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The U.S. Government's Global Hunger & Food Security Initiative

Review of Methods to Assess Diets, Markets, and Cost of an Adequate Diet

Report on Assessment Methods to Inform Large-Scale Food Fortification and Broader Programming to Improve Diets

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Abbreviations and Acronyms

AFE	adult female equivalent
AME	adult male equivalent
CoNA	Cost of a Nutrient Adequate Diet
CotD	Cost of the Diet
DQQ	diet quality questionnaire
EAR	estimated average requirement
FACT	Fortification Assessment Coverage Toolkit
FAO	Food and Agriculture Organization of the United Nations
FortifyMIS	Fortification Management Information System
FORTIMAS	Fortification Monitoring and Surveillance
FRAT	Fortification Rapid Assessment Tool
GAIN	Global Alliance for Improved Nutrition
H-AR	harmonized average requirement
H-UL	harmonized upper level
HCES	household consumption and expenditure survey
ICT	information and communication technology
IMAPP	Intake Modeling, Assessment Planning Program
kcal	kilocalorie
LMIC	low- and middle-income country
LSFF	large-scale food fortification
MAPS	Micronutrient Action Policy Support
MDD-W	minimum dietary diversity for women
MINIMOD	Micronutrient Intervention Modeling
NS-SQ-FFQ	nutrient-specific semi-quantitative food frequency questionnaire
RFS	[USAID] Bureau for Resilience and Food Security
SES	socio-economic status
SQ-FFQ	semi-quantitative food frequency questionnaire
UL	upper level
USAID	U.S. Agency for International Development
WHO	World Health Organization

Glossary of Terms[1]

Apparent intake: The approximated amount of a food (and its nutrients) that a person may ingest. It is calculated through indirect means such as national balance sheets, household economic surveys, and similar methods that do not collect food intake information directly from individuals but through secondary analysis of reports of food availability, access, and/or acquisition. The results can be expressed as per capita or, if assuming intake proportional to energy requirement, per adult male equivalent or per adult female equivalent (WHO 2021b).

Commercial monitoring: The process of collecting and analyzing product samples and reviewing product packaging at retail stores and other food distribution sites to confirm that the product follows specifications, such as micronutrient content and labeling requirements, as outlined in the fortification standards (WHO 2021b).

Consumption monitoring: Refers to procedures and actions aimed to assess, in individuals and populations, the change in nutrient intake that can be attributed to the consumption of a fortified food. The objectives are to track fortified food coverage, micronutrient provision, fortified food utilization, and micronutrient utilization. Formerly known as household/individual monitoring (WHO 2021b).

Coverage: The proportion of the surveyed population that consumes a fortified food during a predetermined period of time. Coverage may be disaggregated by criteria such as age, sex, economic situation, geographical area, ethnic group, and others (WHO 2021b).

Dietary Reference Intake (DRI): A quantitative value of daily nutrient intake that is used as a reference value for planning and assessing nutrient adequacy of diets for apparently healthy people. Examples include estimated average requirements (EARs), recommended daily allowances (RDAs), and tolerable upper intake levels (ULs).

Estimated Average Requirement (EAR): The daily nutrient intake level estimated to meet the needs of half the healthy individuals in a particular age and sex group. The EAR is used to derive the Recommended Dietary Allowance (RDA). This is the reference value to determine the adequacy of nutrients in the diet of populations.

External monitoring: Activities carried out by government inspectors to make sure that food industry follows specified processes to ensure that fortified foods: A) are produced in a manner that should achieve the specifications of the fortification standard and B) conform to the other specifications mentioned in the food standard. The two components of external monitoring include technical audits and factory inspections.

Fortifiable food: Refers to industrially produced food that could be fortified according to national/regional/ local legislation and standards (WHO 2021b).

Fortified food: Refers to a food that is definitively fortified according to qualitative tests, quantitative tests, or a product packaging review (WHO 2021b).

Fortification: The practice of increasing the content of an essential micronutrients (vitamins and minerals), other minerals required in relatively large amounts such as calcium, as well as essential amino acids and essential fatty acids, in a food so as to improve the nutritional quality of the food supply and provide a public health benefit with minimal risk to health.

Fortification vehicle: Staple foods and condiments that are determined to be regularly consumed by the target population(s) and produced by formal industries to which fortificant or premix is added.

[1] Source: USAID, 2021 (USAID Large-scale Food Fortification Guide), unless otherwise noted.

Import monitoring: The actions taken by government inspectors and customs personnel at border entry points to ensure that fortified foods entering a country adhere to labeling requirements and are fortified according to the country's fortification and food standard.

Internal monitoring: The actions taken by food processing operators and quality management personnel to ensure that A) foods are manufactured in a manner that should achieve the specifications of the fortification standard and B) the final product adheres to all the other requirements mentioned in the food standard. It includes both quality assurance (QA) and quality control (QC) procedures.

Large-scale or industrial food fortification: Large-scale food fortification is the addition of vitamins and minerals during processing of commonly consumed staple foods and condiments. For the purposes of the USAID LSFF Programming Guide and USAID's initiative to support LSFF, "large-scale" or "industrial" refers to those food processors that are of sufficient size and sophistication to cover their costs of fortification (equipment, fortificant, operations) within the market price of the fortified foods (typically < 5 percent).

Methodology: a system of methods used in a particular area of study or activity (Oxford Language Dictionary 2022)**.** In this document, methodology refers to the suite of methods available to analyze food consumption, micronutrient intake, and diet cost to inform the design of LSFF and broader programming.

Method: a particular form of procedure for accomplishing or approaching something, especially a systematic or established one (Oxford Language Dictionary 2022).

Monitoring: The continuous collection and review of data and information on program implementation activities for the purposes of identifying problems (such as non-compliance) and taking corrective actions so that the program fulfills its stated objectives.

Nutrient adequacy: This refers to a diet that supplies sufficient quantities of specific vitamins or minerals that satisfies the recommended nutrient intakes for humans.

Nutrient deficiency: Inadequate intake, absorption, and/or metabolic availability of essential nutrients required to support basic physiologic processes necessary for health. Deficiencies can be caused by insufficient amounts of a micronutrient in the diet or by disease, infection/inflammation, malabsorption, parasitism, or bleeding.

Nutrient inadequacy: This refers to a diet that is unable to supply sufficient quantities of specific vitamins or minerals and therefore it fails to support good nutrition and health

Quantitative, open 24-hour dietary recall: A structured interview intended to capture detailed information about the quantities of all foods and beverages (and possibly, dietary supplements) consumed by a respondent in the past 24 hours, most commonly, from midnight to midnight the previous day (National Cancer Institute 2022a; FAO 2018). The term "open" refers to the dietary recall using open-ended questions regarding food consumption, in contrast to closed-ended questions regarding consumption of specific foods or from specific food groups.

Recommended Dietary Allowances (RDAs): Defined by the United States Food and Nutrition Board and conceptually the same as the Recommended Nutrient Intake (RNI), but may have slightly different values for some micronutrients. It is set at the Estimated Average Requirement (EAR) plus 2 standard deviations. This is the reference value to determine the adequacy of nutrients in the diet of individuals.

Recommended Nutrient Intake (RNI): Defined by WHO, the daily intake that meets the nutrient requirements of almost all apparently healthy individuals in an age- and sex-specific population group. It is set at the Estimated Average Requirement (EAR) plus 2 standard deviations. This is the reference value to determine the adequacy of nutrients in the diet of individuals.

Regulatory monitoring: Actions taken by government inspectors to ensure that fortified foods comply with the specifications of the food standards. It includes external monitoring at food processors, import monitoring at border entry points, and commercial monitoring at retail and food distribution locations.

Tolerable Upper Intake Level (UL): The highest average daily nutrient intake level unlikely to pose risk of adverse health effects to almost all (97.5 percent) apparently healthy individuals in an age- and sex-specific population group. This value is used to confirm safety of the micronutrient supply to individuals and populations.

Tool: A software program and/or systematically organized set of information and resources, generally designed to be used together to collect, analyze, and/or apply to answer specific questions (Oxford Language Dictionary 2022).

Executive Summary

Introduction

The purpose of this document is to describe the findings from a literature review that was conducted to identify a methodology to assess diets, markets, and cost of an adequate diet for the [USAID Large-Scale Food Fortification (LSFF) Programming Guide](#) (USAID 2022) and broader USAID programming to improve diets.[2] The methodology is designed to provide guidance for the secondary analyses of existing data for program needs assessment and design/redesign, to be implemented in less than six months and at a cost of less than $100,000 USD. We propose steps for the methodology, and the method and data sources for each step. We also describe information needs, methods, suitable data sources, and examples of tools for program monitoring and evaluation. However, as requested by USAID, monitoring and evaluation are not included in the methodology for the guide. We include in annexes key details about the data sources and tools. The primary audience for this document is USAID and USAID partners.

Background

Inadequate dietary intake of micronutrients is one cause of micronutrient malnutrition, which continues to be a serious problem in low- and middle-income countries (LMICs) (Victora et al. 2021; Baily et al. 2015). Large-scale food fortification—the addition of vitamins and minerals during processing of commonly consumed staple foods and condiments in formal industries—can be a cost-effective strategy to improve micronutrient adequacy when designed and implemented appropriately (WHO and FAO 2006; Keats et al. 2021). However, despite implementation of mandatory fortification programs in over 140 countries, LSFF has not reached its potential in terms of its adoption and effective implementation, compliance by industry, and coverage of fortified foods for those with potential to benefit in LMICs (Osendarp et al. 2018). Limited progress is due in part to lack of data, use of existing data, and application of methods and processes to collect, use and interpret data for appropriate, evidence-based decision making and monitoring the contribution of LSFF. USAID is reaffirming its decades-long commitment to reducing micronutrient inadequacies and their associated deficiencies by supporting LSFF as one of the main interventions. With this purpose, USAID has developed a results framework and a programming guide to help Missions and implementing partners achieve objectives and results. USAID has requested that USAID Advancing Nutrition identify suitable methods for the guide to assess food consumption, micronutrient intake, availability of fortifiable[3] and fortified foods in markets, and the potential contribution of fortifiable food vehicles to micronutrient adequacy, as well as to estimate the cost of an adequate diet with and without LSFF. The methods must be able to be conducted with existing data in less than six months and at a cost of less than $100,000 USD. This literature review will guide the selection of the assessment methods to include in the guide.

Methods

USAID Advancing Nutrition used a manual search strategy to conduct a review of English-language gray literature and published articles from 2007 to present.[4] We began by reviewing the references section of our USAID-approved concept note for this activity, which included an initial search. We then used "snowball" searching by reviewing the reference lists from the selected documents in the concept note. We also conducted forward citation searching by reviewing documents that cited the literature that we considered of particular importance. Lastly, we conducted searches in PubMed, Google Scholar, and

[2] Broader programming includes biofortification, increasing diversity in the production and/or consumption of foods, improving the diversity of foods available in markets, and other activities to improve diets.
[3] Throughout the literature review, the term "fortifiable food" refers to centrally processed food amenable to large-scale food fortification.
[4] We selected 2007 because it is after the publication of the seminal 2006 World Health Organization (WHO) and Food and Agriculture Organization of the United Nations (FAO) guidelines on food fortification with micronutrients.

Google to fill information gaps. We found 175 articles, including descriptive and validation studies and reviews, manuals, guides, and websites that informed the methods that were considered in this review.

Summary of Proposed Needs Assessment and Design Methodology to Guide LSFF Programming

Table ES-1 shows the steps in the proposed methodology to assess diets, markets, and cost of an adequate diet, based on the findings of this literature review. The table describes, for needs assessment and design, the step in the methodology, the information need, for each information need, the method and the data sources for secondary analysis, and the technical expertise needed to conduct the analyses. The cost and time to conduct each analysis is relatively low, for example, less than $100,000 USD and less than 6 months from analysis to final report. As noted above, the methodology is designed for all analyses to be conducted with existing data (i.e., no primary data collection). An acronym key and a color code key for the data sources can be found in the table notes, along with other important table footnotes. A glossary of terms that readers may find useful can be found before the executive summary of this review. Table A2.1 in Annex 2 summarizes all the literature review findings by data source and tool. A detailed description of the data sources and tools can be found in Annex 3.

Table ES-1. Proposed Methodology for Needs Assessment and Design to Guide LSFF and Broader Programming[a]

Information Need and Method, by Step[b]	Secondary Data Sources										
	Quantitative open 24-hour dietary recall	Semi-quantitative food frequency	Household food consumption - HCES	Food Balance Sheets	Market assessment	Agri-food information systems	National Micronutrient Survey	Household survey w/ food sample collection	Market price survey	HCES price data	Consumer Price Index
Step 1. Needs Assessment											
Information need: Adequacy of micronutrient intake/supply											
Method: Estimate current micronutrient adequacy of diets using the EAR cut-point method, or the full-probability method when intake distributions are not normally distributed (disaggregated as appropriate/feasible)											
Potential Data Sources	●	●	●	●							
Step 2. Design/Redesign											
Information need: Fortifiable food consumption											
Method: Estimate the amount of the fortifiable foods consumed per individual (by age and/or sex), per AME, per capita per day; or available amount per capita per day in the food supply (disaggregated as appropriate/feasible)											
Potential Data Sources	●	●	●	●							
Information need: Availability and average price of fortifiable foods in markets											
Method: Estimate the percent of markets with the fortifiable food of interest and the average price (disaggregated as appropriate/feasible)											
Potential Data Sources					●	●					

Information Need and Method, by Step[b]	Secondary Data Sources										
	Quantitative open 24-hour dietary recall	Semi-quantitative food frequency	Household food consumption - HCES	Food Balance Sheets	Market assessment	Agri-food information systems	National Micronutrient Survey	Household survey w/ food sample collection	Market price survey	HCES price data	Consumer Price Index
Information need: Predicted contribution of food fortification to micronutrient adequacy											
Method: Estimate micronutrient adequacy with and without LSFF using the EAR cut-point method, or the full-probability method when intake distributions are not normally distributed. Potential modeling scenarios: mandatory fortification at current fortification levels (current situation of coverage and compliance, if data available); mandatory fortification at target levels (with good coverage and compliance of current fortification standards or regulations); and fortification of mandatory or new food vehicles varying the levels of micronutrient addition (adjusting the current standards and/or including fortification of other fortifiable vehicles).											
Potential Data Sources: To estimate micronutrient intake	●	●	●	●							
Potential Data Sources: For current fortification, if available[c]							●	●			
Optional Step. Advocacy for Program Support											
Information need: Cost of an adequate diet with/without LSFF											
Method: Linear programming analysis to identify the lowest-cost nutritionally adequate diet with/without fortified foods											
Potential Data Sources: For list of foods	●	●	●								
Potential Data Sources: For food prices					●				●	●	●
Technical Expertise Needed to Conduct the Analysis Using Data Sources											
Technical Expertise											

Sources: Coates et al.2012a; Coates et al.2012b; Engle-Stone et al. 2019; Dary and Imhoff-Kunsch 2012; WHO and FAO 2006; Hotz et al. 2017; Gibson and Ferguson 2008; Dary and Jariseta 2012; Imhoff-Kunsch et al. 2012; Jariseta et al. 2012; Tang et al. 2022; Smarter Futures 2017; Galtier et al. 2014; Friesen et al. 2017; Friesen et al. 2019; Aaron et al. 2016; Neufeld et al. 2017; Mkambula et al. 2020; Micronutrient Initiative 2003; Hess et al. 2013; Berti et al. 1999; Deptford et al. 2018; Untoro et al 2017; Save the Children UK 2018; Daelmans et al. 2013; Untoro et al. 2017; Cost of Nutritious Diets Consortium 2018; Deptford et al 2017; and Knight and Woldt 2017.

Acronym Key: AME: Adult male equivalent; EAR: estimated average requirement; HCES: household consumption and expenditure survey; LSFF: large-scale food fortification.

Data Source Color Code Key:

●	Very good data source, very suitable for the information need, given strengths and limitations
●	Good data source, suitable for the information need, given strengths and limitations
●	Moderately good data source, adequate for the information need, given strengths and limitations
●	May be used, but has/may have significant limitations
	Does not provide relevant information (i.e., blank square)

Technical Expertise Key:

	Required technical expertise—relatively high, e.g., requires senior and mid-level staff with high level of technical expertise and specialized training, capacity and experience in study design, statistics for analysis, interpretation, report writing and/or dissemination.
	Required technical expertise—moderate, e.g., requires senior and/or mid-level staff with general background in nutrition, public health, agriculture, or related area.
	Required technical expertise—relatively low, e.g., does not require staff with technical expertise in nutrition, public health, agriculture, statistics, etc.

Notes

a. Please note that USAID requested that the literature review include methods for needs assessment, design/redesign, monitoring, and evaluation, but that the guide focus on needs assessment and program design/redesign. Also note that prevalence of micronutrient status is important for needs assessment for LSFF, but USAID has requested that for needs assessment, the literature review and guide focus on methods to assess micronutrient intake. Methods to assess biomarkers and micronutrient status are beyond the scope of this review and the guide.

b. Preferably data is nationally representative and able to be disaggregated by geography and/or socio-economic strata and other aspects of interest, such as age and sex. Note that food balance sheet data is only available at the national level and generally cannot be disaggregated.

c. Please note that not all national micronutrient surveys may collect data on the micronutrient content of foods fortified at large scale, but for those surveys that do, the data should provide the information necessary for this method. National micronutrient surveys include, e.g., those supported by the U.S. Centers for Disease Control and Prevention International Micronutrient Malnutrition Prevention and Control CDC/IMMPaCt, GroundWork, and/or the Global Alliance for Improved Nutrition (GAIN).

Most of the suggested methods can be applied to assess broader programming to improve diets. However, in most cases, the methods would need to be adjusted to meet the specific program needs.

Next Steps

Next steps include developing a detailed outline of the methodology to assess diets, markets, and cost of an adequate diet for the USAID LSFF Programming Guide and writing the methodology. The methodology will include a decision tree related to the data landscape, given available data in their local context.

Introduction

The purpose of this document is to describe the findings from a narrative literature review that USAID Advancing Nutrition conducted in 2022 at the request of the U.S. Agency for International Development (USAID). USAID Advancing Nutrition conducted this review to identify a methodology for a USAID Large-Scale Food Fortification (LSFF) Programming Guide (USAID 2022) and broader programming.[5] The methodology will be used to assess diets, markets, and the cost of an adequate diet for program needs assessment and design. The cost of an adequate diet will be assessed with and without LSFF. The primary audience for this document is USAID and USAID partners. The report provides a background description of the activity, the objectives, methods, and findings of the literature review, a summary of the proposed methodology, next steps, and annexes with details about data sources and tools that we reviewed.

[5] Broader programming includes biofortification, increasing diversity in the production and/or consumption of foods, improving the diversity of foods available in markets, and other activities to improve diets.

Background

Inadequate dietary intake of micronutrients is one of the causes of micronutrient malnutrition, which continues to be a serious problem in low- and middle-income countries (LMICs) (Victora et al. 2021; Baily et al. 2015). Large-scale food fortification—the addition of vitamins and minerals during processing of commonly consumed staple foods and condiments in formal industries—can be a cost-effective strategy to improve micronutrient adequacy when designed and implemented appropriately (WHO and FAO 2006; Keats et al. 2021). Advantages include the delivery of micronutrients without the need for changes in dietary habits or food delivery systems, given LSFF involves foods already commonly consumed among target populations. More than 140 countries have mandatory salt iodization programs; 90 have mandated fortification of flour of at least one cereal grain; 50 have mandated fortification of edible oil, margarine, or ghee; and 11 have mandatory fortification of sugar with vitamin A (Luthringer et al. 2015; Osendarp et al. 2018; Heidkamp et al. 2021; Mkambula et al. 2020; Mora et al. 2000). However, LSFF has not reached its potential in terms of its adoption and effective implementation, compliance by industry, and coverage of fortified foods to those with potential to benefit in LMICs (Osendarp et al. 2018). Limited progress is due in part to lack of data, use of available data, and application of methods and processes to collect, use and interpret data for appropriate, evidence-based decision making for program needs assessment, design/redesign, and monitoring the contribution of LSFF, as well as broader programming.

USAID is reaffirming its decades-long commitment to reducing micronutrient inadequacies and their associated deficiencies using LSFF is one of the main interventions. As a part of its efforts to improve LSFF programming, USAID has developed a results framework and programming guide. The purpose of the framework is to guide USAID programming to support LSFF through central and bilateral mechanisms. The programming guide will help Missions and implementing partners achieve the strategic objective and intermediate and sub-intermediate results outlined in the results framework. The guide will be updated to include methods to assess the following components—

1. Diets and nutrient adequacy, market availability and price of fortifiable and fortified foods, and the cost of an adequate diet with/without LSFF
2. food industry capacity and barriers to LSFF
3. the LSFF policy enabling environment.

USAID has asked USAID Advancing Nutrition to work on the first component to identify a methodology that will be incorporated into the guide to assess food consumption, micronutrient intake, market availability of centrally processed fortifiable and fortified foods, and the potential contribution of fortified food on micronutrient adequacy and the comparative cost of an adequate diet with and without LSFF. The guide will help decision makers choose the most appropriate ways to ascertain which micronutrients are consumed in inadequate amounts, what the fortifiable food vehicles are, and how fortification of those foods would contribute to micronutrient adequacy and affect the cost of an adequate diet. USAID has indicated that the methods must be able to be conducted with existing data in less than six months and at a cost of less than $100,000 USD. This literature review will inform the assessment methods that will be included in the guide.

USAID has developed a set of 10 guiding principles for LSFF (USAID 2022). The guiding principles provide a foundation for the Agency's LSFF investments and programming. As we conducted the literature review, we following the three following guiding principles (see the [USAID LSFF Programming Guide]() for the complete list).

- **Guiding principle 4**: All LSFF programming should be based on local context and data, particularly regarding nutritional need and usual intake of fortification vehicles, population coverage, and estimation of the potential impact of food fortification. Such assessments should be based on the theoretical (and actual, if information exists) average nutrient content of the fortified foods at household level and their estimated intake by the targeted populations (disaggregated by geography, urban/rural settings, socioeconomic wealth quintiles, age strata, sex, and season, when possible).

- **Guiding principle 5**: While fortification programs, as well as other micronutrient interventions, need to be adjusted to account for evolving dietary patterns and consider coverage of LSFF and other complementary interventions to improve micronutrient intake within countries, regional harmonization and mutual recognition ("equivalence") of standards and regulatory control procedures among neighboring countries are commonly promoted to be compatible with and not represent a de facto barrier to intercountry food trade.
- **Guiding principle 6**: There is a need for continual testing, adapting, and scaling-up of evidence-based interventions and innovation to address unmet programmatic needs and maximize coverage, as well as to improve the cost-effectiveness and cost-benefit of LSFF programming.

The USAID LSFF Programming Guide has aligned tasks with the **UNICEF Triple-A Cycle** of nutrition programming (UNICEF 1998):

- continuously **Assess** problems
- **Analyze** their causes
- take **Action**

The guide has also aligned tasks with the **Food Systems Dashboard 3-D Describe, Diagnose and Decide** Decision-Making Tool from the Johns Hopkins University, Global Alliance for Improved Nutrition (GAIN), and the Food and Agriculture Organization of the United Nations (FAO). As we conducted the review, we considered the following tasks (see the USAID LSFF Programming Guide for the full set of tasks).

A. ASSESS/DESCRIBE

Task 3: With relevant professionals and institutions, analyze the available national food consumption and micronutrient inadequacy or deficiency data and trends. Such data should be disaggregated by geographic areas, urban and rural settings, wealth strata, age strata, sex, and by season, if data are available, to assess inadequacies and identify potential LSFF vehicles. Data sources include:

- FAO Food Balance Sheets
- Market data
- House Consumption and Expenditure Surveys (HCESs) and/or other national household surveys
- Food/nutrient intake surveys
- Micronutrient biomarker surveys.

Also assess what other interventions are currently in place, their coverage and fidelity/performance, and contribution to dietary intakes.

Task 4: Determine the availability and coverage of potential industrially fortifiable staple and condiment food vehicles in the country based on an estimation of their household consumption profile (see 3 above), market availability, and analysis of current and potential processing capacity/market share by large-scale food industry companies. Data sources include:

- HCESs
- Food consumption surveys
- Fortification Assessment Coverage Toolkit (FACT) surveys
- Food industry records and trend analyses

- Direct market research
- Global Fortification Data Exchange
- Food Systems Dashboard

B. **ANALYZE/DIAGNOSE**

Task 1: Analyze initial assessments of household and market dietary data, food industry, and the policy enabling environment for LSFF, including specific supply-side and demand-side constraints to advancing LSFF within the country.

Task 2: Model contributions of fortified foods relative to their intake to reducing dietary micronutrient inadequacies under three scenarios: (1) current situation of coverage and compliance; (2) with good coverage and compliance of current fortification standards or regulations; and (3) with adjusting the current standards and/or including fortification of other fortifiable vehicles.

Objective

The objective of the literature review is to synthesize the current state of the evidence and application of methods and analytic tools to assess diets, including consumption of fortifiable foods and their potential contribution to micronutrient adequacy; the availability and price of fortifiable and fortified foods in markets; and the cost of an adequate diet with and without LSFF, for needs assessment and design of LSFF and broader programming. The ultimate goal of the literature review is to identify a methodology to include in the USAID LSFF Programming Guide. The methodology is for an initial needs assessment and program design/redesign. The scope for the literature review also encompassed monitoring and evaluation, given USAID felt it was necessary to understand the measurement landscape to make the choices necessary for the initial assessment.

Table 1 lists the questions that we addressed through the literature review, as well as the specific program-level questions that we considered for each method, by program stage. The source of the questions is the USAID-approved concept note for this activity and the literature (WHO 2021b).

Note that an analysis of methods to determine the prevalence of micronutrient deficiency was beyond the scope of this literature review. However, a needs assessment for LSFF and broader programming needs to ask "What are the micronutrient deficiencies in the population, and which population strata are more affected?" and "What is the current coverage and performance of micronutrient intervention programs?" to assist, along with information on adequacy of micronutrient intake, in determining if a food fortification intervention is warranted. Evaluation of LSFF and broader programming should also include an assessment of micronutrient deficiency.

Table 1. LSFF and Broader Program Questions Answered through the Literature Review, by Program Stage

Program stage	Questions answered through the literature review	Specific program-level questions considered in the review of the methods (i.e., Would the method help answer this question to inform the program?)
Needs assessment	What methods exist to assess **micronutrient intake**?	**Micronutrient adequacy**: Which micronutrients are consumed in inadequate quantities, which are consumed in adequate amounts, which are consumed in amounts above the tolerable upper intake level for safe consumption, and which population strata are most affected?
Design/ Redesign	What methods exist to assess **fortifiable food consumption**?	**Fortifiable food consumption**: Which fortifiable foods (staples and condiments) have high and equitable coverage among target households or individuals, and could serve as a probable food vehicle for fortification with the micronutrients that are inadequate in the current diet?
	What methods exist to assess **market availability and price** of fortifiable and fortified foods?	**Market availability and price**: What is the market availability of fortifiable and fortified foods (e.g., staples and condiments) in different geographic regions in the country? What are the brands present in the market in different geographic regions? What is their price?

