



Validity and cross-context equivalence of experience-based measures of food insecurity[☆]

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ABSTRACT

This article reviews evidence for validity and cross-context equivalence of experience-based measures of food insecurity for estimating and monitoring prevalence of countries globally. The measures assess uncertainty, compromised dietary quality, eating less, and going hungry. Their performance is consistent with construction based on factor analysis, Rasch analysis, order of item responses, and cognitive interviewing; reliable based on internal consistency; and accurate based on comparisons with definitive measures and theoretically close determinants and consequences. The measures are construct equivalence across contexts, but responses to some items depend on contexts. By calibrating each country to a global measure, the Food Insecurity Experience Scale provides a valid and scalar-equivalent measure suitable for estimating and monitoring prevalence in a comparable way across countries.

1. Introduction

Food security exists “when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (FAO, 1996). The concept of food security can be used at individual, household, community, national, regional, and global levels (Pelletier et al., 2012; Leroy et al., 2015). Beginning about thirty years ago, as documented by qualitative research (Radimer et al., 1992) and community work (Wehler et al., 1992), food insecurity has been understood as being experienced by households and individuals. These experiences can include uncertainty about food availability and access, insufficiency in the right foods for health, insufficiency in the amount of food, using socially unacceptable ways to acquire food, and feelings of deprivation (Maxwell, 1996; Wolfe et al., 2003; National Research Council, 2006). Food insecurity affects well-being through compromising dietary intake and nutrition (Gunderson and Ziliak, 2015; Jones, 2017) and is also a powerful stressor that affects physical and mental well-being through physical hunger, distress and adverse family and social interactions, worry and anxiety, deprivation and alienation (Hamelin et al., 2002; National Research Council, 2006; Nanama and Frongillo, 2012; Chilton et al., 2014; Koyanagi et al., 2019; Weaver and Hadley 2009), and compromised ability to manage chronic diseases such as HIV (Weiser

et al., 2015) and diabetes (Mendoza et al., 2018).

Food security has been measured in many ways, including based on household income or expenditure, food consumption, home production of food, market distance, and per capita food availability (Maxwell and Frankenberger, 1992; Wolfe and Frongillo, 2001; Cafiero et al., 2014). The understanding that food insecurity was experienced by households and individuals prompted the development in the United States of a method to measure food insecurity that entailed using survey items administered to individuals representing either themselves or their households about their experiences (Radimer et al., 1992). The survey questions were developed drawing on concepts and language from in-depth interviews with individuals in households at high risk of food insecurity. This method originated in the United States and was extended to other countries in the following years (Studdert et al., 2001). During the past thirty years, extensive research has been done to develop, adapt, and establish the validity and cross-cultural equivalence of experience-based measures of food insecurity in many countries. Because the four most commonly used experience-based measures of food insecurity share lineage and are composed of similar sets of items covering four universally experienced sub-constructs of food insecurity, studies of the validity and cross-cultural equivalence of these measures have created a shared body of evidence. The aim of this article is to review the evidence for the validity and cross-context equivalence of experience-based measures of food insecurity, in particular the Food

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Abbreviations

ELCSA	Latin American and Caribbean Food Security Scale
FAO	Food and Agriculture Organization
FIES	Food Insecurity Experience Scale
HFIAS	Household Food Insecurity Access Scale
HFSSM	Household Food Security Survey Module

Insecurity Experience Scale, for estimating and monitoring prevalence at the country level globally.

2. Concepts of validity and cross-context equivalence

A measure of food insecurity assigns numbers to households or individuals to represent the relative degree of food insecurity (Frongillo et al., 2019a). An indicator of food insecurity, in contrast, reflects the presence or absence of a given degree of food insecurity. Indicators are important to describe and communicate about a population, often by presenting a prevalence. For experience-based measures of food insecurity, indicators are usually constructed by classifying values of the measure (i.e., a scale formed from multiple survey items), with the classification based on degree and/or specific meaning of items corresponding to values of the measure (Frongillo et al., 2004).

Two conceptual systems for validity exist in the literature: biometric and psychometric (Frongillo et al., 2019a). In the biometric conceptual system for validity (Frongillo, 1999), “validation is the process of determining whether a measure or indicator is suitable for providing useful analytical measurement for a given purpose and context. A measure or indicator is valid if each of six criteria are met: 1) its construction is well-grounded in theory; 2) its performance is consistent with that theory; it is 3) precise, 4) dependable, and 5) accurate within specified performance standards; and 6) its accuracy is attributable to the well-grounded theory for that purpose and context. That is, a valid measure or indicator will be well-constructed and perform according to its construction; reliable (i.e., precise and dependable); and accurate, with accuracy that is attributable to the theory underlying the construction” Frongillo et al. (2019a). Validity of a measure or indicator is always tied to a particular purpose and context because the measure or indicator can be valid for one purpose or in one context but not others. Possible purposes at the group (i.e., population) level are estimation of prevalence, monitoring, determination of causes and consequences, early warning, targeting, and impact evaluation of programs (Frongillo et al., 2019a). Possible purposes at the individual (i.e., within population) level are screening, diagnosis of problem, diagnosis of solution, and monitoring.

