What Are We Assessing When We Measure Food Security? A Compendium and Review of Current Metrics[1,2]

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ABSTRACT

The appropriate measurement of food security is critical for targeting food and economic aid; supporting early famine warning and global monitoring systems; evaluating nutrition, health, and development programs; and informing government policy across many sectors. This important work is complicated by the multiple approaches and tools for assessing food security. In response, we have prepared a compendium and review of food security assessment tools in which we review issues of terminology, measurement, and validation. We begin by describing the evolving definition of food security and use this discussion to frame a review of the current landscape of measurement tools available for assessing food security. We critically assess the purpose/s of these tools, the domains of food security assessed by each, the conceptualizations of food security that underpin each metric, as well as the approaches that have been used to validate these metrics. Specifically, we describe measurement tools that *1*) provide national-level estimates of food security, *2*) inform global monitoring and early warning systems, *3*) assess household food access and acquisition, and *4*) measure food consumption and utilization. After describing a number of outstanding measurement challenges that might be addressed in future research, we conclude by offering suggestions to guide the selection of appropriate food security metrics. *Adv. Nutr. 4: 481–505, 2013.*

Introduction

Food security matters immensely; it is a topic of keen interest to policy makers, practitioners, and academics around the world in large part because the consequences of food insecurity can affect almost every facet of society. For example, the food price crisis and subsequent food riots in 2007–2008 highlighted the critical role of food security in maintaining political stability. The 870 million people worldwide consuming fewer calories than they require and the myriad associated physical and mental health consequences of such deprivation make the public health importance of food security indisputable (1). Current estimates and future projections of food insecurity are important drivers of governmental policy (e.g., Feed the Future Initiative) and aid decisions (e.g., the World Bank's Global Agriculture and Food Security Program) that affect billions of people. Because a poorly nourished population is a less economically productive one, food security also matters for maximizing economic capacity. For this reason, President Obama called food security "an economic imperative" at the 2012 G8 Summit. Finally, food security matters from a moral perspective; it has been broadly agreed upon as a basic human right since 1948, under Article 25 of the Universal Declaration of Human Rights: "Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care…" (2).

Terminology

Despite, or perhaps because of, the fundamental importance of food security, it is a concept whose definitions and operationalization have been numerous and varied. Indeed, a sufficiently large number of terms have been used in discussions of food security to cause difficulties in identifying what, exactly, is being discussed, measured, or intervened upon. This is partially due to the multi-disciplinary and multi-sectoral nature of food security. Many academic

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disciplines have engaged with it, including agriculture, anthropology, economics, nutrition, public policy, and sociology, as have numerous national and international governmental and nongovernmental agencies. Each discipline has brought with it its own jargon to define food security. "Hunger" has also been conflated with food insecurity, perhaps because the emotive strength of the concept of hunger has frequently been sufficient to move many to action (3).

Though we elaborate more fully on the evolution of the term food security below, in this section, we preface that discussion by distinguishing various terms related to food security and how they relate to each other (**Fig. 1**). Throughout, we envision food security as a continuum with food security and food insecurity positioned at opposing ends. The decision to use one term or the other in discussions is conditioned on the framing of a given argument and, in the case of measurement, the manner in which scales and metrics are constructed.

The most commonly used definition of food security is based on the definition from the 1996 World Food Summit: "Food security, at the individual, household, national, regional and global levels [is achieved] when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (4). This definition suggests that food insecurity is the absence of one or more of these conditions. Food insecurity is sometimes classified as chronic or transitory, with seasonal food insecurity falling between the two types (5). The time frames for chronic and transitory food insecurity classifications have not been made explicit (6). Of note, in Europe, the term food security is often used to describe what in the US is called food safety, the regulation and control of food supply chains in order to monitor food hygiene, toxicity, and traceability (7).

Nutrition insecurity is sometimes used interchangeably with food insecurity, but in fact the definition is much broader. Food insecurity is necessary, but not sufficient for nutrition security (Fig. 1). Nutrition security considers care, health, and hygiene practices in addition to food security. The FAO defines nutrition security as "A situation that exists when secure access to an appropriately nutritious diet is coupled with a sanitary environment, adequate health services and care, in order to ensure a healthy and active life for all household members" (1).

Undernourishment is a term that the FAO uses to describe the state "when caloric intake is below the minimum dietary energy requirement"; it is considered to be "an extreme form of food insecurity" (1). Undernutrition is defined by FAO as "resulting from undernourishment, poor absorption and/or poor biological use of nutrients consumed." Hunger, in contrast, perhaps the least well defined of the terms, is defined in widely varying ways (8). For example, in the recent FAO report on the state of global food insecurity, "undernourished" and "hungry" are used interchangeably (1). The most explicit definition of hunger is found in a 1990 report from the American Institute of Nutrition (now known as the ASN): "The uneasy or painful

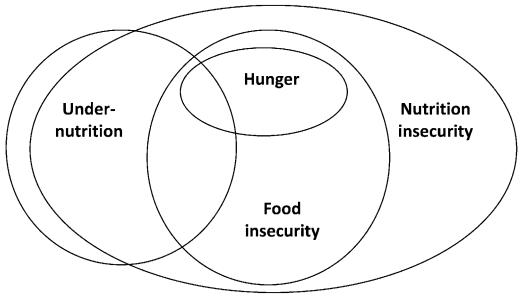

FIGURE 1 Overlapping concepts within the context of food and nutrition insecurity. Adapted from (121, 122) with permission.

sensation caused by a lack of food. The recurrent and involuntary lack of access to food" (9). The definition goes on to state how "hunger … is discussed as food insecurity in this report," which suggests just how problematic the use of these terms can be. Indeed, in a report published by the NRC, an expert panel concluded that it is not clear whether the concept of hunger as both a physiological and socioeconomic construct is appropriately identified in food security scales [i.e., the Food Security Supplement to the Current Population Survey (CPS)[5] the US] (10).

Food insufficiency, or "an inadequate amount of food intake due to a lack of money or resources" (11), has sometimes been used as a synonym of hunger. However, this term was abandoned by the USDA and Department of Health and Human Services once the term "food insecurity" was adopted (C. Olson, Professor, Division of Nutritional Sciences, Cornell University, personal communication).

"Hidden hunger" is a clearly defined term used to refer to micronutrient deficiencies from which ~2 billion people worldwide suffer (1).

Objectives

In light of both the importance and various applications of "food security," our objectives were to: *1*) examine the evolution of the concept of food security; *2*) review the current landscape of approaches and indicators for measuring food security; *3*) critically assess the purpose of these indicators and the conceptualizations of food security that underpin them; and *4*) discuss the challenges and future research needed in the field of food security measurement.

Methods

We conducted a literature review to identify peer-reviewed journal articles and gray literature documents that reported the explicit and empirical measurement of food security. We

[5] Abbreviations used: CFSVA, Comprehensive Food Security and Vulnerability Analysis; CPS, Current Population Survey; CSI, Coping Strategies Index; DDS, diet diversity score; ELCSA, Latin American and Caribbean Household Food Security Scale; FCS, Food Consumption Score; FEWS NET, Famine Early Warning Systems Network; GFSI, Global Food Security Index; GHI, Global Hunger Index; HCES, Household Consumption and Expenditure Survey; HDDS, Household Dietary Diversity Score; HEA, Household Economy Approach; HFIAS, Household Food Insecurity Access Scale; HFSSM, Household Food Security Survey Module; HHS, Household Hunger Scale; IFPRI, International Food Policy Research Institute; IPC, Integrated Food Security Phase Classification; USAID, United States Agency for International Development; WFP, World Food Program.

searched PubMed, CABI, Elsevier, Google Scholar, and Web of Science as well as the Web sites of several international organizations, including the FAO, the World Food Program (WFP), the International Food Policy Research Institute (IFPRI), the United States Agency for International Development (USAID), and several international nongovernmental organizations, including Save the Children and CARE. We reviewed the titles and abstracts or summaries of all identified documents and examined citations from these documents for additional references.

Current Status of Knowledge

Defining food security: an evolving concept

Measurement of national food availability began well before the concept of "food security" was recognized. Beginning in the post-World War I period and increasingly during and following World War II, the international community began to collect national food balance sheet data to facilitate food allocation and distribution efforts in conflict-affected regions (12). Food balance sheet data are "supply side" data, i.e., they measure the total quantity of calories available to a population in the form of foodstuffs produced or imported into a country. This choice of metric implicitly prioritizes the availability of food supplies as the primary consideration for determining a country's food security.

In fact, the term food security itself arose in the early 1970s as a concept of food supply; the food crisis at that time led to concerns that global food supply shortages would threaten political stability (13). Although food availability remains a fundamental component of our current understanding of food security, scholars at the time soon began to recognize that food availability was not sufficient for ensuring household access to food.

Nobel Laureate Amartya Sen's (14) 1981 thesis, "Poverty and Famines: An Essay on Entitlement and Deprivation," brought to the forefront the importance of food access in determining food security by highlighting historical examples of famine conditions in countries with sufficient national food supplies. Sen (14) argued that the poor may lack "entitlements" to food under conditions of high food prices and low demand for wage labor, even if food supplies are sufficient. Given that the poor spend a large proportion of their household income on food and depend on their labor power as their primary asset, such conditions inhibit their access to available food. Emblematic of this shift in thinking, the definition of food security adopted at the 1974 World Food Summit that underscored ensuring "availability at all times of adequate world food supplies" (15), was revised in 1983 to reflect this idea of entitlements by stating that food security also required "physical and economic access to basic food" (16).

The definition of food security continued to evolve as concerns emerged over inequitable distribution and access to food not only within countries, but within households. For example, analyses of data on intra-household behavior suggested that expenditure allocations by women compared with men favored investments in the health, nutrition, and education of children in the household and that parents do not always have identical preferences toward male and female children (17–19). Therefore, the food acquisition behaviors of households are important for translating physical and economic access to food into food security. These findings contributed to an emerging preference for so-called "collective" approaches to modeling household decision-making rather than employing "unitary" models, which assume that households act in unison to make decisions (20). At the same time, by the mid-1990s, alleviating micronutrient undernutrition, particularly deficiencies in iron, vitamin A, and iodine, became the primary focus of nutrition research (21), thereby shifting attention from mere caloric sufficiency to overall diet quality. Both of these trends had implications for the conceptualization of household food security.