Program stage	Questions answered through the literature review	Specific program-level questions considered in the review of the methods (i.e., Would the method help answer this question to inform the program?)
	What methods exist to model the **potential contribution** of fortifiable foods **to micronutrient adequacy of the diet**?	**Contribution to micronutrient adequacy:** Considering current consumption patterns, what would be the potential contribution of food fortification to micronutrient adequacy of the diet for different strata of the population (urban/rural, sub-region, socio-economic status (SES) [including by SES in urban and rural areas])?
	What methods exist to model the **potential contribution** of fortifiable foods, given the micronutrient content, on the **cost of an adequate diet**?	**Contribution to cost of an adequate diet:** What is the cost of an adequate diet with and without LSFF?
Household-Level Consumption Monitoring[a]	What methods exist to **monitor** population-level **consumption of fortified foods** during LSFF and broader program implementation?	What percentage of households have the food that by law or standards should be fortified? In what percentage of households is the food confirmed as fortified (e.g., at least a qualitative test)? What is the average micronutrient content of the food that by law or standards should be fortified?
Evaluation[a]	What methods exist to **evaluate** food consumption and micronutrient adequacy in LSFF and broader programs?	What is the percentage of the population that has inadequate micronutrient intake with and without fortified foods? What is the contribution of the fortified food to micronutrient adequacy, considering the entire diet?

[a]Note that USAID requested that monitoring and evaluation be included in the literature review, but that the guide only include methods to assess diets, markets, and cost of an adequate diet for needs assessment and program design/redesign.

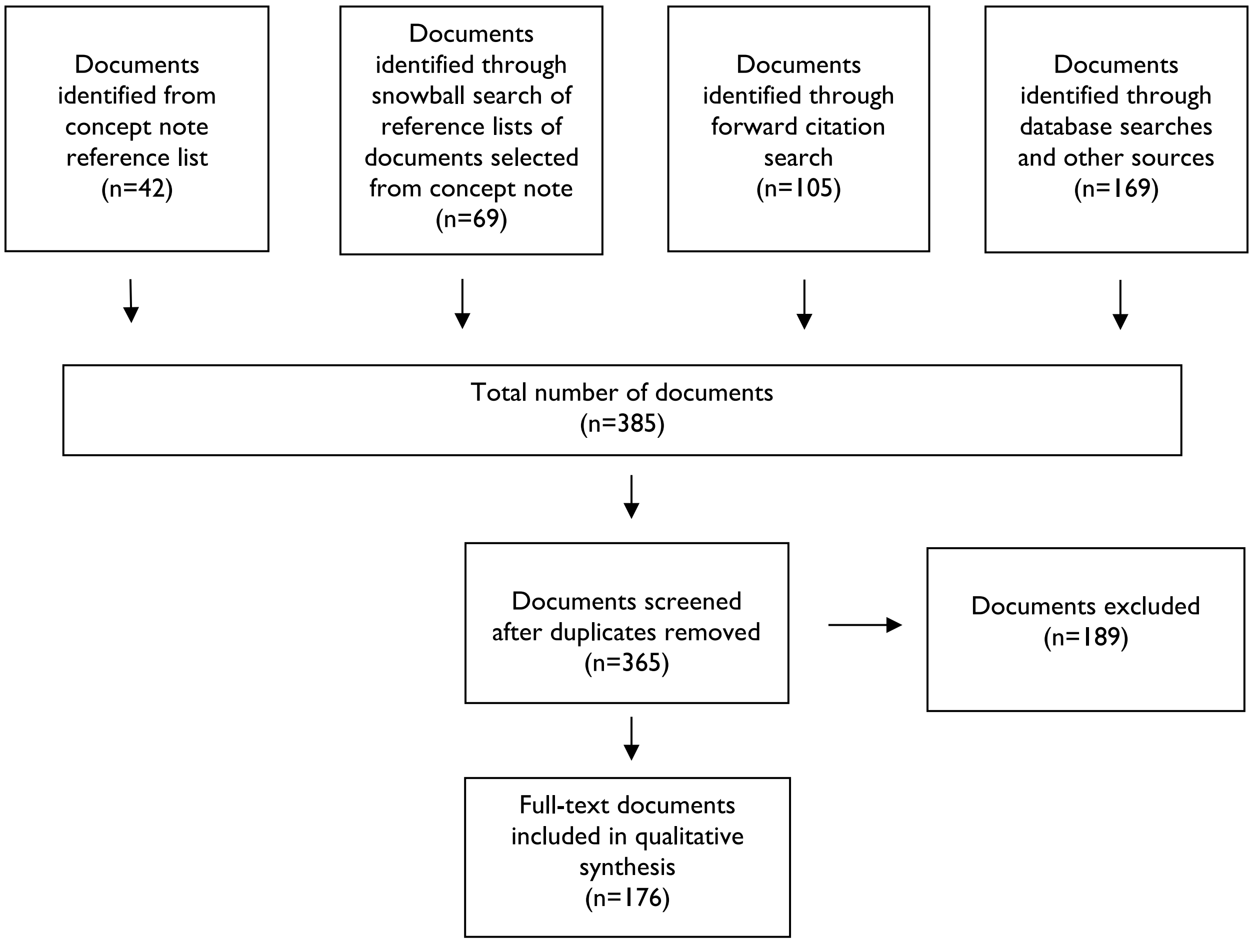
Methods

USAID Advancing Nutrition used a manual search strategy to conduct a narrative review of English-language gray literature and published articles from 2007 to present.[6] We began by reviewing the documents and sources of information in the references section of our USAID-approved concept note for this activity. We selected references with information on methods to assess diets, markets, and diet cost. We then used "snowball" searching by reviewing the reference lists from the selected documents and information sources in the concept note. We also reviewed documents and articles that cited the published and gray literature that we had found and considered of particular importance for specific methods. Lastly, we conducted searches in PubMed, Google Scholar, and Google to fill information gaps. Search terms to fill information gaps included "review; agricultural and food information system; health information system; fortification; LMIC; Micronutrient Intervention Modeling; MINIMOD, Intake Modeling, Assessment Planning Program; IMAPP; cost of an adequate diet; food balance sheet; micronutrient supply; micronutrient adequacy; and food consumption."

We found 175 articles, including descriptive and validation studies and reviews, as well as manuals, guides, and websites that informed the selection of methods to assess diets, markets, and cost of an adequate diet. We used a spreadsheet to synthesize data and information. Although we did not conduct systematic database searches, the review was sufficiently thorough to fulfill its objectives. Figure 1 illustrates the process for document identification and inclusion. Exclusion criteria included documents dated prior to 2007; not in English, Spanish, or French; and not related to methods for needs assessment, design/re-design, monitoring, or evaluation of LSFF or broader programs to improve diets.

[6] We selected 2007 because it is after the publication of the seminal 2006 World Health Organization (WHO) and Food and Agriculture Organization of the United Nations (FAO) Guidelines on food fortification with micronutrients.

Figure 1. Flow Diagram



Findings

In this section we summarize the suggested methods to respond to the needs assessment, design/redesign, monitoring, and evaluation questions posed in this review. The methods for needs assessment and design/redesign involve secondary analysis using existing data sources. We also list suitable data sources, in order of suitability, and examples of tools that may assist in the analysis. Box 1 shows the seven data sources and seven tools that we reviewed. Table A2.1 in Annex 2 summarizes the literature review findings for data sources and tools. For each data source and tool, the table describes the—

- purpose
- strengths and limitations of the data source or tool
- relative cost, time, and technical expertise required for use.

Annex 3 provides additional information about the data sources and tools, including:

- Overview.
- Strengths and limitations.
- Basic steps in use.
- Relative cost, time, and technical expertise to use.
- Examples of countries where each has been used for LSFF.
- Relative availability of secondary data, as appropriate.
- Use to inform broader programming.

Annex 3 also describes two projects that are relevant for this review.

The remainder of this section is organized by:

1. Needs assessment
2. Design/redesign
3. Household-level consumption monitoring
4. Evaluation

In each subsection, we describe the information need, the method to meet the information need, suitable data sources, and examples of tools.

Box 1. Data Sources and Tools Reviewed

Data sources

- Quantitative open 24-hour dietary recall
- Semi-quantitative food frequency questionnaire (SQ-FFQ)
- Household food consumption (HCES)
- Food Balance Sheets
- Nutrient-specific semi-quantitative food frequency questionnaire (NS-SQ-FFQ)
- Fortification Monitoring and Surveillance (FORTIMAS)
- Agri-Food Information Systems

Tools

- Fortification Assessment Coverage Toolkit (FACT)
- Fortification Rapid Assessment Tool (FRAT)
- Diet quality questionnaire (DQQ)
- Intake Modeling, Assessment and Planning Program (IMAPP)
- Cost of the Diet (CotD)
- Optifood
- Cost of a Nutrient Adequate Diet (CoNA)

Needs Assessment

Information Need: Adequacy of micronutrient intake/supply

Method

Information on micronutrient intake is critical for LSFF program needs assessment (WHO and FAO 2006). A common feature of successful LSFF programs is that they use information on micronutrient intake to identify a population's micronutrient intake gaps based on population consumption patterns (Martorell et al. 2017). Information on micronutrient intake is used to identify which micronutrients should be provided through LSFF or other broader interventions (Coates et al. 2012b). The data help to understand which micronutrients are consumed in adequate and inadequate amounts, which are consumed in amounts above the tolerable upper intake level for safe consumption, and which population strata are most affected by inadequate and excessive intake.

The 2006 WHO and FAO-published guidelines on food fortification recommend using population-level food consumption data to estimate consumption, which along with food composition tables that provide the micronutrient content of foods, can be used to estimate micronutrient intake. The guidelines recommend estimating micronutrient adequacy using the estimated average requirement (EAR) cut-point method and the upper level (UL) cut-point method for most micronutrients when EAR and UL values are available. A population's average (median) micronutrient consumption is compared to the age-, sex-, and physiologic status specific EAR and/or UL for the group. There is some variation in the specific dietary reference values (EAR and UL) developed by different expert groups in different countries and at different times. For the EAR and UL cut-point methods, recently developed harmonized average requirements, also known as H-AR and H-UL, are recommended for use (Allen et al. 2020). The harmonized values provide a common basis for establishing food and nutrition policies and evaluating and comparing the adequacy of nutrient intakes across target population groups (Allen et al. 2020). Population groups with micronutrient intakes that fall below the H-AR threshold are classified as having inadequate dietary micronutrient intake. Population groups with micronutrient intakes that are above the H-UL threshold are classified as having intakes in excess of the tolerable upper intake level. The guidelines recommend the use of the full-probability approach for micronutrients when the distribution of requirements is not normally distributed, as is the case for iron in some population subgroups, such as children, menstruating adolescents, and adult women (WHO and FAO 2006).

The critical nutrient density approach can also be used to estimate micronutrient adequacy. The critical micronutrient density is the ratio of the EAR for an age-, sex-, and physiologic status-specific group to their daily average energy requirement, expressed per 1,000 kcal (Vossenaar et al. 2019). The micronutrient density of the diet, which is the ratio of micronutrient consumption to energy consumption, also expressed per 1,000 kcal, can then be compared to the critical micronutrient density. A diet is of inadequate density when the micronutrient density of the diet falls below the critical nutrient density threshold, assuming that energy requirements are being met through the diet. Population groups with micronutrient densities that fall below the critical micronutrient density threshold are classified as having an inadequate dietary micronutrient density. The method is particularly useful when applied to household data when there is no information on the intake of individuals.

Suitable data sources

The options regarding data sources to estimate food consumption, in order of suitability, include:

1. **Quantitative open 24-hour dietary recall**. A quantitative open 24-hour dietary recall is a structured interview intended to capture detailed information about the quantities of all foods and beverages (and possibly, dietary supplements) consumed by a respondent in the past 24 hours, most commonly, from midnight to midnight the previous day (National Cancer Institute 2022a; FAO 2018). The term "open" refers to the dietary recall using open-ended questions regarding food consumption, in contrast to closed-ended questions regarding consumption of

specific foods or from specific food groups. The quantitative open 24-hour dietary recall is the most valid method for dietary data collection, of the methods covered in this review (Coates et al. 2012a; Coates et al. 2017a; Engle-Stone et al. 2019; Dary and Imhoff-Kunsch 2012; WHO and FAO 2006). Best practice is to have repeated recalls on nonconsecutive days in at least a subset of the sample, and appropriate statistical methods are needed to estimate usual intake distributions from 24-hour dietary recall data. When recent[7] nationally representative quantitative open 24-hour dietary recall data exist, they should be analyzed/used for needs assessment. However, few LMICs have nationally representative quantitative open 24-hour dietary recall data due to its cost and complexity (Huybrechts et al. 2017; Coates et al. 2017; FAO 2018), which may limit countries' ability to conduct secondary analyses of these data for LSFF programs. It is important to keep in mind that quantitative, open 24-hour dietary recall data that have been collected for only a specific group of individuals, such as non-pregnant women 15-49 years of age, will not provide information about food consumption and micronutrient intake of other subgroups, such as young children or adolescents.

2. **Semi-quantitative food frequency questionnaire (SQ-FFQ)**. The SQ-FFQ is a diet assessment method where respondents report their usual frequency of consumption of foods, from a food list, over a specific time, e.g., 7 days, including portion sizes, either a standardized portion size or a range of portion sizes (National Cancer Institute, 2022b). This description refers to the SQ-FFQ that is used to estimate consumption of the whole diet, rather than a small number of specific foods. The SQ-FFQ has good validity as a method for collection of dietary data when it is appropriately developed and validated (Coates et al. 2012b). If nationally representative SQ-FFQ data on the full diet are available, including foods relevant for fortification, they can be considered for needs assessment, but few nationally representative SQ-FFQ surveys exist in LMIC (Coates et al. 2012a). If SQ-FFQ data have been collected for only a specific group of individuals, the data will not provide information about food consumption and micronutrient intake of other subgroups.

3. **Household food consumption module of the household consumption and expenditure survey (HCES)**. The household food consumption module of the HCES is used to collect data on the amount of food consumed by the household or the amount of food acquired by the household in a specific reference period (Coates et al. 2012a, Imhoff-Kunsch et al. 2012). HCES are nationally representative surveys, often also representative at the subnational level, which collect data on household socio-economic conditions. The HCES food consumption module is used to measure "apparent consumption" or approximated consumption based on assumptions about intra-household food distribution and consumption.

   The household approximated food consumption or acquisition data from existing HCESs offer moderate validity at a relatively low cost to identify risk of inadequate micronutrient intake; compare risk across geographic and socioeconomic strata; prioritize socio-economic groups or groups in regions; and determine which fortifiable foods may serve as a probable food vehicle for fortification (Coates et al. 2012b; Dary and Jariseta 2012; Imhoff-Kunsch et al. 2012; Jariseta et al. 2012; Tang et al. 2022). The method offers a good balance between validity, usefulness, and cost (Coates et al. 2012b). It is adequate to provide useful information about food consumption and nutrient intake patterns and estimate nutrient density of the diet among population strata to inform LSFF (Dary and Jariseta 2012; Jariseta et al. 2012). Where recent HCES data exist, they can be analyzed/used for needs assessment. However, the HCES food consumption data should be carefully examined regarding appropriateness for the objectives of

[7] For this review, we define "recent" as data collected within the past 5 years. If older survey data exist, they could be considered if the findings reflect current food consumption patterns, which could possibly be determined through discussions with local experts and triangulating with recent available data, such as smaller surveys or studies.

the analysis, for example, whether the food list is adequate to provide information about fortifiable foods (Adams et al. 2022). Food lists may include as few as 16 foods or as many as 550 or more (Fiedler et al. 2012b). The adequacy of the food list may be determined by looking at the level of disaggregation, for example, is oil listed separately from other fats and by type of oil, and whether the list distinguishes between fortifiable (processed) and non-fortifiable (unprocessed) food vehicles and food products made from them, like bread and biscuits from wheat-flour (Adams et al. 2022). The household food consumption data should be relatively recent and/or still reflect current dietary patterns. Note that the household-level data do not provide direct information on target groups defined by age or physiological status, such as children or pregnant women.

The HCES includes modules on household consumption or acquisition; time use and labor; land use and land rights; non-food expenditures; possession of durable goods; farm implements, machinery, and structures; household businesses; income; gifts given out; social safety nets; credit; shocks and coping strategies; and deaths in the household, among others. We do not use the latter data for the needs assessment unless some of the latter data is used to categorize the household to a "wealth quintile". So, for the needs assessment we do not use the entire HCES dataset, but just the data on household consumption or acquisition, and other data as needed to conduct the analysis, such as demographic data or data to identify household wealth category. In the household food consumption or acquisition module, there may be some items listed that we do not consider, such as "bottled water", but generally we consider all the foods listed in the food consumption or acquisition module.

4. **Food Balance Sheets**. Food Balance Sheets (FBS) are a source of secondary data used to provide information on the amount of food supply available for consumption in a specified reference period in a country and determine national-level food consumption patterns (Coates et al. 2012a). The FBS tracks primary commodities such as wheat, rice, fruit, and vegetables and a limited number of processed commodities like vegetable oils and butter. The Food and Agriculture Organization of the United Nations (FAO) develops the FBS, although some countries may calculate the FBS themselves (Coates et al. 2012a). The data can indicate which micronutrients may be inadequate in the national food supply. However, FBS data have low validity in estimating inadequate micronutrient intake (Coates et al. 2012b). FBS report food that is “apparently available” for consumption at the national level and do not directly measure individual food consumption or how food or nutrients are distributed within the population. FBS data do not account for food consumption from foods not in the FBS and do not provide information about which commodities are centrally processed at large scale. FBS data may be a useful starting point to identify possible micronutrients that are inadequate in the diet, but planners should use individual or household-level data to confirm FBS estimates (Coates et al. 2012a).

Examples of tools

Table A1.1 in Annex 1 shows several tools that can be considered for use with quantitative open 24-hour dietary recall data to estimate the risk of inadequate micronutrient intake. We are not aware of any tools have been developed to use data from SQ-FFQ, household food consumption, or food balance sheets to estimate micronutrient intake, but general methods for analysis are described in Annex 3. Selection of tools will depend on the local situation such as specific questions and needs, available data, and analyst capacity and familiarity with various tools.

Design/Redesign

Information Need: Fortifiable food consumption

Method

Information on consumption of fortifiable food among different strata of a population is important for LSFF program design (WHO and FAO 2006). Successful LSFF programs have made effective use of food consumption data to identify appropriate food fortification vehicles (Martorell et al. 2017). Food consumption data can help understand which centrally processed foods that are consumed could serve as probable food vehicles for fortification with the micronutrients that are inadequate in the diet. The method involves cleaning, preparing, and analyzing individual food consumption data; household food consumption or acquisition data; or national food supply data to estimate the amount of the fortifiable food consumed per day or available in the food supply (e.g., per capita per day). Individual-level food consumption data and household-level food consumption or acquisition data can be used to estimate fortifiable food consumption among different strata of the population with an appropriate sampling frame. Strata can potentially include by geographic area, urban/rural settings, socio-economic wealth quintiles, sex, age, and/or season. However, food balance sheet data, which provides information on national-level food supply, do not allow for analysis by strata, only per capita estimates of food availability.

Suitable Data Sources

The options regarding data sources to estimate fortifiable food consumption, in order of suitability, and the rationale for their order of priority, are the same as those indicated above to assess adequacy of micronutrient intake. Namely, the suitable data sources are:

1. Quantitative open 24-hour dietary recall.
2. Semi-quantitative food frequency questionnaire (SQ-FFQ, either of the total diet or a food-specific SQ-FFQ, for example, of fortifiable foods, could meet this information need).
3. Household food consumption module of the household consumption and expenditure survey (HCES).
4. Food Balance Sheets.

Examples of tools

The tools for analysis of quantitative open 24-hour dietary recall data in Table A1.1 in Annex 1 are also relevant for the analysis of consumption of fortifiable foods. Two additional tools relevant for fortifiable food consumption are the Fortification Assessment Coverage Took (FACT) and the Fortification Rapid Assessment Tool (FRAT).

- FACT, developed by the Global Alliance for Improved Nutrition (GAIN) in 2013, uses a SQ-FFQ to collect population-level data on consumption of fortifiable and fortified foods, particularly fortifiable and fortified wheat flour. FACT also uses a household food acquisition and purchase questionnaire to collect household-level data on fortifiable and fortified food acquisition to estimate population-level consumption for foods such as salt, oil, and sugar (Friesen et al. 2019).[8]

[8] The SQ-FFQ in FACT is used for food vehicles that are commonly consumed in prepared forms that may be made inside the home from the raw food vehicle or outside the home, e.g., wheat flour. These types of foods lend themselves more easily to develop a SQ-FFQ (e.g., bread, noodles, etc.,) because one can readily determine a closed list of foods items, provide a range of portion size options for the foods, and reasonably estimate the average amount of the fortified item, e.g., wheat flour, in each food. FACT uses a household food acquisition and purchase questionnaire for food vehicles that are typically purchased in their raw forms and added in large or small quantities to foods prepared at home (e.g., salt, edible oil, and sugar). It does not account for consumption of these food vehicles outside the home given the difficulty of assessing amounts consumed of these food

- FRAT, developed by PATH/Canada in 1997/1998, uses a SQ-FFQ to collect population-level data on consumption of fortifiable foods among specific household members, such as women of reproductive age and young children (Micronutrient Initiative 2003).

If data from use of the FACT and FRAT tools are available, the data should be explored for use to inform the LSFF program design. The FACT and FRAT are described in more detail in Annex 3. Only those aspects of the FACT and FRAT tools and/or data relevant to obtain information on fortifiable food consumption would be used to respond to the information need described in this section of the literature review.

Information Need: Availability and Price of Fortifiable Foods in Markets

Method

The 2006 WHO and FAO guidelines on food fortification do not specifically address methods to assess market availability of foods proposed for fortification. Regarding methods to assess the market availability of existing fortified foods, the WHO and FAO guidelines suggest conducting market surveys on the availability of fortified products in retail stores, either through primary data collection as part of the food fortification program, or by "piggybacking" on existing surveys or ongoing/regular monitoring or data collection systems. The guidelines suggest that in countries with existing routine price data collection systems, a fortified food could be added to the list of monitored products. The guidelines refer to market monitoring as part of monitoring the "service provision" aspect of program performance. The method includes estimating the percent of markets with the fortifiable food of interest and the average price, disaggregated by region if feasible.

Suitable Data Sources

The options regarding data sources to determine market availability and cost of fortifiable foods, in order of suitability, include:

- **Market assessment**: The most suitable data source for information on the availability and cost of fortifiable foods in markets are market assessments designed to specifically collect this type of data.
- **Agri-food information systems**: National agri-food and market information systems typically do not provide information on the market availability of fortifiable foods, brands, or prices (Galtier et al. 2014). However, if an agri-food information system did collect such data, or was adapted to collect such data, the information could be explored for possible use to respond to questions that help inform the design of LSFF.

LSFF program designers should consult with market experts in a country to identify the best sources to provide market-level data on fortifiable foods.

Examples of Tools

Two relevant tools are the market assessment components of the FACT and the FRAT.

- **FACT**: The market assessment component of FACT provides a standardized approach to assess availability of fortifiable and fortified foods at market level (Friesen et al. 2019). The method was reviewed by independent subject-matter experts, pilot tested, and refined for the various contexts in which it has been used (Friesen et al. 2019). A FACT market assessment sampling methodology employs a purposive multi-stage approach where different levels of markets and ultimately retail outlets are sampled sequentially. Purposive sampling yields a non-probability (non-random) sample that is selected based on characteristics of a population and the objective of the study (Friesen et al. 2019). A FACT market assessment can be implemented

vehicles in prepared foods obtained outside the household. (Global Alliance for Improved Nutrition and Oxford Policy Management 2019).

as an independent activity, or it can be added to a FACT household assessment, other surveys, or surveillance systems (Friesen et al 2019). The tool also provides guidance on how to analyze market data and calculate the indicators related to market availability of fortifiable foods.

- **FRAT**: The market component of FRAT assesses market conditions to determine if fortification is feasible from an industrial and commercial standpoint. It involves open-ended interviews with, for example, owners, general managers, and production managers of food manufacturers, processors, distributors, wholesalers, and retailers (Micronutrient Initiative 2003). The FRAT market assessment is not designed to systematically collect quantitative data on availability of fortifiable and fortified foods in markets, brands, or prices, but if a FRAT market assessment was conducted that did collect such data, it could be explored for possible use to respond to design questions for LSFF. The FRAT data should be recent and/or still relevant.

The FACT and FRAT are described in more detail in Annex 3.

Information Need: Modeling the Contribution of Food Fortification to Micronutrient Adequacy

Method

The 2006 WHO and FAO guidelines on food fortification explain that modeling to assess the potential contribution of food fortification on micronutrient adequacy is necessary during the LSFF program design stage to help define and set the fortification program goals. The modeling can also be used during a program review stage to reassess the contribution of food fortification to micronutrient adequacy. The data can help to understand the potential contribution of food fortification on micronutrient adequacy for different strata of the population, such as geographic area, urban/rural settings, by socio-economic wealth quintiles, sex, age, and season, if feasible.

To model the contribution of food fortification to an adequate diet, the 2006 WHO and FAO guidelines recommend using the same method as noted above for estimation of micronutrient adequacy—the EAR cut-point method and the UL cut-point method for most micronutrients, and the full-probability method for micronutrients when the distribution of requirements is not normally distributed.

The EAR and UL cut-point methods and full-probability method are used when modeling the proportion of the population with inadequate intake using different formulations of food fortification. The WHO and FAO guidelines state that food fortification programs should be designed so that when they are implemented, the predicted probability of inadequate micronutrient intake is acceptably low (about 2.5 percent) for population subgroups of concern, while at the same time avoiding risk of excessive intake in other subgroups in the population. Experts have noted that this can be challenging to achieve (Engle-Stone et al. 2019).

As noted above, for the EAR and UL cut-point methods, recently developed harmonized average requirements, also known as H-AR and H-UL, are recommended for use (Allen et al. 2020). The methods described is this review all employ the EAR and UL cut-point approach and the full-probability approach in the case of iron. It is beyond the scope of this review to provide an in-depth description of these methods, but they will be described in detail, as appropriate, in the methods section of the USAID LSFF Programming Guide or accompanying documentation.

The critical nutrient density approach can also be used to model the potential contribution of a centrally fortified food to an adequate diet. Please see "needs assessment" above for more information about the critical nutrient density approach.

The 2006 WHO and FAO guidelines contain four steps to model the potential contribution of a fortified food to micronutrient adequacy:

1. Determine the usual intakes of selected micronutrients in specific population subgroups.

2. Identify the population subgroups at greatest risk of inadequate intake of specific micronutrients.
3. Determine the amount of the food vehicle usually consumed by the population subgroup of greatest risk of inadequate micronutrient intake, and the amount consumed by those with the highest levels of consumption of the food vehicle, to determine potential risk of excess intake.
4. Model the effect of adding different contents of the micronutrient or micronutrients—if more than one micronutrient will be added to the food vehicle—repeating as needed to identify either an appropriate fortification formulation, and/or the percentage of remaining inadequate intake given the conditions that are possible.
    a. The modeling is conducted by recalculating the distribution of the micronutrient intake if the fortified food were to contain higher or lower amounts of the micronutrient.
    b. The modeling helps to identify a level of fortification that prevents inadequate intake in a population at risk but avoids a high proportion of very high intakes.

However, the amount of micronutrients that can be added to a food vehicle is determined not only by the existing micronutrient gaps that are going to be corrected, but also by safety of the fortification levels, the available technology for fortification, and economic constraints/cost of the fortification for industry and the consumer. The approach to determine the micronutrient content in fortified foods cannot only be nutritional, as this is frequently not realistic (Dary 2021). The modeling of the contribution needs to begin with the feasible micronutrient contents that are possible to use, which requires discussions with industry stakeholders, among others (ibid.). Modeling can include estimating micronutrient adequacy under:

- mandatory fortification at current fortification levels (current situation of coverage and compliance, if the data are available)
- mandatory fortification at target -expected- levels (with good coverage and compliance of current fortification standards or regulations)
- fortification of mandatory or new food vehicles, varying the levels of micronutrient addition (adjusting the current standards and/or including fortification of other fortifiable vehicles with fortification formulations that are compatible with technical and economical limitations and trade agreements) (Dary 2022; Adams 2022a).