Cross-context equivalence refers to whether a measure or indicator performs consistently across contexts (Frongillo et al., 2019a). In psychometrics, measurement invariance is a concept parallel to cross-cultural equivalence. Four types of cross-context equivalence are construct, item, measurement, and scalar. Construct equivalence means that a given construct is comparable across contexts. Item equivalence means that an item tapping a given construct is comparable across contexts because the content of the item is understood and interpreted in the same way. Measurement equivalence means that differences in values of a measure between two individuals are comparable across contexts because the constructs, items, and units are the same. Scalar equivalence means that, in addition, zero is defined the same across contexts (or could be defined the same using a simple, known transformation, e.g., Celsius and Fahrenheit scales for temperature) resulting in comparable average scores and prevalence values.

3. Experience-based measures of food insecurity

Four experienced-based measures of food insecurity are commonly used (Leroy et al., 2015), although context-specific experienced-based measures have also been developed in several countries (Marques et al., 2014). These four commonly used measures are composed of similar sets of items covering four sub-constructs of food insecurity: uncertainty, compromised dietary quality or preferences, eating less, and going hungry (i.e., experiencing physical hunger) (Table 1).

The Household Food Security Survey Module (HFSSM) was developed beginning in early 1994 to estimate and monitor the prevalence of food insecurity in the United States among groups of households (Bickel et al., 2000), although it has also been used for targeting interventions, impact evaluations (Frongillo and Wolfe, 2010; Weiser et al., 2015; Heberlein et al., 2016; Frongillo et al., 2019b), and research on the causes and consequences of food insecurity (Leroy et al., 2015). The HFSSM was created by combining and adapting items from two prior scales (Radimer et al., 1992; Wehler et al., 1992). The HFSSM consists of 18 items, with eight items specific to households with children. The items ask whether an experience occurred, with some items also asking how often they occurred. A six-item version has been developed Blumberg et al. (1999), and an adapted HFSSM was tested in several developing countries, including Bolivia, Philippines, and Burkina Faso (Melgar-Quinonez et al., 2006).

The Latin American and Caribbean Food Security Scale (ELCSA) was derived from the Brazilian Food Insecurity Scale, which was adapted from the HFSSM; it was also informed by survey instruments used in Colombia and Venezuela (Pérez-Escamilla et al., 2004; FAO, 2012). The ELCSA was harmonized for use across Latin America and the Caribbean. The harmonized version has been adopted in other Spanish-speaking countries and other regions. The scale consists of 15 items which ask whether an experience occurred, with seven items specific to households with children (Pérez-Escamilla et al., 2004; FAO, 2012).

The Household Food Insecurity Access Scale (HFIAS) was developed by the Food and Nutrition Technical Assistance Project to provide development organizations with a measure to use in evaluating food security programs in low-income countries (Coates et al., 2007). The HFIAS has nine items, each of which asks if the experience described occurred and, if so, how often it occurred.

The Food Insecurity Experience Scale (FIES) was developed by the Food and Agriculture Organization (FAO) with the intention to provide comparable estimates of prevalence across countries that would provide the consistency needed for global monitoring (Cafiero et al., 2018). The FIES has eight items that ask individuals about whether an experience occurred. FAO has implemented the FIES in the nationally representative Gallup World Poll each year starting with 2014 in about 150 countries.

These four experienced-based questionnaires to measure food insecurity were designed to be administered to adults, with the FIES administered to individuals ages 15 and greater. Adults are asked in the HFSSM and the ELCSA questionnaires to report on the experiences of their children. The experiences of children and adolescents with food insecurity, however, differ from the experiences of adults. Children and adolescents experience food insecurity in three sub-constructs of awareness (i.e., cognitive, emotional, and physical awareness) and three sub-constructs of taking responsibility (i.e., participation in adult strategies to address food needs, initiation of strategies, and generation of resources) (Fram et al., 2011; Bernal et al., 2012). Reports by children and adolescents of their experiences of food insecurity are weakly associated with adult reports of household or child and adolescent food insecurity (Fram et al., 2013; Bernal et al., 2016; Frongillo et al., 2019c), and adult reports of child food insecurity are inaccurate compared with child and adolescent reports of their own food insecurity (Bernal et al., 2016). Therefore, a globally applicable questionnaire to assess the food-insecurity experiences of children and adolescents directly from them is being developed and field tested (Fram et al., 2015).