Specifically, "utilization" became considered as a third component, or domain of food security, in recognition that physical and economic access to food and food acquisition are necessary, but insufficient, for ensuring food security within households.

Utilization reflects differences in the allocation of food within households, the nutritional quality of that food, and variation in the extent to which the nutrients in food are able to be absorbed and metabolized by individuals within households (e.g., because of differences in health status or the bioavailability of micronutrients). Thus, delegates at the 1996 World Food Summit adopted a further revised definition of food security that clearly highlighted the importance of diet quality as well as individual, and not just household, dietary needs [see above definition in "Terminology" (4)].

The 1996 FAO definition of food security is widely used today. It incorporates not only the 3 domains of food security discussed above, availability, access, and utilization, but also the idea that the ability to acquire socially and culturally acceptable foods and to do so in acceptable ways is also important. These conditions may be seen as necessary for ensuring adequate food access. The phrase "at all times" also highlights a fourth and less commonly recognized component of food security, i.e., stability of food security over time. Food security often varies across time, whether seasonally or as a result of irregular shocks such as weather events, deaths, or regional conflicts (22). Food insecurity, then, may be chronic or transitory. The two conditions are in fact interconnected and households may experience both at different times. For example, successive exposure to temporary, less severe shocks may precipitate the sale of assets, investment in agricultural production on marginal land, or seeking hazardous or unreliable employment. These coping strategies may then lead to more severe shocks, failed returns on investments, and an eventual fall into a state of chronic food insecurity (23,24).

Figure 2 presents a conceptual pathway linking the loci of food security within the availability, access, and utilization domains. In general, preceding loci are necessary, but not sufficient for food security at the next step in the conceptual pathway. Examples of factors that may be barriers or promoters to

food security appear below the loci. This heuristic simplifies rather complex relationships. For example, physical and economic access are inter-related, cultural acceptability may be seen as preceding other access loci, and the modifying factors shown may have relatively stronger or weaker influences on specific loci within the pathway. In addition, intra-household food allocation relates to individual- rather than household-level access to food and therefore straddles the domains of access and utilization. This complexity illustrates one of the challenges of defining and measuring food security. Indeed, the comprehensiveness of the definition of food security has raised questions as to whether disaggregation of the concept into its component definitions and degrees of severity may be needed to adequately guide policies and programs toward finding appropriate solutions to varying food security challenges (25).

Measuring food security: an evolving toolkit

Food security metrics may focus on food availability, access, utilization, the stability of food security over time, or some combination of these domains. These metrics may draw from data at national, regional, household, and/or individual levels. Such tools may vary from simple indicators for which data can be quickly collected and easily analyzed to comprehensive measures that require detailed, time- and resource-intensive data collection and sophisticated analytic skills to yield results. Food security measures may rely on data from hypothesized determinants of food security (e.g., the price of commodities) or on data from purported consequences of food security (e.g., child malnutrition).

In short, the diversity of food security measurement tools currently available provides a rather dizzying array of options, such that it may not always be clear how the measures differ in their conceptualizations of food security and for what purpose a given tool may best be used. Indeed, the validity of a measurement tool is inseparable from the purpose for which it is intended. Identifying the intended use of a tool and understanding the underlying construct(s) it measures are critically important for determining which metric one should use. The consequences of selecting an inappropriate metric could include: *1*) measuring an unintended domain or loci of food security; *2*) measuring multiple domains or loci without the ability to differentiate between them; *3*) collecting information that is not relevant to those for whom the data will be collected and used; *4*) collecting data at an inappropriate scale; *5*) collecting data that cannot be measured multiple times at the needed time intervals; or *6*) selecting a tool that requires resources beyond those available for adequate data collection and analysis.

Described below and summarized in **Table 1**, we review common food security metrics and present information on what they measure, their stated purpose, the source(s) of the data used, and how these characteristics compare across metrics.

National-level estimates of food security. **Prevalence of undernourishment.** Food security measures developed for use at the country level often emphasize food availability. Tools for measuring food availability, such as food balance sheets, have traditionally drawn from nationally aggregated data on food supply (i.e., total amount of food produced and imported) and utilization [i.e., the quantity of food exported, fed to livestock, used for seed, processed for food and non-food uses, and lost during storage and transportation (12)]. These data are used to create FAO's core food security measure, the prevalence of undernourishment.

Although food supply and utilization data are useful for estimating food shortages and surpluses, developing projections of future food demand, and setting targets for agricultural production (12), they operate under the strong assumption that the mean of the distribution of calorie consumption in the population equals the average dietary energy supply (1). But this is a problematic assumption. Even allowing for the lack of reliable information on food losses and food distribution in food balance sheet data, large disparities have been observed between the number of food-insecure households estimated by these data and estimates made by the USDA (22). The USDA estimates, e.g., use projected calorie consumption estimates for different income groups based on income distribution data in addition to aggregated estimates of food supplies (26).

National-level food security estimates, then, may be viewed as yardsticks for cross-national comparisons and monitoring changes in macro-level trends (e.g., for monitoring progress toward achieving the Millennium Development Goals). However, the types and sources of data used, the assumptions made when calculating food security, and the intended purpose of different measures will inform the accuracy and interpretation of results.

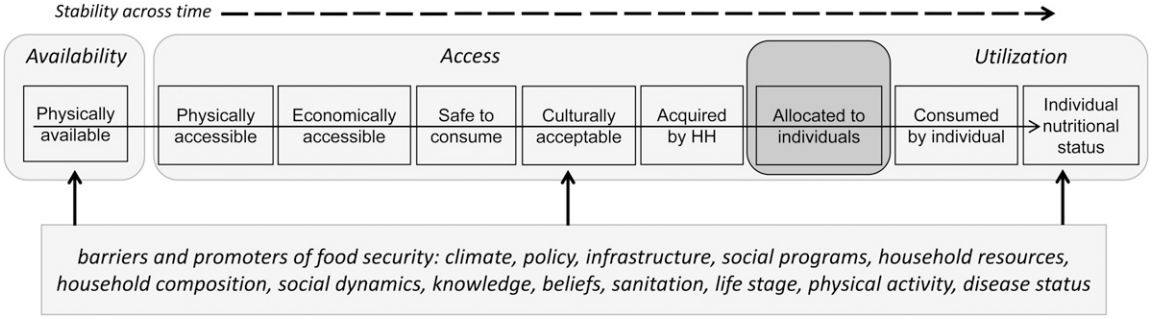

FIGURE 2 The loci within the food security conceptual pathway by domain of food security.

TABLE 1 Food security metrics, their measured domains, and the purposes for which they are commonly used

Metric	Measurement	Scale	Domains/loci measured	Date source	Purpose(s)	Recall period
Prevalence of undernourishment	Calculates food availability using nationally aggregated food supply and food utilization data	National	Physical availability or access	Food balance sheets	Monitor hunger Millennium Development Goal Provide cross-national comparisons Facilitate global and regional governance of food security Serve as advocacy tool	1 y
Share of food expenditure by the poor[1]	Average share of total expenditures spent on food by households belonging to the lowest income quintile	National	Economic access	HCESs	Provide cross-national comparisons Facilitate global and regional governance of food security Serve as advocacy tool	Variable
Relative dietary supply index[1]	Ratio of the dietary energy supply in the country (per capita), normalized by the country's average dietary energy requirement (i.e., the average caloric needs of the population based on age, sex, and height distributions)	National	Physical availability or access	Food balance sheets	Provide cross-national comparisons Facilitate global and regional governance of food security Serve as advocacy tool	1 y
Domestic food price volatility[1]	Index of observed variability in the annual food price level index	National	Economic access	FAO/ILO food price data	Provide cross-national comparisons Facilitate global and regional governance of food security Serve as advocacy tool	1 y
GHI	Ranks countries on a 100-point scale using 3 equally weighted indicators: *1*) undernourishment; *2*) child underweight; and *3*) child mortality	National	Physical availability or access Nutritional status	Food balance sheets WHO Global Database on Child Growth and Malnutrition Demographic and Health Survey data Multiple Indicator Cluster Survey data	Compare differences in hunger across countries	Variable

(Continued)

TABLE 1 (*Continued*)

Metric	Measurement	Scale	Domains/loci measured	Date source	Purpose(s)	Recall period
GFSI	Index of 30 indicators within 3 domains of food security: affordability (6 indicators), availability (10), and quality and safety (14)	National	Physical availability or access Economic access Food quality Food quantity Food safety	Quantitative (e.g., food consumption as proportion of total household expenditure, micronutrient availability) Qualitative (e.g., government commitment to increasing nutritional standards, existence of adequate crop storage facilities) Expert consensus	Provide cross-national comparisons of food security status, determinants, and outcomes	Variable
FEWS NET	Monitors a variety of information including data on long-term and real-time satellite rainfall records, the NDVI, temperature, agricultural production, prices, trade, economic shocks, political instability, and local livelihoods	National Regional	Physical availability or access Economic access	Various (e.g., weather, climate, agriculture production, prices, trade, political stability, economic shocks)	Serve as early warning system (scenario development to forecast food emergencies 6–12 mo in advance) Assist governments and food relief agencies in planning for food emergencies Monitor changes over time via monthly reports on current and projected food insecurity	Variable
CFSVAs	Combines secondary data analyses with collection of primary data from 13 core modules to assess food security status and examine underlying causes of vulnerability	National Regional	Physical availability or access Economic access Food quantity	Household surveys Secondary data	Assess baseline food security status of country or region to inform intervention planning Examine underlying causes of food vulnerability	Variable
HCESs	Collect data on all foods acquired by household, including food purchases, foods from own production and foods received in kind; often limited to monetary value of these foods	National Regional Household	Economic access Food quantity Food quality	HCESs	Measure income, consumer price indices, socioeconomic status, and food and non-food expenditures Provide complementary data to food balance sheet data to facilitate cross-national comparisons and subnational analyses	Variable (e.g., 1 wk, 1 mo, 12 mo)

