accessed 30 September 2016).

factors (i.e. micronutrient deficiency causal analysis and consumption patterns stratified by various population groups, including by age, wealth, and geography.)

Table A7.1 also gives an indication of key fortification projects that have been supported by various donor agencies and technical support partners in the past 20 years. This is not an exhaustive list, but only meant to be indicative of current and previous technical and financial support countries have received in the past for fortification activities.

Figure A7.1: National food fortification implementation stages[379]



[379] GAIN (2016) internal model.

Table A7.1: Categorisation of EC priority countries on nutrition, with indication of key support projects

Country	Salt	Veg oil	Wheat flour	Maize flour	Rice	Sugar	Fish/soy sauce	Past and current support project, lead, duration
Afghanistan	Improve	Build	Build					1. USAID-funded wheat, oil and salt fortification project, GAIN, Sept 2015–Sept 2017 2. KBZF-funded salt iodisation project, GAIN, 2011–2014
Angola	Build	Build	Build	Build				None
Bangladesh	Improve	Improve			Build			1. Netherlands-funded oil and salt fortification project, GAIN, 2013–June 2017 2. BMGF-funded salt iodisation, GAIN and UNICEF Partnership, 2009–2015 3. Canada-funded salt fortification project, MI, unknown
Benin	Improve	Improve		Build	Build			USAID-funded, Partnership for Sustainable Food Fortification in West Africa (Fortify West Africa), HKI, January 2011 – 30 January 2017
Burkina Faso	Improve	Improve		Build				USAID-funded, Partnership for Sustainable Food Fortification in West Africa (Fortify West Africa), HKI, January 2011 – 30 January 2017
Burundi	Build	Build	Build	Build				Previous: Project Healthy Children fortification advocacy project. Ended in 2015
Cambodia	Improve	Build			Build		Build	Previous: BMGF-funded condiment fortification project, GAIN, 2010–2015
Cameroon	Improve	Build		Build				USAID-funded, Partnership for Sustainable Food Fortification in West Africa (Fortify West Africa), HKI, January 2011 – 30 January 2017
Chad	Build							None
Côte d'Ivoire	Improve	Improve			Build			1. BMGF-funded wheat flour (Iron, Zinc, Folic Acid, B-vitamins) and vegetable oil (vitamin A) project, GAIN, 2005–2009 2. USAID-funded, Partnership for Sustainable Food Fortification in West Africa (Fortify West Africa), HKI, January 2011 – 30 January 2017
Cuba	Improve	Build	Build		Build			None
DRC	Build	Build						None
Ethiopia	Improve	Build	Build					1. Netherlands-funded oil and salt fortification project, GAIN, 2016–June 2017 2. Canada-funded salt fortification project, MI, unknown
Gambia	Build	Build	Build					USAID-funded, Partnership for Sustainable Food Fortification in West Africa (Fortify West Africa), HKI, January 2011 – 30 January 2017
Guatemala	Improve	Sustain	Sustain	Sustain		Sustain		None recently, several projects in the 70s and 80s

Country	Salt	Veg oil	Wheat flour	Maize flour	Rice	Sugar	Fish/soy sauce	Past and current support project, lead, duration
Guinea-Bissau	Improve	Improve						USAID-funded, Partnership for Sustainable Food Fortification in West Africa (Fortify West Africa), HKI, January 2011 – 30 January 2017
Haiti	Build	Build		Build	Build			None
Honduras	Improve	Sustain	Sustain	Sustain		Sustain		None recently, several projects in the 70s and 80s.
Kenya	Improve	Sustain	Build	Build				Previous: BMGF-funded oil, wheat and maize fortification, GAIN, 2011–2015
Lao PDR	Build				Build		Build	None
Madagascar	Build							None
Malawi	Improve	Build		Build		Sustain		Previous: Project Healthy Children fortification advocacy project. Ended in 2015 Irish Aid-Sugar fortification support – 2010–2014
Mali	Build	Improve		Build				1. BMGF-funded oil and rive fortification project, GAIN, 2004–2008 2. USAID-funded, Partnership for Sustainable Food Fortification in West Africa (Fortify West Africa), HKI, January 2011–30 January 2017
Mauritania	Build	Improve	Build					None
Mozambique	Improve	Improve	Improve	Build		Build		1. EU-funded fortification project, WFP 2. USAID-funded fortification project, GAIN, Oct 2016–Sept 2017 3. UNICEF Salt Iodisation Support – July 2016–Sept 2017 4. Irish Aid-funded fortification support, HKI, unknown
Myanmar	Build	Build			Build			1. unknown funding for rice fortification support, PATH, unknown
Nepal	Improve	Build	Build	Build	Build			None
Niger	Build	Build						1. BMGF-funded salt iodisation project, GAIN and UNICEF Partnership, 2009–2015 2. USAID-funded, Partnership for Sustainable Food Fortification in West Africa (Fortify West Africa), HKI, January 2011 – 30 January 2017
Nigeria	Improve	Build	Sustain	Build	Build	Improve		Previous: Gates-funded oil, wheat, sugar and salt fortification, GAIN, 2008–2015
Pakistan	Improve	Improve	Improve					1. BMGF-funded salt iodisation project, GAIN and UNICEF Partnership, 2009–2015 2. USAID-funded wheat and oil fortification, GAIN, Sept 2015–Sept 2017 3. DFID-funded wheat and oil fortification, Mott McDonald, March 2016–March 2020