Table 1

Comparison of items from the Household Food Security Survey Module, Latin American and Caribbean Household Food Security Measurement Scale, Household Food Insecurity Access Scale and Food Insecurity Experience Scale.

Sub-construct	Household Food Security Survey Module	Latin American and Caribbean Household Food Security Measurement Scale	Household Food Insecurity Access Scale	Food Insecurity Experience Scale
	In the last 12 months (or 30 days):	During the last 3 months:	In the past four weeks:	During the last 12 months, was there a time when:
Uncertainty	We worried whether our food would run out before we got money to buy more. Was that often true, sometimes true, or never true for your household? The food that we bought just didn't last, and we didn't have money to get more. Was that often, sometimes, or never true for your household?	Were you worried that you would run out of food before being able to buy or receive more food? Did you run out of food before having money to buy more?	Did you worry that your household would not have enough food? Were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources? Did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other	You were worried you would run out of food because of a lack of money or other resources? You were unable to eat healthy and nutritious food because of a lack of money or other resources? You ate only a few kinds of foods because of a lack of money or other resources?
Compromised dietary quality or preferences	We couldn't afford to eat balanced meals. Was that often, sometimes, or never true for your household?	Did you run out of money to have a healthy and varied diet? Did you have to consume just a few foods because you ran out of money?	Were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources? Did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other	

Table 1 (continued)

Sub-construct	Household Food Security Survey Module	Latin American and Caribbean Household Food Security Measurement Scale	Household Food Insecurity Access Scale	Food Insecurity Experience Scale
Eating less	Did you or other adults in your household ever cut the size of your meals or skip meals because there wasn't enough money for food? Did you ever eat less than you felt you should because there wasn't enough money for food?	Did you or any adult in your household ever reduce the size of meals or skipped meals because there wasn't enough money to buy food? Did you ever eat less than what you thought you should because there wasn't enough money to buy food?	types of food? Did you or any other household member have to eat fewer meals in a day because there was not enough food? Did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food? Was there ever no food to eat of any kind in your household because of lack of resources to get food? Did you or any household member go to sleep at night hungry because there was not enough food?	You had to skip a meal because there was not enough money or other resources to get food? You ate less than you thought you should because of a lack of money or other resources? Your household ran out of food because of a lack of money or other resources? You were hungry but did not eat because there was not enough money or other resources for food?
Going hungry	Were you ever hungry but didn't eat because there wasn't enough money for food? Did you lose weight because you didn't have enough money for food? Did you or other adults in your household ever not eat for a whole day because there wasn't enough money for food?	Did you ever feel hungry but didn't eat because there wasn't enough money to buy food? Did you lose weight because you didn't have enough money to buy food? Did you or any adult in your household ever go without eating for a whole day or just had one meal in a whole day because there wasn't enough money to buy food?		You went without eating for a whole day because of a lack of money or other resources?

The Household Food Security Survey Module and the Latin American and Caribbean Household Food Security Measurement Scale have both adult-

referenced and child-referenced items; for the comparison only the adult-referenced items are shown.

4. Evidence of validity of experience-based measures

4.1. Construction

In-depth qualitative research from multiple countries established that individuals in food-insecure households have experiences that can fall into one or more of four constructs: quantity of food, quality of food, psychological, and social (Wolfe et al., 2003; Nanama and Frongillo, 2012). Experiences in the quantitative construct range from (least to most severe) food depletion (i.e., low food stocks) to having to eat less food than usual to going one or more days without food (i.e., physical hunger) (Radimer et al., 1992; Wolfe et al., 2003). Experiences in the qualitative construct range from having to buy and eat less-preferred foods to having to eat a nutritionally inadequate diet to not able to eat the right food and meals for health. The psychological construct involves how an individual knows, perceives, and feels in two sub-constructs: 1) an uncertain food situation and not having the right foods for health lead to feelings of worry and anxiety worry, and 2) lack of choice and need to make compromises lead to feelings of deprivation and embarrassment. The social construct involves two sub-constructs: 1) accessing food in socially unacceptable ways such as having to rely on a food pantry (less severe), buying food on credit (less severe), having to ask others for food or meals (more severe), and borrowing money for food (more severe), with severity also depending on frequency; and 2) socially or culturally less normative patterns of eating (Radimer et al., 1992; Wolfe et al., 2003).