(Continued)

TABLE 1 (*Continued*)

Metric	Measurement	Scale	Domains/loci measured	Date source	Purpose(s)	Recall period
FCS	FCS = $a_1x_1 + a_2x_2 + \ldots + a_8x_8$, where 1…8 = food group, a = frequency (7-d recall), x = weight. Weight: meat, milk, and fish = 4, pulses = 3, staples = 2, vegetables and fruits = 1, sugar and oil = 0.5). Cut-off values: poor FS = 0–21, borderline FS = 21.5–35, acceptable FS = >35.	National Regional Household	Food quality	CFSVAs WFP Emergency Food Security Assessments Household surveys	Establish prevalence of food insecurity Monitor changes in food security Assist in determining food needs to calculate food rations	7 d
HDDS	Sums equally weighted response data on the consumption of 12 food groups; score obtained from 0 to 12	National Regional Household	Food quality	Household surveys	Serve as a FS impact indicator for USAID Title II funded programs Help establish prevalence of FS Assess household-level dietary diversity Assess changes in DD/FS over time	24 h
CSI	Locally adapted list of coping strategies and the frequency of their use is generated through focus group discussions with stakeholders; severity weightings are assigned to each strategy	National Regional Household	Economic access Food quantity Food quality	Focus group interviews and discussions	Target food aid and monitor its impact Identify vulnerable households (original) Facilitate comparisons across contexts (comparative) Estimate long-term changes in FS	30 d
HEA	Broadly assesses livelihoods using geographic patterns of shared livelihood strategies, and wealth and assets	Regional Household	Physical availability or access Economic access	Rapid rural appraisal techniques (e.g., semistructured interviews, focus group discussions) Review of various secondary data sources	Assess poverty and livelihood vulnerabilities Identify appropriate, context-specific interventions	Variable
HFIAS	Sums responses to 9 questions related to four domains of food security including 4-level frequency response questions; a score from 0 to 27 is obtained and may be categorized into a 4-level variable	Regional Household	Anxiety Food preferences Economic access Food quantity	Household surveys	Assess FS status within regions or households Monitor and evaluate the impact of FS interventions	30 d

(Continued)

TABLE 1 (*Continued*)

Metric	Measurement	Scale	Domains/loci measured	Date source	Purpose(s)	Recall period
HHS	Sums responses from three questions related to hunger and lack of food including 3-level frequency response questions; a score from 0 to 6 is obtained and may be categorized into a 3-level variable	Regional Household	Economic access Food quantity	Household surveys	Assess hunger status within and across contexts Target interventions Monitor and evaluate the impact of interventions on household hunger	30 d
Months inadequate household food provisioning	Sums total number of months in the past year the household did not have enough food to meet the family's needs	Regional Household	Economic access Food quantity	Household surveys	Evaluate impact of interventions to improve food access (e.g., program to improve agricultural production, storage, and household purchasing power) Measure seasonal differences and/or changes in households' abilities to address food vulnerability	12 mo
Anthropometry	Examples include height, recumbent length, weight, MUAC, and skinfold measurements (combined with age and sex data to create anthropometric indices)	National Regional Household Individual	Individual nutritional status	Demographic and Health Survey data Multiple Indicator Cluster Survey data Household surveys	Assess prevalence of malnutrition Identify at-risk populations or individuals Monitor changes in nutritional status over time Evaluate nutritional impact of interventions	N/A

[1] See also an analysis by the National Academy of Sciences examining the strengths and limitations of 3 food security indicators (i.e., prevalence of undernourishment, household consumption and expenditure data, and anthropometry) [Table I 1–1, p. 14 (36)] as well as the suite of FAO food security indicators [Table A2.2, p. 54 (1)]. Part of FAO suite of complementary indicators (1). CFSVA, Comprehensive Food Security and Vulnerability Analysis; CSI, Coping Strategies Index; DD, dietary diversity; FCS, Food Consumption Score; FEWS NET, Famine Early Warning Systems Network; FS, food security; GFSI, Global Food Security Index; HCES, Household Consumption and Expenditure Survey; HDDS, Household Dietary Diversity Score; HEA, Household Economy Approach; HFIAS, Household Food Insecurity Access Scale; MUAC, mid-upper arm circumference; NDVI, Normalized Difference Vegetation Index; USAID, United States Agency for International Development; WFP, World Food Program.

For this and other reasons, the FAO now publishes a set of additional food security indicators along with estimates of its "prevalence of undernourishment" measure. These metrics examine variations of the dietary energy supply and undernourishment measures (e.g., share of energy supply derived from cereals, roots, and tubers; average supply of protein of animal origin; prevalence of undernourishment considering energy needs for higher amounts of physical activity, etc.) as well as information on food prices using data on country purchasing power parities and inflation rates and food deficits (1). These additional indicators, 26 in total, offer complementary data for interpreting undernourishment estimates and begin to assess food security components beyond just food availability; e.g., food access (e.g., share of food expenditure of the poor) and factors that determine food access (e.g., domestic food price volatility, political stability, and absence of violence).

Global Hunger Index. Other institutions have also developed indices that measure one or more aspects of food security at the country level. For example, the Global Hunger Index (GHI), developed by IFPRI, aims to measure "hunger" using 3 equally weighted indicators: *1*) undernourishment (i.e., the proportion of undernourished people as a percentage of the population); *2*) child underweight (i.e., the proportion of children younger than 5 y who have a low weight for their age); and *3*) child mortality (i.e., the mortality rate for children younger than age 5 y) (27). Countries are ranked on a 100-point scale and categorized as having "low" to "extremely alarming" hunger.

Data for the child mortality and undernourishment components of the index come from UNICEF and the FAO, respectively. The child underweight component of the index comes from 3 sources: the WHO Global Database on Child Growth and Malnutrition, Demographic and Health Survey data, and UNICEF's Multiple Indicator Cluster Survey reports.

The stated purpose of the index is to "[highlight] successes and failures in hunger reduction" and "[raise] awareness and understanding of regional and country differences in hunger" [(27), p. 7]. The term "hunger" as used here ostensibly represents a manifestation of severe food insecurity. However, the component measurements of the GHI also reflect child health and undernutrition, the determinants of which are not necessarily associated with food insecurity (e.g., access to health services, household water and sanitation environments, care for women and children). Interpretation of the GHI as a measure of food security or hunger, then, becomes complicated by this additional information captured by the index.

Global Food Security Index. The Global Food Security Index (GFSI) is another multi-dimensional tool for assessing country-level trends in food security. It was designed by the Economist Intelligence Unit (one of several companies of the publicly traded multinational, the Economist Group) and sponsored by DuPont. The index uses a total of 30 indicators within 3 domains of food security, affordability (6 indicators), availability (10), and quality and safety (14), to provide a standard against which country-level food security can be measured (28)

Similar to other national-level metrics, the GFSI ranks the performance of countries in achieving food security, but it does so using quantitative and qualitative indicators that reflect not only food availability, but food access (e.g., food consumption as a proportion of total household expenditure, proportion of population living under or close to the global poverty line, food prices) and diet quality (e.g., dietary availability of micronutrients). The GFSI is recalculated quarterly based on shifts in food price data. In addition to relying on data from the Economist Intelligence Unit, World Bank, FAO, WFP, and the World Trade Organization, the GFSI relies on expert panels and analysts from the academic, nonprofit, and public sectors. These experts provide subjective scoring to create many of the qualitative indicators that inform the index, assign weights to the indicators, and, in fact, select the indicators that are included in the index. This reliance on expert opinion and consensus departs from the FAO and IFPRI approaches discussed above; however, subjective interpretation of data are in fact commonly used for developing food security metrics, as will be discussed below. Indeed, the complexity of factors contributing to food security and the importance of context in interpreting these factors has led to some institutions prioritizing consultative methods for developing food security measurement tools.

Global monitoring and early warning systems. In contrast to the above metrics, which are used for making national-level estimates of food security, the next 3 measurement tools are more predictive in nature and are used to monitor food security in areas of high risk for severe food insecurity.

Famine Early Warning Systems Network. The Famine Early Warning Systems Network (FEWS NET) is a network of international and regional partners funded by USAID that produces monthly food security updates for 25 countries. The intent is to provide evidence-based analysis to support decision makers in mitigating food insecurity (29). Regional teams monitor and analyze a potpourri of information that could include data on long-term and real-time satellite rainfall records, the Normalized Difference Vegetation Index, temperature, agricultural production, prices, trade, economic shocks, political instability, and local livelihoods (29). FEWS NET was initially created to help avert emergency famine situations such as those that occurred in Sudan and Ethiopia in the mid-1980s. However, the network has since evolved to monitor not only droughts and crop failures that cause acute food insecurity but also the underlying causes of chronic food insecurity, such as persistent poverty and livelihood vulnerability. In an attempt to align with a global standard for food security classification, FEWS NET transitioned its classification system to the Integrated Food Security Phase Classification (IPC) system in April 2011 (30).

IPC. The IPC is a set of protocols for broadly assessing the food security situation within a given region (31). The IPC draws

upon data from a wide range of sources to establish common classifications, or phases, for the severity and magnitude of food insecurity in specific contexts. The purpose of the IPC, then, is to identify the severity and magnitude of food insecurity in a given region, compare food security outcomes, and identify strategic action objectives across contexts based on these classifications (32).

The IPC relies on Demographic and Health Survey and Multiple Indicator Cluster Survey data, data from household budget surveys, and consultations with government and nongovernmental organization authorities. Another key input into the IPC classification approach is the WFP's Comprehensive Food Security and Vulnerability Analyses (CFSVAs), which are discussed in more detail below. Similar to the GFSI, the IPC approach relies on building consensus among a team of multi-sectoral experts who are brought together to evaluate and debate evidence with key stakeholders (31). Food insecurity phases are assigned by these experts ranging from "minimal" to "stressed," "crisis," "emergency," or "famine." These classifications can be applied to geographic scales ranging from villages to provinces. The analysts also assign heuristic reliability scores to each data source that contribute to the classifications and assign a confidence level to the final phase classification (32). Thus, the IPC approach is not a model-based approach but rather a consultative one that relies on the subjective interpretation by experts of accumulated evidence from multiple domains, including food consumption, livelihood change, nutrition and health, and hazards and vulnerability (31).