Country	Salt	Veg oil	Wheat flour	Maize flour	Rice	Sugar	Fish/soy sauce	Past and current support project, lead, duration
Rwanda	Build	Build						Project Healthy Children fortification advocacy project. Ongoing
Senegal	Build	Sustain	Sustain		Build			1. BMGF-funded oil, wheat and salt fortification, GAIN, 2009–2015 2. USAID-funded, Partnership for Sustainable Food Fortification in West Africa (Fortify West Africa), HKI, January 2011 – 30 January 2017
Sierra Leone	Improve	Improve						USAID-funded, Partnership for Sustainable Food Fortification in West Africa (Fortify West Africa), HKI, January 2011 – 30 January 2017
Somalia	Build							None
Sri Lanka	Improve		Build		Build			None
Sudan	Build	Build	Build					None
Tanzania	Improve	Improve	Sustain	Build				1. James Percy-funded QA/QC project, GAIN, September 2016–Sept 2018 2. Gates-funded fortification catalyst project, GAIN, 2011–2015 3. DFID-funded fortification project, HKI, 2012–2015
Timor-Leste	Build	Build		Build	Build			None
Uganda	Improve	Improve	Improve	Improve				Previous: Gates-funded oil, wheat and maize fortification, GAIN, 2009–2013
Yemen	Build	Build	Build					None
Zambia	Build	Build	Build	Build		Sustain		Previous: Gates-funded maize fortification, GAIN, 2009–2011
Zimbabwe	Build	Build	Build	Build		Build		Project Healthy Children fortification advocacy project. Ongoing

Annex 8: HarvestPlus biofortified crops released – June 2016

Biofortified Crops Released - June 2016

Fourteen biofortified crops are being grown in more than 32 African, Asian, and Latin American countries with 15 million people benefitting from eating more nutritious biofortified foods.

IRON BEANS

- Bolivia
- Brazil
- Colombia
- DR Congo
- El Salvador
- Guatemala
- Honduras
- Kenya (t)
- Malawi
- Nicaragua
- Panama
- Rwanda
- Tanzania
- Uganda
- Zimbabwe

VIT A SWEET POTATO

- Bangladesh
- Brazil
- Burkina Faso
- Burundi
- China
- Ethiopia
- Ghana
- Guatemala
- India
- Kenya
- Madagascar
- Malawi
- Mozambique
- Nicaragua (t)
- Nigeria
- Panama (t)
- Rwanda
- South Africa
- Tanzania
- Uganda
- Zambia

VIT A CASSAVA

- Brazil
- Cameroon (t)
- Colombia (t)
- DR Congo
- Ethiopia (t)
- Ghana
- Guatemala (t)
- Kenya (t)
- Malawi
- Mozambique (t)
- Nigeria
- Panama (t)
- Sierra Leone
- Tanzania (t)
- Uganda (t)
- Zambia (t)

VIT A MAIZE

- Brazil
- Cameroon (t)
- China (t)
- Colombia (t)
- DR Congo
- Ethiopia (t)
- Ghana
- India (t)
- Kenya (t)
- Malawi
- Mali
- Mozambique
- Nepal (t)
- Nigeria
- Pakistan
- Panama (t)
- Rwanda (t)
- Sierra Leone (t)
- South Africa (t)
- Tanzania (t)
- Uganda (t)
- Zambia
- Zimbabwe