Suitable Data Sources

The options regarding data sources on the diet to model the contribution of food fortification to micronutrient adequacy, in order of suitability, and the rationale for their order of priority, are the same as those indicated above to assess adequacy of micronutrient intake: 1) quantitative open 24-hour dietary recall; 2) total diet SQ-FFQ (i.e., not just of a limited number of specific foods); 3) household food consumption module of the HCES; and 4) food balance sheets.

Regarding modeling the "current" situation of fortification noted by Dary (2022) above, there are two potential data sources on amounts of micronutrients present in products that are already fortified as part of LSFF. One is the FACT that includes questions on coverage of fortified foods, as well as testing the micronutrient content of composite fortified food samples. The FACT micronutrient content testing can be conducted with either household or market food samples (Jungjohann 2022). Market food sample collection may be more frequently conducted in many countries given its reduced costs compared to household-level food sample collection and/or as part of ongoing monitoring efforts (Friesen 2022b). Another potential data source for population-level data on the coverage and micronutrient content of foods fortified at large scale include national micronutrient surveys. Examples include collection of household-level data on the micronutrient content and coverage of:

- Salt fortified with iodine; wheat flour and semolina flour fortified with iron; maize flour, sugar, and oil fortified with vitamin A in **Nigeria** (Food Fortification Initiative et al. 2018).

- Salt fortified with iodine; wheat flour, wheat bread, and maize meal fortified with iron in **South Africa** (Centers for Disease Control and Prevention et al. 2017a).
- Salt fortified with iodine, wheat flour and maize flour fortified with iron, and oil fortified with vitamin A in **Tanzania** (Tanzania National Bureau of Statistics et al. 2016) and **Uganda** (Centers for Disease Control and Prevention et al. 2017b).
- Salt fortified with iodine and wheat flour fortified with iron in **Nepal** (Ministry of Health and Population, Nepal et al. 2016).
- Salt fortified with iodine and white wheat flour fortified with iron in **Oman** (Ministry of Health of Oman, et al. 2004).
- Bread fortified with iron in **Jordan** (Ministry of Health Jordon et al. 2021).
- Wheat flour fortified with iron and oil fortified with vitamin A in **Ghana** (University of Ghana et al. 2017).
- Salt fortified with iodine, and wheat flour and bread fortified with iron in **Uzbekistan** (Ministry of Health of the Republic of Uzbekistan et al. 2019).
- Salt fortified with iodine in **Gambia** (National Nutrition Agency (NaNA)-Gambia et al. 2019), **Sierra Leone** (Ministry of Health and Sanitation Sierra Leone et al. 2015); and **Somalia** (Ministry of Health FGS, FMS, Somaliland, et al. 2020).

Four of these surveys used the Fortification Assessment Coverage Toolkit (FACT) developed by the Global Alliance for Improved Nutrition (Nigeria, South Africa, Tanzania, and Uganda).

Examples of Tools

The tools for analysis of quantitative open 24-hour dietary recall data in Table A1.1 in Annex 1 are also relevant for the analysis of the contribution of food fortification to micronutrient adequacy.

It is noteworthy that two projects include a focus on modeling the contribution of food fortification to micronutrient adequacy, as well modeling the contribution of complementary interventions to improve micronutrient intake.

- **The Micronutrient Intervention Modeling (MINIMOD) project**, implemented by the University of California Davis, includes a Nutrition Benefits Model, which uses either quantitative open 24-hour dietary recall data or household consumption data from HCES to estimate usual dietary intake and dietary inadequacy and model the effects of food fortification, as well as other interventions, on the prevalence of inadequate micronutrient intake. The results are specific for geographic area and time frame.
  - The Nutrition Benefits Model is used to determine the program "reach", defined as the proportion of individuals who consumed any additional amount of a specified micronutrient due to a given program (Vosti et al. 2020).
  - The model is also used to determine "effective coverage", defined as the proportion of individuals who had inadequate dietary intake for a specified micronutrient and subsequently would achieve adequate micronutrient intake as a result of one or more micronutrient intervention programs.
  - As a part of the process of calculating effective coverage, the model is used to (Nutrition Modeling Consortium 2017):
    - Estimate usual nutrient intakes using the National Cancer Institute (NCI) method (when using 24-hour dietary recall data).
    - Estimate the percentage of the target population below the EAR and the percentage above the UL.

        ▪ Simulate the contribution of different amounts of the micronutrient added to the fortifiable food or fortified food.
        ▪ Reassess the percentage of the target population below the EAR and the percentage above the UL.
    - MINIMOD includes three models, the "Nutrition Benefits Model", the "Cost Model", and the "Economic Optimization Model". The "Nutrition Benefits Model" is the model that is relevant for this literature review. We are not proposing to use every model of MINIMOD, given the other two models are outside the scope of what USAID is requesting for this literature review and activity.
    - Note that MINIMOD as a project also conducts baseline scenarios that can be used for needs assessment.
- **The Micronutrient Action Policy Support (MAPS) project**, implemented by the University of Nottingham, is co-creating a web-hosted tool to estimate micronutrient deficiencies and inadequate micronutrient intake and explore pathways to improve nutrition in Malawi, Ethiopia, and Burkina Faso. The MAPS team has used household consumption data from HCES to estimate food consumption and micronutrient intake and model various scenarios of fortification and their contribution to micronutrient adequacy using the adult male equivalent or adult female equivalent approach, as well as the nutrient density approach.
    – The team uses the estimated average requirement (EAR) and upper level (UL) cut-point approaches and the full-probability approach for iron; as well as H-ARs and H-ULs to estimate prevalence of inadequate and excess micronutrient intake, respectively.
    – MAPS provides the code in the R statistical software on GitHub to conduct the analysis.
    – Various aspects of the online version of the MAPS tool are under development but we are focusing on the part of the MAPS methodology that is used to estimate dietary micronutrient supplies and risks of inadequate intake. We are not proposing to use every aspect of the MAPS tool.

Both projects are developing tools to facilitate analysis and/or access to data for decision making around LSFF and improving micronutrient intake. More details regarding the two projects can be found in Annex 3.

Information Need: Modeling the Contribution of Food Fortification to the Cost of an Adequate Diet (Optional—for advocacy, as needed)

Method

Price and affordability are key barriers to accessing sufficient, safe, nutritious food to meet dietary needs and food preferences (Herforth et al. 2021). LSFF can be a very cost-effective intervention to address micronutrient malnutrition when designed and implemented appropriately (WHO 2021a). This is especially true when a widely and consistently consumed affordable food vehicle is available or could be made available throughout the year, because industrial fortification of such foods could provide significant returns for a low cost (WHO 2021a; WHO and FAO 2006). Modeling and assessing the contribution of a fortified food on the cost of an adequate diet can help determine if a fortified food may make adequate diets affordable and accessible. The information is not critical as an input into the design of an LSFF program but may be useful for advocacy for the LSFF program, so is considered an optional analysis, selected based on local need.

There is a lack of extensive literature on methods to model the contribution of food fortification to the cost of an adequate diet. However, linear programming analysis is a method that has been used to identify a low-cost nutritionally adequate diet (Briend et al. 2021). It is a mathematical technique that minimizes a linear function of a set of variables to generate optimal solutions while simultaneously satisfying multiple constraints (Van Dooren 2018; Briend et al. 2001). It can be used to minimize the cost of a diet while fulfilling constraints introduced to ensure it is nutritionally adequate. As an example, the

World Food Program has used linear programming extensively to model the contribution of food fortification to the cost of an adequate diet, in addition to modeling the contribution of other interventions on diet cost (WFP 2022). The World Food Programme's objective is to use the findings to advocate for interventions, such as LSFF, to improve micronutrient adequacy in populations vulnerable to malnutrition. Software programs such as Microsoft Excel have a linear program function known as a "solver function". Optimized diets that are identified through linear programming should be discussed with local nutritionists and individuals in the populations of interest and tested to confirm that they are compatible with general food-consumption patterns (Briend et al. 2001).

Suitable Data Sources

Table 2 provides the input data needed for linear programming analysis to model diets/diet cost and potential data sources (Briend et al. 2001; Ferguson et al. 2006; Daelmans et al. 2013). Data inputs include a list of foods consumed; the nutritional constraints on the minimum energy and nutrient content in the diet; food-consumption constraints including the maximum acceptable daily portions of individual foods, the percentage of energy provided by a food or foods (if desired), and the minimum and maximum servings per week; the costs of foods, and food composition tables.

For the list of foods, quantitative or qualitative open 24-hour dietary recall data from population-based surveys is a good source of information. Individuals conducting the linear programming analysis may use population-based semi-quantitative food frequency, food frequency, or HCES data, but the utility of these data sources will depend on the extensiveness of the food lists. Population-based weighed-food records are also a potential data source, but few exist given their cost, source requirements, and complexity.

Analysts may use FAO and WHO recommended nutrient requirements, or recommended nutrient intakes from other official government sources or international bodies, for constraints regarding nutrient intake. For micronutrient intake constraints, experts have recommended that the analysis use the harmonized average requirements (H-ARs, Allen et al. 2020). Analysts can discuss the intake constraints with international and country-level experts.

Analysts will need quantitative dietary intake data, such as from a quantitative open 24-hour dietary recall and/or semi-quantitative food frequency questionnaire, to identify food-consumption constraints for the linear programming models. Examples of the kind of data needed include the maximum acceptable daily portions of individual foods, and if desired, the percentage of energy provided by a food or foods. Food frequency data is useful to determine constraints regarding the minimum and maximum servings per week of individual food items.

Food prices can be determined from market surveys, household consumption and expenditure surveys, and/or consumer price index information from official government sources. There is no particular priority in terms of the food cost data options. Price estimates for foods not currently fortified but with the potential to be fortified would need to be discussed with the companies that would produce the fortified food and with country experts and government officials.

Analysts can use data on the nutrient composition of foods from country-specific food composition tables or other food composition tables or published information regarding the nutrient content of foods as appropriate/needed.

Analysts should discuss all potential data sources with local experts to identify the sources considered the most valid and that will be accepted by policymakers, planners, and government officials (Knight et al. 2022).

Table 2. Input Data Needed for Linear Programming Analysis and Potential Data Sources

Input Data Needed for Linear Programming Analysis	Potential Data Sources
List of foods	• 24-hour dietary recall (quantitative or qualitative, open, population-based data) • Semi-quantitative food frequency or food frequency (population-based data) • Household consumption (from HCES)
Nutritional constraints on the minimum energy and nutrient content in the diet	• FAO and WHO recommended energy intakes • Harmonized average requirements (H-AR) for micronutrients • Other recommended nutrient intake amounts, as appropriate
Food-consumption constraints: • Maximum acceptable daily portions of individual foods • If desired, percentage of energy provided by a food or foods • Minimum and maximum servings per week	• 24-hour dietary recall (quantitative, open, population-level data) • Semi-quantitative food frequency or food frequency (population-based data) • Household consumption (from HCES)
Cost of foods	• Market surveys • Household consumption and expenditure surveys • Consumer price index (official government data)
Food composition tables	• Country-specific food composition tables • Additional food composition tables as appropriate/needed

Examples of Tools

There are two noteworthy tools that use linear programming to optimize diets at the lowest feasible cost—Cost of the Diet (CotD) and Optifood.

- **Cost of the Diet**: The CotD uses linear programming to select a combination of foods that would meet nutrient needs at the lowest cost (Deptford et al. 2017; Save the Children UK 2018). It can be used to create "what if" scenarios to model how the cost of an adequate diet may change given interventions such as food fortification, biofortification, supplementation, cash transfers, etc., which is useful for advocacy or to demonstrate the potential in terms of program design considerations (Untoro et al. 2017). CotD can be used for analysis at the individual or household level (Daelmans et al. 2013). The World Food Program has used HCES data for modeling in CotD (Knight 2020). However, the CotD "diet" cannot necessarily be used to make a recipe or meal. The CotD results provide an economic benchmark of the lowest possible cost of a diet that meets nutrient needs. A realistic diet that meets micronutrient needs and considers dietary patterns and preferences will likely cost more than the nutrient-adequate diet selected by the software program. Results do not represent the distribution of dietary patterns within the population.
- **Optifood**: The Optifood tool uses linear programming to analyze foods consumed by and acceptable to a target population to facilitate formulation of food-based dietary recommendations to meet micronutrient needs (Deptford et al 2017; Daelmans et al. 2013).

Optifood specifically aims to select realistic diets according to the dietary habits and local food supply and access. If micronutrient needs cannot be met, interventions such as food fortification or supplementation can be modeled in the software to help fill the micronutrient gaps. Optifood can determine which micronutrient requirements are the most expensive to achieve, model diet costs and the proportion of costs required for each food in the most nutritious model diet, and analyze the potential contribution to nutrient adequacy and cost of adding new foods to the local diet. Optifood can be used for population-level analysis for individual groups, such as women or children of specific ages or physiological status—it is not used for analyses at the household level (Daelmans et al. 2013). HCES data have been used for modeling in Optifood (Knight et al. 2021). Results do not represent the distribution of dietary patterns within the population.

More information about these tools can be found in **Annex 3**. We are proposing to use the diet cost modules of these tools, not all aspects of each tool.

Household-Level Consumption Monitoring

Information Need: Coverage of Fortified Foods and Micronutrient Content of Composite Fortified Food Samples (Household Level)

Method

Household-level consumption monitoring is important during LSFF program implementation to ensure that (WHO 2021b)

- the coverage of the fortified food and intake of nutrients from the fortified food is as expected based on the design of the program
- the expected nutrition and health benefits are likely.

According to WHO (2021b), ideally consumption monitoring will include collection of data to calculate the following:

- **Fortified food coverage**: The percentage of households with the specific food that by law or standards should be fortified and is confirmed to be fortified (among the households that provided samples of the specific food).
- **Micronutrient content of fortified food**: The average additional content of micronutrients in the food that by law or standards should be fortified (additional content in terms of the amount above what is in the unfortified food).
- **Fortified food intake**: The average daily intake of a food that by law or standards should be fortified (among consumers of the specific fortified food).
- **Micronutrient intake from fortified food**: The average additional amount of micronutrients delivered daily by consumption of the food that by law or standards should be fortified (among consumers of the specific fortified food).

However, experts have suggested that estimates of micronutrient intake from fortified foods are best interpreted in the context of the whole diet, instead of just analyzing the consumption of the fortified food (Engle-Stone 2022a; Friesen 2022a). For example, providing 40 percent of the EAR is good if a population is below the EAR but it is not useful if the population is already consuming, for example, twice the EAR (Engle-Stone 2022a). It is not clear that quantitative dietary intake data are needed to monitor an LSFF program, particularly if the program is well designed, that is, designers selected the foods and fortification amounts to fill identified nutrient gaps in the diet of the population of interest. For a well-designed LSFF program, it should be sufficient to monitor if foods that by law or standards should be fortified are indeed fortified, and the coverage of the fortified food (Friesen 2022a, Engle-Stone 2022a). It may be best to assess the specific contribution of fortified foods to the diet at the program evaluation stage when full dietary intake data are available (Friesen 2022a). In addition, LSFF program planners and implementers may lack the financial and human resources to collect the data necessary to calculate each of the indicators listed in the four bullets above. Therefore, some experts have suggested that of the indicators listed above, **fortified food coverage** and **micronutrient content of the fortified food** may be the most feasible to prioritize for monitoring (Engle-Stone 2022a; Friesen 2022a).

Calculation of these indicators at the household level may be conducted through data collection in a representative population-based survey. Survey enumerators ask respondents about the presence in the household of foods that by law or standards should be fortified and collect food samples, when available in the household. Laboratory analysts conduct spot tests to determine whether the food samples are fortified, create composite samples, e.g., by cluster, and determine the micronutrient content of the composite samples. One potential limitation of household-level fortified food sample collection is that the fortified food may not be available in households at the time of the survey (Jungjohann 2022). If this is a likely situation in many households, the food samples for the survey can be collected in markets instead of households. Note that information on micronutrient content of fortified foods could be used to inform new modeling scenarios if appropriate secondary data on total dietary intake exist (refer to the section on *Modeling the Contribution of Food Fortification to Micronutrient Adequacy* above).

The questions regarding fortified food consumption (or acquisition) and food sampling can be included in existing national-level surveys, for example national micronutrient surveys, Demographic and Health Surveys, household consumption and expenditure surveys, or others. In this way the data on fortification coverage and extent of fortification will periodically be available. If it is not feasible to collect household-level data on fortified food coverage and micronutrient content of fortified food through existing national-level surveys or a stand-alone survey, implementers can consider collecting market-level data on the presence and average micronutrient content of fortified foods. However, this would not be considered market monitoring. It would be considered consumption monitoring, with the samples coming from markets instead of households (Dary 2022).

Another option for data collection for consumption monitoring is through establishing a monitoring system or using an existing monitoring system. Fortification Monitoring and Surveillance (FORTIMAS) is a monitoring approach that uses, in part, non-probabilistic sentinel site data collection in health centers and schools to determine the percent of households that have purchased a fortified food and the percent of households with fortified food (Smarter Futures 2017). FORTIMAS was designed to track the population coverage and impact of flour fortification programs but can be applied to other fortification programs as well. It is designed to triangulate sentinel site data with data on industry production, sales, and fortification quality and existing information systems (e.g., health) and national surveys (e.g., national micronutrient surveys). Successful application and data quality will depend on data available in local health information systems, local data collection and processing capabilities and resources, and levels of health center and school attendance. More details on FORTIMAS can be found in Annex 3.

Note that the *USAID Large-Scale Food Fortification Programming Guide* defines monitoring as "The continuous collection and review of data and information on program implementation activities for the purposes of identifying problems (such as non-compliance) and taking corrective actions so that the program fulfills its stated objectives." Although the term "consumption monitoring" is used in this section of the literature review, the collection and review of data for consumption monitoring referred to here is not "continuous". In practice, the frequency of data collection or even whether consumption monitoring is conducted will depend on available resources. WHO indicates that ideally, some degree of consumption monitoring will occur regularly, although WHO does not define "regularly" (WHO 2021b). As indicated above, one way to minimize costs is to add consumption monitoring questions to regularly conducted surveys.

According to WHO, consumption monitoring should only be implemented after regulatory monitoring, that is, internal, external, import, and commercial monitoring, demonstrates that foods are fortified in the country (WHO 2021b). Otherwise, the consumption monitoring activity will be an inefficient use of resources (WHO 2021b, Pachón and Dary 2018). The following bullets describe each type of regulatory monitoring.

- **Internal monitoring** refers to industry procedures, actions, and tests to manufacture fortified food to achieve/adhere to specifications of fortification standards; it includes quality assurance and quality control.
- **External monitoring** refers to government food control authority activities to ensure fortified foods achieve/conform to specifications of fortification standards; it includes auditing and inspection.
- **Import monitoring** refers to food control authority inspectors and border customs personnel activities to ensure foods that are supposed to be fortified meet fortification standards upon entry into the country.
- **Commercial monitoring** refers to collection and analysis of product samples and reviewing product packaging at retail stores and other food distribution sites to confirm they follow specifications in fortification standards, such as micronutrient content and labeling requirements.

During the program implementation stage, WHO indicates that it is imperative that companies establish effective internal monitoring and quality assurance systems, that the government executes effective external, import, and commercial monitoring, and that a system exists to use the generated data to make program improvements (WHO 2021b; Pachón and Dary 2018).[9] This internal and external monitoring is needed to ensure that centrally processed fortified foods meet established fortification standards (WHO 2021b).

However, it can be challenging for governments to establish sustainable regulatory monitoring given the necessary cost, time, and technical expertise (Rowe 2020). It may likely be necessary to conduct household-level consumption monitoring before regulatory monitoring can demonstrate that foods are fortified to specified standards (Dary 2022). Note that assessment methods for regulatory monitoring are beyond the scope of this literature review.

Suitable data sources and/or surveys and surveillance systems for data collection

Examples of surveys that may exist in a country and that could serve as a platform for adding consumption monitoring questions and fortified food sample collection are:

- national micronutrient surveys
- national food consumption surveys
- national nutrition surveys
- national health surveys[10]
- household income and expenditure surveys
- food security surveys
- STEPwise approach to surveillance (STEPS) surveys.[11]

As noted above, several national micronutrient surveys have already included questions on food fortification and collection of fortified food samples. Several of these surveys have collected data using

[9] to confirm they follow specifications in fortification standards, such as fortificant content and labeling requirements (WHO 2021b).

[10] For example, the demographic and health survey (DHS).

[11] The WHO STEPwise approach to surveillance (STEPS) is an internationally comparable, standardized and integrated surveillance tool through which countries can collect, analyze and disseminate core information on noncommunicable diseases. For more information please see: https://www.who.int/teams/noncommunicable-diseases/surveillance/systems-tools/steps.

the FACT. In addition, such questions and food sample collection could also be added to ongoing data collection activities as part of health or nutrition surveillance systems.

The options regarding data sources to estimate micronutrient adequacy of the diet, using the micronutrient content of the composite samples of fortified foods, are the same as those indicated above for needs assessment. In order of suitability, starting with the most suitable, the options are the quantitative open 24-hour dietary recall, SQ-FFQ, HCES, and FBS. The rational for their order of priority is also the same as that indicated in the needs assessment section above.

Examples of Tools

The Fortification Assessment Coverage Toolkit (FACT) provides standardized methods for the collection, analysis, and synthesis of data to estimate population-level household coverage of fortifiable and fortified foods and individual-level consumption of fortifiable and fortified foods, as well as micronutrient contributions of fortified foods to the diet (Friesen et al. 2019). It is specifically designed to respond to key consumption monitoring questions. FACT uses validated instruments, when available; and can provide data disaggregated at various levels, depending on sampling, sample size, and demographic information collected. The FACT also provides a standardized approach to assess fortified food coverage and the micronutrient content of fortified foods in markets (Friesen et al. 2019). FACT indicators can be assessed as part of a stand-alone household and/or market survey or integrated into other surveys and/or surveillance systems (Friesen et al 2019). More details on FACT can be found in Annex 3.

Evaluation

Information Need: Prevalence of Adequate Micronutrient Intake and Contribution of Fortified Food to Micronutrient Adequacy

Method

The 2006 WHO and FAO guidelines on food fortification note that, although impact evaluations for food fortification programs are rarely done due to their cost and complexity, they are important to ensure the programs help populations vulnerable to malnutrition meet their micronutrient needs but also avoid excess intake in other subpopulations, especially because industrially processed fortified foods have become more widely consumed in LMICs (Engle-Stone et al. 2019). Evaluations are also important for making program and policy decisions and providing answers to key questions such as whether the intake of a specific nutrient has increased, or nutrient adequacy has improved. Experts recommend that ideally, LSFF program designers should plan for evaluations from the design phase, including a baseline survey and at the appropriate time, an end line or follow-up impact evaluation (Martorell et al. 2017). The evaluation should help to identify areas for improvement and better understand the causes behind specific outcomes.

The WHO and FAO guidelines mention three evaluation approaches: 1) adequacy, to assess if the intake of micronutrients is acceptable, requiring a cross-sectional survey of nutrient intake; 2) plausibility, to be able to state that it is plausible that the food fortification program was the cause of changes; in the context of nutrient adequacy, this would require a quasi-experimental or case-control study design; and 3) probability, to determine with a pre-specified level of probability that changes in nutrient adequacy were due to the fortification program, which would require a double-blind, randomized, experimental design. The selection of the approach depends on the evaluation purpose, available resources, and level of precision needed for decision-making. Experts have emphasized that evaluations should be carried out after it is clear from regulatory and household monitoring that the program is operating efficiently, because otherwise the evaluation would not be a good use of resources (WHO and FAO 2006; Rowe 2020; WHO 2021b, Pachón and Dary 2018). WHO has recommended that an evaluation of LSFF program impact on nutrition and health outcomes should be conducted when the foods that are centrally fortified are consumed regularly by at least 80% of the target population and the fortification program has been operating successfully and consistently for 12 to 18 months (WHO 2012b). The FAO and WHO guidelines do not indicate how frequently evaluations should be conducted. As with monitoring, however—whether, how, and how often an LSFF program evaluation is conducted will depend on the local context, such as available resources and if available, monitoring findings. Evaluations should be conducted by independent research groups or international agencies to ensure they are impartial. In summary, the methods to evaluate changes in food consumption and micronutrient adequacy will include surveys with a design that is aligned to country needs and resources.

Evaluations can serve formative (i.e., to identify and address issues) or summative purposes (i.e., to permit conclusions related to the program for accountability purposes) (Neufeld and Friesen 2018). In the context of food fortification, evaluations tend to collect biological samples to be analyzed for nutritional biomarkers (Pachon and Dary 2018). Neufeld and Friesen (2018) have summarized evaluations of LSFF interventions by study design, nutrient, and food vehicles. Most evidence for the "impact" of food fortification programs stems from observational studies (e.g., ecological, cross-sectional, and cohort designs), which do not allow for causal attributions, while evidence from randomized studies is scarce. Because pre-post cross-sectional surveys do not allow for attribution of causality with regard to biomarker changes in response to fortification, it is suggested that regulatory and consumption monitoring data, if available, be reported as part of the evaluation (Pachon and Dary 2018). LSFF program baseline and impact evaluations should include collection of data on micronutrient deficiencies (Coates et al. 2012a; WHO and FAO 2006), but the methods to assess micronutrient deficiencies are beyond the scope of this literature review.

Specific questions to evaluate LSFF programs can be added to existing surveys to make efficient use of resources (Dary 2022). Examples of surveys are the same as those listed for monitoring, such as national micronutrient surveys, food consumption surveys, health surveys, or household consumption and expenditure surveys. For evaluation, additional questions would be added to the survey, beyond those asked for monitoring. For example, the survey would include questions regarding intake of the whole diet, not just the fortified food, using, for example, quantitative open 24-hour dietary recall, SQ-FFQ, or household consumption, in that order of preference, given the more detailed dietary data collected with the first method, compared to second and last method. For a program evaluation, it would be important to include assessment of the whole diet to have updated data on consumption patterns. As with monitoring, fortified food samples would also be collected as a part of a survey for LSFF program evaluation. The data on food consumption and micronutrient content of the fortified food would allow for determination of the percentage of the population with adequate micronutrient intake and the contribution of the fortified food to micronutrient adequacy, considering the whole diet. Typically, an evaluation of a fortification program would measure the change in micronutrient adequacy and/or status before and after implementation. Ultimately, a team of experts and key stakeholders in a country will make decisions regarding program evaluation considering the local situation.

The method to analyze the food consumption data to estimate micronutrient adequacy is the same as that used in the needs assessment phase—the EAR cut-point method and the UL cut-point method for most micronutrients, the full probability approach for micronutrients when the distribution of requirements is not normally distributed and using the appropriate H-AR and H-UL. This same method is used to estimate the contribution of the fortified food to micronutrient adequacy. The critical nutrient density approach can also be used to estimate micronutrient adequacy.

Suitable Data Sources and/or Surveys for Data Collection

Examples of surveys that may exist in a country and that could serve as a platform for adding evaluation questions and fortified food sample collection are—

- national micronutrient surveys

- national food consumption surveys
- national nutrition surveys
- national health surveys
- household income and expenditure surveys
- food security surveys
- STEPwise approach to surveillance (STEPS) surveys.[12]

As noted above, several national micronutrient surveys have already included questions on food fortification and collection of fortified food samples, however, they would need to add specific questions regarding food consumption (i.e., the entire diet).

Examples of Tools

The tools for analysis of quantitative open 24-hour dietary recall data in Table A1.1 in Annex 1 are also relevant for the analysis of the estimation of micronutrient adequacy for program evaluation.