FEWS NET and IPC have historically emphasized classification only of acute food insecurity. However, given the diversity of data considered in phase classification decisions not just on environmental and economic shocks but more broadly on poverty and livelihoods, IPC has recently introduced tools for classifying chronic food insecurity. These tools, designed to classify conditions wherein households are persistently food insecure even in the absence of shocks, are still in prototype form (31). This is a welcome development, as explicit recognition of chronic food insecurity may lead to better monitoring and therefore improved programming to address it.

Vulnerability analysis and mapping methodology. The WFP employs several different kinds of assessments to conduct food security analyses that are collectively known as vulnerability analysis and mapping. Chief among these assessments are CFSVAs (see above section on IPC). These analyses are undertaken in crisis-prone, food-insecure countries to assess food security status and examine underlying causes of vulnerability (33). They rely on secondary data analyses and collection of primary data through household surveys. Exemplifying the complexity of food security measurement, these surveys contain 13 core food security assessment modules: food consumption patterns, expenditures, household assets, sources of water, access to sanitation, household composition and education, housing materials, access to credit, livelihoods/sources of income, agriculture, livestock, external assistance, and shocks and coping strategies (33). Food security monitoring systems, emergency food security assessments, crop and food security assessment missions, joint assessment missions, and market assessment and bulletins are among the other assessments carried out by WFP as part of vulnerability analysis and mapping in its mission to strengthen the capacity of countries to reduce hunger (34).

Measuring household food access. Although some of the food security measurement tools described thus far assess more than just available national food supplies, they also do not emphasize household-level behaviors and determinants of food access because of their focus on national- or regional-level estimates and trends. Household-level measures of food security are concerned with food security dynamics between and within households. Because these measures rely on data from household surveys, they are able to more accurately capture the "access" component of food security than measures that rely on nationally aggregated data.

Food access refers to physical and economic access to food; however, many of the tools used to measure food access actually measure food acquisition or food consumption. These concepts are commonly used interchangeably to refer to food access, yet they are important to distinguish for measurement purposes.

Household consumption and expenditure surveys. Data on household food consumption and expenditures from household-level surveys are increasingly important for assessing household food acquisition. The FAO, which has traditionally focused on food balance sheet data to calculate national-level estimates of the prevalence of undernourishment, has in fact recently resolved to make fuller use of increasingly available data sets based on household consumption and expenditure surveys (HCESs) and living standard measurement surveys (35). Analyses using these survey data do not make the same assumptions about food consumption (e.g., postharvest losses and non-food uses), the distribution of energy supplies within countries, or the demographic composition of households as compared with analyses using food balance sheet data (36). HCESs measure poverty (i.e., monetary expenditures as a proxy for income), assess consumer price indices and household socioeconomic status (e.g., education, housing type/quality, assets, health-seeking behavior, income), and examine patterns of food and nonfood consumption among households (37).

Data on food expenditures usually reflect only the monetary value of foods. Yet more accurate measurement of household food acquisition requires estimation of the quantities of foods acquired (to be able to estimate, e.g., the quantity of foods consumed per capita, diet diversity, or dietary energy availability per capita) (38). HCESs often operate under the assumption that household food acquisition equals household food consumption. Although many of these surveys have improved in recent years to include modules with

detailed questions on food expenditures, including quantities of purchased foods, self-produced foods, and gifts or transfers (36), the assumption of acquisition-consumption equality may hold only for population-level estimates of food consumption (i.e., some randomly selected survey households are drawing down food stocks acquired before the survey reference period and others are purchasing new foods so that household-level differences become random error) (38). However, for household-level estimates of food security, these data may provide widely varying estimates of household food consumption that will not provide sufficiently accurate estimates for some purposes (e.g., monitoring the food security status of the same households over time). Food acquired may also be wasted, lost, fed to animals, or gifted. Thus, over- or underestimations of food intakes may result if relying solely on food expenditures data (39).

HCESs offer a less costly and time-consuming alternative to detailed dietary intake assessments or observed-weighed food records for assessing food consumption. Given this fact, and the expanding use and accuracy of HCESs as food security-monitoring tools in many countries, these data will likely make increasing contributions to estimates of food acquisition worldwide. Use of HCESs to measure acquisition should be clearly distinguished from the use of these surveys to measure physical or economic access to food. These surveys are well suited for the former purpose; however, because economic access to food does not always equate to food acquisition, these surveys may be more limited in their ability to measure household food access. Similarly, the fact that HCES data do not account for individual consumption, especially among vulnerable groups such as infants, young children, and pregnant and lactating women, and do not capture data on food wasted or consumed away from the household means that other methods will continue to be needed for accurate dietary intake assessment.

The dietary diversity proxy. Dietary food group diversity is a commonly used measurement in part, because food group consumption data are easy to collect and dietary diversity consistently demonstrates positive associations with both the nutrient quality of diets (40–44) and child anthropometry (45–47). Dietary diversity, however, has also gained considerable traction as an indicator of food security (48). It has been shown to be associated with various measures of household socioeconomic status that are commonly considered proxy indicators of household food security, including food and non-food expenditures (47,49), per capita daily caloric availability (50), household assets and education (51,52), and household income (53). The diversity of household diets may be linked to these measures in part, because poor households will frequently use additional income to purchase nonstaple foods, thereby increasing household dietary diversity (49,54,55). Because the kinds of foods available to households vary widely across cultural contexts, there is no unique definition of dietary diversity for all settings. This presents a challenge to measuring dietary diversity across settings and using indicators of dietary diversity to represent the same underlying phenomenon.

Food Consumption Score. The WFP's flagship indicator for establishing the prevalence of food insecurity in a country or region is the Food Consumption Score (FCS). It is heavily informed by the linkage between dietary diversity and household food access. The FCS combines data on dietary diversity and food frequency using 7-d recall data from CFSVAs and emergency food security assessments (56). The respondent reports on the frequency of household consumption of 8 food groups (i.e., "staples," which include foods as diverse as maize, rice, sorghum, cassava, potatoes, millets, etc., pulses, vegetables, fruit, meat and fish, dairy products, sugar, and oil). The frequency of consumption of each food group is then multiplied by an assigned weight for each group and the resulting values are summed to obtain the FCS. This score is then recoded to a categorical variable using standard cutoff values. The assigned weights for each food group (i.e., meat, milk, and fish = 4, pulses = 3, staples = 2, vegetables and fruits = 1, sugar and oil = 0.5) were determined by a team of analysts based on the energy, protein, and micronutrient densities of each food group. "Poor" food security scores reflect the fact that households may be falling short of consuming at least one staple food and one vegetable each day of the week and "acceptable" scores are based on an expected daily household consumption of oil and pulses in addition to staples and vegetables (56).

The FCS is intended to monitor changes in food security in countries, to identify food-insecure regions within and across countries for program targeting, and to determine the food needs of food-insecure populations to calculate food rations. Because it is used to make time-sensitive decisions, e.g., regarding the targeting of food rations in emergency situations, complex data collection and analysis are often not feasible. The data on which the FCS are based are relatively easy to collect and the indicator itself is simple to calculate.

In African contexts, the FCS has been shown to be positively associated with kilocalories consumed per capita per day, asset indices, and total monthly household expenditures (56) and in a validation study using data from Burundi, Haiti, and Sri Lanka, the score demonstrated positive associations with calorie consumption per capita (57) (**Table 2**). This same validation study also found, however, that the cutoffs for determining levels of food insecurity severely underestimated food insecurity as measured by calorie consumption per capita and that the weightings of food groups did not improve associations with energy intake (57). The cutoffs for the FCS may also need to be adjusted upwards in situations where nearly all households consume sugar and oil regularly, effectively establishing a minimum FCS of 7 for all households (56). The standardization of cutoffs and weightings for the FCS allows for greater comparability of the score across contexts. However, these weightings may obscure important national or regional differences. For example, in regions where fruits and vegetables are not easily accessible to some families,

TABLE 2 Key validation studies of dietary diversity proxy measures and experience-based measures of household food access[1]

Location (reference)	Purpose	Tools used	Results/conclusions
FCS			
Burundi, Haiti, Sri Lanka (57)	Validate the quantitative aspect (food quantity) of FCS and alternative diet diversity and food frequency indicators constructed from FCS against calorie consumption per capita per day from survey data	FCS (unmodified)	Positive associations ($P < 0.05$) were observed between calorie consumption per capita and the FCS Provision of food aid weakened the association of FCS and calorie intake
Burkina Faso, Lao People's Democratic Republic, northern Uganda (64)	Compare performance of FCS and HDDS in food insecurity assessment	FCS (unmodified) HDDS (unmodified)	Both indicators demonstrated similar strength of correlation with household total expenditure, total food expenditure, and per capita food expenditure Similar classification of the most food-insecure areas within subnational levels, though the 2 indicators are not interchangeable
DDSs including HDDS			
Ethiopia (63)	Assess prevalence and determinants of prenatal serum zinc Examine association of dietary diversity and zinc deficiency	Sum of the number of different food groups (12 maximum) consumed 24 h prior to the assessment	Compared with women with high DDS (DDS ≥6), the risk of ZD was 1.87 (95% CI: 1.02–2.91) and 2.57 (95% CI: 1.57–4.18) times higher among those with optimal (DDS = 4 or 5) and low DDS (DDS ≤3), respectively Food insecurity, low dietary diversity, dependency on maize staple diet, and plant-source foods were key predisposing factors to zinc deficiency
South Africa (91)	Describe the relationship between a DDS and other food security measures in a livelihood survey	A household score (0–9) based on 9 food groups eaten in the previous 24 h (modified HDDS)	HHs with low DDS (≤4) had fewer assets and experienced more food shortages than HHs with higher DDS (>4) HHs with low DDS had higher HFIAS scores (16.0, 95% CI: 15.0–17.0) than HHs with high DDS (9.8, 95% CI: 8.8–10.9) DDS is a promising food security indicator for use in livelihood surveys
Mozambique (rural) (65)	Describe the performance of dietary diversity indicators in predicting energy intake ratio for the assessment of household energy consumption	Simple count of 9 food groups consumed based on 24-h recall. Weighted food group score based on the sum of the number of times per day each of 4 different food groups was consumed multiplied by a weight for each group (i.e., 4 for animal-source foods, 3 for legumes, 2 for grains, and 1 for fruits/vegetables/other foods)	Count of food groups and weighted food group score were correlated ($P < 0.01$) with energy intake ratio; differences among the 2 indicators were very small
Uganda (urban) (60)	Determine associations between dietary diversity and household food security, access to food aid, and the practice of agriculture among urban households with people living with HIV/AIDS	Sum of the number of different food groups (12 maximum) consumed in the previous 24 h	Consumption of a diverse diet was positively associated with household socioeconomic status ($P = 0.04$), a food security score ($P = 0.000$), access to food aid ($P = 0.004$), and practicing agriculture ($P = 0.016$)