ZINC MAIZE

- Colombia (t)
- El Salvador (t)
- Guatemala (t)
- Honduras (t)
- Nicaragua (t)
- Panama (t)

ZINC RICE

- Bangladesh
- Bolivia (t)
- Brazil (t)
- China (t)
- Colombia (t)
- Guatemala (t)
- India
- Nicaragua (t)
- Panama (t)

IRON PEARL MILLET

- Burkina Faso (t)
- Ghana (t)
- India
- Mali
- Tanzania (t)

ZINC WHEAT

- Bolivia
- Bangladesh (t)
- Brazil (t)
- China (t)
- Ethiopia (t)
- India
- Nepal (t)
- Pakistan (t)
- South Africa (t)

IRON/ZINC LENTIL

- Bangladesh
- Ethiopia (t)
- India
- Nepal
- Pakistan (t)

IRON/ZINC COWPEA

- Brazil
- India
- Nigeria (t)

IRON IRISH POTATO

- Ethiopia (p)
- Rwanda (p)

VIT A SQUASH

- Brazil (t)

IRON/ZINC SORGHUM

- India (t)
- Mali (t)
- Nigeria (t)

VITAMIN A BANANA

- Burundi
- Cameroon
- DR Congo
- Nigeria
- Rwanda (t)
- Tanzania (t)
- Uganda (t)

(t) = pending release

Annex 9: WHO technical consultation on biofortification, 6–8 April 2016: list of peer review papers

No.	Title	Objective
1	Biofortified crops: agronomic biofortification, conventional plant breeding, and bio-engineering	To review the different food technologies for biofortification with special emphasis on agronomic biofortification, conventional plant breeding and bio-engineering.
		To analyse and compare the applicability of those technologies worldwide, highlighting risks and benefits of each one in relation to health and nutrition, as well as to environmental, economic and ecological aspects.
2	Biofortified crops production, use and consumption	To define and describe the worldwide market for biofortified crops, characteristics and trends, considering the different options in food technologies for biofortification and a wide range of biofortified crops based on continental, regional and national practices.
		To establish an analysis of consumption patterns of the different types of biofortified crops.
		To prepare a map of current biofortified crop production, availability and use by WHO regions and summarise any available data on consumption worldwide.
3	Bioavailability of biofortified crops	To review the factors that affect bioavailability of key micronutrients in biofortified crops with special emphasis on iron, vitamin A and zinc. Consider the chemical and physical properties of the biofortified crops and also of complete meals or special cooking or dietary practices.
		To summarise the common changes in stability of key micronutrients in biofortified crops during their production and through the food processing, packaging, storage, cooking and meal preparation.
		To review positive and negative effects of the interactions among multiple nutrients in biofortified crops.
4	Models for estimating nutrient fortification levels in different biofortified crops	To describe the different approaches that can be used to estimate safe and efficacious amounts of key micronutrients in biofortified crops, clearly stating mathematical assumptions and considerations in terms of stability, bioavailability, cost and diet.
5	Economic feasibility and impact of biofortified crops: from consumers to added productivity and economic development	To review the financial issues related to the introduction of biofortified crops in different settings, considering facilitating and hindering factors to their production and consumption. Considerations for the inclusion of biofortified crops in countries with different levels of seed and food market development.
		To review the effect of biofortified crops on the local economy, agricultural sector, social protection, education, and water and sanitation. Include an economic, social and environmental analysis of the cost of biofortified crop production.
		To review of the supply chain: from seeds to the table.
6	Legal framework for biofortified crop production	To describe the legal framework for the production and use of biofortified crops, differences in regulations for agronomic biofortification, conventional plant breeding, and bio-engineering. Economic and health advantages and disadvantages of regulatory processes for biofortified crops. Provide specific examples in countries with pro and against policies and regulations about them.