Examples of tools for collection of quantitative open 24-hour dietary recall data include:

- INDDEX24 Dietary Assessment Platform: Developed by the International Dietary Data Expansion (INDDEX) Project, the INDDEX24 Dietary Assessment Platform is an integrated dietary research platform that leverages the INDDEX24 Mobile App and the Global Food Matters Database to improve 24-hour dietary recall data collection in low- and middle-income countries.
- OpenDRS—Open-access Dietary Recall System: Developed by the University of California Davis, OpenDRS is an interactive, multiple-pass 24-hour dietary recall written in XLSForm for use through survey tools such as Open Data Kit (ODK), SurveyCTO or other platforms supporting XLSForm. Researchers share sample XLSForm, Stata and SAS code for use with a tablet or web browser. The form was developed for use in low- and middle-income countries, and all aspects can be modified as needed to support study objectives. OpenDRS is provided open access for not-for-profit use only.

The U.S. National Institutes of Health National Cancer Institute provides useful information and resources for the development, application, and analysis of food frequency questionnaires, including the SQ-FFQ.

The World Bank Living Standards Measurement Study shares helpful resources on collecting and analyzing household consumption and expenditure survey data (FAO and World Bank 2018).

Use of Methods to Assess Broader Programming to Improve Diets

The suggested methods can be applied to assess broader programming to improve diets, particularly for needs assessment, as can most of the data sources and the tools, depending on the context and need. However, in all cases, it is important to review the specific program needs and if needed, adapt methods and tools to the local context and pre-test them prior to use.

[12] The WHO STEPwise approach to surveillance (STEPS) is an internationally comparable, standardized and integrated surveillance tool through which countries can collect, analyze and disseminate core information on noncommunicable diseases. For more information please see: https://www.who.int/teams/noncommunicable-diseases/surveillance/systems-tools/steps.

Summary of Proposed Needs Assessment and Design Methodology to Guide LSFF Programming

Table 3 shows the steps in the proposed methodology to assess diets, markets, and cost of an adequate diet, based on the findings of this literature review. The table describes, for needs assessment and design, the step in the methodology, the information need, for each information need, the method and the data sources for secondary analysis, and the technical expertise needed to conduct the analyses. The cost and time to conduct each analysis is relatively low, for example, less than $100,000 USD and less than 6 months from analysis to final report. As noted above, the methodology is designed for all analyses to be conducted with existing data (i.e., no primary data collection). An acronym key and a color code key for the data sources can be found in the table notes, along with other important table footnotes. A glossary of terms that readers may find useful can be found before the executive summary of this review. Table A2.1 in Annex 2 summarizes all the literature review findings by data source and tool. A detailed description of the data sources and tools can be found in Annex 3.

Table 3. Proposed Methodology for Needs Assessment and Design to Guide LSFF and Broader Programming[a]

Information Need and Method, by Step[b]	Secondary Data Sources										
	Quantitative open 24-hour dietary recall	Semi-quantitative food frequency	Household food consumption - HCES	Food Balance Sheets	Market assessment	Agri-food information systems	National Micronutrient Survey	Household survey w/ food sample collection	Market price survey	HCES price data	Consumer Price Index
Step 1. Needs Assessment											
Information need: Adequacy of micronutrient intake/supply											
Method: Estimate current micronutrient adequacy of diets using the EAR cut-point method, or the full-probability method when intake distributions are not normally distributed (disaggregated as appropriate/feasible)											
Potential Data Sources	●	●	●	●							
Step 2. Design/Redesign											
Information need: Fortifiable food consumption											
Method: Estimate the amount of the fortifiable foods consumed per individual (by age and/or sex), per AME, per capita per day; or available amount per capita per day in the food supply (disaggregated as appropriate/feasible)											
Potential Data Sources	●	●	●	●							
Information need: Availability and average price of fortifiable foods in markets											
Method: Estimate the percent of markets with the fortifiable food of interest and the average price (disaggregated as appropriate/feasible)											

Information Need and Method, by Step[b]	Secondary Data Sources										
	Quantitative open 24-hour dietary recall	Semi-quantitative food frequency	Household food consumption - HCES	Food Balance Sheets	Market assessment	Agri-food information systems	National Micronutrient Survey	Household survey w/ food sample collection	Market price survey	HCES price data	Consumer Price Index
Potential Data Sources					🟢	⚪					
Information need: Predicted contribution of food fortification to micronutrient adequacy											
Method: Estimate micronutrient adequacy with and without LSFF using the EAR cut-point method, or the full-probability method when intake distributions are not normally distributed. Potential modeling scenarios: mandatory fortification at current fortification levels (current situation of coverage and compliance, if data available); mandatory fortification at target levels (with good coverage and compliance of current fortification standards or regulations); and fortification of mandatory or new food vehicles varying the levels of micronutrient addition (adjusting the current standards and/or including fortification of other fortifiable vehicles).											
Potential Data Sources: To estimate micronutrient intake	🟢	🔵	🟠	⚪							
Potential Data Sources: For current fortification, if available[c]							🟢	🟢			
Optional Step. Advocacy for Program Support											
Information need: Cost of an adequate diet with/without LSFF											
Method: Linear programming analysis to identify the lowest-cost nutritionally adequate diet with/without fortified foods											
Potential Data Sources: For list of foods	🟢	🔵	🟠								
Potential Data Sources: For food prices					🔵				🔵	🔵	🔵
Technical Expertise Needed to Conduct the Analysis Using Data Sources											
Technical Expertise	🧠🧠🧠	🧠🧠🧠	🧠🧠🧠	🧠🧠🧠	🧠🧠	🧠🧠	🧠🧠	🧠🧠	🧠🧠	🧠🧠	🧠🧠

Sources: Coates et al.2012a; Coates et al.2012b; Engle-Stone et al. 2019; Dary and Imhoff-Kunsch 2012; WHO and FAO 2006; Hotz et al. 2017; Gibson and Ferguson 2008; Dary and Jariseta 2012; Imhoff-Kunsch et al. 2012; Jariseta et al. 2012; Tang et al. 2022; Smarter Futures 2017; Galtier et al. 2014; Friesen et al. 2017; Friesen et al. 2019; Aaron et al. 2016; Neufeld et al. 2017; Mkambula et al. 2020; Micronutrient Initiative 2003; Hess et al. 2013; Berti et al. 1999; Deptford et al. 2018; Untoro et al 2017; Save the Children UK 2018; Daelmans et al. 2013; Untoro et al. 2017; Cost of Nutritious Diets Consortium 2018; Deptford et al 2017; and Knight and Woldt 2017.

Acronym Key: AME: Adult male equivalent; EAR: estimated average requirement; HCES: household consumption and expenditure survey; LSFF: large-scale food fortification.

Data Source Color Code Key:

🟢	Very good data source, very suitable for the information need, given strengths and limitations
🔵	Good data source, suitable for the information need, given strengths and limitations
🟠	Moderately good data source, adequate for the information need, given strengths and limitations
⚪	May be used, but has/may have significant limitations

	Does not provide relevant information (i.e., blank square)

Technical Expertise Key:

	Required technical expertise—relatively high, e.g., requires senior and mid-level staff with high level of technical expertise and specialized training, capacity and experience in study design, statistics for analysis, interpretation, report writing and/or dissemination.
	Required technical expertise—moderate, e.g., requires senior and/or mid-level staff with general background in nutrition, public health, agriculture, or related area.
	Required technical expertise—relatively low, e.g., does not require staff with technical expertise in nutrition, public health, agriculture, statistics, etc.

Notes

a. Please note that USAID requested that the literature review include methods for needs assessment, design/redesign, monitoring, and evaluation, but that the guide focus on needs assessment and program design/redesign. Also note that prevalence of micronutrient status is important for needs assessment for LSFF, but USAID has requested that for needs assessment, the literature review and guide focus on methods to assess micronutrient intake. Methods to assess biomarkers and micronutrient status are beyond the scope of this review and the guide.

b. Preferably data is nationally representative and able to be disaggregated by geography and/or socio-economic status and other aspects of interest, such as age and sex. Note that food balance sheet data is only available at the national level and generally cannot be disaggregated.

c. Please note that not all national micronutrient surveys may collect data on the micronutrient content of foods fortified at large scale, but for those surveys that do, the data should provide the information necessary for this method. National micronutrient surveys include, e.g., those supported by the U.S. Centers for Disease Control and Prevention International Micronutrient Malnutrition Prevention and Control CDC/IMMPaCt, GroundWork, and/or the Global Alliance for Improved Nutrition (GAIN).

Next Steps

Next steps include developing a detailed outline of the methodology to assess diets, markets, and cost of an adequate diet for the USAID LSFF Programming Guide and writing the methodology. The methodology will include a decision tree related to the data landscape, given available data in their local context.

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Annex 1. Examples of Tools for Use with Quantitative Open 24-hour Dietary Recall Data

Table A1.1 Examples of Tools to Estimate Food Consumption, Risk of Inadequate Micronutrient Intake, and Model the Contribution of Food Fortification to Micronutrient Adequacy Using Quantitative Open 24-hour Dietary Recall Data

Example of Tools and Description	
Data entry, management, and processing	CS Dietary Software Program. Software system to support entering, managing, and processing data from quantitative open 24-hour dietary recall surveys. HarvestPlus and SerPro S.A developed the software (Intake 2022).
Assessing usual dietary food and micronutrient intake distributions	National Cancer Institute (NCI) Method. Method to estimate the distribution of usual intake for a population or subpopulation (National Cancer Institute 2021). Simulating Intake of Micronutrients for Policy Learning and Engagement (SIMPLE) Macro: Statistical code that operates with the NCI Method to facilitate estimation of usual intake distributions and conduct predictive modeling using 24-hour dietary recall data for food and nutrients consumed 'nearly-daily'; used to estimate inadequate or excessive nutrient intake (Luo et al. 2021). University California Davis and the National Cancer Institute developed the statistical code. Multiple Source Method (MSM): Software program to calculate usual dietary intake. The former Department of Epidemiology of the German Institute of Human Nutrition Potsdam-Rehbrücke (DIfE) developed the software program (DIfE 2020). Statistical Program to Assess Dietary Exposure (SPADE): Statistical program to assess habitual dietary exposure. The Dutch National Institute for Health and Environment (Rijksinstituut voor Volksgezondheid en Milieu, RIVM) developed SPADE (RIVM 2018).
Estimating micronutrient intake	Intake Modeling, Assessment and Planning Program (IMAPP): Software that determines usual intake distributions and calculates the predicted prevalence of inadequate and excessive intake of each micronutrient before and after fortification. WHO developed IMAPP in collaboration with Dr. Alicia Carriquiry of Iowa State University, Dr. Lindsay Allen of the United States Department of Agriculture (USDA), Agricultural Research Service (ARS) Western Human Nutrition Research Center, and Dr. Suzanne Murphy of the University of Hawaii (WHO 2010).

Annex 2. Summary of Literature Review Findings: Data Sources and Tools to Assess Diets, Markets, and Cost of an Adequate Diet

Table A2.1 summarizes the literature review findings by data source and by tool. For each data source or tool, the table describes its—

- purpose
- strengths and limitations
- relative cost, time, and technical expertise required for its use.

The following data sources and tools are included in the table:

Data sources

- Quantitative open 24-hour dietary recall
- Semi-quantitative food frequency questionnaire (SQ-FFQ)
- Household food consumption (HCES)
- Food Balance Sheets
- Nutrient-specific semi-quantitative food frequency questionnaire (NS-SQ-FFQ)
- Fortification Monitoring and Surveillance (FORTIMAS)
- Agri-Food Information Systems

Tools

- Fortification Assessment Coverage Toolkit (FACT)
- Fortification Rapid Assessment Tool (FRAT)
- Diet quality questionnaire (DQQ)
- Intake Modeling, Assessment and Planning Program (IMAPP)
- Cost of the Diet (CotD)
- Optifood
- Cost of a Nutrient Adequate Diet (CoNA)

The arrows for cost in the table are defined as follows (note that for data sources, the arrows refer to use of existing data for secondary analysis—no primary data collection):

- 3 arrows: Relatively high, e.g., ≥ 500,000 USD per survey for analysis of secondary data.
- 2 arrows: Moderate, e.g., between 100,000 and 500,000 USD per survey for analysis of secondary data.
- One arrow: Relatively low, e.g., ≤ 100,000 USD per survey for analysis of secondary data.

The arrows for time in the table are defined as follows:

- 3 arrows: Relatively high, e.g., ≥ 12 months from study design to final report.
- 2 arrows: Moderate, e.g., between 6 to 12 months from study design to final report.

- One arrow: Relatively low, e.g., ≤ 6 months from study design to final report.

The arrows for technical expertise in the table are defined as follows:

- 3 arrows: Relatively high, e.g., activity requires senior and mid-level staff with high level of technical expertise and specialized training, capacity, and experience in study design, statistics for analysis, interpretation, report writing and/or dissemination.
- 2 arrows: Moderate, e.g., activity requires senior and/or mid-level staff with general background in nutrition, public health, agriculture, or related area.
- One arrow: Relatively low, e.g., activity does not require staff with technical expertise in nutrition, public health, agriculture, statistics, etc.

Table A2.1 Summary of Literature Review Findings: Data Sources and Tools to Assess Diets, Markets, and Cost of an Adequate Diet—Purpose, Strengths, Limitations, and Estimated Level of Cost, Time, and Technical Expertise to Use the Data Source or Tool (For Data Sources—Refers to Data Analysis Using Secondary Data—No Primary Data Collection).

Data Source or Tool	Purpose	Strengths	Limitations	Cost	Time	Technical Expertise
Data Source: Quantitative open 24-hour dietary recall[a]	For collecting individual-level, quantitative dietary information; uses a multiple-pass interviewing technique to collect food and beverage names and amounts consumed in a 24-hour period.	Relatively high degree of validity, of data sources reviewed, for estimating individual intake and sources of intake. Relatively high degree of accuracy. Provides individual food consumption and micronutrient intake from all food sources. Can account for food preparation methods and effect on nutrient content. Can be used to assess equity of coverage with appropriate sampling, sample size, and collection of data on measures of vulnerability. Can be used to identify the distribution of usual intake if appropriate data and analytical methods (i.e., must account for within-person variation) are used.	Requires accurate recall of foods consumed and quantities. Accuracy depends in part on good quality food composition tables. Details on staple food brands and where they are sourced may not be recorded (this is useful to inform LSFF).	↑	↑	↑↑↑
Data Source: Semi-Quantitative	For collecting individual-level data on frequency	Can provide information on frequency of consumption of specific foods.	Data not as accurate as 24-hour dietary recall for estimating	↑	↑	↑↑↑

Data Source or Tool	Purpose	Strengths	Limitations	Cost	Time	Technical Expertise
Food Frequency (SQ-FFQ)	of food consumption and portion sizes from a pre-defined list over a specified period of time (e.g., 7 days).	Can provide estimates of food consumption. Can provide estimates of micronutrient intake. Can be used to assess equity of coverage with appropriate sampling, sample size, and collection of data on measures of vulnerability.	consumption and nutrient adequacy. Developing and validating SQ-FFQ is resource-intensive. Accuracy depends in part on good quality food composition tables. Details on staple food brands and where they are sourced may not be included. Cannot often be transferred between contexts due to lack of common foods and standard portion sizes. May not reflect the eating patterns of a given population due to being composed of a pre-specified food list.			
Data Source: Household food consumption (from Household Consumption and Expenditure	For collecting data on household-level food consumption and/or expenditures based on a defined, country-specific food list.	Provides a good balance between validity, usefulness, and cost. Data collected routinely every 3–5 years in many LMICs.	Food list may be limited or lack detail about fortifiable or fortified foods. Accuracy depends in part on good quality food composition tables.	⬆	⬆	⬆⬆⬆

Data Source or Tool	Purpose	Strengths	Limitations	Cost	Time	Technical Expertise
Survey [HCES])	Data are collected retrospectively for a set period (e.g., the 7- or 14-day period prior to the survey).	Longer recall period provides estimates of intake over time (e.g., 7 or 14 days). Usually has large sample size that is representative of different population strata (e.g., urban/rural, wealth quintile). Can be used to assess equity of coverage with appropriate sampling, sample size, and collection of data on measures of vulnerability. Data often collected over a one-year period, so can account for seasonality to some degree.[13]	Usually does not include questions about brand and source of fortifiable or fortified foods. Food acquisition data do not generally distinguish between food acquired for consumption versus storage, gifts, animals, charity, and resale. Does not usually adequately capture foods consumed away from home or food waste. Use may require assumptions about how food is distributed within the household (e.g., in proportion to energy needs), which may not be accurate. Is not appropriate for estimation of individual consumption. Requires accurate recall of household food consumption or acquisition.			
Data Source: Food Balance Sheets	Source of secondary data for use in determining national-level commercial availability of	Standardized data that allow for comparisons over time. Provides proxy information on trends of population-level consumption patterns based on	Data limited to primary commodities and minimally processed foods.	⬆	⬆	⬆⬆⬆

[13] HCES data may be collected over the period of a year, so it captures seasons, but does not necessarily capture all seasons for all target groups or geographic areas and does not repeat measures of the same household in different seasons.

Data Source or Tool	Purpose	Strengths	Limitations	Cost	Time	Technical Expertise
	primary commodities and some processed commodities for consumption; and patterns, levels, and trends in national availability of commodities, including imports and exports.	food available for consumption in food supply. Free and easy to use/analyze.	Data are only available at summary/aggregate national level. No indication of which commodities are industrially processed at large scale. Data may be incomplete or underreported Delays in FAO or NSO processing affect timeliness of data availability.			
Data Source: Nutrient-Specific Semi-Quantitative Food Frequency (NS-SQ-FFQ)	For collecting individual-level data on frequency of consumption and portion sizes of foods that contain key nutrients of interest. Data are collected over a specified period of time (e.g., 7 days). Note: Not recommended for use with LSFF at this time given limitations.	May be useful where fortified foods or supplements are thought to be the main contributors to micronutrient intake. If the NS-SQ-FFQ is validated and provides cost and time savings, it potentially could be used to address specific questions for LSFF program evaluation.	May not work well for nutrients that are distributed across many foods. Would require accurate recall of foods consumed and quantities.	⬆	⬆	⬆⬆⬆
Data Source: Fortification monitoring and	Approach that uses, in part, non-probabilistic sentinel site data	Designed to use data collection resources as wisely as possible, in a sequential manner when	Does not provide statistically representative cross-sectional estimates of prevalence.	⬆	⬆	⬆⬆⬆

Data Source or Tool	Purpose	Strengths	Limitations	Cost	Time	Technical Expertise
surveillance (FORTIMAS)	collection in health centers and schools to determine the percent of households that have purchased a fortified food and the percent of households with fortified foods.	specific indicator milestones are met. Designed to triangulate sentinel site data with data on industry production, sales, and fortification quality and existing information systems (e.g., health) and national surveys (e.g., national micronutrient surveys).	Successful use will depend on data available in local health information systems, local data collection and processing capabilities and resources, and levels of health center and school attendance. Tools require adaptation to local context and testing.			
Data Source: Agri-Food Information Systems	Government, non-governmental organization, professional organization, or private industry information systems that provide information such as cereal grain and livestock prices, information on weather (temperature, rainfall, wind), crop production, etc.	Information system exists in many low- and middle-income countries.	Usually do not collect detailed data on brands and their prices in a wide range of market types in diverse regions. Do not collect samples for testing micronutrient content of fortified foods.	Will vary by country	Will vary by country	Will vary by country
Tool: Fortification Assessment Coverage Toolkit (FACT)	Developed to provide standardized methods to collect, analyze and synthesize data on quality,	Uses validated instruments, where available. For monitoring, includes methods to measure micronutrient content in food vehicles in households and/or markets.	Market methodology is not a census and may not identify every brand available for a given food vehicle.	⬆	⬆	⬆⬆

Data Source or Tool	Purpose	Strengths	Limitations	Cost	Time	Technical Expertise
	coverage and consumption of fortified foods as part of program monitoring efforts; can be used to collect data on fortifiable food consumption for program design; can be used to collect data at household and/or market level.	Collects information on household use, frequency of use, and selected individual consumption of fortified food vehicles. Can be used to assess equity of coverage with appropriate sampling, sample size, and collection of data on measures of vulnerability. Can be stand-alone survey or incorporated into existing national survey.	Household assessment does not capture the total diet or intra-household distribution. Household assessment does not capture foods purchased and consumed outside of the household, so may underestimate fortification coverage or amounts of fortified foods consumed. Requires accurate recall of foods consumed and quantities.			
Tool: Fortification Rapid Assessment Tool (FRAT)	For identifying food vehicles for fortification and for setting micronutrient content; is a hybrid food-frequency questionnaire and 24-hour dietary recall that measures consumption of a small set of potentially fortifiable foods among individuals. Market component used	Relatively simple to design and administer. Designed for fortification programs. Can provide information on frequency of consumption and estimates of intake of potential food fortification vehicles.	Does not collect data to measure micronutrient intake; cannot be used to make estimates of actual risk of dietary inadequacy. Tools have not been validated. Does not collect information on source of fortifiable foods (home produced, from small enterprise or large-scale producer). Market assessment tool did not perform well when tested in country; questions remain regarding its usefulness even after revisions.	⬆	⬆	⬆⬆

Data Source or Tool	Purpose	Strengths	Limitations	Cost	Time	Technical Expertise
	to assess if fortification is industrially/ commercially feasible.					
Tool: Diet Quality Questionnaire (DQQ)	Standardized tool to collect data to estimate the Minimum Dietary Diversity for Women (MDD-W) indicator, along with new indicators that capture dietary risk factors for noncommunicable disease among adults. Note: If DQQ data exist, consider for use to complement existing data; but due to limitations, it cannot serve as the sole data source for LSFF decision making.	Includes questions about prior day consumption of sentinel foods from 29 food groups.[b] Can be used to assess dietary patterns and trends in the general population. Could be used to provide general description of the diet (MDD-W); consumption of specific food groups.	Cannot be used to identify specific micronutrient inadequacies. Does not identify consumption of specific foods. Changes cannot be made in the DQQ questionnaire, given this would compromise its validity.	⬆	⬆	⬆⬆
Tool: Intake Modeling, Assessment and Planning	Software program to estimate if the amount of a micronutrient proposed for a fortifiable food or	Uses a software program, which does not require coding skills and can assist users in conducting the calculations. Has a detailed user's manual.	Software not designed to use household-level estimates of micronutrient intake, e.g., HCES data.	⬆	⬆	⬆⬆

Data Source or Tool	Purpose	Strengths	Limitations	Cost	Time	Technical Expertise
Program (IMAPP)	existing fortified food would be a safe level of intake for most individuals who consume the food and if it might improve micronutrient adequacy.		Lack of 24-hour dietary recall data in LMIC limits opportunities to use the method.			
Tool: Cost of the Diet (CotD)	Software to model and estimate the amount and combination of local foods needed to provide a typical family with a diet that meets their average needs for energy and recommended intakes of protein, fat, and micronutrients, using linear programming analyses. Also estimates the minimum cost of foods that meet the nutrient needs of a typical household (minimizes diet cost).	Useful for advocacy, to guide thinking and stimulate debate on cost drivers of micronutrient adequate diets. Can be used for "what if" scenarios to model how the cost of an adequate diet may change given interventions such as food fortification. Can be used for analysis at the individual or household level.	Not necessarily a diet that households would consume. Results do not represent the distribution of dietary patterns within the population.	⬆	⬆	⬆⬆⬆

Data Source or Tool	Purpose	Strengths	Limitations	Cost	Time	Technical Expertise
Tool: Optifood	Software used to facilitate formulation of food-based dietary recommendations to meet micronutrient needs, with focus on selecting realistic diets according to the dietary habits and local food supply and access; analyzes the potential contribution on nutrient adequacy and cost of adding new foods to the local diet.	Facilitates formulation of food-based dietary recommendations to meet micronutrient needs. Can model interventions like food fortification and impact on cost of an adequate diet. Specifically aims to select realistic diets according to dietary habits and local food supply and access. Can use quantitative open 24-hour dietary recall or HCES data. Can analyze model diet costs and the proportion of costs required for each food in the most nutritious model diet. Can analyze the cost of adding new foods to the local diet.	Use of household food consumption data as input data for Optifood requires assumptions about the intrahousehold distribution of food. Results do not represent the distribution of dietary patterns within the population.	⬆	⬆	⬆⬆⬆
Tool: Cost of a Nutrient Adequate Diet (CoNA)	Price index used to demonstrate the ability of local food systems to deliver the nutrients needed for a population's health. Note: Not recommended for use for objectives	A price index designed to demonstrate the ability of local food systems to deliver the nutrients needed for health. Used for raising awareness and advocacy about access to nutritious diets. Tracks and compares the cost of nutrients over long periods of time and across	Not intended to reflect what people spend or purchase. Results available only when accurate prices and nutrient composition data are available for the full range of foods used to meet nutrient needs. Results do not represent the distribution of dietary patterns within the population.	⬆	⬆	⬆⬆⬆

Data Source or Tool	Purpose	Strengths	Limitations	Cost	Time	Technical Expertise
	of this literature review given its purpose.	different populations, given the model does not include information on typical food habits.	Requires software able to perform linear programming.			

[a] If data were to be collected, there would be three arrows each for "cost" and "time". [b] Sentinel foods are foods that are the most frequently consumed items within a food group in a given population. Note: FortifyMIS is an online data collection and data sharing approach for fortification monitoring (Rowe 2020). It provides data on external, import, and commercial monitoring for enforcement. Although systems and tools for enforcement are beyond the scope of this review, data from a good FortifyMIS could be used to triangulate/reinforce the other methods noted above.

Sources: **Quantitative open 24-hour dietary recall**: Coates et al.2012a; Coates et al.2012b; Engle-Stone et al. 2019; Dary and Imhoff-Kunsch 2012; WHO and FAO 2006. **SQ-FFQ**: Coates et al. 2012b; Hotz et al. 2017, Gibson and Ferguson 2008; **Household food consumption (from HCES)**: Coates et al. 2012b; Dary and Jariseta 2012; Imhoff-Kunsch et al. 2012; Jariseta et al. 2012; Tang et al. 2022). **Food Balance Sheets**: Coates et al. 2012a; **NS-SQ-FFQ**: Wirth et al. 2020. **FORTIMAS**: Smarter Futures 2017; **Agri-food information systems**: Galtier et al. 2014; **FACT**: Friesen et al. 2017; Friesen et al. 2019; Aaron et al. 2016; Neufeld et al. 2017; Mkambula et al. 2020. **FRAT**: Micronutrient Initiative 2003; Coates et al. 2012a; Hess et al. 2013; Dary and Imhoff-Kunsch 2012, Berti et al. 1999. **DQQ**: Diet Quality Project 2021a; Diet Quality Project 2021b; **IMAPP**: WHO 2010. **Cost of the Diet**: Deptford et al. 2018; Untoro et al 2017; Save the Children UK 2018. **Optifood**: Daelmans et al. 2013; Untoro et al. 2017; Cost of Nutritious Diets Consortium 2018; Deptford et al 2017; Knight and Woldt 2017. **Cost of a Nutrient Adequate Diet**: Cost of Nutritious Diet Consortium 2018; Herforth et al. 2020; Bai et al. 2020; Bai et al. 2021; Bai etal. 2022; Masters et al. 2018.

Annex 3. Additional Information on Data Sources, Tools, and Projects

This annex provides additional information about the data sources and tools reviewed, as well as two relevant projects. Section A3.1 is on data sources, Section A3.2 is on tools, and Section A3.3 provides information about two projects.