(Continued)

TABLE 2 (*Continued*)

Location (reference)	Purpose	Tools used	Results/conclusions
Bangladesh, Egypt, Ghana, India, Kenya, Malawi, Mali, Mexico, Mozambique, and the Philippines (50)	Identify the extent to which diet diversity is an appropriate measure of household food access	In all countries but Bangladesh and Philippines, number of unique foods consumed in previous 7 d (Bangladesh: previous 24 h; Philippines: previous 1 mo)	In every sample, there was a positive association ($P < 0.05$) between dietary diversity and household per capita consumption as well as household per capita daily caloric availability from nonstaples; these associations were generally found across all seasons Changes in dietary diversity are a good indicator of changes in household per capita consumption and household per capita caloric availability
Radimer/Cornell measure of hunger and food security (8)			
New York, US (rural) (115)	Describe the associations between the Radimer/Cornell hunger and food insecurity scale to measures of household food supply and nutrient intake	10-item Radimer/Cornell measure of food insecurity including household-, adult-, and child-level questions	Satisfactory internal validity (i.e., Cronbach's α = 0.84) Food insecurity was inversely associated with income and positively associated with participation in food programs, low education and employment, and low fruit and vegetable consumption The results support the validity of the measure and show its ability to differentiate households experiencing increasingly severe food insecurity and hunger
New York, US (rural) (116)	Assess the validity of questionnaire-based measures of hunger and food insecurity using food security items from the Radimer/Cornell measure, the CCHIP, and NHANES III	10-item Radimer/Cornell measure of food insecurity including household-, adult-, and child-level questions	Radimer/Cornell and CCHIP showed high specificity (63–71% of truly food secure classified as such) and sensitivity (84–89% of truly food insecure classified as such) compared with defined criterion Radimer/Cornell and CCHIP measures may be used to screen for hunger and food insecurity in similar rural areas
ELCSA Haiti (95, 117)	Test the association between food insecurity and malaria in Haiti using convenience sample of 153 women with children aged 1–5 y	16-item ELCSA administered in Spanish using a 3-mo recall period	ELCSA was considered internally valid (Cronbach's α = 0.92) Severe food insecurity was a risk factor for perceived clinical malaria [OR = 5.97 (95% CI: 2.06–17.28)] Authors suggest that policies and programs that address food insecurity may also reduce malaria risk in Haiti

(Continued)

TABLE 2 (*Continued*)

Location (reference)	Purpose	Tools used	Results/conclusions
Mexico (118)	Test the validity of the ELCSA in a sample of households with children <18 y in Mexico	16-item ELCSA administered in Spanish using a 3-mo recall period	ELCSA was considered internally valid (Cronbach's $\alpha = 0.93$) Inverse, dose-response relationship was observed between household income and level of food insecurity severity ($P < 0.001$) Prevalence of severe food insecurity was 18.9 and 3.3% in households where the respondent had no formal education and a college-level education, respectively
HFIAS			
Iran (119)	Assess the validity of HFIAS in urban Tehran	9-item HFIAS with 30-d recall period	HFIAS had a Cronbach's $\alpha = 0.855$; 11.8, 14.4, and 17.5% of households were severely, moderately, and mildly food insecure, respectively Income and expenditure as well as levels of education were lower in food-insecure households compared with food-secure households ($P < 0.05$) HFIAS showed acceptable levels of internal consistency, criterion validity, and reliability in assessing food insecurity
Tanzania (88)	Assess validity and reliability of HFIAS among poor, rural households in Tanzania	9-item HFIAS with 30-d recall period	The HFIAS showed strong internal consistency (Cronbach's $\alpha = 0.83–0.90$) Food security was positively associated with maternal education, husband's education, household wealth status, and animal-source food consumption ($P < 0.05$)
Burkina Faso (89)	Approximate adequacy of urban household diets using HFIAS and IDDS	9-item HFIAS with 30-d recall period	HFIAS was negatively associated with household's mean adequacy ratio ($P < 0.001$) using energy and 11 micronutrients HFIAS is useful for approximating adequacy of household diets but not for targeting given insufficient predictive power
Ethiopia (90)	Assess validity and dependability of HFIAS among community health volunteers	9-item HFIAS administered at 3 time points in 2008	Accounting for repeated measures on participants, household per capita income was inversely associated with HFIAS score ($P < 0.0001$) in a dose-response manner Among severely food insecure households, the likelihood of previous-day consumption of meat was 8.3% aggregated over the data collection rounds compared with 26.3% for food-secure households

(Continued)

TABLE 2 (*Continued*)

Location (reference)	Purpose	Tools used	Results/conclusions
HHS and HFIAS			
Ethiopia (120)	Examine household food security and hunger	HHS and HFIAS	HHS and HFIAS were compared using 16 food insecurity-coping strategies, 12 of which were negatively associated with HHS scores and 9 of which were negatively associated with HFIAS scores ($P < 0.05$) Correlation of HHS and HFIAS was strong (Pearson $r = 0.677$; $P < 0.000$) Likelihood of food insecurity decreased with higher household wealth index
Mozambique, Kenya, South Africa, Zimbabwe, Malawi, West Bank Gaza Strip (93)	Validate the HFIAS by examining the extent to which the scale is internally, externally and cross-culturally valid	Various permutations of the HFIAS, including: 9-item 4-frequency scale, 9-item 3-frequency, 5-item 3-frequency, 3-item 3-frequency	Several scales were internally valid for some data sets though no scales showed internal consistency across all of the data sets Only one scale showed cross-cultural equivalence, the 3-item, 3-frequency scale comprised of items 7, 8, and 9 of the HFIAS; this, the HHS, showed equal item discrimination and expected associations with HH wealth and income

[1] CCHIP, Community Childhood Hunger Identification Project; DDS, diet diversity score; ELCSA, Latin American and Caribbean Household Food Security Scale; FCS, Food Consumption Score; HDDS, Household Dietary Diversity Score; HFIAS, Household Food Insecurity Access Scale; HH, household; HHS, Household Hunger Scale; IDDS, Individual Diet Diversity Score.

consuming these food groups may be an indication of food security, yet the weighting of fruits and vegetables in the FCS calculation (i.e., lower than staple foods) may hide this important dynamic. In addition, the positive associations observed between the FCS and household calorie consumption do not necessarily equate to positive associations with nutrient intakes.

Household Dietary Diversity Score. Dietary diversity was also selected as one of the indicators of choice for measuring household food access in the results frameworks of USAID Title II-funded programs. The instrument, developed by the Food and Nutrition Technical Assistance Project, is known as the Household Dietary Diversity Score (HDDS) (58). The score is calculated by summing equally weighted response data on the consumption of 12 food groups (i.e., cereal grain staples, roots and tubers, vegetables, fruits, meat, eggs, fish, pulses and nuts, dairy products, oils and fats, sugar, and condiments). The individual responsible for food preparation in the household is asked if anyone in the household consumed any item from the food group in the previous 24 h. These responses are summed to obtain a score from 0 to 12. The HDDS has no standard cutoffs for defining food insecurity though (only cutoffs based on income data or tertiles of the score) (58). Similar diet diversity scores (DDSs) have been developed to assess the nutritional quality of individual diets (59).

The HDDS and slight variations of it have been shown to be positively associated with household food security as measured by a weighted sum of coping strategies (60), a lower odds of having inadequate calorie availability at the household level (61), employment and income (62), and a lower odds of zinc deficiency (63) (Table 2).

FCS vs. HDDS. The FCS and HDDS share a common emphasis on dietary diversity as a proxy for household food access, though they differ in recall period, the number and definition of food groups, the weighting of food groups, assessment of cutoff points for defining food-insecure households, and the combination of food frequency information with dietary diversity data. Despite these differences, they have been shown to perform similarly in diverse contexts. In a comparison of the 2 indicators using household survey data from Burkina Faso, the Lao People's Democratic Republic, and Uganda, prevalence-adjusted κ coefficients showed substantial agreement in all countries except Uganda (i.e., there was agreement in the percentage of food groups consumed as measured by both indicators) (64). Both indicators were also correlated with other measures of food security in all countries (e.g., per capita total, food, and non-food expenditures). Differences in how the indicators are constructed, however, made direct comparisons difficult and there were greater differences observed in food group consumption across the 2 measures for more food-secure households (64).

Both measures require minimal data collection and may be useful for monitoring food security programs, though as always, there may be trade-offs in the use of the indicators.

As noted earlier, the cutoffs for the FCS may underestimate food insecurity. However, use of the FCS, which combines food frequency and diet diversity data, may be preferable to a diversity-only indicator if it is possible to collect the additional data (57). The larger number of food groups assessed by the HDDS, on the other hand, allows for more disaggregated analyses of dietary patterns (64). Adapting the indicators using context-specific data for food group selection and weighting may be desired (65); however, this process requires additional resources and will limit comparability of results to other regions.