The HFSSM was developed to yield a scale that behaved as one dimension; having one dimension was deemed important for simplicity of construction and communication to achieve the primary purpose of having a measure for national monitoring (Bickel et al., 2000). Rasch modeling was used to help guide selection of items to be included in the scale (Bickel et al., 2000). Rasch modeling assumes one latent dimension, equal discrimination of items, conditional independence of items on the latent dimension, and that items can be ranked by degree of difficulty or severity, with fewer affirmations expected for items that are deemed more severe. The HFSSM also assumed that the items would exhibit a near-Guttman property meaning that most individuals affirming a given item would also affirm all items deemed less severe. As a result of the focus in this development of yielding a one-dimensional scale, the psychological sub-construct of feeling deprived and embarrassed and the two social sub-constructs were not included among the set of items that were selected. The other three commonly used scales are similar in the sub-constructs included. One item about feeling ashamed was tested in Costa Rica but was not included in the HFIAS because it loaded more poorly than the other items in a factor analysis (i.e., did not fit well with the one dimension) (González et al., 2008) and because asking about social unacceptability and feelings of shame might be difficult to do in a way that was equivalent across contexts. Other experienced-based measures of food insecurity developed for specific contexts have included items assessing these psychological and social sub-constructs (Frongillo and Nanama, 2006). For each of these scales, the number of affirmed items (and the frequency of them for the HFIAS) are summed to create a score and then thresholds are applied to create indicators.

A detailed review of the HFSSM by the United States National Research Council [2006] confirmed that the HFSSM is well-constructed and performs in a manner consistent with its construction. The HFSSM is well-constructed because of its grounding in understanding gained from formal in-depth interviews and informal contact with food-insecure individuals and households (Frongillo, 1999). The performance of the HFSSM being consistent with construction has been demonstrated in four ways (Frongillo, 1999). Factor analysis confirmed the conceptualized sub-constructs in empirical data. The proportion of affirmative

responses reflects the conceptualized sequence of severity, i.e., items assumed to be more severe are affirmed less frequently. Cognitive interviewing ensured that items ask a meaningful question that respondents can answer and interpret as intended. The patterns of affirmative responses were consistent across sub-groups of the population.

The ELCSA, which was adapted from the HFSSM with input from focus groups to ensure good construction, also performs consistent with construction (Leroy et al., 2015). The HFIAS was constructed by a team of experts (Coates et al., 2007) using information from a review of the commonalities in the experience of food insecurity and how it is expressed across cultures (Coates et al., 2006) and performs as expected.

The FIES was constructed after consultation with a broad set of stakeholders (Cafiero et al., 2018). The FIES was constructed assuming a Rasch model, meaning one latent construct. Factor analysis with FIES data showed that one factor explained a high proportion of the variance, consistent with one latent construct (Grimaccia and Naccarato, 2020). Using the FIES data, each respondent to the survey module is assigned a probability of having severity equal to or greater than a specified threshold of severity (Cafiero et al., 2018). The scales from different countries are made comparable by calibrating each against a common global reference scale. The global reference scale was developed based on median normalized severities of each FIES item. This global reference scale was used to calibrate the scale for each country separately by equating the mean and standard deviation of the Rasch severity parameters of the items that appear to be common between the country scale and the global reference scale, providing anchoring points. Four or more items could be used as anchoring points in nearly all (151 of 153) countries, and 6 or more items could be used as anchoring points for 121 countries (79%). Two specific severity thresholds were used to obtain for individuals the probability of severe food insecurity and the probability of moderate and severe food insecurity. From 2014 FIES data for Sub-Saharan Africa, the Rasch assumptions of equal discrimination and conditional independence were found to be largely met, but about one-third of countries had evidence of lack of fit for one item on “went without eating for a whole day”; these results confirm that FIES is useful in that region, but the one item could benefit from further cognitive interviewing in a few countries (Wambogo et al., 2018).

4.2. Reliability

Reliability of scales at the individual level is usually assessed by internal consistency of items, which does not differentiate precision and dependability. Internal consistency of the HFSSM, ELCSA, and HFIAS has been uniformly high, with Cronbach alpha ≥ 0.85 (National Research Council, 2006; González et al., 2008; Leroy et al., 2015). Reliability across countries for the FIES estimated through the Rasch model was 0.740 on average (range 0.68–0.83) and greater than 0.70 for 88% of countries in 2014 (Cafiero et al., 2018). Reliability for the FIES estimated as Cronbach alpha was 0.93 (Grimaccia and Naccarato, 2020). Unreliability in estimating country prevalence for a sample size of 1000 as is typical of the Gallup World Poll is much smaller than at the individual level and small compared to sampling error (Cafiero et al., 2018).

4.3. Accuracy

Accuracy is the extent to which a measure provides unbiased assessment of what is intended (Frongillo, 1999; Leroy et al., 2015; Frongillo et al., 2019a). Accuracy is most often demonstrated by comparing the measure to one or more criterion measures. Ideally the criterion used is a definitive measure which sometimes is called a gold-standard measure. A definitive measure “relies on first principles (i.e., the fundamental and self-evident basis) to achieve high accuracy, i.e., with little or no error, and reflects in a fundamental way the theoretical structure” of what it purports to represent (Frongillo et al., 2019a). When a definite measure is not available, accuracy can be demonstrated by comparing with a theoretically closely related determinant or

consequence as a criterion measure.