No.	Title	Objective
		Review regional and global legal frameworks for harmonisation of regulations to maintain safety and quality standards and to reconcile law requirements with the technology and the possible benefits involved.
7	Food safety and environmental considerations of biofortified crops	To describe benefits and risks of biofortified staple crops on nutrition and other health-related outcomes in populations.
		To review the acceptability of the biofortified crops and foods and need for changes in cultural or dietary habits.
		To review evidence on effects of biofortification on biodiversity and in health issues, including long-term effects on consumers' health, agricultural biodiversity and dietary diversity.
8	Determinants of equity in access to biofortified crops	To identify factors preventing the consumption of biofortified crops and their differential impact across social groups (e.g. women, children, elderly, rural populations), especially among those who are most vulnerable to micronutrient deficiencies.
		Include equity considerations on access to biofortified seeds, crops or products including the autonomy of less educated people to adopt any new technology or product, or the possible inequities on seed dissemination depending on the seed market in the country.
9	Seed markets, trade and intellectual property	To describe the mechanisms for distributing or sharing better crops and products with the global community, including higher-yielding varieties or enhanced nutritional foods.
		To review the impact of biofortification on productivity and improvements in the livelihoods of adopting/consuming households. Review the process of technology transfer from laboratories or technicians to the field. Also suggest mechanisms for the incorporation of farmers and small-scale producers in the process of developing biofortified varieties that are acceptable by both producers and consumers.
10	Ethical considerations in biofortification of crops	The access to foods, including biofortified crops, raises a number of ethical issues. These include questions about the respect for religious beliefs, protection of vulnerable groups and respect for consumers' choices, to name a few.
		To review ethical considerations about biofortified crops. To describe how biofortification as part of integrated strategies in public health, needs to be planned and implemented.
11	Country experiences and case studies	To describe the country's experience and history of biofortification – from inception to current status.
		To highlight challenges in the process of introducing biofortification as a technology and approach for addressing micronutrient malnutrition.
		To describe some elements/factors for success and key steps in moving from research to implementation, highlighting achievements and the impact of the programme and plans for sustainability.

Source: http://www.who.int/nutrition/callforauthors_staplecrops_biofortified_vitminarels/en/ (accessed 23 June 2016)

Annex 10: The GAIN/UNICEF USI partnership project

The GAIN / UNICEF USI Partnership project[380] was financed by the Bill & Melinda Gates Foundation. It had a total financial value of US$ 39,998,865, with an implementation period of 8 years (from 2008 to 2016). Originally, it covered 14 priority countries selected for having a large population not yet protected against iodine deficiency: Bangladesh, China, Egypt, Ethiopia, Ghana, India, Indonesia, Niger, Pakistan, Philippines, Russia, Senegal, Nigeria and Ukraine. In the fifth year, Madagascar and Sudan were added to the project in order to address important USI programmatic gaps.

Table A11.1: Main project activities

Act.	Title	Description	% of budget
1	Project coordination and management	- Hiring the project team - Organisation of steering committee meetings	10
2	Global supply	- Development of guidelines for regulatory monitoring and QA/QC - Support global dissemination of KIO3 - Establishment of the global premix facility - Development of a business model for consolidated small-scale salt production	12
3	Global advocacy	- Global advocacy with donor, transnational industry, civil society - Achieve global consensus on salt iodisation and sodium reduction strategies - Coalition and network-building - Promote comprehensive and integrated fortification - Support development of integrated communication and advocacy strategy - Support harmonisation of regional trade and standards	
4	Global evidence and results	- Development of performance measurement framework - Building and maintaining a technical advisory consultant roster - Develop informed programme guidance for elimination of IDD	3
5-9	National-level coordination, planning, implementation	- Conduct situational assessments in countries - Development of national strategy plans for each country -.Establishment of Partnership management and bi-annual Partnership work plans -.Ensuring operational implementation and financial modality mechanism	67
10	National-level M&E	- Development of national M&E plans - Conduct periodic sub-national coverage surveys - Capacity strengthening of national counterparts - Conduct baseline and end-line surveys	2
		Indirect costs	7

[380]GAIN/UNICEF (2016) *Global Development Final Report, Intensification of Business-Oriented Approaches towards the Global Elimination of Iodine Deficiency through Universal Salt Iodization*. Geneva/New York, March.

The Partnership project faced a series of challenges, which had an impact on overall levels of success:

- Difficulty to scale up USI in settings with fragmented salt industry, e.g. Ghana, the Philippines and Senegal. The project concluded that future investments in the promotion of iodisation towards small-scale salt producers might not be a viable route towards eliminating ID without some mechanism to better consolidate small producers. Market-based approaches for USI require a certain level of industry consolidation for which sustainable business models on iodised salt can be developed. This is the case in India and Ethiopia, for example, where central iodisation facilities are under discussion or have been established in close collaboration between the Salt Producers Associations and government agencies.
- USI achievements are difficult to sustain in case of insufficient political commitment, resulting in a shift to other public health and nutrition priorities. In collaboration with SUN, FFI and HF-TAG, the project undertook substantial advocacy on USI, targeted at policy-makers, national coalitions and fortification alliances.
- Limited regulatory monitoring leads to poor compliance of salt producers with national standards. The project developed training guidelines for regulatory monitoring of USI programmes, and organised contextualised training sessions in a number of countries. The USI regulatory monitoring still needs integrating into the already established food safety and quality control systems within national governments.
- Despite intensive efforts to increase the coverage of iodised salt, certain segments of the population remain unreached. The project succeeded in promoting the inclusion of USI in public distribution systems (e.g. in India) and, through various studies, explored how best to market iodised salt targeting different sub-groups of the population. This entailed assessing the viability to collaborate with small-scale salt producers; promotion of the use of iodised salt in condiments and sauces which are widely used by marginal groups; knowledge generation on the types of salt being consumed by the different groups; studies on the types of packaging that would be best liked by these sub-groups; and assessment of the knowledge gaps on USI among these population groups.
- The need to integrate salt reduction and USI programmes. The project collaborated with WHO/PAHO for organisation of international meetings and a publication of guidelines for how national governments can implement such integrated programmes. Further work is still needed on the development of improved monitoring tools and guidance on joint data collection and analysis.

In most of the countries covered, the partnership was able to quantify the project's results in terms of iodised salt consumption. Over the project period, the overall coverage with adequately iodised salt has slightly increased from 72.5% to 75.0%. The increase in proportion of the population reached with salt containing any iodine was also moderate: from 85.2% to 89.8%. Coverage was generally found to be somewhat higher among households with a higher socioeconomic status. Further analysis at country level revealed that very large achievements were made in Ethiopia, Pakistan and Senegal, while slight improvements or consolidation took place in Egypt, China, India, Indonesia and the Philippines. However, in Bangladesh, Ghana and Niger, a negative trend was observed that is currently under investigation for potential enabling environment, supply-side, and demand-side factors that could have resulted in this.

These results match the available information on national-level trends in iodine nutrition. The end-line median UIC among school-age children was satisfactory (> 100 µg/l) for all countries, while the baseline data indicated this was not the case in Ethiopia and Pakistan at the beginning of the project. The impact on iodine nutrition among women of reproductive age was less convincing; end-line results indicated a persistence of problems in Ethiopia, Senegal and Pakistan.

Annex 11: Examples of food fortification logos from selected LMICs

Fortified food logo from Solomon Islands

The logo at left was created by Solrice (the leading rice importing company in Solomon Islands) for use on all domestically produced fortified foods as well as imported rice and wheat flour in that island nation.