Measures based on participatory adaptation. Although the metrics of household food access examined thus far are intended for use across contexts without adaptation, measures based on participatory adaptation are informed by context-specific information collected from groups of stakeholders in the communities and districts where food security will be measured.

Coping Strategies Index. The Coping Strategies Index (CSI), developed by the humanitarian organization CARE and the WFP, is one such example of a participatory approach to assessing food security. It employs a series of questions regarding how households cope with food shortfalls to construct a numeric score that can be used for targeting food aid, monitoring the impact of food aid, and estimating long-term changes in food security (66). However, these questions will not be the same across contexts.

The CSI is constructed from a list of coping strategies that households rely on in times of food deprivation or that they may use to manage problems of food access that they see arising in the future. Though a list of generic coping strategies is suggested along with common coping domains, a locally adapted list is generated through focus group discussions with stakeholders who represent the population of interest. Information on the relative frequency of use of the strategies over the previous month must also be collected during these interviews and combined with the information on the strategies themselves. Given that the same perceptions and behaviors do not always indicate the same severity of food insecurity across contexts (67), a second round of focus group interviews is then suggested to assign severity weightings to the established list of coping strategies. These weightings are then grouped and scores are assigned to each group. Frequency categories are also assigned scores and all of the information is combined to yield a final index score from household survey data that incorporate questions on the identified coping strategies.

The final CSI score for any given household is not very meaningful by itself. However, when compared with CSI scores calculated for other households in the same community or region using the same adapted index or when comparing scores on the same households over time, the CSI serves as a comparative indicator of household food security (66).

More recently, a reduced version of the CSI has been developed that uses only the 5 most common coping strategies employed in response to food shortages as reported from a selection of survey data that incorporate the CSI (68,69). This reduced version of the index does not provide comprehensive information on the range of food-insecure households in a region and therefore may not be as useful for identifying vulnerable households as compared with the original CSI. However, measurement of the same sets of behaviors and use of standardized severity weightings allows the reduced index to more easily compare the food security status of households across contexts (69).

The CSI, both in its original and reduced forms, has been shown to be positively correlated with household assets, total expenditure per capita, and percentage of expenditures on food in several sub-Saharan African countries (68,70,71).

Household economy approach. The Household Economy Approach (HEA), developed in the early 1990s by the humanitarian organization Save the Children Fund in collaboration with the FAO, is another participatory approach to understanding household food security. The HEA differs from all metrics described until now in that it is an analytical framework, not a measure of food security in and of itself (72). Yet, although the HEA is not a standard data collection tool, it prescribes a set of procedures for assessing livelihood vulnerabilities that produces information that can be used in much the same way as data generated using other food security measures.

Similar to the CSI, the HEA draws largely from rapid rural appraisal techniques (e.g., semistructured interviewing of focus groups) rather than household survey data. The analysis motivated by the framework centers on a broad assessment of livelihoods, including: *1*) delineating geographic patterns of shared livelihoods; *2*) grouping households based on wealth and assets; and *3*) categorizing household livelihood strategies (72). The analysis may be advanced further, however, to predict the effect of potential hazards on the livelihoods and food security of households through an "outcome analysis" that entails analyzing potential hazards and assessing the coping capacity of households to deal with different shocks (72).

The HEA has been used extensively in poverty and vulnerability assessments, especially in sub-Saharan Africa, to assess the ability of households to access food and income as well as to identify appropriate interventions to improve access in the face of specific shocks (73). A meta-analysis of 49 case studies that used the HEA to assess household vulnerability to food insecurity in southern Africa revealed poverty, environmental stressors, and conflict to be the direct causes of inadequate food access in the region (74). Use of the HEA also identified deteriorating social capital (e.g., loss of social connectedness, reciprocity, trust relations, and social networks, and the disintegration of family units) as a fundamental driver of increasing vulnerability in the region (74).

The multi-tiered approach of the HEA and its reliance on consultative, qualitative information allow for a contextual understanding of household livelihood vulnerability in specific settings. Such information can be valuable both in

emergency situations for identifying food needs as well as for longer term development efforts that require identifying poverty reduction strategies. The HEA though, unlike the CSI, is not designed to produce a quantifiable output that may be used on a larger scale in quantitative household surveys. It trades the benefits of a standard food security measure that allows for comparisons across settings for access to context-specific information on numerous domains of food security in a given region. This comprehensive approach may allow for more in-depth insights into the nature of food security and its determinants that simpler indicators might not detect; e.g., uncovering the importance not only of poverty and environmental stressors, but also declining social capital as drivers of food insecurity.

Direct, experience-based measures. Distinct from approaches that measure household food access through indirect, or "second generation" indicators (75) (e.g., household income and expenditures, dietary diversity, livelihood strategies), experience-based approaches to measuring household food access attempt to directly measure families' behaviors and lived experiences of household food security using questionnaires. Some of these approaches may also utilize participatory adaptation techniques; however, they differ from those approaches above in that they attempt to directly measure food security.

United States Household Food Security Survey Module. Evidence of rising amounts of hunger in the United States in the early 1980s motivated then President Ronald Reagan to form an advisory committee to assess the scale of the problem and make recommendations for improving food assistance programs (76). In 1984, the President's Task Force on Food Assistance issued a report acknowledging a woeful lack of data on hunger in the United States and expressing the need for a reliable measure that would distinguish medical definitions of hunger from poverty-related hunger (77). This report motivated 2 seminal research studies that sought to understand families' lived experiences of hunger and food insecurity: *1*) the Community Childhood Hunger Identification Project, a 7-site survey of 2335 low-income families in the United States with children under 12 y of age (78); and *2*) an in-depth study of hunger in central New York that included interviews with 32 African American and Caucasian women from urban and rural areas as well as a quantitative survey of 189 similar women from the same areas (8,79).

The empirically rooted, qualitative measures of food security and hunger that emerged from these groundbreaking studies informed the development of what is now known as the Household Food Security Survey Module (HFSSM), an 18-question survey module that asks families to report their subjective experiences of 4 domains of food insecurity: *1*) anxiety about household food supplies; *2*) perceptions that the quality or quantity of accessible food is not adequate; *3*) reduced adult food intake; and *4*) reduced food intake by children (77). Households are classified as either food secure, having low food security, or very low food security depending on the number of food-insecure conditions and behaviors they report (80). The HFSSM was first administered in 1995 as a supplement to the monthly CPS carried out by the Census Bureau to monitor unemployment and poverty in the United States. Since that time, ~45,000 households respond to the HFSSM annually as part of the CPS and the survey module has been incorporated into the NHANES as well as data collection tools of other research efforts.

The HFSSM has been shown to be a valid measure of food security and hunger for populations and individuals (81). Given its strong performance measuring food security across a number of subgroups in the United States, the direct, questionnaire-based measurement approach of the HFSSM was thought to have the potential to serve as a common means of measuring food security in low-income countries (81). Several studies using adapted versions of the HFSSM in sub-Saharan Africa, Latin America, and South Asia soon emerged that found the direct, questionnaire-based measure of household food security was associated with total expenditure per capita (82), total daily per capita food expenditures (82,83), net income per adult, total assets, and adult energy intake (84) as well as income strata and dietary diversity (85). In a meta-analysis using data from these and other studies in countries outside the United States, insufficient food quantity, inadequate food quality, and uncertainty and worry about food were common domains of food insecurity experienced universally across the sample countries (67). The relative response frequencies of the food insecurity domains were similar across several countries as well (e.g., worry was the most prevalent domain reported and going hungry was the least prevalent), again suggesting commonalities in the continuum of experienced severity of food insecurity across countries (67). This growing body of evidence suggested, then, that a measurement tool similar to the HFSSM might be able to be successfully administered in many different contexts to gather information on the ability of households to securely access food.

Yet, based on the meta-analysis, it was also clear that adaptations of the HFSSM did not fully capture the experience of food insecurity by all households in all contexts; several subdomains of food insecurity reported by respondents were missing from the measure, including feelings of shame, alienation, and helplessness associated with food insecurity, as well as acquiring food in socially acceptable ways. In addition, substantial variation existed across countries in households' approaches to managing food insecurity. Because of this variation in response patterns, the authors suggested that universal cutoffs for defining food-secure compared with moderately or severely food-insecure households across all countries, as was done with the HFSSM in the United States, was not possible (86).

Household food insecurity access scale. Nonetheless, based on empirical research that employed adaptations of the HFSSM in low- and middle-income countries, a set of 9 generic questions was developed that was thought to represent universal domains of the access component of household food security (87). This set of questions, known as the

Household Food Insecurity Access Scale (HFIAS), generated a score from 0 to 27 that was designed to reflect a single statistical dimension of food security, with the aim of providing programs a simple tool for targeting, monitoring, and evaluation efforts. A 4-level categorical variable reflecting prevalence of food insecurity could also be calculated from these data. In contrast to the HFSSM, the HFIAS included only 9 questions (vs. a maximum of 18 for the HFSSM), asked respondents to recall experiences of food insecurity over the previous 4 wk (vs. 12 mo), and incorporated frequency response questions (e.g., if the condition was experienced rarely, sometimes, or often) into the calculation of the scale score.

Since its development, the HFIAS has been widely used as a monitoring indicator in the evaluation frameworks of USAID Title II food security programs. Food security as measured by the HFIAS has been shown to be positively associated with household wealth, animal-source food consumption, and maternal education (88), dietary adequacy (89), household per capita income (90), household assets (91), dietary diversity (90,91), and a lower odds of underweight (BMI <18.5 kg/m^2) and wasting (mid upper-arm circumference <230 mm for males and <220 mm for females) among HIV-positive adults (92) (Table 2).