The accuracy of the HFSSM in comparison to a definitive measure has been done in three studies. The definitive measures were obtained by classifying households or individuals using in-depth information from interviews (Frongillo et al., 1997; Wolfe et al., 1998; Wolfe et al., 2003). Good sensitivity (84%, 92%, and 89%) and specificity (71%, 75%, and 69%) were found, demonstrating that the HFSSM accurately classified households that were truly food secure as food secure and that were truly food insecure as food insecure (Table 2). In addition, a context-specific experienced-based measure of food insecurity developed in Burkina Faso was compared with a definitive classification obtained by having an observer with in-depth knowledge classify households; the measure had accuracy of 0.68–0.72 from area under the receiver operating characteristic curve (Frongillo and Nanama, 2006). An experienced-based measure of food insecurity developed in the United States for children aged 6–17 years was compared with a definitive classification obtained by in-depth interviews; for four child sub-constructs of food insecurity (Fram et al., 2011), the measure had accuracy of 0.77–0.85 from area under the receiver operating characteristic curve (Fram et al., 2013).

The accuracy of the HFSSM also has been demonstrated using criterion measures such as poverty status, education, program participation, and quantity and quality of dietary intake in groups of households (Frongillo, 1999; Leroy et al., 2015). In one early study, the percentage of households with income < \$10,000 per year was 11.2, 31.7, 36.2, and 50.9, respectively, in comparison to four ordinal categories of food insecurity from food secure to severely food insecure (Kendall et al., 1995). A measure of dietary quality, the frequency (times/week) of consumption of fruits and vegetables, was 27.6, 22.2, 20.7, and 15.5, respectively, in comparison to the ordinal categories of food insecurity (Kendall et al., 1996). The validity of the 6-item HFSSM has been demonstrated in Hawaii and among Latinos (Blumberg et al., 1999). The HFSSM adapted to Bolivia, Philippines, and Burkina Faso was negatively associated with expenditures reflecting both quantity and quality of food (Melgar-Quinonez et al., 2006). For instance, daily per capita expenditure on animal-source foods was associated with food insecurity score, with correlations 0.38, 0.26, and 0.31 in Bolivia, Philippines, and Burkina Faso, respectively. Furthermore, from a large number of studies, the HFSSM measure of food insecurity has been demonstrated to be associated, accounting for other social and economic variables, with many adverse health and developmental consequences in children and adults that are both nutritional and non-nutritional in nature: higher prevalence of inadequate intake of key nutrients, risk of overweight in women and some girls, depressive symptoms and risk of suicide in adolescents, behavior problems and shame in children, academic and social developmental delays in children, and poor physical and mental health (National Research Council, 2006; Cotugna and Forbes 2008; Sharkey et al., 2012; Chilton and Rabinowich, 2012; McIntyre et al., 2013; Bernal et al., 2014; To et al., 2014; Fram et al., 2015; Jackson and Vaughn, 2017; Frongillo et al., 2021).

The accuracy of the ELCSA has been demonstrated for households in comparison to determinants or consequences of food security including quantity and quality of food (Pérez-Escamilla et al., 2004; Melgar-Quinonez et al., 2005; Pérez-Escamilla and Pinheiro de Toledo Vianna, 2012; Pinheiro de Toledo Vianna et al., 2012). Across multiple samples for example, 13–32% of households with severe food insecurity

consumed fruits, non-root or tuber vegetables, and meat compared to 71–91% of households with food security. When compared with usual total energy consumption of all household members, the ELCSA had poor sensitivity (63%) and specificity (62%) for differentiating households that were food-insecure and food-secure (Jiménez et al., 2012), but total energy consumption is not a definitive measure of food insecurity.

Accuracy for the HFIAS was examined in Costa Rica by comparing with poverty, education, income, and health insurance coverage (González et al., 2008). For example, the percentage of households with food security was 71, 23, and 6 for non-poor, poor, and extremely poor households, respectively. In Mozambique, 44% of households with low socioeconomic status were food-insecure compared with 26% of households with middle or high socioeconomic status (FAO, 2008). Food-insecure households consumed less fish than food-secure households at both pre- and post-harvest times, with a 66% reduction in fish consumption post-harvest in food-insecure households compared to a 36% reduction in food-secure households. In Burundi, the HFIAS was significantly associated with total annual food production, livestock keeping, and coffee production in each of two years (Desiere et al., 2015). In rural Lebanon, the Arabic version of the HFIAS was associated with mother's and father's education levels, number of cars and electrical appliances in the household, income, weight-for-age and length-for-age of the child, child's dietary adequacy, mother's body mass index, and crowding index (Naja et al., 2014). The HFIAS had modest accuracy for predicting body mass index in a population with HIV in Ethiopia, with area under the receiver operating characteristic curve of 0.73 (Hussein et al., 2018).