The data sources reviewed include—

- Quantitative open 24-hour dietary recall
- Semi-quantitative food frequency questionnaire (SQ-FFQ)
- Household food consumption (HCES)
- Food Balance Sheets
- Nutrient-specific semi-quantitative food frequency questionnaire (NS-SQ-FFQ)
- Fortification Monitoring and Surveillance (FORTIMAS)
- Agri-Food Information Systems

The tools reviewed include—

- Fortification Assessment Coverage Toolkit (FACT)
- Fortification Rapid Assessment Tool (FRAT)
- Diet quality questionnaire (DQQ)
- Intake Modeling, Assessment and Planning Program (IMAPP)
- Cost of the Diet (CotD)
- Optifood
- Cost of a Nutrient Adequate Diet (CoNA)

The projects that are described include—

- Micronutrient Intervention Modeling (MINIMOD)
- Micronutrient Action Policy Support (MAPS)

The information for data sources and tools generally includes the following:

- Overview
- Strengths and limitations
- Basic steps to use
- Cost, time, and technical expertise
- Examples of country use
- Relative availability of secondary data, as appropriate
- Use to inform broader programming.

For estimates of relative cost in USD, time in months, and levels of technical expertise needed for each method, please see Annex 2, Table A2.1, "Summary of Literature Review Findings: Data Sources and Tools to Assess Diets, Markets, and Cost of an Adequate Diet".

Please note that several data sources and tools are included below but are not suggested for use for LSFF at this time given their limitations. They are included given interest in their possible use and the importance of providing a rationale for suggesting they not be used.

A3.1 Data Sources

A3.1.1 Quantitative Open 24-hour Dietary Recall

Overview

The quantitative open 24-hour dietary recall is a structured interview intended to capture detailed information about all foods and beverages (and possibly, dietary supplements) consumed by the respondent in the past 24 hours, most commonly, from midnight to midnight the previous day (National Cancer Institute 2022a; FAO 2018). The method can be used to describe a population's food consumption and nutrient intake, including mean usual intake. By collecting dietary data on a sub-population of survey participants on at least two non-consecutive days, statistical techniques can be used to estimate usual dietary intake distributions for a group (National Cancer Institute 2022a; FAO 2018). Seasonality can be addressed by (Deitchler et al. 2020)—

- collecting data over multiple seasons or repeating data collection in different seasons, so that dietary intake data for all strata or sub-groups are equally represented in each season; or
- collecting data in the season that is of the longest duration and therefore somewhat more representative of usual intakes over the year; or
- collecting data in a period that represents an intermediate situation between the "lean" season when food availability is the lowest and the post-harvest season when food availability is the highest.

Strengths and Limitations

The strengths of the method include (Coates et al. 2012a; Coates et al. 2017a; Engle-Stone et al. 2019; Dary and Imhoff-Kunsch 2012; WHO and FAO 2006):

- Provides a relatively high degree of validity, among the sources that we reviewed, for estimating individual intake and sources of intake.
- Provides a high degree of accuracy in assessing nutrient intake, if properly implemented.
- Provides detailed, quantitative estimates of individual food consumption and nutrient intake, capturing total dietary intake from all food sources.
- Can account for food preparation methods and effect on nutrient content of foods.
- Can be used to identify the distribution of usual intake if appropriate data are available and analyzed with appropriate methods (i.e., if a second quantitative open 24-hour dietary recall is collected on a sub-population of the survey to estimate usual intake; it must account for within-person variation).
- Can be used to provide disaggregated data by geographic area, age group, sex, and/or ethnic group, if sampling is conducted in a way to obtain representative samples from these groups.
- Can be used to assess equity of coverage with appropriate sampling, sample size, and collection of data on measures of vulnerability.

The limitations of the method include (Coates et al. 2012a, Engle-Stone et al. 2019, Dary and Imhoff-Kunsch 2012; Mkambula et al. 2020; Huybrechts et al. 2017; Coates et al. 2017a; FAO 2018):

- When secondary data are used it requires a high level of expertise to clean, prepare, and analyze the data.
- This method usually does not provide information on the use of supplements (but this can be added to the questionnaire).

- If individuals sampled for the survey are not representative of the population, the data will not represent the distribution of dietary patterns within the population.
- Requires respondents to accurately remember and report consumption, in terms of the foods consumed and quantities.
- Accuracy depends in part on good quality food composition tables.
- May not include adequate detail regarding source of fortified or fortifiable staple foods (e.g., whether wheat flour or maize flour was home produced or purchased, and if purchased, whether it was centrally processed or processed by a small or medium-sized enterprise), but additional questions can be added to questionnaire.

Basic Steps to Use

Gibson and Ferguson (2008) describe the steps to process data to obtain nutrient intakes and analyze the nutrient intake data. Basic processing steps include:

2. Convert all food portion sizes to grams.
3. Check for coding errors including incorrect adjustment of portion sizes to weight equivalents, wrong or improbable weights of foods eaten, and insufficient information for coding ingredients of mixed dishes.
4. Compile and code weight equivalents for raw ingredients of mixed dishes and if using recipes, process recipe data to calculate the amount of each ingredient consumed.
5. Select a suitable computerized nutrient analysis system for the quantitative 24-hour dietary recall data.
6. Identify or compile appropriate nutrient database or food composition table for analysis of nutrient content of foods consumed.
7. Link food lists with the nutrient composition database.

Basic steps to analyze the nutrient intake data include—

1. Calculate nutrient intake from information on grams of food consumed and food composition table data, multiplying the nutrient value for each food by the amount of food consumed per day for each food item and nutrient of interest and summing the results by nutrient.
2. Adjust the distribution of observed intakes to usual intakes.
3. Prepare the data for statistical analysis, including data cleaning to examine descriptive statistics for outliers and correct any implausible values, missing values, etc.
4. Evaluate the nutrient intakes of the population in relation to the H-AR and H-UL, or other agreed upon nutrient reference values.
5. Conduct statistical analysis, e.g., mean intake of two or more groups, proportion at risk of inadequate micronutrient intake among two or more groups, etc.

An example of software to support data entry, management, and processing is CS Dietary Software Program. Calculations can also be done using statistical programs such as STATA, SAS, or R. There are a few methods that can be applied to estimate usual intake distributions from quantitative open 24-hour dietary recall data. Failure to apply appropriate statistical methods for this purpose will result in a distribution of nutrient intakes with inflated variance, which will bias estimates of the prevalence of inadequate or high nutrient intakes. A recent review compared four methods to estimate usual daily consumed nutrient intake: Iowa State University (ISU), the National Cancer Institute (NCI), the Multiple Source Method (MSM) and the Statistical Program to Assess Dietary Exposure (SPADE) (Laureano et al. 2016). The Simulating Intake of Micronutrients for Policy Learning and Engagement (SIMPLE) Macro is a user-friendly tool written in the SAS programming language that helps users implement the NCI method to facilitate estimation of usual intake distributions for food and nutrients consumed 'nearly-daily'. The tool can also be used to model the contribution of fortified foods or supplements to usual nutrient intake.

Cost, Time, and Technical Expertise

- **Cost**: Costs would only involve data preparation, processing, and analysis. Therefore, costs will generally be less than 100,000, but total cost will depend on:
  - Sample size and subpopulations for reporting (age, sex, ethnic group).
    - National food consumption surveys using the quantitative open 24-hour dietary recall have used sample sizes of about 2000, but sample size calculations should be conducted for each survey to ensure estimates of food consumption and micronutrient intake will be representative for the subgroups required (Coates et al. 2012a).
  - Number of repeat quantitative open 24-hour dietary recalls conducted.
  - Indicators being measured
  - Nutrients, foods, or food groups of interest, e.g., estimating intake of foods that are not frequently consumed requires a larger sample size of repeat quantitative open 24-hour dietary recalls to estimate usual intake.
  - Experience and expertise of the analysis team.
- **Time**: The time required for data preparation, processing, and analysis of quantitative open 24-hour dietary recall data will vary according to the size and quality of the dataset and availability of comprehensive food, recipe and ingredient lists and a food composition database (*Intake –* Center for Dietary Assessment 2019). The data preparation, processing, and analysis should take less than 6 months.
- **Technical expertise**: The technical expertise needed for data preparation, processing, analysis and report writing is high. Necessary technical experts include a public health nutritionist, at least one team member with an in-depth knowledge of the context and local foods, a statistician, and a data analyst with experience in analyzing and interpreting quantitative open 24-hour dietary recall data.

Examples of Countries That Have Used Quantitative Open 24-hour Dietary Recall for LSFF

Examples of countries that have used quantitative open 24-hour dietary recall data to inform LSFF program design include Cameroon (Engle-Stone et al. 2012), Ethiopia (Hafebo et al. 2015), Palestine (Abdeen et al. 2015), and Uganda (Harvey et al. 2010). Nigeria conducted a National Food Consumption and Nutrition Survey from 2001 to 2003, but it is not clear from published literature if the data have been used to design or evaluate food fortification programs (Maziya-Dixon et al. 2004).

Countries with LSFF programs that have used quantitative open 24-hour dietary recall data for evaluation include Costa Rica and Guatemala (Martorell et al. 2017), Chile (Hertrampf and Cortés 2004), and Philippines (Angeles-Agdeppa et al. 2019). There are few examples of the use of quantitative open 24-hour dietary recall for evaluation of LSFF programs because few evaluations of LSFF programs had been conducted (Coates et al. 2012a).

Availability of Secondary Data

Given the high cost and complexity of collecting and analyzing 24-hour dietary recall data, the availability of nationally representative quantitative open 24-hour dietary recall data in LMIC is limited (Huybrechts et al. 2017; Coates et al. 2017a). This may change as the data collection and analysis become easier, and there is more advocacy for collection of quantitative, open 24-hour dietary data. WHO and FAO, through the Global Individual Food consumption data Tool (GIFT), is working to improve access to publicly available existing quantitative individual food consumption data from all countries around the world.

Use of Quantitative Open 24-hour Dietary Recall Data to Inform Broader Programming to Improve Diets

Quantitative open 24-hour dietary recall data can be used to evaluate broader programming to improve diets. For example, 24-hour dietary recall data can be used to better understand patterns of food consumption and opportunities to improve food consumption and micronutrient intake. A quantitative open 24-hour dietary recall at the point of program evaluation can provide information on how patterns of food consumption changed and if and how much promoted foods were consumed by target populations. Examples include information on consumption of biofortified crops, micronutrient-rich crops, or micronutrient-rich animal source foods (Engle-Stone et al. 2015).

A3.1.2 Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ)

Overview

The SQ-FFQ is a diet assessment method where respondents report their usual frequency of consumption of foods, from a pre-defined list of food items, over a specific time, e.g., 7 days (National Cancer Institute, 2022b). The SQ-FFQ also includes portion sizes, either a standardized portion size or a range of portion sizes (National Cancer Institute, 2022b). SQ-FFQ have been used to assess the whole diet, or consumption of specific foods, such as fortifiable or fortified foods, in the diet. Hotz (et al. 2017) found that SQ-FFQ of the whole diet may have similar outcomes as the reference method, the quantitative open 24-hour dietary recall method, at about the same cost (Hotz et al. 2017). However, SQ-FFQ have been shown to contain systematic error (National Cancer Institute 2022b). The error in portion size reporting with the SQ-FFQ is not clear in the literature, and hence, the method may be better for program monitoring that does not require accurate quantitative estimates of food consumption (Coates et al. 2012a).

The SQ-FFQ involves intensive preparatory work to develop the food list; develop the standard portion size categories for each food item; develop the food composition table, including mean nutrient values for groups of foods; and validate the SQ-FFQ questionnaire and food composition table, which can require a substantial amount of time and cost, particularly when used to assess the whole diet (Coates et al. 2012b). This will offset time or cost savings in the data collection.

Gibson and Ferguson (2008) report that, in their experience, rural women in Africa find it easier to respond to specific questions related to food consumption during the previous day (e.g., quantitative open 24-hour dietary recall), compared to reporting habitual food intakes over a pre-defined period (e.g., over 7 days in an SQ-FFQ). This may be the case in other populations and may depend on characteristics of the population and the diet.

It is difficult to develop an SQ-FFQ that works equally well for all nutrients. For example, between- and within-respondent variation is higher with intake of, e.g., vitamin A, which is found in high concentrations in a few foods (Coates et al. 2012a). Between- and within-respondent variation tends to be lower for intake of micronutrients like iron and zinc, which tend to be more widely distributed in foods that are eaten on most days of the year (Ibid.), although this will depend on the context and dietary patterns.

Strengths and Limitations

The strengths of the method include (Coates et al. 2012b; Hotz et al. 2017, Gibson and Ferguson 2008, Engle-Stone 2022a):

- Can provide information on frequency of consumption of specific foods.
- Can provide estimates of food consumption.
- Can provide estimates of micronutrient intake.
- Can assess equity of coverage with appropriate sampling, sample size, and collection of data on measures of vulnerability.

- May be particularly useful for planning and monitoring when it is sufficient to know how many people consumed a food and how often.

The limitations of the method include (Coates et al. 2012b; Hotz et al. 2017, Gibson and Ferguson 2008, National Cancer Institute 2022b, Engle-Stone 2022a):

- Data not as accurate as 24-hour dietary recall for estimating consumption and nutrient adequacy (e.g., more biased assessments of absolute quantities compared to quantitative open 24-hour dietary recall or other short-term diet assessments).
- Developing and validating SQ-FFQ is resource-intensive.
- Accuracy depends in part on good quality food composition tables.
- Details on staple food brands and where they are sourced may not be included.
- Cannot often be transferred between contexts due to lack of common foods and standard portion sizes.
- Lacks detailed information about food preparation, specific food and beverages consumed, and brands, and contextual information about intake (e.g., which foods and beverages are consumed at the same meal).
- May not reflect the eating patterns of a given population due to being composed of a pre-specified food list.

Basic Steps to Use

The basic steps to process SQ-FFQ data include:

1. Convert all portion sizes into standard measures of weight in grams.
2. Multiply the portion size in standard units by the frequency of consumption and divide by the recall period to determine the average amount consumed per day.
3. Check for coding errors including incorrect adjustment of portion sizes to weight equivalents, wrong or improbable weights of foods eaten, and insufficient information for coding ingredients of mixed dishes.
4. Compile and code weight equivalents for raw ingredients of mixed dishes, if relevant.
5. Select a suitable computerized nutrient analysis system for the SQ-FFQ data.
6. Identify or develop a nutrient database with food composition table data, including values for SQ-FFQ food categories (e.g., food groups) composed of aggregate food items.
7. Link food lists with nutrient composition database.

Basic steps to analyze the SQ-FFQ nutrient intake data are the same as those for the quantitative open 24-hour dietary recall (see above), with the exception that SQ-FFQ data are usually considered to represent "usual" intake, so the statistical adjustment to estimate usual intake distributions is not necessary. Analysts could directly calculate descriptive statistics such as mean nutrient intake.

Cost, Time, and Technical Expertise

- **Cost**: Costs would only involve data preparation, processing, and analysis. Therefore, costs will generally be less than 100,000. Total cost will depend on:
  - Sample size and subpopulations for reporting (age, sex, ethnic group).
  - Indicators being measured
  - Experience and expertise of analysis team.
- **Time**: The time required for data preparation, processing, and analysis of the SQ-FFQ data will vary according to the size and quality of the dataset and availability of comprehensive food composition databases. The data preparation, processing, and analysis should take less than 6 months.
- **Technical expertise**: The technical expertise needed for data preparation, processing, analysis, and report writing is high. Necessary technical experts include a public health nutritionist, at

least one team member with an in-depth knowledge of the context and local foods, a statistician, and a data analyst with experience in analyzing and interpreting SQ-FFQ data.

Examples of Countries That Have Used the SQ-FFQ for LSFF

Countries with LSFF programs that have used the SQ-FFQ include Bangladesh, Cote d'Ivoire (Abidjan), India (Rajasthan), Nigeria (Kano and Lagos), Senegal, South Africa (Gauteng and Eastern Cape), Tanzania, and Uganda (Friesen et al. 2017; Aaron et al. 2017). Results in the latter countries focused on household coverage of specific fortified foods, including edible oil and wheat and maize flours. In Pakistan the SQ-FFQ was used to determine household use of fortifiable salt, oil/ghee, and wheat flour (Global Alliance for Improved Nutrition and Oxford Policy Management 2018). SQ-FFQ was also used in Mozambique to evaluate the coverage of iron-fortified wheat and maize flours and vitamin A-fortified sugar and vegetable oil, as well as reach across population groups (International Policy Centre for Inclusive Growth 2019). All the latter surveys used the SQ-FFQ as a part of FACT, with a specific focus on fortifiable or fortified foods, not the complete diet.

Availability of Secondary Data

Given the high cost and complexity of collecting and analyzing SQ-FFQ data for the full diet, the availability of nationally representative SQ-FFQ data on the complete diet in LMIC is limited (Coates et al. 2012a). Most SQ-FFQ data in the context of LSFF have been used as a part of FACT and the Fortification Rapid Assessment Tool (FRAT) and have focused on specific fortifiable and/or fortified foods.

Use of SQ-FFQ Data to Inform Broader Programming to Improve Diets

SQ-FFQ data can be used for needs assessment, design, monitoring, and evaluation of broader programming to improve diets. For example, SQ-FFQ data can be used to better understand food consumption and opportunities to improve food consumption and micronutrient intake during the needs assessment and design stage of programs. An SQ-FFQ during monitoring and at the point of program evaluation can provide information on how patterns of food consumption have changed and if and how much promoted foods were consumed by target populations.

A3.1.3 Household Food Consumption (from Household Consumption and Expenditure Survey, HCES)

Overview

HCES, also known as Household Income and Expenditure Survey, Household Budget Survey, or Living Standards Measurement Study, are nationally representative surveys, often also representative at the subnational level, that collect data on household socio-economic conditions, including the amount of food consumed by the household or the amount of food acquired by the household in a specific reference period (Coates et al. 2012a, Imhoff-Kunsch et al. 2012). The data from the surveys are used for updating the consumer price index, analyzing household poverty and living conditions, and to inform national accounts (Micha et al. 2018). HCES food consumption data are based on a food list. The HCES measures "apparent consumption" based on assumptions about intrahousehold food distribution and consumption. Some HCES collect data on food consumption, while others collect data on food acquisition, for example, how much food was acquired in the past 7 or 14 days, and if the food was acquired through purchase, home production, gift, donation, or barter (Weisel and Dop 2012, Fiedler et al. 2012a, Fiedler et al. 2013, and Coates et al. 2017b). The HCES data does not represent the entire diet of a household. It does not include collection of data on individual consumption and portion sizes (Coates et al. 2012a; Dary and Jariseta 2012).

Strengths and Limitations

The strengths of the method include (Coates et al. 2012a; Micha et al. 2018, Imhoff-Kunsch et al. 2012; Tang et al. 2022):

- Data are collected routinely every 3–5 years in many LMICs.
- Can be used to estimate apparent household (family) food consumption and nutrient intake.
- Longer recall period provides estimates of intake over time (e.g., 7 or 14 days).
- When used in large-scale, population-based surveys (e.g., HCES), has large sample size that is representative of different population strata.
- Usually can be stratified by area (e.g., urban, rural, other relevant geographic area), socio-economic status, and/or education level.
- Can be used to assess equity of coverage with appropriate sampling, sample size, and collection of data on measures of vulnerability.
- The food lists used in the food consumption or acquisition questionnaire could potentially be adjusted to include foods of interest for fortification.
- Data often collected over a one-year period, so can account for seasonality to some degree.[14]
- Provides a good balance between validity, usefulness, and cost.

Limitations include (Coates et al. 2012a; Micha et al. 2018; Imhoff-Kunsch et al 2012; Fiedler et al. 2012b; Berti 2012; Tang et al. 2022):

- Requires capacity and time to prepare and analyze the data.
- May use a food list that is limited or lacks detail, e.g., the food list could be missing fortifiable foods or insufficient information to determine if a food is fortifiable.[15]
- Does not include questions about whether purchased fortifiable food vehicles are acquired from large-scale producers versus small or medium-scale producers.[16]
- HCESs that collect data on food acquisition do not generally distinguish between food acquired for consumption and food acquired for storage, gifts, animals, charity, and resale.
- Does not usually adequately capture foods consumed away from home or food waste.
- Accuracy depends in part on good quality food composition tables.
- Use may require assumptions about how food is distributed within the household (e.g., in proportion to energy needs), which may not be accurate.[17]
- Is not appropriate to estimate individual consumption, especially for young children.
- Requires respondents to accurately remember and report household consumption or acquisition over the recall period.
- Quantities of food consumed or acquired are often reported in a wide range of non-standard units that require conversion to a standard unit (e.g., grams, kgs) before use. If non-standard unit conversion factors are not available, this can be an important barrier to the use of HCES data.

[14] HCES data may be collected over the period of a year, so captures seasons, but does not necessarily capture all seasons for all target groups or geographic areas and does not repeat measures of the same household in different seasons.

[15] Food lists may include as few as 16 foods or as many as 550 or more (Fiedler et al. 2012b).

[16] If fortifiable food vehicles are purchased primarily from SMEs, even a well implemented LSFF program that fortifies the food vehicle will not have a significant impact on micronutrient intake.

[17] A 2012 study found that among 28 studies covering 18 countries in Africa, Asia, and Latin America, ranging from 20 to 3,000 households per study, intrahousehold distribution of food in most countries was relatively equitable, within a 20 percent margin. In the absence of evidence to the contrary, the study's author felt it was reasonable to assume equitable intrahousehold distribution of food when designing food fortification programs, but for program evaluation, individual assessment of intake is still needed (Berti 2012). Harris-Fry (et al. 2022) found HCES overestimate household-level quantities and underestimate women's share of household foods, but context- and food-specific quantity and allocation corrections that they derived from a small sample of 24-hour dietary recalls almost eliminated mean bias.

- Does not currently provide information on the use of micronutrient supplements or intervention coverage.

Basic Steps to Use

Imhoff-Kunsch (et al. 2012) and Adams et al. 2022 provide steps in the use of household food consumption or acquisition data from HCES to estimate household-level apparent food consumption of fortifiable and fortified foods and micronutrient intake. The basic steps are:

1. Obtain the secondary, de-identified dataset from the World Bank Living Standards Measurement Study data portal or from the entity that manages the data in country.
2. Identify key variables like urban/rural, socioeconomic status, ethnic groups, geographic areas, food consumed (or acquired), and amounts.
   – As a part of this step, identify purchased foods that may serve as potential fortification vehicles, and the quantity and units of measure in grams or kilograms. The list of potentially fortifiable food vehicles will vary by country but may include wheat flour and wheat flour-containing foods like breads and pasta, maize flour, rice, vegetable oil, sugar, salt, bouillon cubes, margarine, and others.
   – Note that HCES are large, population-based surveys so all estimates should be statistically weighted, as appropriate—weighting variables should be included in the datasets.
3. Use standard conversion factors to convert all units of measure to metric units. If nonstandard measures such as loaves, satchels, bags, sacks, etc. are used, estimate their weight, in grams.
4. Adjust food consumption quantities for the nonedible portion of foods (e.g., banana skins).
5. Divide the food amount by the number of days of the recall period in the survey to produce estimates of daily apparent consumption.
6. Estimate weight equivalents of fortified or fortifiable ingredients in purchased foods, e.g., wheat flour in purchased breads, cakes, and crackers. This is referred to as wheat flour equivalents. and can be constructed to account for the amount of flour in wheat flour-containing foods. The wheat flour equivalents are calculated for each household by multiplying the amount of each food item in grams by the percent of wheat flour that it contains.
7. Match food items to data from food composition tables to estimate the household micronutrient supply. Estimate micronutrient losses from storage and/or cooking, as appropriate.
8. Calculate the adult male equivalent (AME) or adult female equivalent (AFE) units to be able to determine the food intake per adult equivalent and the micronutrient intake per adult equivalent. This will allow comparisons across households of varying size (Weisell and Dop 2012).
   – AME or AFE units are constructed based on the FAO estimate of individual energy requirements, which are age- and sex-specific, to serve as a reference value. For example, energy requirement of a 19- to 30-year-old male, based on a high activity level, would be 3,050 kcal/day, which would then be an AME of 1. This would then be the reference value and other age and sex groups would be weighted accordingly based on their estimated energy needs. For example, the AME of a 19- to 30-year-old woman would be 0.79 (2,400/3,050 kcal/day). A weight, or adjustment factor, is assigned to each person in the household, and these individual weights are summed to provide an estimate of household AME units. The number of persons living in each household and the age and sex of each household member are needed to construct AME or AFE units. AME/AFE units are used under the assumptions that the FAO energy requirements are

true for the population of interest and that food is shared in proportion to energy requirements.[18]

9. Generate estimates of apparent food consumption per AME or AFE for each household for each food item, including fortifiable foods and/or fortified foods, by dividing daily household consumption/acquisition of each food item in grams or milliliters by household AME or AFE units. Distinguish between estimates of apparent consumption by consumers and non-consumers.
   - Apparent food consumption can be estimated for the total population and for different strata. Apparent food consumption can either include only those who consumed or acquired the specific food product ("consumers" also identified as "observed" consumers) or can include everyone ("consumers" + "non-consumers").
   - To estimate consumption among those who consumed or acquired more than "0" grams or milliliters of a specific food ("consumers"), exclude households that reported purchasing "0" grams or milliliters of a specific food.
   - Inclusion of the "zeros" (those who consumed "zero" because they did not consume or acquire the food) provides an estimate that incorporates both coverage (percentage of the population purchasing the food item) and apparent consumption.
   - Reporting consumption by "consumers" alone provides information about apparent food consumption by the true consumers.
   - Reporting both estimates is informative because the estimate for "consumers" provides information about what consumption might be if everyone had access to, could afford, and consumed the fortified food, and estimates for "consumers" + "non-consumers" give a measure of what the program might achieve at a population level.
10. Identify outliers. Extreme outliers can be defined, e.g., as those values that are more than 3 times the interquartile range (Q3 + [3 × IQR]). Amounts that are possible outliers can be cross checked by comparing the amount purchased with the price paid. This two-step process of managing unrealistic values relies on two data points and is a more conservative approach than managing outliers based on using a formula alone. The final step in managing outliers will be discussed in detail in the methods guide.
11. Estimate the adequacy of the household micronutrient supply per AME or AFE, compared to appropriate nutrient reference values for the reference male (for AME) or reference female (for AFE). For example, the harmonized average requirement (H-AR) nutrient reference values could be used (Allen et al. 2019). The H-AR were selected from standards set by the European Food Safety Authority (EFSA) and the Institute of Medicine (IOM), giving priority to those published most recently. EARs from other expert panels may be discussed with the team of experts in a country. This will provide an estimate of the percent of households with adequate micronutrient supply based on micronutrient consumption/acquisition per AME or per AFE. For estimation of iron intake use the full-probability approach, given the skewed nature of the requirement distribution (National Research Council 1986). For iron and zinc, we will need to consider the appropriate nutrient reference values given the bioavailability of these nutrients in the diet.
12. Calculate micronutrient density of the household micronutrient supply. Note that either micronutrient density and/or micronutrient adequacy per AME or AFE (see below) may be calculated.
   - Micronutrient density is the ratio of the amount of a micronutrient in the diet to the energy provided by the same diet, frequently expressed as the amount of the micronutrient per 1,000 kilocalories (kcal) of energy (Vossenaar et al. 2019, Gibson and Cavalli-Sforza 2012).

[18] Weisel and Dop (2012) provide additional explanations of the use of the AME.