Although these studies demonstrated positive associations between the HFIAS and common proxies of household food security, some authors did report surprising findings using the HFIAS. In urban Burkina Faso, e.g., receiver-operating characteristic analyses were conducted to assess the performance of the HFIAS in predicting dietary adequacy per adult-equivalent (89). The area under the receiver-operating characteristic curve was sufficiently low as to conclude that use of the HFIAS would lead to a large proportion of households being misclassified according to the adequacy of their diets (i.e., energy and micronutrient content). In urban Ethiopia, a translated but not locally adapted version of the HFIAS was administered to a sample of HIV/AIDS volunteer caregivers (90). The likelihood of affirmative responses to questions increased as monthly per capita income decreased, though some questions deviated from this trend in item response curves, suggesting that households in different income strata may have interpreted HFIAS questions differently. The authors also reported that HFIAS scores improved during 3 rounds of data collection in 2008 despite concomitant increases in local grain prices. They cite "response drift" as a possible cause, i.e., respondents had adjusted their internal standards of food security as a result of encountering increasingly food-insecure households in their capacity as volunteer caregivers. Given that the HFIAS relies on subjective report of food insecurity experiences, changing internal standards or values could result in changed perceptions of one's food security status and therefore an altered score on the HFIAS.

Household hunger scale. The authors of the HFIAS recently conducted a validation study of the HFIAS using 7 data sets from 6 countries (93). Based on the results of the analyses, they recommend a new scale known as the Household Hunger Scale (HHS) that comprises the final 3 questions of the HFIAS, all of which pertain to the consequences of severe food insecurity (question 7: Was there ever no food at all in your household because there were not resources to get more? question 8: Did you or any household member go to sleep at night hungry because there was not enough food? question 9: Did you or any household member go a whole day and night without eating anything because there was not enough food?). The new 3-item scale (which now includes only 3 frequency responses—never, sometimes/rarely, or often—rather than the 4 recommended in the HFIAS) was found to have the highest potential to be internally, externally and cross-culturally valid among the various scales tested, including the full 9-item HFIAS and variations of it.

Using Rasch models to assess whether increasing item-step severity of the scales demonstrated monotonic trends (indicating internal validity) and item equivalence in different settings (indicating cross-cultural validity), the HFIAS did not meet established criteria (93). Qualitative feedback on the adaptation and implementation of the HFIAS confirmed the discrepancies observed in item ordering and severity calibrations. For example, difficulties were reported in finding words to convey the original meaning of HFIAS questions in different languages, the amount of time dedicated to preparatory activities such as questionnaire translation and adaption varied widely, and there was confusion in distinguishing between items on the HFIAS (93). These findings call into the question the degree to which the HFIAS is measuring the same underlying constructs across contexts.

It may not be surprising that the 3-item HHS is a more valid cross-cultural tool given that extreme manifestations of hunger such as going to bed hungry are easily recognizable, negative experiences across most cultures. In contrast, anxiety about food, meal disruption, and perceptions of diet monotony or that socially unacceptable food is being consumed—conditions reflecting low to moderate food insecurity—is context and culture specific and therefore open to greater interpretation. However, the emphasis of the HHS on hunger, rather than food security, limits the measurement potential of the HHS. Its authors suggest that the HHS be used to complement the use of other food security measures, especially where more comprehensive, validated, experienced-based measures exist.

Latin American and Caribbean Household Food Security Scale. The Latin American and Caribbean Household Food Security Scale (ELCSA – Escala Latinoamericana y del Caribe de Seguridad Alimentaria) (94), a 16-item scale variant of the HFSSM, is one such example of a regionally validated, experience-based measure. The ELCSA has been shown to be internally and externally valid, comparable across countries in Latin America, and has been used for research purposes throughout the region (95,96). To date, the ELCSA is the only comprehensive region-specific, experience-based food security measure that has been validated in such a way. However, the FAO is launching an initiative to create a similar experience-based measure from which

data would be available for many countries on an annual basis to complement existing food security measures (1).

Measuring food utilization: anthropometry. Food utilization, the third domain of food security, encompasses the allocation of food within households (i.e., the amounts and kinds of foods consumed by individual household members), the nutritional quality of that food, and the bioavailability of nutrients in those foods. Measuring food utilization is essential to understanding the distribution of food within households. Even in households with adequate food supplies, allocation of those supplies to individual household members may be unequal and result in nutritional deficiencies (97).

Anthropometry has traditionally been used as a proxy measure of food utilization. Anthropometric measurements, i.e., measurements of body dimensions, are commonly viewed as a gold standard measure of nutritional status and have been strongly linked to mortality outcomes (98) as well as morbidity, cognitive development, and chronic disease (99). Anthropometry also serves as a broad indicator of health and socioeconomic well-being (100). Though an abundance of more advanced methods exists for measuring body composition (101), simple body measurements commonly used in field surveys include height, recumbent length (for very young children), weight, mid-upper arm circumference, and measurements of skinfolds. These measurements, together with an individual's age and sex, are compared against a population reference or standard in order to create anthropometric indices that may reflect chronic or acute undernourishment (102).

Although anthropometry is often considered a proxy measure of food utilization, nutritional status as reflected in anthropometry is not influenced solely by food intake. An individual's health status, influenced by one's hygiene and sanitation environment and access to caregiving and health services, is also central to nutrition, growth, and development (103). Therefore, food utilization estimates that rely on anthropometric measurements alone capture more than just food intake and may misrepresent the extent to which inadequate intake or unequal food distribution are problems.

Assessment of individual dietary intakes within households allows for a more accurate estimation of intra-household food allocation and utilization. However, such disaggregated dietary data are not commonly available given the great deal of time and resources needed to collect such data. Twenty four-hour recall assessments, e.g., require respondents to recall everything they consumed in the prior day. These assessments are time intensive, must be administered by trained staff, and require detailed analyses using locally adapted food composition tables (104).

Conclusions

Many measures, many constructs, many uses

As conceptualizations of food security have evolved beyond the mere availability of sufficient national-level food supplies (70,105), metrics of food security have similarly evolved. We have compiled here a comprehensive list of food security metrics used by different organizations, at different scales and for different ends, using the defining domains of food security, availability, access, and utilization, as an organizing structure. This categorization, however, oversimplifies the rather complex landscape of food security metrics.

It is clear, e.g., that the available metrics are not always explicit about which domain or locus (within domains) that they are measuring in the food security conceptual pathway (Fig. 2). Several of the metrics, e.g., provide information on more than one domain of food security (Table 1). The GFSI incorporates data on 30 indicators of food security, including measures of affordability, availability, quality, and safety. FEWS NET and IPC analyses similarly draw upon information from a wide range of data sources that include determinants of both food availability and access. Other measures, such as the GHI, include components that may not be immediately related to food security (e.g., child mortality), whereas indicators such as DDSs draw from consumption data (i.e., food utilization) but use these data as an indicator of food access, a different domain of food security than utilization and one that encompasses aspects that dietary diversity does not address (e.g., the social acceptability of food acquisition, food preferences, and food safety). Finally, others measures, such as the experience-based measures, try to measure the experience of food security directly in a way that cuts across domain categorizations.

The purposes for which the metrics were designed also differ greatly (Table 1). Some measures are uniquely suited to monitoring regional changes over time, contributing to early warning and global monitoring systems (e.g., FEWS NET), whereas others were developed primarily as analytic tools to facilitate cross-national comparisons (e.g., GFSI, GHI). The FAO prevalence of undernourishment measure is used to monitor the Millennium Development Goal for hunger, thereby facilitating global and regional governance of food security (36). The HFIAS, and now HHS, are used to assess the prevalence of household food insecurity and hunger and detect changes over time, typically in the context of development programs. The CSI serves as a monitoring tool, to inform development programs, and also to help guide the targeting of food aid. Similarly, the HEA's livelihoods approach is designed to identify households' food and non-food needs in order to inform emergency assistance programs as well as longer term development efforts (72). Dietary diversity measures, anthropometric indicators, and expenditure data from HCESs are all proxy indicators (of diet quality, nutritional status, and household income or food consumption, respectively) used as stand-alone measures or to complement other indicators for purposes of assessment, targeting, monitoring, and evaluation.

This diversity of available measures is both a boon and barrier to the food security community. On one hand, practitioners, researchers, and decision-makers have a rich palette from which to select appropriate measurement tools. On the other, the continued emergence of new metrics,

with many institutions having their own trademark measure, has left the field awash in measurement tools. Although all pertain to the measurement of food security, the conceptualizations of food security underpinning each measure are not always explicit.

Measurement challenges

The food security metrics outlined above measure multiple domains of food security, draw from a diversity of data sources, and serve many different applications. However, considerable challenges remain to measuring food security, including: *1*) adequately measuring dietary adequacy and distinguishing the constructs it represents; *2*) differentiating the various components of food access; *3*) applying cutoff points for defining food insecurity; *4*) mitigating potential response bias from experience-based measures; *5*) acknowledging trade-offs; and *6*) validating measures amid great diversity in approaches to measurement and conceptualization of food security.

Dietary adequacy and food security. Measurement of food security has advanced beyond just assessment of food availability to include many measures of economic access. However, this same emphasis has not been placed on measures of diet quality. Data from HCESs, if properly collected, may allow for population-level estimates of diet quality. Some data collected to inform the creation of CSIs may also provide information on diet quality. Yet more rigorous measures of diet quality from 24-h dietary recall or food frequency recall data, e.g., are not commonly employed for food security assessments because of the time and resources needed to collect and analyze such data. Dietary diversity indicators raise other measurement challenges. For example, how many and which food groups to include in the measure, how to account for the quantity of each food group consumed, what recall period to use, and how to assign cutoff values for defining levels of dietary diversity (64,106).

Importantly, dietary diversity indicators are not comprehensive measures of household food security. The causal relationships among dietary diversity, household socioeconomic factors, food security, and nutritional status have not been well established despite the use of dietary diversity indicators as proxies for all of these underlying constructs (48). These constructs, though often correlated, may in fact not be interchangeable. The choice of an indicator, then, should be informed by the construct that one intends to measure. Selecting food groups, e.g., to include in a measure of dietary diversity might be based on the nutrient content of the different food groups or the economic value of those food groups depending on whether one intends to assess diet quality or economic access to food (106). Assigning weights to food groups will further allow measures to be tailored to a specific end, e.g., whether emphasizing availability of energy and protein or the micronutrient content of diets.