Examining the accuracy of a measure in comparison to a definitive or other criterion measure is insufficient to confirm that the apparent accuracy is due to the well-grounded understanding upon which the measure was constructed (Frongillo, 1999; Frongillo et al., 2019a). A measure that is only apparently accurate may be useless (Frongillo et al., 2019a). Demonstrating attribution of accuracy is done by comparing a measure with competing measures and examining alternative explanations (Frongillo et al., 2019a). Two studies in the United States and Burkina Faso have demonstrated that an experienced-based measure of food insecurity was associated with a definitive measure of food insecurity above and beyond competing measures that potentially represented alternative explanations for the association (Frongillo, 1999; Frongillo and Nanama, 2006). In each study, the experienced-based measure predicted the definitive measure after accounting for the competing measures.

Using the individual-level data from the 2014 Gallup World Poll, the probability of moderate and severe food insecurity from the FIES was a stronger predictor of health problems and subjective well-being than the other measures of living conditions, i.e., household income, shelter, and employment (demonstrating accuracy) (Frongillo et al., 2017). Food insecurity predicted additional variability in health problems and subjective well-being after accounting for the competing measures of living conditions (demonstrating attribution of accuracy). Using the same data aggregated to the country level, the average probability of moderate and severe food insecurity was strongly associated with other measures of country economic and social development with, for example, correlations of −0.759, 0.792, 0.743, 0.804, and −0.706 with logarithm of gross domestic product per capita, logarithm of total fertility rate, infant

Table 2

Accuracy of experienced-based measures at household or individual level demonstrated by comparison to definitive classification.

Location	Sample	Study	N	Sensitivity	Specificity	Area under the receiver operating characteristic curve ^a
Upstate NY	Household	Frongillo et al. (1997)	148	0.84	0.71	0.78
Upstate NY	Seniors	Wolfe et al. (1998)	24	0.92	0.75	0.83
Burkina Faso	Household	Frongillo and Nanama (2006)	126	–	–	0.72, 0.68
South Carolina	Children	Fram et al. (2013)	87	–	–	0.77–0.85

^a The area under the receiver operating characteristic curve has range 0 (i.e., chance) to 1 (perfect accuracy).

mortality rate, logarithm of maternal mortality rate, and female mean years of school, respectively (demonstrating accuracy) (Frongillo et al., 2019d). Food insecurity was more strongly associated with subjective well-being than the other measures of country economic and social development examined and explained variation in subjective well-being after accounting for the other measures (demonstrating attribution of accuracy). Using individual-level FIES data from 2014 to 2019, both absolute and relative food insecurity were associated with more mental health symptoms and lower subjective well-being (Elgar et al., 2021).

In similar analyses at the country level, the FIES prevalence of moderate and severe food insecurity was correlated highly with the FAO prevalence of undernourishment (0.79), child malnutrition (0.60), World Bank poverty rate (0.84), Human Development Index (−0.86), and the World Health Organization under-5 mortality rate (0.87) (demonstrating accuracy) (Cafiero et al., 2018). Across 92 countries having the required measures, the prevalence of moderate and severe food insecurity was a significant predictor of variation in child mortality rate, explaining about one-third of the variability after accounting for the prevalence of undernourishment and the prevalence of extreme poverty (demonstrating attribution of accuracy).

Several other studies have presented evidence of the accuracy of the FIES. At the country level, food insecurity of Arab youth was correlated about 0.6 with measures of subjective well-being (Asfahani et al., 2019). At the individual level, food insecurity was associated with intimate partner violence in Ethiopia (Andarge and Shiferaw, 2018) and with low education, limited social capital, and living in a country with low gross domestic product per capita in Latin America and the Caribbean (Smith et al., 2017a). With the 2014 global data, food insecurity was associated with poverty (Grimaccia and Naccarato, 2019), and with low levels of education, weak social networks, less social capital, low household income, and being unemployed (Smith et al., 2017b).

5. Evidence of cross-cultural equivalence of experience-based measures

Insufficient food quantity, inadequate food quality, uncertainty and worry, and concerns about social acceptability about food were important experiences of food insecurity in all or nearly all cultures based on analysis of content of 22 scales and related ethnographies derived from 15 different countries (Coates et al., 2006). Furthermore, some sub-constructs and items were common across contexts. The same perceptions and behaviors in one context, however, did not necessarily reflect comparable severity in another context. Therefore, although construct equivalence is expected for the four common constructs, and item equivalence expected for the first three sub-constructs when measured by carefully selected items, measurement or scalar equivalence across all contexts may not directly result from a set of survey items for experiences of food insecurity.