- Micronutrient density provides an estimate of diet quality. Micronutrient density is less influenced by age and sex in a population than daily intakes and can be compared with a population mean nutrient density that does not require weighting based on national population distributions or calculation of adult equivalents (Gibson and Cavalli-Sforza 2012).
- The micronutrient density of the household food supply can then be compared with the critical micronutrient density for any household member, defined as the ratio of the household member's daily micronutrient requirement to his/her daily energy requirement, again often expressed per 1,000 kcal (Vossenaar et al 2019). If the household micronutrient density meets the critical micronutrient density needs of household members with the highest micronutrient requirements relative to their energy requirements, the household diet is likely adequate to meet members' micronutrient requirements, if household members are meeting their energy requirements and food consumption within the household is in proportion to energy needs. This will provide an estimate of the percent of households with adequate micronutrient density of the household diet.

Cost, Time, and Technical Expertise

- **Cost**: Given HCES data are commonly available as secondary data, the costs are generally just those related to cleaning, preparation, and analysis of the data. Costs may range from approximately 80,000 to 100,000 USD for the HCES food consumption data cleaning, preparation, analysis, and report writing.[19]
- **Time**: The time required to clean, prepare, and analyze HCES data and complete the final report to estimate food consumption and nutrient intake is comparable to that required for similar activities for the quantitative open 24-hour dietary recall, or somewhat less, depending on the complexity of the survey. The time frame may range from approximately 5 to 6 months.[20]
- **Technical expertise**: The technical expertise required to analyze HCES data to calculate food consumption, nutrient intake, and identify potential food vehicles is high, but bit less than that needed for the quantitative open 24-hour recall method, for example, fewer inputs from a nutritionist. Necessary technical experts include a statistician and data analyst with experience analyzing the food consumption data from the HCES, and to a lesser extent, a public health nutritionist experienced in analysis and interpretation of food consumption data from HCES. If the nutritionist is not from the country, it's also important to have expertise from in-country collaborators with extensive familiarity with diets across the country to make the most accurate food composition table matches possible. For example, for fresh fish, which of several fresh fish varieties would be the most appropriate match for the country; or for palm oil, it is refined, red palm oil, or both, and if red, would typical cooking practices impact vitamin A retention, etc.

Examples of Countries That Have Used Household Food Consumption or Acquisition Data from an HCES for LSFF

Examples of countries with LSFF programs that have used HCES food consumption data for needs assessment and program design include Zambia (Fiedler and Lividini 2014), India (Bhagwat et al. 2014), Tanzania (mentioned in Coates et al. 2012a), Guatemala (Fiedler et al. 2010), and Uganda (Fielder and Afidra 2010). Adams (et al. 2022) describes additional examples of the use of HCES data to inform LSFF in Bangladesh, Malawi, Nepal, and Solomon Islands, among others.

[19] The costs are estimates from the review lead author's experience managing an HCES food consumption analysis activity.
[20] The time in months is an estimate from the author's experience managing an HCES food consumption analysis activity.

Availability of Secondary Data

As of 2012, there were over 700 HCESs covering 116 LMIC. Examples of countries that have conducted HCES include Bangladesh, Nepal, Cameroon, Ethiopia, Ghana, Kenya, Liberia, Malawi, Mozambique, Niger, Senegal, Tanzania, and Uganda (Fiedler et al. 2012b).

Use of Household Food Consumption or Acquisition Data from HCES to Inform Broader Programming to Improve Diets

The household food consumption or acquisition data from HCES may be useful to provide household level data to inform the design of broader programming to improve diets. For example, the data can be used to better understand household-level patterns of food consumption, household-level micronutrient supply, and opportunities to improve food consumption and micronutrient intake. HCES food consumption data have been used in Zambia and India to model the potential impact of biofortification on micronutrient adequacy (Lividini and Fiedler 2015; Stein et al. 2008). However, the data is limited to the foods on the HCES food list and thus does not provide information about the household's whole diet and does not provide information about intra-household food allocation and individual food consumption. Adding foods to the HCES food list for the food consumption portion of the questionnaire would need to be discussed with the institution implementing the survey in each respective country.

A3.1.4 Food Balance Sheets

Overview

Food Balance Sheets (FBS) are a source of secondary data used to determine national-level food supply patterns in a country (Coates et al. 2012a). FBS are also referred to as national food accounts, supply/utilization accounts, food disappearance data, and food consumption level estimates (Coates et al. 2012a). The Food and Agriculture Organization of the United Nations (FAO) develops the FBS, although some countries may calculate the FBS themselves (Coates et al.2012a). FAO compiles online FBS data annually for about 185 countries and a total of around 100 food commodity groups worldwide that may potentially be available for human consumption in the country (FAO 2018). They are the most used data sources for estimating food supply at the national level in developing countries (Coates et al. 2012a).

The FBS track primary commodities such as wheat, rice, fruit, and vegetables and a limited number of processed commodities like vegetable oils and butter. FBS do not provide information about which commodities are centrally processed at large scale. Industry-level data from, e.g., manufacturers or industry associations, may be useful when FBS do not provide data on processed foods, and other data sources, like HCES data, are unavailable or do not provide the necessary level of detail (Coates et al. 2012a). FBS data can be found on the FAO website.

FBS are composed of four categories of data:

- production and trade
- production stocks
- feeding and seeding rates
- losses in industrial processing

The FBS data are often calculated as an average for several years to decrease inaccuracies caused by lack of information on stocks. FBS for individual commodities, and for the overall food supply, are calculated using the following simplified equation:

Food available for consumption = (**quantity imported** + **quantity produced**) – (**quantity exported** + **seed** + **animal feed** + **waste** + **other uses**) + **changes in stocks** (Coates et al. 2012a).

FBS data provide reports on food that is "apparently available" for consumption at the national level. The FBS data can be used to (Coates et al. 2012a; Coates et al. 2012b):

- Broadly suggest which micronutrient inadequacies may be common in the country due to shortfalls in availability of nutrient-rich foods and infer the extent of the nutrient gaps, on an aggregate level.
  - FBS data provide information on the amount of food available for consumption in a specified reference period in a country. The data can indicate which micronutrients may be inadequate in the national food supply.
  - However, FBS data do not provide information on the distribution of inadequate food supply and does not account for the supply of foods not in the FBS.
  - FBS data may be a useful starting point to identify possible micronutrients that are inadequate in the diet, but LSFF program designers should use individual- or household-level data to confirm FBS estimates, because FBS data alone cannot provide sufficient information to serve as a basis for determining which micronutrients should be added to fortifiable foods (Coates et al. 2012a). If there are no national dietary data or relevant HCES, FBS data on micronutrient availability could be triangulated with other information that might indicate inadequate micronutrient intake or deficiency, such as anemia prevalence, stunting, program coverage data, or an analysis of data from several smaller diet or biomarker studies (Engle-Stone 2022b). If FBS data suggest that national supply of a micronutrient is grossly inadequate, there could be a problem, but apparent adequate micronutrient supply does not exclude the possibility of inadequate intake in subgroups in the population (Engle-Stone 2022b; Adams 2022b).
- Suggest which foods may be suitable fortification vehicles.
  - Trend data from FBS have been used to assist fortification programmers in selecting appropriate food vehicles and in setting fortificant levels. Traditionally, FBS data have been used to identify candidate vehicles by calculating estimated per capita daily consumption of various food items. The FBS data measure "apparent consumption" at the national level—a proxy approach that is less valid than direct measures like quantitative open 24-hour dietary recall and also less valid for this purpose than the HCES, which derives consumption estimates from household-level measures of apparent consumption.
  - The FBS estimates are gross averages across the population. As the FBS data are collected annually, they are useful to show trends in food available for consumption over time and the likely continued demand for candidate vehicles.
  - However, the FBS data do not provide information on the proportion of the population that consumes a fortifiable vehicle, so it is not possible to determine the potential program coverage.
- Identification of the level of fortification.
  - FBS data can be used to triangulate other data regarding consumption of fortifiable foods, but food fortification specialists should prioritize individual and household-level data over FBS data to determine fortification levels that will help to reduce the prevalence of inadequate intake and minimize the risk of excessive micronutrient intake among those who consume the food vehicle (Coates et al. 2012a). Although FBS data are readily available, they are not valid for estimating intakes (Coates et al. 2012a). They are "blunt, national-level measures of food availability and cannot measure variations in the distribution of food availability across key geographic or demographic segments of the population" (Coates et al. 2012a). In the absence of national individual or household food consumption data but where fortification is considered essential, FBS data could possibly be considered with other data sources, such as smaller dietary

studies, to select fortification levels. As noted in the main body of this review, the identification of the level of fortification is also determined by factors other than nutritional, such as safety of the fortification levels, the available technology for fortification, and economic constraints/cost of the fortification for industry and the consumer (Dary 2021).

Strengths and Limitations

The strengths of FBS as a data source include: (Del Gobbo et al. 2015, Coates et al. 2012a, Kuyper et al. 2017):

- Data are available for nearly every country worldwide.
- Data are updated annually since 1961.
- Data are nationally representative and can be used to show trends over time.
- Data represent official government figures.
- Data are supplied cost-free and publicly available.
- Data are developed using comparable methods across countries.
- Data, when used with food composition tables, can estimate per capita availability of micronutrients.

Limitations of FBS as a data source include: (Beal et al. 2017; Coates et al 2012a; Coates et al. 2012b; Del Gobbo et al. 2015):

- Data are based on input variables for each food item that are prone to error. For example, input variables come from total national production, exports, imports, nonhuman use like livestock feed, waste from farms, distribution, and processing.
  - National production data may be underestimated in countries with high production taxes, due to under reporting.
  - Import and export data may be underestimated in countries where large amounts of trade are unrecorded, or where the focus may be on imports, for tax purposes, more than exports.
  - FBS data do not account for all sources of waste, such as waste from cooking, spoilage, etc., all changes in stocks (often only changes in government stocks), and production from unofficial source like home production.
- Estimates of dietary consumption capture food availability rather than actual intake. The data represent the total average food supply at the national level and do not provide information on individual consumption and the proportion of the population that consumes a food, or disaggregated data on consumption by demographics such as by socioeconomic status, age, or sex. As a result, FBS data cannot be used to estimate a fortification vehicle's reach and coverage.
  - FBS data are used to estimate the annual per capita quantity of food available for consumption, which is used as a proxy for "annual per capita consumption." An assumption in the estimation is universal consumption of a food item, which is rarely the case.
- Certain food items may not be included in the FBS, like flour or processed foods; or food items may be grouped, e.g., poultry meat reported in the aggregate to represent chicken, turkey, etc. Aggregate food groups may be difficult to match to food composition table data.
- Tend to overestimate national dietary consumption. For example, Del Gobbo et al. 2015 found that estimated FAO per capita food supply estimates exceeded Global Dietary Database estimates by between 75 to 270 percent for major food groups.
- Data are not always available for every country.
- Data are not always consistent in terms of measurement unit or time period. FAO makes data adjustments to overcome these inconsistencies, but if unable to do so, FAO will not produce a FBS until more data are provided.

- Limited studies exist to validate the use of FBS to estimate food consumption and nutrient intake (note that there is a strong conceptual basis that FBS cannot be used to estimate the latter with a high degree of validity).
- Lag in data reporting.

Basic Steps to Use

FBS are usually obtained from FAO, but some countries also calculate national FBS. Food fortification programmers may consider using FBS data for two purposes, if individual- or household-level food consumption data are not available:

- Estimate micronutrient availability in the national food supply
    - Used to suggest which micronutrients may be inadequate in the national diet due to shortfalls in the national food supply.
- Estimate availability of potential fortification vehicles in the national food supply
    - Used to suggest which foods may be suitable fortification vehicles.

Basic steps for using FBS food availability data to estimate which micronutrients may be inadequate in the national food supply include (Gibson et al. 2012; Joy et al. 2014; Mark et al. 2016; Del Gobbo et al. 2015; Arsenault et al. 2015):

1. Select food commodities from the FAO FBS and download information on availability of the food item in kilocalories per capita per day for the country. Kilocalories per capita per day is recommended instead of grams per capita per day to account for inedible portions, given FAO weight represents the market weight, which includes inedible portions, and FAO does not provide information on the weight conversions for inedible portions. Kilocalories per capita per day represents the edible portion of the food items.
    a. For foods grouped into one FBS category, to estimate the proportion of the total weight attributed to each food in the aggregate commodity, three potential options are: equal weighting; weighting based on food consumption data from national dietary surveys; and weighting based on available production and trade statistics on the FAO website.
2. Select the appropriate food composition tables and calculate the micronutrient content of the daily available supply of the food item, per capita per day, and per 1,000 kilocalories (i.e., micronutrient density), for each commodity. If foods are usually consumed in cooked form, use food composition table entries for the cooked form.
3. Compare the per capita intakes and micronutrient densities calculated in Step 2 to estimated average per capita dietary requirements and densities for the micronutrients, based on the age and sex distribution of the national population, and considering, as appropriate, bioavailability, such as for iron and zinc, and specifically for zinc, considering the phytate to zinc molar ratio.
4. Estimate micronutrients most likely to be inadequate in the country's available food supply using the estimated average requirement cut-point method (used by Joy et al., 2014 and Mark et al. 2016). For iron, estimate adequacy of the food supply using the full probability approach. Risk of inadequate micronutrient intake is then the estimated daily per capita availability of the micronutrient in the food supply divided by the weighted country-specific EAR. Note that there is a need to make an assumption about the coefficient of variation to account for inter-individual variation in dietary intake.[21] Analysts should consult with a statistician experienced in working with this type of data for nutrition purposes.

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[21] Mark et al. 2016 state that this method assumes that the intakes and requirements of the nutrient are independent, the distribution of intakes in the population are more variable than the distribution of requirements, and the distribution of requirements in the group is symmetrical around the EAR. Mark et al. 2016; Joy et al. 2014; and Wuehler et al. 2005 used a

Basic steps for using FBS food availability data to estimate availability of potential food fortification vehicles in the national food supply include (Coates et al 2012a):

1. Determine if information on vehicles of interest is available on the FAO FBS. Note that the FAO definitions of food may differ significantly from what programmers need and may require additional analysis to be used.
    a. The FAO FBS are intended to include data on all potentially edible commodities. In practice, FBS cover all major food groups, including primary crops up to the first stage of processing and livestock and fisheries products up to the second, and sometimes third stage of processing. Fortification vehicles are often included in this as they are typically minimally processed foods. However, FAO FBS do not include more highly processed foods.
2. If selecting a more processed fortification vehicle, such as milled wheat flour, calculate the national availability of the commodity for consumption. The FAO Food Balance Sheet Handbook includes instructions in Section III.
    a. For example, FAO FBS include data on milled, white rice but do not include milled wheat and milled maize flour. Programmers would need to apply the extraction rate to the primary commodity data to calculate apparent flour consumption.
3. Access FBS data on the national availability in grams/capita/day for the vehicles and time period of interest (if per capita rate is not available, one can divide the supply by annual FAO data on population to calculate supply per capita).
4. Compare results and consider feasibility of fortification of the potential food vehicle and model the potential impact given the findings.

Given that FBS do not provide information on food consumed or nutrients available for consumption at regional, household, or individual level, it cannot be used to understand whether a potential fortified food vehicle will benefit the households or individuals most at risk for micronutrient deficiencies (Gibson et al. 2012). Some studies have tried to account for individual-level variation, such as inequalities related to household economic access or gender, by using a coefficient of variation (Mark et. al 2016; Ritchie et al 2018). However, this does not account for differences by population subgroups or micronutrients. There is also limited data to inform the choice of the coefficient of variation to use.

Ritchie et al. (2018) also applied a regional average percentage to account for food loss and waste, which is not considered in FBS supply calculations.

Cost, Time, and Technical Expertise

Cost: A key advantage to using FBS data is that they are accessible and cost-effective. The only associated costs are the resources needed to analyze the secondary data (Coates e.t al 2012a). It should be feasible to conduct the analysis with under 100,000 USD.

Time: The amount of time needed to clean, prepare, and conduct the secondary analysis of the FBS data is about 5 to 6 months. The most time-consuming step will most likely involve standardizing the data, matching food items or groups to food composition data, and completing the analysis. For example, time may be needed to calculate the availability of processed commodities using information on primary commodities and converting quantities of food available into estimates of available micronutrients (Coates et al. 2012b).

Technical Expertise: Necessary technical experts to conduct the preparation and analysis of the FBS data include a statistician and data analyst with experience in standardizing, analyzing, and interpreting FBS data and a public health nutritionist with extensive knowledge of a country's nutrition context. This

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coefficient of variation of 25 percent to account for inter-individual variation in dietary intake, while Arsenault et al. 2015 use 25 percent for zinc, niacin, and vitamin B6, 30 percent for calcium, riboflavin, and folate, 40 percent for vitamin C, and 45 percent for vitamin A. Arsenault et al. 2015 assumed a normal distribution except for nutrients with a coefficient of variation larger than 30 percent, which were assumed to be log-normally distributed.

includes familiarity with diets in the country to make the most accurate food composition table matches possible and familiarity with relevant data sources to triangulate data and tailor the analyses to specific micronutrient needs (Coates et al. 2012b).

Examples of Countries That Have Used FAO Food Balance Sheets for LSFF

Several researchers have analyzed FBS data to estimate micronutrient content of the national food supply, but few have indicated that the analysis was specifically used to inform LSFF. Even in cases where the authors mention the possible use of the findings to inform LSFF, it is not clear if the analyses were in fact used to inform LSFF programs. Examples of studies include:

- Cashman and O'Dea 2019: Used FBS data to model the potential impact of adding different levels of vitamin D to four food vehicles (plant-based oil, wheat flour, maize flour, and milk) on average per capita vitamin D supply in seven low- and middle-income countries.
- Ritchie et al. 2018: Used FBS data to calculate the average supply of micronutrients through the commodity chain and population-level risk for inadequate micronutrient intake for iron, zinc, calcium, vitamin A, vitamin B6, vitamin B12, and folate in India. The authors suggest that LSFF is one of the strategies that could be used to fill micronutrient gaps in the diet.
- Beal et al. 2017: Used FBS data to estimate the micronutrient density of the food supply, prevalence of inadequate intake of 14 micronutrients, and average prevalence of inadequate intake of micronutrients in all countries with FBS data between 1961 and 2011. The authors comment on the role of LSFF in improving micronutrient intake over time and further encourage improvements in LSFF, as well as other strategies, to improve diets.
- Mark et al. 2016: Used FBS data to estimate the prevalence of inadequate intake for vitamin A, thiamine, riboflavin, folate, vitamin B12, calcium, and zinc in Bangladesh, India, Iran, Maldives, Nepal, Pakistan, and Sri Lanka. The authors indicate that the FBS findings are useful for advocacy. They also state that to facilitate the implementation of strategies to improve diets, including fortification, they encourage conducting nationally representative nutrition assessment surveys to determine the true burden of micronutrient malnutrition and inadequate micronutrient intake.
- Arsenault et al. 2015: Used FBS data to estimate micronutrient content in the food supply for vitamin A, vitamin C, riboflavin, folate, calcium, and zinc in Bangladesh, Senegal, and Cameroon. The authors state that the FBS findings provide an informative and relatively easy starting point to assess the situation and initiate discussions about micronutrients in the food supply. They indicate that the availability of national dietary intake data would be preferable to validate the findings from the analysis of FBS data. The authors mention strategies to improve micronutrient intake, including LSFF.
- Joy et al. 2014: Used FBS data to estimate risk of inadequate micronutrient intake for calcium, copper, iron, iodine, magnesium, selenium, and zinc in 46 African countries and suggest fortification as a potential strategy to fill micronutrient gaps.
- Gibson and Cavalli-Sforza 2012: Used FBS data to estimate inadequate micronutrient intake, using nutrient density goals, for iron, zinc, calcium, niacin, vitamin B1, vitamin B2, vitamin B12, and vitamin A for fortification planning in Cambodia, South Korea, North Korea, Malaysia, Mongolia, New Zealand, Laos, Philippines, Solomon Islands, Vanuata, Vietnam, Brunei, Papua New Guinea, New Caledonia, China, Fiji, and Kiribati. The authors state that the nutrient density approach could be applied to FBS data to rank countries according to likely micronutrient deficits, but the approach does not provide information on distribution of nutrient supply for fortification program planning.
- Smith et al. 2016: Used FAO FBS data with their Global Expanded Nutrient Supply (GENuS) model to estimate nutrient availabilities for 23 individual nutrients across 225 food categories for thirty-four age-sex groups in nearly all countries. The authors indicate that the model can be used to estimate the impact of fortification in meeting nutritional adequacy.

- The Flour Fortification Initiative uses data on wheat production, imports, exports, and total amount available for consumption in its country feasibility assessments for prospective fortification programs (Coates et al. 2012a).

Use of the data from FAO Food Balance Sheets to Inform Broader Programming to Improve Diets

FBS data may be useful to provide initial data for needs assessment for broader programming to improve diets. For example, the FBS data can be used to better understand national-level food supply, how the food supply and available food in grams per capita per day compares with recommendations in national food-based dietary guidelines, if the nutrient content of the food supply is adequate to meet the population's nutrient needs, and changes in trends over time. Examples of FBS use include:

- As noted above, Arsenault (et al. 2015) used FBS data in Bangladesh, Senegal, and Cameroon to estimate the micronutrient content of the food supply. The authors then used linear programming models to determine a mix of crops that could fill the micronutrient gaps in the diet while minimizing the use of additional agricultural land. The authors indicate that enhanced livestock production, biofortification, and imports, in addition to food fortification and increased crop production, may be needed to improve diets.
- After Ritchie and colleagues (2018) used FAO Food Balance Sheet data from India to estimate risk of inadequate micronutrient intake, as noted above, the authors conducted scenario analysis to identify potential intervention points in the food system and their capacity to address inadequate micronutrient intake, including increased meat and dairy intake, reduction in supply chain losses, increases in crop yields, and a combination of these strategies.
- Kuyper (et al. 2016) assessed the gap between the current food supply and that required to support a healthy diet for the population of Cameroon. The authors compared FBS data on the national per capita availability of foods in seven groups to the total per capita per day consumption needed per group to meet the requirements of a 'healthy diet' based on the Dietary Approaches to Stop Hypertension (DASH) guidelines. The dietary gap assessment illustrated how the FBS data could be used to better understand how food supply patterns need to change to achieve healthier dietary patterns.

FBS data can be used to inform biofortification programs. HarvestPlus has used FBS data to identify countries with high per capita availability of key staples for consumption, such as rice, wheat, and maize, to determine appropriate country candidates for its biofortification programs (Coates et al. 2012a).

FBS data can be used for advocacy. Wessels and Brown (2012) used FBS data to estimate the prevalence of inadequate dietary zinc intake for 188 countries. The authors suggested that the findings be used to determine the need for direct biochemical and dietary assessments of population zinc status as a part of nationally representative nutrition surveys targeting countries estimated to be at high risk. The findings helped to advocate for greater public attention to inadequate zinc intake and zinc deficiency. As noted above, Mark et al. 2016 and Arsenault et al. 2015 both indicate that FBS data can be a good starting point to raise awareness about risk of inadequate micronutrients in the food supply and be used to advocate for action, whether conducting national-level micronutrient and food consumption surveys or interventions to improve diets.

A3.1.5 Nutrient-Specific Semi-Quantitative Food Frequency Questionnaire (NS-SQ-FFQ)

Overview

The NS-SQ-FFQ is an SQ-FFQ designed to estimate intakes of specific nutrients of interest from fortified foods (and/or biofortified foods) and also other sources in the diet (Wirth et al. 2020). GAIN developed the NS-SQ-FFQ in 2019 as a simplified dietary assessment method to estimate the extent to which a nutrient gap in the diet is being filled by consumption of fortified and/or biofortified foods. The aim of the development of the NS-SQ-FFQ was to estimate micronutrient intake but at lower cost and with less time than that needed for GAIN's SQ-FFQ that is used to assess the whole diet. GAIN had conducted a study that found that the SQ-FFQ, when used to assess the whole diet, produced results that were similar to the reference method that they employed in the study, the quantitative open 24-hour dietary recall, but at about the same cost (Hotz et al. 2017). If it worked well, the NS-SQ-FFQ could potentially be used to evaluate LSFF programs to answer the following questions:

- What percentage of the population is consuming the centrally processed fortified food?
- What is the average consumption of the fortified food in grams per day?
- What is the percentage of the population that has inadequate micronutrient intake?
- How has the percent of the population with inadequate micronutrient intake changed since the baseline?
- What is the contribution of the fortified food to micronutrient adequacy, considering the entire diet (or at least all the major foods in the diet that contain the micronutrient of interest)?

The NS-SQ-FFQ does require preparatory work similar to the SQ-FFQ, such as developing a food list, standard portion sizes with a photo album, collecting information on recipes, and developing the food composition table, and in addition, identifying the foods with high content of the key micronutrients of interest that are consumed by the target population.

The limitations of the NS-SQ-FFQ include (Wirth et al. 2020):

- Substantial preparatory work is required.
- Risk of recall bias, similar to the SQ-FFQ, given it involves asking respondents to recall what they consumed during the past 7 days.
- Assumes recent consumption is indicative of usual consumption, which may not be the case if there are seasonal differences in food consumption.
- Similar to the SQ-FFQ, it is difficult to develop an NS-SQ-FFQ that works equally well for all nutrients. Feasibility and ease of use may vary by micronutrient, depending on the food sources.
- Does not collect information on supplement use, though this could be added.

The NS-SQ-FFQ could be considered as a potential data source for LSFF design and for monitoring and evaluation after evidence is available regarding its validity and the cost, time, and technical expertise necessary for its use. The method does not appear to have been applied yet in any program settings.

A3.1.6 Fortification Monitoring and Surveillance (FORTIMAS)

Overview

FORTIMAS is an approach that uses, in part, non-probabilistic sentinel site data collection in health centers and schools to determine the percent of households that have purchased a fortified food and the percent of households with a specific food or foods confirmed to be fortified (Smarter Futures 2017). FORTIMAS was designed to track the population coverage and impact of flour fortification programs, but it can be applied to other fortification programs as well, like salt or oil.

The FORTIMAS system is designed to use data collection resources as wisely as possible, in a sequential manner when specific indicator milestones are met. For example, as part of the FORTIMAS system:

- When the flour industry and national food-control agency reports show that sufficient quality fortified flour is marketed to meet the per capita consumption of close to 80 percent or more of a population in a designated geographic area, then the fortified food can be monitored in communities and households via sentinel sites.

- When population coverage of fortified food through FORTIMAS sentinel sites is 80 percent or higher for at least a year, then micronutrient deficiencies, like anemia, can be monitored through the FORTIMAS health center sentinel sites.
- When FORTIMAS sentinel sites show that the following criteria are met – that there is sufficient production of fortified food that meets fortification standards, sustained high population coverage of the fortified food, and decreasing trends in the prevalence of micronutrient deficiencies, then an LSFF program evaluation can take place, e.g., through a representative, national-level population-based survey, as a part of the larger LSFF program monitoring and evaluation.

The sample FORTIMAS questionnaire for health centers is used to collect information such as the date of the interview, respondent's age, if the respondent recognizes the fortification logo, how much centrally processed fortified food is purchased by the respondent's household in a week, and the number of household members greater than 5 years of age. Data on results of biomarker tests can also be entered, such as hemoglobin, serum ferritin, and serum folate.

The sample FORTIMAS questionnaire for schools is a form completed by a school-age child that includes the date, whether the household buys flour in the market and if yes, what brand, whether the flour sack has a fortification logo, and how the household flour is stored. The child brings a sample of the household flour to the school to be tested by, for example, a teacher at the school, for the presence of the micronutrient of interest.

FORTIMAS does not just depend on data from health center or school sentinel sites. It also uses fortification data on production, sales, and fortification quality from industry, like flour millers; importers; food control agencies; wholesalers; bakeries; and markets. In addition, relevant information from existing information systems, like the health information system, could be incorporated into FORTIMAS. FORTIMAS data should be triangulated with data from national surveys, like the Demographic and Health Survey, Multiple Indicator Cluster Survey, HCES, or national micronutrient surveys.