Deconstructing household food access. Household food access fundamentally refers to physical and economic access to food, yet measures that aim to assess food access often measure household food acquisition or household food consumption (e.g., using HCESs). These 3 concepts, access, acquisition, and consumption, must be clearly differentiated to understand the construct being measured as well as the dynamics of pathway that are needed for evaluating how programs and policies succeed or fail in achieving impacts. Food access and acquisition may be most relevant for understanding household-level behaviors, whereas consumption references an individual's utilization of food, whether an adult who decides on their own what to consume or a young child who is fed by a caregiver. As stated earlier, identifying the construct to be measured and the purpose for which the measurement will be used are crucial first steps in deciding on a measurement tool. This is especially important for measurement of food access, a concept that encompasses several constructs (Fig. 2) that programs or policies may affect individually, collectively, or not at all.

Shame from acquiring food in socially unacceptable ways, another aspect of food access, is conspicuously absent from the metrics reviewed here. This is despite social unacceptability being identified as a common domain of food insecurity across many cultural contexts (67,79). Indeed, a question probing this domain was included in earlier versions of the HFIAS but was dropped from the final version of the scale because of the sensitive nature of the topic and the difficulty in eliciting accurate responses (87). For this reason, few surveys include questions related to the acceptability of food acquisition and therefore few data are available to assess this component of food security.

Similarly, the safety of foods acquired by households is often absent from food security metrics despite increasing concerns related to mycotoxin contamination of food (107), foodborne illness, chemical contaminants, and zoonotic disease (108). Food safety, then, is another locus in the food security conceptual pathway (Fig. 2), a necessary, yet insufficient condition within the domain of household food access.

Categorizing food insecurity. Another challenge to food security measurement is the identification of appropriate cutoffs to use both within a setting and when comparing across regions or countries. Several food security measures provide clear guidance on the assignment of cutoff values for defining levels of food insecurity. The IPC, e.g., provides clear classification criteria, because its priority response objectives are directly determined by this classification. Other measures produce quantitative scores (e.g., the CSI, FCS, HFIAS) for which classification of food insecurity into categorical levels may not be as important as comparing the range or variation of scores across a given region or population. For these measures, unlike the consensus-based approach of the IPC, using distribution-specific cutoffs of the scores (e.g., tertiles or quartiles) together with other proxy measures of food security may be appropriate. When additional data are available, determining cutoffs

based on sensitivity and specificity analyses of an indicator's performance in predicting a related outcome may be helpful.

Establishing boundaries for defining chronic, transitory, and seasonal food insecurity has also proven challenging, in part because the timeframes for defining each condition may be context dependent. The meaning of food insecurity severity may also differ across social and economic contexts (68). One approach has been to consider both the periodicity, or duration, of food insecurity together with the intensity of food insecurity (109). As noted earlier, the conditions of chronic and recurrent transitory food insecurity are in fact interconnected as are states of moderate and severe food insecurity. Considering both duration and intensity, Devereux (109) defines the following categories of food insecurity: moderate chronic (chronic hunger); severe chronic (high infant mortality and crude mortality rate); moderate transitory (e.g., seasonality); and severe transitory (emergencies).

Regardless of the approach, when attempting to categorize food insecurity, or when developing or applying cutoffs to food security measures, it is important that the criteria used to establish cutoffs and categories are well described and that the biases these criteria may introduce to the interpretation of food security severity are made clear.

Response bias. Experience-based measures of food security rely on information that reflects cultural or personal values of deprivation that may not necessarily coincide with more objective measures of the phenomenon (110). These measures may present a moral hazard risk if respondents expect aid or support based on their responses to questions (25). The evidence suggesting that this "exaggeratory effect" may pose a threat to the quality of existing data collected using experience-based measures is minimal (93). However, one study reviewed here did report the possibility of so-called "response drift," wherein respondents may have adjusted their internal standards of food security based on changing environmental conditions (90).

A further bias may exist wherein one individual's perceptions of food security do not necessarily represent the experience of all household members (69), yet experience-based measures such as the HFIAS and HHS require the respondent to answer on behalf of all household members. The respondent is typically the female head of household or person in the household most involved in food preparation and meals and is therefore also likely most closely attuned to the food security experiences of other household members, especially young children. However, in many contexts, it is unclear the extent to which a respondent's experiences of food security align with those of others in the household.

Furthermore, recall bias may introduce error into measurements even if the respondent adequately represents the food security status of other household members. In many rural settings in particular, the concept of time may be fluid and ensuring consistency in the definition of recall periods across respondents may be difficult. This may be especially challenging if surveys that take several weeks or months to implement are carried out during seasonal transitions such that the time of recall for those interviewed early differs from those interviewed later in substantive ways that are relevant to food security measurement. Cognitive testing of questionnaires in different contexts prior to implementation and training survey enumerators to properly communicate to respondents the same conceptual understanding of recall periods and question content may help to mitigate these response biases.

Acknowledging trade-offs. All metrics have inherent strengths and limitations and those who use them in their work must ultimately acknowledge these trade-offs. Indeed, a common trade-off seen among food security metrics is comprehensibility and contextual detail exchanged for simplicity and comparability. This trade-off is clearly observed in the development of experience-based food security measures. The HFIAS, while still a relatively simple measure, was found to be not as comparable across contexts as the simpler HHS, which measures only the most severe, hunger-specific elements of the food insecurity experience. Even the HFIAS, because of the statistical constraints placed on it as a uni-dimensional scale, does not capture all of the important elements of household food security (86).

A special case of this comprehensibility-simplicity trade-off is reflected in the decision to collect household- instead of individual-level data. Household-level data on food consumption, e.g., require considerably less time and fewer resources to collect than individual-level data. However, these data do not allow for an examination of intra-household allocation decisions that are widely recognized as central to understanding the utilization component of food security. Rigorous data on the diets of infants and young children may be especially important for understanding intra-household food security, yet collecting this information requires additional data collection that is not commonly included in food security metrics. The breastfeeding practices of caregivers, e.g., and the diversity, consistency, frequency, and timing of the introduction of complementary foods fed to these children are central determinants of child growth and development (111). This information is usually collected in dedicated survey modules separate from questions on food security. However, it may be important to include in food security assessments, especially when the nutritional status of children is an outcome of interest.

Explicitly acknowledging trade-offs as part of the process of identifying available resources and the data needs of a project will likely assist in the selection of a measurement tool.

Measurement validation. Approaches to validating food security metrics are as varied as the conceptualizations of the measurement tools themselves. The literature documenting the development and validation of recent experience-based measures reflects this divergence in approaches. These measures have been validated by examining associations with net income per adult; total household assets; adult

energy intake; child anthropometry (84); probability of daily intake of fruits, vegetables, meat, fish, and dairy (85); total daily per capita food expenditures (82,83); household wealth status; animal-source food consumption; maternal education (88); mean adequacy ratio (89); dietary diversity (90,93); net income per consumption unit; and a household wealth score (93) (Table 2). Qualitative strategies have also been used to assess the validity of food security instruments, including ethnographic methods (67,84,112) and cognitive interviewing (113). The approaches here seem aligned with a "convergence of evidence" approach that leverages information from different sources using different indicators to cross-reference measurements (82). These triangulating measures span a wide range of constructs from income, wealth, and socioeconomic status to dietary intake, quality, diversity, and nutritional status. However, though these different data are being used to measure the same concept, the domains and loci of food security that they measure are highly varied. Do these different constructs equally represent the different domains of food security? Does an association with a given construct have the same meaning across contexts? Should a valid indicator of household food security show strong associations with all of these constructs? Or does food security represent a latent construct that is greater than the sum of its constituent parts?

These questions, though deserving of further debate and discussion to advance our theoretical understanding of food security, also miss the larger point. The strength and relevance of an indicator depend on the purpose for which it is intended (114). Indeed, there may be no objective "best" indicator for a given construct. Valid measures must be well-grounded in an understanding of the phenomenon that they intend to measure and their performance should be consistent with that understanding, in addition to exhibiting precision, dependability, and accuracy (81). These criteria are often very challenging to meet when the underlying construct an indicator is attempting to measure is quite simple, let alone for a phenomenon like food security, which is quite complex. The World Food Summit definition of food security certainly reflects this complexity. The definition's comprehensiveness, although well suited as a political tool to motivate action around food security and hunger on multiple fronts, may preclude its use as a guide for operationalizing food security metrics.

Suggestions for the selection of food security metrics

The preceding discussion perhaps poses more questions than it does provide answers regarding approaches to measurement of food security. As discussed, among other considerations, deciding on an appropriate approach very much depends on the conceptualization of the construct to be measured and the intended use of the data to be collected. Answering the following questions will likely be useful in guiding the selection of appropriate food security metrics: *1*) What component(s) of food security do you intend to measure (e.g., food availability, food access, utilization of food, or stability)? *2*) Who will use your data, and what type of data are most useful to them? *3*) What is the purpose of the data (Table 1)? Is it for early famine warning, targeting food aid, screening at-risk households for intervention, monitoring changes in food security status over time, monitoring program utilization, evaluating programs and policies, or advocacy? *4*) What is the periodicity to be evaluated? Is it chronic or acute food insecurity? Will there be repeated measures? *5*) At what point in the causal pathway (Fig. 2) does your measurement fall? *6*) At what scale are you measuring food security (national, regional, household, individual)? *7*) What resources are available for planning, data collection, analysis, and the intended application of the findings?

Table 1 outlines the food security components measured by the various metrics outlined in this review as well as the purpose(s) for which the metrics were designed.

Food security programs may benefit from a more critical and systematic assessment of program needs and the intended use of data. A convergence of evidence approach may be appropriate in some circumstances, but at least in the context of program evaluation, it will be a rare program that is positioned to concurrently address all domains or loci of food security in the conceptual pathway. Therefore, identifying metrics that are especially well suited to the needs and resources of a program is essential for more efficient and effective measurement of food security.

The diversity of sectors and disciplines for which food security is relevant means that the scholarship, approaches to program development and evaluation, and formulation of policy in this broad field will remain equally diverse. However, this diversity, especially with regard to measurement approaches, need not be homogenized so long as the process by which metrics are selected and employed remains thoughtful and systematic, thereby strengthening the relevance of the evidence base for all.

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