Scalar equivalence of the HFSSM has been demonstrated in the U.S. through examining the pattern of responses for items across groups (Frongillo, 1999). Construct and item equivalence of the HFSSM items was demonstrated across Bolivia, Burkina Faso, and the Philippines from cognitive interviewing (Melgar-Quinonez et al., 2006). For the ELCSA, scalar equivalence has been demonstrated across groups within countries and measurement equivalence demonstrated across the Latin American Spanish-speaking countries (Melgar-Quinonez et al., 2010). For the HFIAS, the first six of the nine items of the scale that reflect less severe experiences of food insecurity (e.g., worry, changes in diet quality or reductions in quantity) were found to be construct equivalent but not measurement or scalar equivalent because the pattern of item responses were dissimilar across eight countries (Deitchler et al., 2010). Therefore, scores and prevalence across countries were not comparable. The three items that were least frequently affirmed and reflect severe food insecurity were scalar equivalent across the countries.

FAO developed the FIES intending to overcome these limitations in equivalence to provide adjusted scales with scalar equivalence so that

comparable estimates of prevalence are obtained across countries (Cafiero et al., 2018). To obtain scalar equivalence, a global reference scale was developed as described earlier. Estimates of the scale in countries were compared across the surveys in 2014, 2015, and 2016 and were found to be highly stable (Cafiero et al., 2018). For monitoring progression towards the Sustainable Development Goals, given the modest sample size per year in nearly all countries, combining data across years such as through using three-year moving averages would reduce the variability contributed by both the small instability in annual estimation and sampling error (Cafiero et al., 2018).

6. Conclusion

Experience-based measures have proven suitable for providing useful analytical measurement to estimate and monitor prevalence of food insecurity and evaluate interventions and programs. The availability of these measures has resulted in extensive research about the determinants and the substantial consequences of food insecurity among households and individuals. The commonly used measures (i.e., HFSSM, ELCSA, HFIAS, and FIES) are composed of similar sets of items that cover the same four universally experienced sub-constructs of food insecurity and consequently share the same body of evidence of validity that has accrued over the past thirty years. The evidence for validity and construct equivalence of these measures for differentiating households as to food insecurity is strong. Prior to the development of the FIES, the evidence on equivalence concluded that responses to some items depend on cultural and social contexts, preventing scalar equivalence across countries. The three HFIAS items that reflect severe food insecurity (i.e., hunger) had been shown to be scalar equivalent, but a scale based only on these items is not useful because only the most severe food-insecurity experiences are measured. The FIES provides a valid and scalar-equivalent scale that is suitable for estimating and monitoring prevalence of experiencing food insecurity in a comparable way across countries.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

- Andarge, E., Shiferaw, Y., 2018. Disparities in intimate partner violence among currently married women from food secure and insecure urban households in South Ethiopia: a community based comparative cross-sectional study. *BioMed Res. Int.* 4738527. <https://doi.org/10.1155/2018/4738527>.
- Asfahani, F., Kadiyala, S., Ghattas, H., 2019. Food insecurity and subjective wellbeing among Arab youth living in varying contexts of political instability. *J. Adolesc. Health* 64, 70–78. <https://doi.org/10.1016/j.jadohealth.2018.08.010>.
- Bernal, J., Frongillo, E.A., Herrera, H., Rivera, J., 2012. Children live, feel, and respond to experiences of food insecurity that compromise their development and weight status in peri-urban Venezuela. *J. Nutr.* 142, 1343–1349.
- Bernal, J., Frongillo, E.A., Rivera, J., 2016. Food insecurity reported by children, but not by mothers, is associated with lower quality of diet and shifts in foods consumed. *Matern. Child Nutr.* 12, 546–557.