FORTIMAS is not meant to provide statistically representative cross-sectional estimates of the prevalence of micronutrient deficiencies in the population, so it is not an appropriate approach for LSFF program evaluation. A statistically representative survey would be needed to determine the latter.

FORTIMAS is also not appropriate for needs assessment or program design. It is meant to be implemented as a monitoring system for fortification programs.

Although FORTIMAS addresses some consumption monitoring questions, it does not address all the consumption monitoring questions outlined in this review. The FORTIMAS monitoring system and indicators, as described in FORTIMAS documentation, do not respond to the following consumption monitoring question of interest in this review:

- *What is the average micronutrient content of the food that by law or standards should be fortified?*
    - FORTIMAS, as described, is not designed to respond to this question, but it could be adapted to respond to it if funds were available for laboratory analysis of food samples brought to schools by students, so that not just the presence of the micronutrient of interest is tested, but also the amount of the micronutrient in the flour or other fortified food.

The documentation available on FORTIMAS does not include validated tools. Where FORTIMAS already exists, validated tools could potentially be included in the approach. For example, the FACT survey questionnaire could be implemented using the FORTIMAS sentinel site approach. However, there are several criteria that should be met for the FORTIMAS data to provide reasonably reliable monitoring data and do so in a way that is feasible for health center and school staff:

- There should be a high level of health center attendance among the target population for the LSFF program, considering, e.g., urban and rural areas, wealth categories, sex, age categories, educational levels, and ethnic groups.
- There should be a high level of school attendance among the target population for the LSFF program, also considering the demographic and socio-economic groups mentioned above.
- Food insecurity should not impede the capacity of households to share food samples for testing at the school sentinel sites. If it might, this will need to be considered, as it will affect the coverage results.
- Health centers should have adequate staff who have the time, interest, and technical capacity to take on this additional sentinel site work, or additional staff may need to be hired or brought in to support the data collection at the sentinel sites, or support provided by university students as part of their coursework.
- Schools should have adequate staff who have the time and interest to take on this additional sentinel site work, or additional staff may need to be hired or brought in to support the data collection and testing at the sentinel site or ensure the food samples are appropriately transported to a laboratory for analysis. University students may also be able to support these efforts as part of their coursework.
- Funds and technical expertise must be available to train health center and school staff in the methods on a periodic basis.

Strengths and Limitations

FORTIMAS strengths include:

- Designed to use data collection resources as wisely as possible, in a sequential manner when specific indicator milestones are met.
- Designed to triangulate sentinel site data with data on industry production, sales, and fortification quality and existing information systems (e.g., health) and national surveys (e.g., national micronutrient surveys).

FORTIMAS limitations include:

- Does not provide statistically representative cross-sectional estimates of prevalence.
- Successful use will depend on data available in local health information systems, local data collection and processing capabilities and resources, and levels of health center and school attendance.
- Tools require testing and validation.

Basic Steps to Use

1. Select administrative areas, sub-areas, and data collection points where sentinel data will be collected.
2. Determine the minimum number of subjects or households from which to collect data, balancing resources with the need for sufficient data for prevalence estimates.
3. Determine reporting frequency.
4. Recruit respondents at sentinel sites at health centers; coordinate with schools for school children to bring samples of specific food vehicles.
5. Test food samples or send to laboratory.
6. Analyze data and review with stakeholders for discussion and decision making.

Cost, Time, and Technical Expertise

- **Cost**: The costs of FORTIMAS will be context specific. FORTIMAS may require more cost and time than secondary analysis, since it involves setting up a system that will require coordination

and oversight. But an advantage is that once it is set up, it can be used to monitor and update data over time. Costs include:
  - Technical and managerial staff to oversee the surveillance system.
  - Training for health center staff and school personnel.
  - Funds for supervisory and support visits to surveillance sites.
  - Staff to enter, clean, and analyze the data.
  - Funds for testing kits and/or laboratory analyses.
  - Resources for follow-up/use of data for decision making.
- **Time**: The time to conduct FORTIMAS will be context specific (Smarter Futures 2017).
- **Technical expertise**: The technical expertise required to prepare for, collect, analyze, and report on FORTIMAS surveillance data includes individuals with education, background, and experience with public health nutrition, sampling, statistics and analysis, and a laboratory and lab staff who can analyze food samples for micronutrient content.

Examples of Countries That Use FORTIMAS for Program Monitoring

Obare et al. 2017 noted that in Mozambique there was a FORTIMAS training for Ministry of Health staff. FORTIMAS has also been used in the Republic of Georgia and Turkmenistan to monitor iodized salt (Gerasimov 2022). We did not find other instances in the literature where FORTIMAS had been mentioned as used by a country.

Use of FORTIMAS to Inform Broader Programming to Improve Diets

FORTIMAS was developed for fortification programs. Its suitability for broader programs to improve diets requires validation. The appropriateness of the system for broader programming may be context specific and could be explored.

A3.1.7 Agri-Food Information Systems

Overview

Agri-food information systems are generally not designed to respond to the priority market-related questions outlined in this review. National agri-food and market information systems typically do not provide the brand-level information at the diverse level of markets needed to be able to respond to the LSFF needs assessment and design questions "What is the market availability of fortifiable and fortified foods (e.g., staples and condiments) in different geographic regions in the country? What are the brands present in the market in different geographic regions? What is their price?" Agri-food information systems also are not designed to provide information on micronutrient content of foods.

Current agri-food information systems in LMIC can take several forms and provide a limited or broad range of services (Galtier et al. 2014).

- Public agri-food information systems, supported by public institutions and funded, at least partially, by the state, usually focus on provision of information, like cereal grain and livestock prices, or information on weather (temperature, rainfall, wind).
- Information systems supported by professional organizations and non-governmental organizations may focus on sharing information with farmers and farmer organizations, traders, or consumers on crop production, buying, and selling decisions, and weather, which may be linked with broader market support programs like credit, storage, training, regulations, and business advice.
- Information systems can also be linked to commodity exchange – which generate prices and share information about commodity prices.
- Agri-food information systems can also be supported by private enterprise that charge users a fee for information and services that help them improve market efficiency.

Given the focus and level of information shared through agri-food information systems, they do not appear to be an appropriate source of information to assess the market availability of food fortification vehicles and existing fortified foods. This also pertains to [FEWS NET](), which does not contain the level of detail to be useful for LSFF programming, i.e., brands and their prices in a range of market types in diverse regions of a country. However, if the agri-food information system could be adapted to collect information on the market availability of fortifiable or fortified foods, brands, and prices, it could be considered for use to inform LSFF design.

A3.2 Tools

A.3.2.1 Fortification Assessment Coverage Toolkit (FACT)

Overview

The FACT was developed by the Global Alliance for Improved Nutrition (GAIN) in 2013 to provide standardized methods to collect, analyze, and synthesize data on quality, coverage, and consumption of fortified foods as part of program monitoring efforts in population-based and targeted fortification programs. The FACT has been reviewed by independent subject-matter experts, pilot tested, and refined for the various contexts in which it has been used (Friesen et al. 2019). The toolkit was developed to provide consumption monitoring results with technical rigor at relatively lower cost and shorter time than more intensive methods, such as the quantitative open 24-hour dietary recall (Friesen et al. 2017).

FACT has two components, a household survey and a market assessment, which collect different indicators using different methods.

- The household survey, for consumption monitoring, has an individual-level assessment module that uses the SQ-FFQ for fortifiable and fortified wheat flour consumption, and a household questionnaire on food purchase and acquisition for other fortifiable and fortified foods.
  - The SQ-FFQ in FACT is used for food vehicles that are commonly consumed in prepared forms that may be made inside the home from the raw food vehicle or outside the home, e.g., wheat flour (Global Alliance for Improved Nutrition and Oxford Policy Management 2019). These types of foods lend themselves more easily to develop a SQ-FFQ (e.g., bread, noodles, etc.,) because one can readily determine a closed list of foods items, provide a range of portion size options for the foods, and reasonably estimate the average amount of the fortified item, e.g., wheat flour, in each food.
  - FACT uses a household food acquisition and purchase questionnaire for food vehicles that are typically purchased in their raw forms and added in large or small quantities to foods prepared at home (e.g., salt, edible oil, and sugar). It does not account for consumption of these food vehicles outside the home given the difficulty of assessing amounts consumed of these food vehicles in prepared foods obtained outside the household.
- The market assessment includes a survey for marketplace and retail outlet registration, brand registration for food vehicles, and sample registration for food samples.

Data can be collected with any level of representativeness (e.g., national, state, urban, and rural, etc.,) depending on stratification, sampling design, and sample size, and can include diverse population groups (Neufeld et al. 2017). FACT surveys can be implemented as an independent household survey and/or market survey or the modules can be added to other surveys or surveillance systems (Friesen et al 2019).

The FACT survey is designed to generate indicators at household and market levels that are aligned with the impact pathway for fortification programs.

Household Level

At the household level, the FACT focuses on assessing three main areas—

1. Availability and fortification quality of fortified foods at the household level.
2. Assessment of coverage, consumption, and micronutrient contribution of fortified food vehicles.
3. Assessment of equity in coverage, consumption, and micronutrient contribution by identifying vulnerable population subgroups.

The data collected with the FACT can be used for indicators that are important for consumption monitoring of LSFF programs, such as:

- The percent of the target population consuming the fortified food.
- The average daily consumption of the fortified food.
- The average additional content of micronutrients in the fortified food due to fortification.
- The average additional amount of micronutrients consumed daily by the target population through the consumption of the fortified food.

Market Level

At the market level, FACT assesses—

1. The availability of brands of each food vehicle.
2. The fortification quality of food vehicles by brand compared to fortification standards.

The data that is collected can also include:

- Whether the brand is imported or produced in the country/locally.
- Type of food vehicle, e.g., wheat flour, oil, sugar, etc.
- Supplier type, e.g., importer/exporter, distributor, packer/re-packer, etc.
- Retail outlet type, e.g., outdoor market, retail shop, supermarket, wholesaler, etc.
- Market hub or geographic administrative area.

The data that is collected with the FACT can be used for indicators that are important for LSFF program design and/or monitoring of LSFF programs, such as (WHO 2021b; Friesen et al. 2019):

- Total number of brands of a food vehicle that are available.
- Micronutrient content of a food vehicle brand.
- Proportion of food vehicle brands that are fortified (to any extent).
- The percentage of retail and market samples of fortified products that meet fortification specifications.

Strengths and Limitations

Household Level

The strengths of methods used to estimate indicators recommended in the FACT manual (Friesen et al. 2017; Friesen et al. 2019; Aaron et al. 2016; Neufeld et al. 2017):

- Uses standardized methods with validated instruments, where available, for consumption monitoring.
- Includes methods to measure micronutrient contents in food vehicles from household or market samples to assess the adequacy of fortification in comparison with mandated levels and estimate the micronutrient contribution of fortified foods to the diet.
- Used to collect information on household use of a fortified food vehicle and also consumption frequency in the past week and amount consumed by individual household members, e.g., woman of reproductive age 15-49 years and child 6-23 months.

Strengths of implementing a standalone household survey (not specific to FACT):

- Can assess equity of coverage with appropriate sampling, sample size, and collection of data on measures of vulnerability (e.g., poverty, subnational area, sex, age, ethnic group, etc.)

The limitations of methods used to estimate indicators recommended in the FACT manual (Engle-Stone et al. 2019; Aaron et al. 2016; Aaron et al. 2017):

- Does not capture the total diet.
- For the household food acquisition and purchase questionnaire, does not capture foods purchased and consumed outside of the household, which may result in underestimating the potential coverage of fortification interventions.

Limitations of implementing a standalone household survey (not specific to FACT):

- Requires a high level of technical capacity to prepare for and implement the survey and analyze the data.
- Cost and effort are still substantial for data collection.

Market Level

The strengths of the method at the market level include that it (Friesen et al. 2019):

- Uses a standardized method with validated instruments.
- Includes methods to measure micronutrient contents in food vehicles from market samples to assess the adequacy of fortification in comparison with mandated levels.

The limitations of the method at the market level include (Friesen et al. 2019):

- The market methodology is not a census, and therefore may not identify every single brand available across the country for a given food vehicle.
    - The method aims to maximize the number of food vehicle brands that can be found in markets at the time of the survey and that represent the majority of the available brands on the market.

Limitations of implementing a standalone market assessment (not specific to FACT):

- The investment in time, cost, and effort to collect the market data can still be substantial (although it is lower than that of a household survey).

Basic Steps to Use

The FACT manual provides a good overview of the basic steps to use the FACT (Friesen et al. 2019). The GAIN website also includes useful links to templates and guides for the FACT survey, available here. The list of key steps below is not necessarily in chronological order, as several activities would usually be conducted simultaneously, or via an iterative process. Please note that these steps are specifically for analysis of data collected from a stand-alone FACT survey and may not be relevant if FACT indicators are integrated into other data collection platforms.

Household Component

For consumption monitoring, the basic analysis steps are:

1. Clean the data by checking for completeness, errors, and implausible values. Abide by decisions outlined in the protocol regarding handling of values that are outliers. Document all cleaning activities. Preserve a copy of the raw datasets to ensure transparency. Do not correct a value without first preserving the original value.
2. Prepare the data for analysis and create the data dictionary that defines the variables in the dataset. Prepare the data validation report that describes the data management system, the data management team, the sampling for each survey component, data checks, and how the data was cleaned.

3. Send food samples to the selected laboratory for analysis. GAIN describes in the [FACT Manual]() considerations for selecting the laboratory, the results that the lab should provide, how to decide which micronutrients to analyze and nutrient analysis methods,
4. Analyze the data per the data analysis plan.
5. Write the survey report, including recommendations based on the findings. GAIN provides a report template here. The FACT Manual includes tips for report writing and data visualization. Share findings with stakeholders for feedback, revise, and finalize.
6. Disseminate the findings, considering the various stakeholder audiences and their needs, including key decision makers. Align dissemination products with audience needs. Options include, e.g., technical reports, publication in a peer-reviewed journals, briefs, press releases, webinars, videos, social media, and other forms of dissemination.
7. Prepare the data and documentation for archiving in the USAID Development Data Library. Review the necessary steps at the USAID DDL website. Archive in other repositories as necessary, for example, following any country specific guidance.

Market Component

For the market component of FACT, the basic analysis steps include:

1. Clean and analyze the data and send food samples to a laboratory.
2. Write report and disseminate findings.

Cost, Time, and Technical Expertise

- **Cost**: Costs would involve data preparation, processing, and analysis and should generally be less than 100,000. Total cost will depend on:
  - Sample size and subpopulations for reporting (age, sex, ethnic group).
  - Indicators being measured
  - Experience and expertise of analysis team.
- **Time**: The time required for data preparation, processing, and analysis of the FACT data will vary according to the size and quality of the dataset and availability of comprehensive food composition databases. The data preparation, processing, and analysis should take less than 6 months.
- **Technical expertise**: The technical expertise needed for data preparation, processing, analysis, and report writing is relatively high. Necessary technical experts include a public health nutritionist, at least one team member with an in-depth knowledge of the context and local foods, a statistician, and a data analyst with experience in analyzing and interpreting data from a FACT survey. If laboratory samples were collected, accredited laboratory technicians would be needed to assess the micronutrient content of the collected food samples.

Examples of Countries That Have Used FACT for Consumption Monitoring

Countries with LSFF programs that have used FACT for consumption monitoring include Bangladesh, Cote d'Ivoire (Abidjan), India (Rajasthan), Nigeria (Kano and Lagos), Senegal, South Africa (Gauteng and Eastern Cape), Tanzania, and Uganda (Friesen et al. 2017; Aaron et al. 2017). Results in the latter countries focused on household coverage of edible oil and wheat and maize flours. FACT surveys have also focused on household coverage with iodized salt in Bangladesh, Ghana, Senegal, Indonesia, Philippines, India, Ethiopia, Niger, Tanzania and Uganda (Knowles et al. 2017). In Pakistan, a FACT survey was implemented in households in three provinces, Balochistan, Punjab, and Sindh, to provide data on household coverage and consumption of fortifiable foods among children under five years of age and women of reproductive age, including data on household use, source, brand, quantity purchased, and cost of fortifiable salt, oil/ghee, and wheat flour (Global Alliance for Improved Nutrition and Oxford Policy Management 2018). An adapted FACT survey in Mozambique evaluated the coverage of iron-fortified wheat and maize flours and vitamin A-fortified sugar and vegetable oil, as well as reach across population groups (International Policy Centre for Inclusive Growth 2019).

Examples of Countries That Have Used the FACT Market Component for Program Design or Monitoring

The FACT market survey was used in Bangladesh to assess the availability of oil brands across eight divisions of Bangladesh, fortification quality (the extent to which vitamin A content was aligned with fortification standards) of oil brands and producers, and the market volume represented by available edible oil types (Jungjohann et al. 2021). In Burkina Faso, the FACT market survey was used to assess the presence of brands and producers of rice, tomato paste, bouillon cubes and maize flour in sampled urban market hubs across the country (Global Alliance for Improved Nutrition 2018). In Pakistan a FACT market survey was conducted in four provinces (Balochistan, Punjab, Sindh, and Khyber Pakhtunkhwa), to assess the availability and fortification quality of brands of salt, oil/ghee, and wheat flour (Global Alliance for Improved Nutrition and Oxford Policy Management 2018).

Availability of Secondary Data

Between 2013 and 2017, 18 FACT household assessments were conducted in 16 countries and 7 FACT market assessments were conducted in 6 countries (3 of which were combined with a household assessment) to assess large-scale fortification programs (Friesen et al. 2019).

Use of the FACT to Inform Broader Programming to Improve Diets

Household Level

The FACT may be useful to provide household level data or individual-level data to inform the design of broader programming to improve diets, however, the survey would need to be adjusted to address the specific survey questions and tested in the country. For example, foods other than fortified or fortifiable foods could be added to the FACT to better understand production, purchase, and/or consumption and micronutrient content. FACT has been used to estimate the coverage multiple micronutrient powder (MNP) use in five countries (Leyvraz et al. 2017).

GAIN developed and tested a FACT module that assesses coverage and consumption of biofortified foods (Petry et al. 2020). GAIN also developed a simplified dietary assessment method aimed to better estimate adequate intakes or "effective coverage", to estimate the dietary gap in micronutrient intake, interpret the nutrient contribution from fortified foods, and assess the extent to which it meets or exceeds requirements in on-going programs (Wirth et al. 2020).

Market Level

The FACT market component is designed answer questions about brands of fortifiable foods in markets, price, and the amounts of micronutrients in existing fortified foods. It could be feasible to adapt the market survey to assess the presence of foods that are potentially biofortifiable and the micronutrient content of biofortified foods in markets. This information would be useful for program design and monitoring and might also provide an opportunity to contribute to data for food composition tables for a specific country or region. The FACT market component could also be used to assess the existence of processed foods in markets, and perhaps the potential for processing, if combined with other sources of information, such as key informant interviews and focus group discussions with various stakeholders, including consumers. The FACT market survey would need to be adapted and tested for use to inform broader programming to improve diets.

A3.2.2 Fortification Rapid Assessment Tool (FRAT)

Overview

FRAT was developed by PATH/Canada in 1997/98, under a contract with the Micronutrient Initiative. FRAT was initially developed primarily to inform vitamin A fortification programs (Hess et al. 2013). It was tested in Bangladesh, Brazil, and Burkina Faso (Berti et al. 1999). The first FRAT guidelines were released in 2000 and revised in 2003 (Micronutrient Initiative 2003).

Household Level

For household-level data collection, FRAT includes a questionnaire that combines a simplified open 24-hour dietary recall and a food frequency questionnaire. These provide information about consumption patterns of potential food vehicles to inform design phase decisions about the most appropriate food vehicle(s) for fortification (Micronutrient Initiative 2003). The FRAT questionnaire has six parts:

- Parts 1 and 2: To collect information on background characteristics and consumption patterns of a woman between 16-45 years.
- Part 3 and 4: To collect information on background characteristics and consumption patterns of a child 12-36 months.
- Part 5: To collect general information about food availability and storage.
- Part 6: To collect information on the calibration measures for specific foods.

The key questions that the FRAT aims to answer with regards to consumption are:

- Do young children and women of childbearing age consume the candidate food?
- What is the range of consumption levels?
- Is consumption restricted by low socioeconomic status?
- Are there major regional variations in consumption patterns?

However, the FRAT is not meant to measure micronutrient intake, nor does it allow to estimate actual risk of dietary inadequacy.

Regarding food consumption, the enumerator specifically asks the respondent about consumption of foods or beverages prepared with “X” fortifiable food item in the past 24 hours, how the food or beverage was prepared, and the amount that was consumed. The questionnaire includes a question about how many times in the past 7 days the respondent consumed foods with the specific fortifiable food item. There is also a question about the seasons during which the specific fortifiable food item is consumed. If feasible, the enumerator records where and how the fortifiable food item is stored.

The FRAT is used to collect household-level data. The FRAT questionnaire can be implemented as a stand-alone survey or incorporated into an existing survey.

Market Level

FRAT also includes a market survey. The market survey component of FRAT assesses the market conditions to determine if fortification is feasible from an industrial and commercial standpoint. The market survey involves open-ended interviews with, e.g., owners, general managers, production managers, etc., of food manufacturers and processors, distributors and wholesalers, and retailers. The FRAT market survey is used to answer the following questions:

- Who are the key players in the food industry for specific fortifiable foods?
- What is the movement of the fortifiable food from the grower or importer through to the consumer, the distribution system, the turnover rate, and the coverage by regions?
- What is the manufacturing process for the fortifiable food?
- What is the technical capacity of the industry to fortify the food and what technical or industrial improvements would be needed?

- What is the range of prices of various brands or types of the fortifiable food that are most commonly consumed by various groups of the population?

Strengths and Limitations

The strengths of the tool include (Micronutrient Initiative 2003; Coates et al. 2012a):

- Relatively simple to design and administer.
- Designed for fortification programs.
- Can provide information on frequency of consumption and estimates of intake of potential food fortification vehicles.

The limitations of the tool include the following (Micronutrient Initiative 2003; Coates et al. 2012a; Hess et al. 2013; Dary and Imhoff-Kunsch 2012, Berti et al. 1999):

Household Level

- FRAT does not collect data to measure micronutrient intake and cannot be used to make estimates of actual risk of dietary inadequacy (Micronutrient Initiative 2003).
    - Dary and Imhoff-Kunsch (2012) indicate that, regarding FRAT, "Although found to be useful to inform fortification programs, the instrument did not reduce the need for individual-level surveys of relatively large scale."
- The partial 24-hour recall method suggested in the FRAT has not been validated (Berti et al. 1999).
    - The team that tested the FRAT in countries assumed it would be at least as accurate as the conventional quantitative, open 24-hour dietary recall and food frequency methods on which it was drawn from, but did not test the latter assumption. The field-testing report indicates that "reasonable decisions about food fortification can be made even with large errors in the estimates of consumption frequency" (Berti et al. 1999), however, no reference or evidence is provided for this statement. Validation against a reference method would help determine the level of accuracy of the FRAT method.
    - The FRAT questionnaire includes questions that, given the type of information requested and the way they are asked, should be tested via cognitive testing. For example: "Since you got up yesterday morning, what was the first food or beverage you consumed that was prepared with Food "X"?" and "How many days, in the last 7 days, did you eat foods/beverages prepared with Food X?" Cognitive testing via cognitive interviews helps to determine if a question captures what it intends to capture and if it makes sense to respondents. It involves more than the pre-test that is outlined in the FRAT manual.
- The FRAT does not collect data on whether the fortifiable food was sourced from a large-scale producer (Coates et al. 2012b; Hess et al. 2013). Even if the percentage of the population that is consuming the fortifiable food is high, if the food item is obtained from home production or sourced from a small or medium enterprise, large-scale fortification of the food will not produce the desired impact.
- If quantitative open 24-hour dietary recall data or sufficiently detailed household food consumption data are available, it is quicker and less expensive to use the existing 24-hour dietary recall or household food consumption data to inform LSFF program design. If 24-hour dietary recall or household food consumption data are not available, it is still necessary to look at methods other than FRAT, given FRAT does not respond to data needs regarding estimating micronutrient intake.

Market Level

- The FRAT market assessment tool does not help answer the following priority market-related questions outlined in this review:

- What is the market availability of fortifiable and fortified foods (e.g., staples and condiments) in different geographic regions in the country? What are the brands present in the market in different geographic regions? What is their price?

- The original FRAT market assessment did not perform well when tested in countries and even after revisions, questions about its usefulness remain (Berti et al. 1999).
  - The testing team found it difficult to select objective criteria for the sample size and sample selection and the content for the interview guide.
    - The general guidance to conduct qualitative focus group discussions until no new meaningful information is found ran contrary to FRAT's aim that users know from the beginning the required resources to achieve accurate results. In the testing, the sample sizes were selected for convenience rather than based on scientific justification.
    - There was no method to rapidly and systematically collect the necessary market data that would be applicable across countries.
  - The testing team felt that although it might be important to understand the food market, it may not be critical to conduct a FRAT market assessment to decide if a fortification program should be implemented because market conditions can change in response to industry and/or government efforts.
  - We could not find recent literature on the FRAT market assessment or experiences with its use.

Use of FRAT for Consumption Monitoring

It has been suggested that FRAT could be adapted and used for consumption monitoring (Coates et al. 2012b; Hess et al. 2013). However, FACT was specifically designed for consumption monitoring and appears to be better suited for it. The FRAT, as designed, does not respond to the following consumption monitoring questions because it does not include household collection and laboratory analysis of fortified foods:

- In what percentage of households is the fortified food confirmed as fortified (e.g., at least a qualitative test)?
- What is the average micronutrient content of the food that by law or standards should be fortified?

A3.2.3 Diet Quality Questionnaire (DQQ)

Overview

The DQQ is a standardized tool to collect data to estimate the Minimum Dietary Diversity for Women (MDD-W) indicator, along with new indicators that capture dietary risk factors for noncommunicable disease among adults (Global Diet Quality Project 2021a). The tool includes questions about prior day consumption of sentinel foods from 29 food groups. Sentinel foods are foods that are the most frequently consumed items within a food group in a given population. The food lists in the DQQ are not meant to be exhaustive.

The DQQ can be used to assess dietary patterns and trends in the general population. Separate country adapted questionnaires are specially designed for infants and young children under 2 years of age to provide data for the WHO and UNICEF infant and young child feeding (IYCF) indicators. The DQQ was developed with support from USAID.

The following are examples of indicators for adults that can be calculated from the DQQ data:

- Percent of WRA 15-49 years consuming minimum dietary diversity
- Percent of the target population consuming all recommended food groups
- Percent of the target population with zero animal-source food consumption
- Percent of the target population with zero consumption of legumes, nuts, or seeds

- Percent of the target population with zero consumption of fruits or vegetables
- Percent of the target population consuming ≥ 400 grams of fruits and vegetables
- Percent of the target population consuming whole grains
- Percent of the target population consuming each food group
- Average global dietary recommendations score of a target population

The DQQ cannot be used to respond to the questions that have been outlined in this review. For example, it cannot be used to identify which specific micronutrients are inadequate in the diet, the percent of the target population that has inadequate intake for a specific micronutrient, or the amount of fortifiable or fortified foods consumed. However, the DQQ, via calculation of the MDD-W, can provide information on the percent of WRA 15-49 years consuming a diet of minimum diversity. A higher prevalence of MDD-W among a group of WRA is a proxy for better micronutrient adequacy in a given population (FAO 2021). The DQQ has been validated to collect information on consumption of food groups but does not have questions about consumption of fortified foods or fortifiable foods. Questions about consumption of fortified or fortifiable foods could be added before or after the DQQ but cannot be added within the DQQ because this would compromise the validity of the questionnaire (Global Diet Quality Project 2021b). The DQQ can be used to provide **contextual information** about the quality of the diet in a target population, so could be used to provide **descriptive information** to complement data about the target population's diet.