Fortified food logo from Morocco

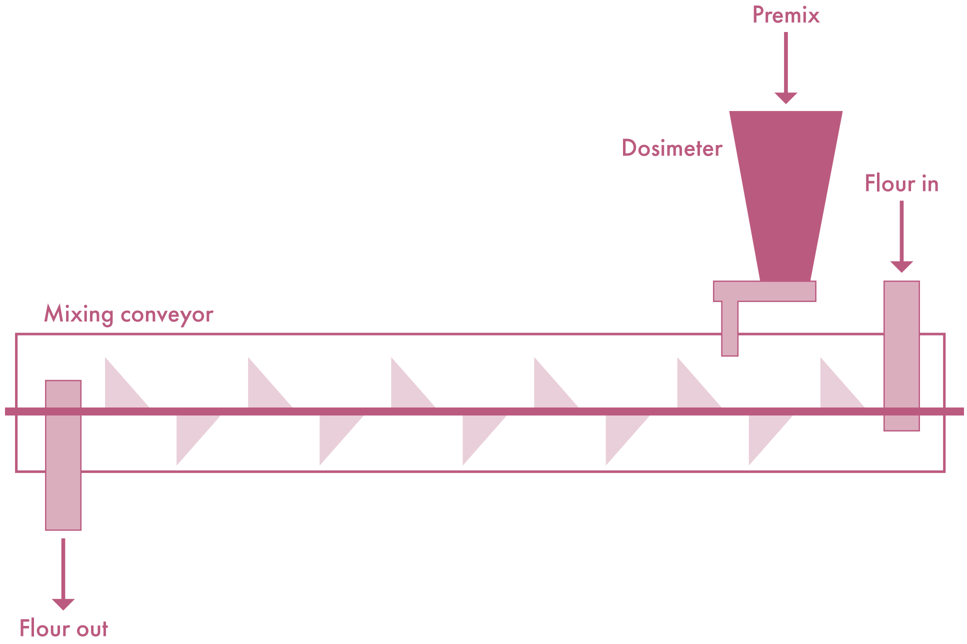
Fortified food logo from S. Africa

Fortified food logo from Uganda

Fortified bread logo from Vietnam

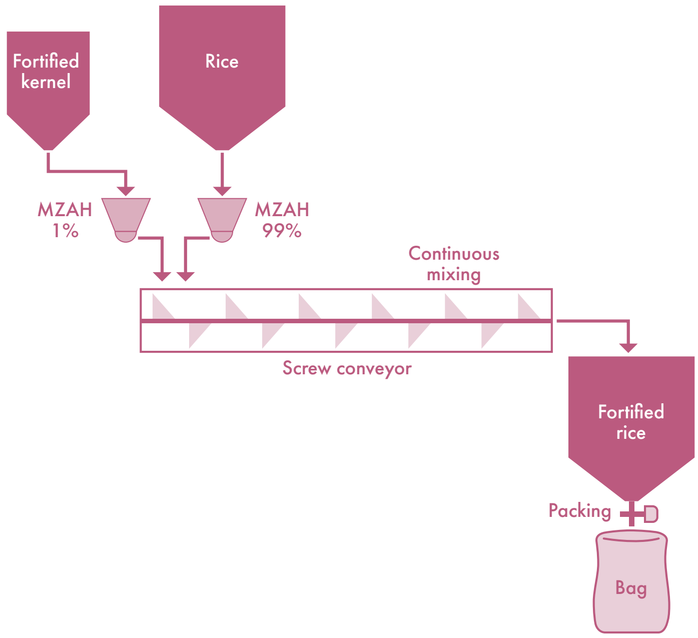
Annex 12: Schematic diagrams of basic systems for mixing premix and fortified kernels with flour and rice, respectively

Figure A13.1: Schematic diagram for adding a micronutrient premix to flour in mixing conveyor.



Source: Food Fortification Initiative (http://www.ffinetwork.org/)

Figure A13.2: Schematic diagram for blending fortified kernels to unfortified rice through continuous mixing.



Source: Sarah Zimmerman, Food Fortification Initiative (personal communication, June 2016).

Annex 13: Guidelines for the concentrations of specific micronutrients to fortified flour and rice

Table A14.1: Average levels of nutrients to consider adding to fortified wheat and maize flour based on extraction, fortificant compound and estimated per capita flour availability[§].

Nutrient	Flour extraction	Compound	Level of nutrients to be added (ppm) by estimated per capita *fortifiable* wheat and maize flour availability (g/day)			
			<75	75–149	150–300	>300
Iron	Low	NaFeEDTA	40	40	20	15
		Ferrous sulphate	60	60	30	20
		Ferrous fumarate	60	60	30	20
		Electrolytic iron	NR*	NR*	60	40
	High	NaFeEDTA	40	40	20	15
Zinc	Low	Zinc Oxide	95	55	40	30
	High	Zinc Oxide	100	100	80	70
Folic Acid	Low or High	Folic acid	5.0	2.6	1.3	1.0
Vit. B12	Low or High	Cyanocobalamine	0.04	0.02	0.01	0.008
Vit. A	Low or High	Vit. A Palmitate	5.9	3.0	1.5	1.0

[§]Adapted from 2009 WHO consensus statement on flour fortification (http://www.who.int/nutrition/publications/micronutrients/wheat_maize_fort.pdf)

*Not recommended

Table A14.2: Nutrient levels proposed for fortified rice according to daily per capita consumption of rice.

Nutrient	Compound	Level of nutrients (mg/100g) to be added to fortified rice based on per capita rice consumption (g/day)			
		<75	75–149	150–300	>300
Iron	Micronised ferric pyrophosphate	12	12	7	7
Zinc	Zinc Oxide	9.5	8	6	5
Folic Acid	Folic acid	0.50	0.26	0.13	0.10
Vit. B12	Cyanocobalamin	0.004	0.002	0.001	0.0008
Vit. A	Vit. A Palmitate	0.59	0.3	0.15	0.1
Thiamine	Thiamin mononitrate	2.0	1.0	0.5	0.35
Niacin	Niacin amide	26	13	7	4
Vit. B6	Pyridoxine hydrochloride	2.4	1.2	0.6	0.4

Adapted from: De Pee, S (2014), 'Proposing nutrients and nutrient levels of rice fortification', *Ann. NY Acad. Sci*. 1324 (2014) 55–66.