A3.2.4 Intake Modeling, Assessment and Planning Program (IMAPP)

Overview

IMAPP was developed by WHO in collaboration with Dr Alicia Carriquiry of Iowa State University, Dr Lindsay Allen of the United States Department of Agriculture (USDA), Agricultural Research Service (ARS) Western Human Nutrition Research Center, and Dr Suzanne Murphy of the University of Hawaii (WHO 2010). IMAPP uses a software program to estimate if the amount of a micronutrient proposed for a fortifiable food or existing fortified food would be a safe level of intake for most individuals who consume the food and if it might improve micronutrient adequacy. IMAPP can also be used for identifying baseline scenarios for needs assessment.

IMAPP requires dietary intake data from a representative sample of at least 100 individuals in each age-, sex-, and physiological status category for each region and season of interest, as applicable (WHO 2010). The software allows the user to specify bioavailability factors for iron and zinc. It calculates the usual intake distribution and models the predicted prevalence of inadequate and excessive intake of each micronutrient before and after fortification. The software uses the EAR cut-point method and the UL cut-point method to estimate whether micronutrient intake is adequate or exceeds safe upper levels, with the exception of iron, for which it uses the full-probability approach.

To estimate usual intake distributions, which helps to avoid overestimation of intake estimates, IMAPP will need either:

- at least two days of dietary data (nonconsecutive) on a representative subsample, or
- an external estimate of within-person variation from another study.

The program includes default values so that the user does not need to find these. So, users can use IMAPP with single recall datasets, but they should interpret the results with caution. The software output includes the prevalence of inadequate micronutrient intake and the prevalence of excessive intake for each of the age-, sex- and physiological groups in each region and season before fortification. The program also estimates the additional amount of micronutrient necessary to reach a specified prevalence target, through one or several fortified foods and/or interventions. When the user enters an amount of micronutrient for the food vehicle, the software calculates the estimates. The user can adjust and recalculate the estimates as needed.

IMAPP can also be used to estimate a population's micronutrient adequacy for monitoring and/or evaluation, if the necessary 24-hour dietary recall data are available (WHO 2010).

Strengths and Limitations

Strengths of the method include:

- Its use of a software program, which can assist users in conducting the calculations and does not require the ability to write code.
- It has a detailed user's manual.
- It uses quantitative open 24-hour dietary recall data, which helps ensure a relatively high degree of accuracy in the modeling.
- Datasets with only a single day of recall data per person can be analyzed when a suitable external estimate of within-person variation from another study is available.

Limitations of IMAPP include:

- The software is not designed to use household-level estimates of micronutrient intake, e.g., use of HCES data. Validation of the software would be required for use with HCES data.
- The lack of 24-hour dietary recall data in LMIC limits the opportunities to use the method.

Basic Steps to Use

IMAPP has a very detailed manual (Iowa State University 2018). The detailed steps will not be repeated in this literature review. The manual can be acquired through contacting Dr. Alicia Carriquiry, alicia@iastate.edu.

The very basic steps to use IMAPP include:

1. Download the IMAPP software from the website: IMAPP website.
2. Complete screens 1 to 5. Screens 4 and 5 are especially critical to customize IMAPP analysis to the data.
3. Prepare input data in a CSV or Excel file. Note that IMAPP requires data that includes a second quantitative 24-hour dietary recall on a subset of the sample to determine the distribution of usual dietary intake.
4. To determine prevalence of inadequacy in population groups, complete screen 6.
5. To determine a food fortification plan and assess its efficacy for all population groups, complete screens 7 and 8.

Cost, Time, and Technical Expertise

- **Cost**: The IMAPP software is free. If secondary quantitative open 24-hour dietary recall data are available, the cost will primarily include the technical expertise necessary to conduct the analysis using the software.
- **Time**: The time for the analysis should be relatively quick, once the 24-hour dietary recall data file is prepared (including all data cleaning and processing) and other necessary parameters identified, e.g., it could just take a few days to conduct the analysis.
- **Technical expertise**: The use of the software does require familiarity with nutrition and having a background in statistics or a statistician on the team will be very helpful.

Examples of Countries That Have Used IMAPP for LSFF Program Design

- A research group used IMAPP in Mongolia to model the contribution of wheat flour, edible oil, and milk on bioavailable micronutrient intake in summer and winter under different fortification guidelines within various population subgroups, including urban and rural and by sex (Bromage et al. 2018b).
- Researchers used IMAPP in Kiribati to determine usual thiamine intake distributions and thiamine inadequacy among specific population groups. IMAPP was also used to model the

fortification of wheat flour, rice, sugar, and plant-based oils with thiamine to reach the desired prevalence of nutrient adequacy (Green et al. 2021).

- A study team used IMAPP to simulate the impact, effectiveness, and safety of fortifying wheat flour with calcium, using available dietary intake data from Argentina, Bangladesh, Italy, the Lao People's Democratic Republic (Lao PDR), Uganda, Zambia, and the United States. The team estimated the amount of a micronutrient to add to a food vehicle to decrease the level of nutrient inadequacy without exceeding the recommended upper limit (Cormick et al. 2021).

Use of IMAPP to inform broader programming to improve diets: The literature includes at least one example of IMAPP's use in Ethiopia to model calcium supplementation among pregnant women (Tesfaye et al. 2018). The method could potentially be used to model biofortification, however, it was developed primarily to inform fortification programs. Its use for modeling the contribution of various nutrition interventions to micronutrient adequacy could be explored. However, the need for 24-hour dietary recall data is a limitation, given lack of such data in many LMIC.

A3.2.5 Cost of the Diet (CotD)

Overview

The CotD method, developed by Save the Children, uses linear programming software to model and estimate the amount and combination of local foods needed to provide a typical family with a diet that meets their average needs for energy and recommended intakes of protein, fat, and micronutrients at the lowest possible cost to the household (Deptford et al. 2017; Save the Children UK 2018). The software selects from local foods entered in the program, along with their costs and nutrient content. Based on this information and other parameters, CotD uses linear programming to select a combination of foods that would meet nutrient needs at the lowest cost, which is referred to as the "diet". The "diet" is hypothetical, based upon the lowest cost combination of all available foods for the target population that were entered into the software.

Strengths and Limitations

CotD strengths include (Untoro et al. 2017; Daelmans et al. 2013):

- Can be used for advocacy, to guide thinking on what drives costs for meeting micronutrient needs and to stimulate debate.
- Can be used to create "what if" scenarios to model how the cost of an adequate diet may change given interventions such as food fortification, biofortification, supplementation, cash transfers, etc.
- Can be used for analysis at the individual or household level.
- Provides an economic benchmark of the lowest possible cost of a diet that meets nutrient needs.

CotD limitations include:

- CotD diet is not necessarily a diet that households would consume; it cannot necessarily be used to make a recipe or meal.
- Results do not represent the distribution of dietary patterns within the population.

Basic Steps to Use

Save the Children has a Practitioner's Guide for Cost of the Diet. The guide describes in detail the use of the method and the information will not be repeated here. Very basic steps in method use include:

- Define the objectives of the analysis and the data needs.
- Determine whether existing data can be used for secondary analysis or primary data collection will be necessary. For example, can existing market, HCES, or consumer price index data be used, or will it be necessary to collect data on food costs?

- Prepare existing data for secondary analysis (e.g., clean the data and convert to price per 100 gram edible portion) or collect primary data and clean and prepare data for analysis.
- Set analysis parameters in the software program. For example, if analyzing the household diet, define the members of the household by sex, age, and physiological status (e.g., pregnant woman, lactating woman). Select foods from the software's food composition table for inclusion in the analysis. Include costs for each food selected for the analysis. Set portion sizes. Set constraints (limits) for consumption of foods, food groups, and total amount of food.
- Run the software program with the data inputs for a standard analysis and set up and model "what if" scenarios, altering settings as needed (e.g., foods, food composition table data, portion sizes, etc.).
- Interpret the findings and share/discuss with key stakeholders.

Relative Cost, Time, and Technical Expertise

- **Cost**: The CotD software is free. If existing data is available for secondary data analysis, the main cost will be for the technical expert to conduct the analysis. If primary data collection is needed, the cost will also include that of a survey lead, data collectors, and a survey administrator, in addition to the technical expert, and data collection costs, such as equipment, supplies, transport, per diem, and lodging.
- **Time**: Save the Children estimates that it will take about six to eight weeks for preparation of the secondary data, data analysis, and report writing. If data must be collected, they estimate six months for the data collection, analysis, and report writing, depending on the number of markets and data collectors.
- **Technical expertise**: The method requires a technical expert in nutrition who has been trained in and has experience using the CotD software. If data collection is required, technical experts will also be needed with experience in survey implementation.

Examples of Countries Where Cost of the Diet Has Been Used for LSFF

CotD has been used by WFP to model the contribution of fortified staple foods to the cost of an adequate diet in Democratic Republic of Congo, Ethiopia, Ghana, Lesotho, Mali, Nepal, Niger, Philippines, Rwanda, Somalia, Sri Lanka, Tajikistan, Uganda, and Zambia (World Food Programme 2016, 2018a to 2018f, 2019a to 2019c, 2021a to 2021d; Ethiopia Public Health Institute and World Food Programme 2021; World Food Programme and Ghana Health Services 2016; World Food Programme and UNICEF 2019). Save the Children has conducted extensive CotD analyses, however, they mostly modeled fortified complementary foods for young children, and rarely modeled LSFF, except fortified rice in Bangladesh (Save the Children 2013).

Use of Cost of the Diet to Inform Broader Programming to Improve Diets

CotD can be used to model the contribution of interventions to the cost of an adequate diet. For example, CotD has been used to model biofortification, supplementation, and school meals, on the cost of an adequate diet (World Food Program 2021).

A3.2.6 Optifood

Overview

The Optifood method, developed by WHO in collaboration with LSHTM, the USAID-funded Food and Nutrition Technical Assistance (FANTA) Project, and the software development company Blue Infinity, uses linear programming software to analyze foods consumed by and acceptable to a target population (Knight and Woldt 2017; Untoro et al. 2017; Cost of Nutritious Diets Consortium 2018). Optifood is used to facilitate formulation of food-based dietary recommendations to meet micronutrient needs (Deptford et al 2017; Daelmans et al. 2013). Optifood specifically aims to select realistic diets according to the dietary habits and local food supply and access. If micronutrient needs cannot be met, interventions such as food fortification or supplementation can be modeled in the software to help fill the micronutrient gaps. The diets that Optifood generates are hypothetical.

Optifood can be used to:

- assess the nutritional adequacy of the local food environment.
- identify "problem nutrients"—nutrients that are difficult to acquire from the local diet in amounts adequate to meet recommended intake.
- identify the best local food sources of problem nutrients.
- determine which micronutrient requirements are the most expensive to achieve.
- model diet costs and the proportion of costs required for each food in the most nutritious model diet.
- analyze the potential contribution on nutrient adequacy and cost of adding new foods to the local diet.

Optifood can be used for population-level analysis for individual groups, such as women or children of specific ages or physiological status—it is not used for analyses at the household level (Daelmans et al. 2013). HCES data have been used for modeling in Optifood (Knight et al. 2021). Optifood results do not represent the distribution of dietary patterns within the population.

Strengths and Limitations

Optifood strengths include (Untoro et al. 2017; Daelmans et al. 2013):

- Specifically aims to select realistic diets according to the dietary habits and local food supply and access.
- Can use quantitative open 24-hour dietary recall or HCES data.
- Can analyze model diet costs and the proportion of costs required for each food in the most nutritious model diet.

- Can analyze the potential contribution on nutrient adequacy and cost of adding new foods to the local diet.

Optifood limitations include (Untoro et al. 2017; Daelmans et al. 2013):

- Use of household food consumption data as input data for Optifood requires assumptions about the intrahousehold distribution of food.
- Results do not represent the distribution of dietary patterns within the population.

Basic Steps to Use

A draft manual exists for Optifood, however, our understanding is that it requires updating. The draft manual can be obtained by contacting Elaine Ferguson at elaine.furguson@lshtm.ac.uk. Knight and Woldt (2017) developed a report, available here, that includes detailed information about Optifood and its use. Basic steps in Optifood use include:

1. Prepare data for entry in Optifood, such as preparing the food lists, portion sizes, minimum and maximum consumption limits for each food, servings per week from foods and food groups, classification of foods as staples or snacks, and cost of food items. The source of the data can be existing quantitative open 24-hour dietary recall data or HCES data.
2. Adjust Optifood food composition table data as needed per local or regional information on food composition. Select the target group and micronutrients for analysis within the software program. Also enter input data from the first step above.
3. Test the input data in Optifood and adjust as needed (for example, kilocalories limits may need to be adjusted/expanded to allow more flexibility in the linear programming modeling to allow for feasible solutions).
4. Analyze the data in Optifood. The Optifood cost module can be used to generate the cost of the modeled diets.

Relative Cost, Time, and Technical Expertise

- **Cost**: The Optifood software is free. If existing data is available for secondary data analysis, the main cost will be for the technical expert to conduct the analysis. If primary data collection is needed, the cost will also include that of staff to manage and implement the survey and analyze the data, and equipment and logistics for data collection. The costs for data collection can be high, given the need for input data from quantitative open 24-hour dietary recalls.
- **Time**: The time for the analysis in Optifood using existing data is approximately 2 months, which includes cleaning and preparing the data, data analysis, and report writing. If data must be collected, the process will take from 9 to twelve months, given the processes necessary for data collection.
- **Technical expertise**: The method requires a high level of technical expertise, including a technical expert in nutrition who has been trained in and has experience using the Optifood software. If data collection is required, technical experts will also be needed with experience in survey implementation and collection of quantitative open 24-hour dietary recall data.

Examples of Countries Where Optifood Has Been Used for LSFF

We found one study that used Optifood to model the cost of an adequate diet that considered centrally processed fortified foods (Brouzes et al. 2021). Three studies modeled diets that included centrally processed fortified foods but did not analyze costs (Fahmida et al. 2014; Vossenaar et al. 2016; Wessells et al. 2019). Most of the Optifood studies that we found modeled diets that included fortified complementary foods for young children or other types of interventions, but not LSFF.

Use of Optifood to Inform Broader Programming to Improve Diets

Optifood can be used to model the contribution of interventions to the cost of an adequate diet, including biofortification, fortified complementary foods, addition of new foods to the diet, and/or supplements. For example, Optifood was used in Kenya to model biofortified cassava and diet cost (Talsma et al. 2017).

A3.2.7 Cost of a Nutrient Adequate Diet (CoNA)

Overview

CoNA is a price index used to demonstrate the ability of local food systems to deliver the nutrients needed for a population's health (Masters et al. 2018; Bai et al. 2020). It is a method, but for this review it is summarized with CotD and Optifood given its focus on cost. By design, the purpose of CoNA is to quantify the cost, at market prices, of acquiring a sufficient quantity of locally available food items to meet a population's nutrient requirements (Bai et al. 2022). CoNA provides a lower bound on total costs, as a first step towards quantifying affordability (Bai et al. 2022). The method uses linear programming to show the minimum cost of achieving minimum adequacy for energy and selected micronutrients in a chosen target group (e.g., adult women). It can be used to analyze a food system in a country or across countries (Cost of Nutritious Diet Consortium 2018; Herforth et al. 2020; Bai et al. 2021). CoNA also can show the nutrients that are the most constraining and the foods that contribute most to meeting each nutrient requirement.

The method requires food composition data, nutrient requirement data for a given target group, and food prices for a diversity of foods (Cost of Nutritious Diets Consortium 2018). CoNA is used for population-level analysis for individual groups, such as adult women—it is not used for analyses at the household level (Herforth et al. 2020). It can be used for raising awareness and advocacy about access to nutritious diets. CoNA is designed to track and compare the cost of nutrients over long periods of time and across different populations (Cost of Nutritious Diets Consortium 2018). It is not intended to reflect what people spend or purchase. Results are available only when accurate prices and nutrient composition data are available for the full range of foods used to meet nutrient needs. The model does not include information on typical food habits. The results do not represent the distribution of dietary patterns within the population. Use of the method requires software able to perform linear programming.

A3.3 Projects

A3.3.1 Micronutrient Intervention Modeling (MINIMOD)

Overview

The MINIMOD project is implemented by the University of California Davis (Nutrition Modeling Consortium 2018; Brown et al. 2015; Adams et al. 2021). MINIMOD includes three models:

- **Nutrition Benefits Model.** The Nutrition Benefits Model is used to estimate usual dietary intake and dietary inadequacy and model the effects of food fortification (as well as other programs) on the prevalence of inadequate micronutrient intake. The modeling can be applied to either quantitative open 24-hour dietary recall data or household food consumption data from HCES. The results are specific for geographic area and time frame. The model uses the EAR and UL cut-point methods and the full-probability method for iron.
- **Cost Model**: The Cost Model uses activity-based costing to estimate costs of potential interventions, including planning, establishing interventions, operational costs and M&E costs. It also considers start-up, fixed, variable, private sector, and caregiver/household costs, as well as marginal/incremental costs, for example, from adding an intervention to an existing platform or new program/platform.
- **Economic Optimization Model**: The Economic Optimization Model takes the data from the above two models for estimated program impacts and estimated program costs and uses linear programming to find the most cost-effective set of micronutrient intervention programs. It includes summary measures of impacts, costs and cost savings looking at alternative sets of

interventions and can be used to identify pathways for more effective and cost-effective programs.

The Nutrition Benefits Model is relevant for this literature review. The Cost Model and Economic Optimization Model provide valuable information for decision making, but cost and economic optimization are beyond the scope of this review.

The Nutrition Benefits Model is used to determine the program "reach", defined as the proportion of individuals who consumed any additional amount of a specified micronutrient due to a given program (Vosti et al. 2020). The model is also used to determine "effective coverage", defined as the proportion of individuals who had inadequate dietary intake for a specified micronutrient and subsequently would achieve adequate micronutrient intake as a result of one or more micronutrient intervention programs. As a part of the process of calculating effective coverage, the model is used to (Nutrition Modeling Consortium 2017):

1. Estimate usual nutrient intakes using the National Cancer Institute (NCI) method (or using the AME or nutrient density methods to analyze household food consumption data, e.g., from HCES).
2. Estimate the percentage of the target population below the EAR and the percentage above the UL.
3. Simulate the contribution of different amounts of the micronutrient added to the fortifiable food or fortified food.
4. Reassess the percentage of the target population below the EAR and the percentage above the UL.

The MINIMOD project has modeled interventions that provide vitamin A, vitamin B12, folate, iron, zinc, and iodine (Brown et al. 2015; Adams et al. 2021). The target beneficiary groups are children 6-59 months and women of reproductive age.

Strengths and Limitations

The strengths of the MINIMOD modeling include (Nutrition Modeling Consortium n.d.; Brown et al. 2015; Adams et al. 2021):

- It can use quantitative open 24-hour dietary recall data, which provides a high degree of accuracy in modeling estimates.
- It can use HCES food consumption data, which provides moderately good modeling estimates; the use of HCES data would be advantageous given its routine collection and the lack of nationally representative quantitative open 24-hour dietary recall data in LMIC.
- If sample sizes and sampling design allow, it can be used to model estimates for different socio-demographic groups and regions.
- It can be used to model various scenarios of fortification at the population-level for groups or household level, depending on the available dietary data.
- Tools have been developed to improve access to and usability of the modeling (e.g., the SIMPLE Macro to estimate usual intake distributions and predictive modeling [Luo et al. 2021]; code developed in Python).
- Training on the modeling has been conducted in Cameroon and Ethiopia.

The limitations of MINIMOD modeling include:

- It requires relatively high levels of technical expertise to run the models/support from the designers.
- Few nationally representative secondary quantitative open 24-hour dietary recall data are available, which limits usability of the modeling approach with 24-hour dietary recalls.
- Given the potential use of HCES data, the limitations noted above for HCES data will also apply.

Basic Steps in MINIMOD Analyses

The basic steps in the use of the MINIMOD Nutrition Benefits Model are described by [Engle-Stone (et al. 2015)](#) and include obtaining, cleaning, and preparing quantitative open 24-hour dietary recall data or household food consumption data from HCES for use in the MINIMOD model, calculating dietary inadequacy using the EAR cut point method or the full probability approach in the case of iron, and modeling different scenarios of fortification. MINIMOD has an Open Science Framework site where the team has uploaded manuscripts. The site may later also include statistical analysis plans and additional resources (https://osf.io/yc8nw/).

Cost, Time, and Technical Expertise for MINIMOD Modeling

- **Cost**: If secondary quantitative open 24-hour dietary recall or HCES food consumption data are used, the cost will be related to data cleaning, preparation, and analysis. Depending on the size and quality of the dataset, the costs may range from approximately 80,000 to 100,000 USD for data cleaning, preparation, analysis, and report writing. If data collection is required, the costs will increase substantially.
- **Time**: If secondary data is used, the data cleaning, preparation, and analysis could be completed in about 5 to 6 months. The MINIMOD team estimates that if data need to be collected, the full nutrition benefits model could be developed in approximately 12 months.
- **Technical expertise**: The technical expertise required to analyze the open 24-hour dietary recall data or HCES food consumption data and model it using the MINIMOD method is relatively high. At this point in time, technical assistance from the MINIMOD developers is required to plan and run the analyses.

Examples of Countries in which MINIMOD has Worked

To date, MINIMOD has been applied in Burkina Faso, Cameroon, Ethiopia, Ghana, Haiti, Nigeria, and Senegal (Nutrition Modeling Consortium 2020; Brown et al. 2015, Engle-Stone 2022a).

Use of MINIMOD to Inform Broader Programming to Improve Diets

MINIMOD has been used to model the contribution of broader programming, beyond LSFF, to micronutrient adequacy, including supplementation and biofortification (Engle-Stone et al. 2015; Vosti et al. 2020; Adams et al. 2021). Specifically, MINIMOD was applied in Cameroon to model the contribution of vitamin A supplementation and biofortification of maize with vitamin A.

A3.3.2 Micronutrient Action Policy Support (MAPS)

Overview

The MAPS project is implemented by the University of Nottingham in collaboration with the London School of Hygiene and Tropical Medicine (LSHTM), University of California Davis, Lilongwe University of Agriculture and Natural Resources (LUANAR), British Geological Survey, Addis Ababa University, and the International Food Policy Research Institute (IFPRI). The MAPS project is co-creating a web-hosted tool to estimate micronutrient deficiencies and explore pathways to improve nutrition in Malawi, Ethiopia, and Burkina Faso. The Bill & Melinda Gates Foundation has provided funding to support MAPS activities in these countries, while USAID has also supported the application of the MAPS method in Malawi.

MAPS builds upon past studies that have used HCES data to model the potential contribution of fortified foods to micronutrient adequacy, for example, studies conducted in Guatemala, Uganda, Bangladesh, Zambia, and Solomon Islands (Fiedler and Helleranta 2010; Fiedler and Afidra 2010; Fiedler et al. 2014b; Fiedler et al. 2013b; Imhoff-Kunsch et al. 2019). The MAPS project team cleans, prepares, and analyzes HCES data; uses HCES data to model various scenarios of fortification and their contribution to micronutrient adequacy using the adult male equivalent or adult female equivalent approach, as well as the nutrient density approach; uses the estimated average requirement (EAR) and upper level (UL) cut-point approaches and the full-probability approach for iron; and provides the code in the R statistical software on GitHub to conduct the analysis. A MAPS team area of focus is capacity strengthening so that individuals in the countries where MAPS works can independently conduct the analysis. The method is adequate for the purpose of modeling and assessing the potential contribution of food fortification to an adequate diet. The findings must be used together with safety, technology, and economic considerations and complemented with stakeholder discussions to identify and model appropriate fortification levels.

Strengths and Limitations

The strengths of MAPS include (Tang et al. 2021):

- It uses data (HCES) that is often available in LMIC every 3 to 5 years, so there is no need to collect data.
- Analyses can often be conducted for different socio-demographic groups, given HCES data include large datasets often representative at subnational levels, e.g., urban, rural, by wealth quintile (national and within urban and rural subpopulations).
- Can be used to model various scenarios of fortification at the household level.
- Includes R code for the analysis on GitHub, so the underlying code is easy to access.[22]
- It has a small but increasing number of individuals in LMIC gaining capacity to use the method (e.g., Malawi, Tanzania, Ethiopia).

Limitations of MAPS include (Tang et al. 2021):

- Given the method uses HCES data, the limitations noted above for HCES data will also apply to this method.

Basic Steps Used in MAPS Analyses

The initial steps for HCES data cleaning, preparation, and analysis are the same as those described in Annex 3.1 (Imhoff-Kunsch et al. 2012). Tang (et al. 2021) provides a description of the modeling conducted by MAPS. Note that these steps are general to the use of HCES data, not necessarily specific to MAPS, but are still useful to share, given they have been used by the MAPS team.

1. Scenarios are modeled to compare estimates of the potential contributions of fortified food (e.g., oil, sugar, wheat flour) to meet the EAR and critical nutrient density and not exceed the UL. The scenarios modeled can include, for example:
    a. "No fortification" scenario, which assumes the food vehicles are not fortified with any micronutrients. This scenario provides estimates of the baseline (i.e., without fortification) adequacy of diets and serves as a point of comparison to understand the potential contribution of a country's fortification program to improving the micronutrient adequacy of diets.
    b. Where fortification is taking place, a "status quo" fortification scenario, which models large-scale food fortification at current levels of fortification. The foods may or may not be fortified at government-mandated standard levels. The levels, for each food fortification vehicle, can be based on the analyzed micronutrient content of fortified food samples collected at sentinel sites in markets throughout the country, or from government or industry monitoring.
    c. Where fortification is taking place, an "improved compliance" scenario, which represents a hypothetical improvement in industry compliance to the national standards guidelines on average nutrient contents at the point of fortification, and adjusts for expected losses. The Food Fortification Formulator tool can be used to adjust for expected losses, before preparation for consumption at home (Dary and Hainsworth

[22] GitHub is a software sharing platform. Please see GitHub for more information.

2008). This scenario results in higher micronutrient contents of each food vehicle compared with those modeled in the status quo scenario.

   d. Where a fortifiable food is not yet being fortified, the micronutrient composition of the fortifiable product is adjusted to simulate a fortified product. Various amounts of the micronutrient can be modeled in the fortifiable food to model the contribution to micronutrient adequacy.
   e. The micronutrient composition of products made with the fortified food, e.g., fortified wheat flour (like bread, scones, chapati, etc.,) is adjusted based on the proportional contents of wheat flour to reflect the various fortification scenarios.
2. The modeling can be conducted for various socio-demographic or geographic groups for each scenario.
3. Where HCES data is collected over seasons, the modeling can also consider seasonal patterns in micronutrient supply over time through use of seasonality curves.

Cost, Time, and Technical Expertise

Given MAPS uses HCES data, the cost, time, and technical expertise noted for HCES data will also apply to MAPS.

Examples of Countries in which MAPS has worked

To date, the MAPS team has worked in Malawi. Plans exist to also work in Tanzania, Ethiopia, Nigeria, and Burkina Faso.

Use of MAPS to Inform Broader Programming to Improve Diets

MAPS could model the contribution of broader programs to micronutrient adequacy if the foods of specific interest are included in the HCES food list. For example, if there are plans to biofortify a type of bean or maize or rice, and these items are on the HCES food list, it will be feasible to model the contribution of the biofortified food to micronutrient adequacy. Adding foods to the HCES food list for the food consumption portion of the questionnaire would need to be discussed with the institution implementing the survey in each respective country.

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