- Bernal, J., Frongillo, E.A., Herrera, A., Rivera, J.A., 2014. Food insecurity in children but not in their mothers is associated with altered activities. *J. Nutr.* 144 (24), 1619–1626. <https://doi.org/10.3945/jn.113.189985>.
- Bickel, G., Nord, M., Price, C., Hamilton, W., Cook, J., 2000. *Guide to Measuring Household Food Security*, Revised 2000. Economic Research Service, US Department of Agriculture, Alexandria, VA.
- Blumberg, S.J., Bialostosky, K., Hamilton, W.L., Briefel, R.R., 1999. The effectiveness of a short form of the household food security scale. *Am. J. Publ. Health* 89, 1231–1234. <https://doi.org/10.2105/AJPH.89.8.1231>.
- Cafiero, C., Melgar-Quinonez, H.R., Ballard, T.J., Kepple, A.W., 2014. Validity and reliability of food security measures. *Ann. N. Y. Acad. Sci.* 1331, 230–248. <https://doi.org/10.1111/nyas.12594>.
- Cafiero, C., Viviani, S., Nord, M., 2018. Food security measurement in a global context: the food insecurity experience scale. *Measurement* 116, 146–152. <https://doi.org/10.1016/j.measurement.2017.10.065>.
- Chilton, M., Rabinowich, J., 2012. Toxic stress and child hunger over the life course: three case studies. *J. Appl. Res. Child.* 3 (1). <http://digitalcommons.library.tmc.edu/childrenatrisk/vol3/iss1/3>.
- Chilton, M.M., Rabinowich, J.R., Woolf, N.H., 2014. Very low food security in the USA is linked with exposure to violence. *Publ. Health Nutr.* 17 (1), 73–82. <https://doi.org/10.1017/S1368980013000281>.
- Coates, J., Frongillo, E.A., Rogers, B.L., Webb, P., Wilde, P.E., Houser, R., 2006. Commonalities in the experience of household food insecurity across cultures: what are measures missing? *J. Nutr.* 136, 1438S–1448S. <https://doi.org/10.1093/jn/136.5.1438S>.
- Coates, J., Swindale, A., Bilinsky, P., 2007. *Household food insecurity access scale (HFIAS) for measurement of food access: indicator guide (v.3)*. In: *Food and Nutrition Technical Assistance Project. FANTA/Academy for Educational Development*, Washington D.C.
- Cotugna, N., Forbes, S., 2008. A backpack program provides help for weekend child hunger. *J. Hunger Environ. Nutr.* 2 (4), 39–46. <https://doi.org/10.1080/19320240802032099>.
- Deitchler, M., Ballard, T., Swindale, A., Coates, J., 2010. Validation of a measure of household hunger for cross-cultural use. *Food and Nutrition Technical Assistance II Project (FANTA-2)*. AED, Washington, DC.
- Desiere, S., D'Haese, M., Niragira, S., 2015. Assessing the cross-sectional and inter-temporal validity of the household food insecurity access scale (HFIAS) in Burundi. *Publ. Health Nutr.* 18, 2775–2785. <https://doi.org/10.1017/S1368980015000403>.
- Elgar, F.J., Pickett, W., Pfortner, T.K., Gariépy, G., Gordon, D., Georgiades, K., Davison, C., Hammami, N., MacNeil, A.H., Azevedo Da Silva, M., Melgar-Quinonez, H.R., 2021. Relative food insecurity, mental health and wellbeing in 160 countries. *Soc. Sci. Med.* 268, 113556. <https://doi.org/10.1016/j.socscimed.2020.113556>.
- FAO, 1996. *Rome Declaration on World Food Security and World Food Summit Plan of Action*. Food and Agricultural Organization of the United Nations, Rome.
- FAO, 2008. *Report on Use of the Household Food In Security Access Scale and Household Dietary Diversity Score in Two Survey Rounds in Manica and Sofala Provinces, Mozambique, 2006-2007*. Food and Agriculture Organization, Rome.
- FAO, 2012. *Escala Latinoamericana y Caribeña de seguridad alimentaria (ELCSA): Manual de uso y aplicaciones*. FAO Regional Office, Latin America, Santiago, Chile.
- Fram, M.S., Frongillo, E.A., Jones, S.J., Williams, R.C., Burke, M.P., DeLoach, K.P., Blake, C.E., 2011. Children are aware of food insecurity and take responsibility for managing food resources. *J. Nutr.* 141, 1114–1119. <https://doi.org/10.3945/jn.110.135988>.
- Fram, M.S., Frongillo, E.A., Draper, C.L., Fishbein, E.M., 2013. Development and validation of a child-report assessment of child food insecurity and comparison to parent-report assessment. *J. Hunger Environ. Nutr.* 8, 128–145. <https://doi.org/10.1080/19320248.2013.790775>.
- Fram, M.S., Bernal, J., Frongillo, E.A., 2015. The measurement of food insecurity among children: review of literature and concept note. UNICEF Innocenti Research Centre, Florence, Italy. Innocenti Working Papers No. 2015-08. <https://www.unicef-irc.org/publications/pdf/Food%20security.pdf>. (Accessed 24 November 2021).
- Frongillo, E.A., 1999. Validation of measures of food insecurity and hunger. *J. Nutr.* 129, 506S–509S. <https://doi.org/10.1093/jn/129.2.506S>.
- Frongillo, E.A., Rauschenbach, B.S., Olson, C.M., Kendall, A., Colmenares, A.G., 1997. Community and international nutrition questionnaire-based measures are valid for the identification of rural households with hunger and food insecurity. *J. Nutr.* 127, 699–705. <https://doi.org/10.1093/jn/127.5.699>.
- Frongillo, E.A., Nanama, S., Wolfe, W.S., 2004. Technical guide to developing a direct, experience-based measurement tool for household food insecurity. In: *Food and Nutrition Technical Assistance*. Academy for Educational Development, Washington D.C.
- Frongillo, E.A., Nanama, S., 2006. Development and validation of an experience-based measure of household food insecurity within and across seasons in northern Burkina Faso. *J. Nutr.* 136, 1409S–1419S. <https://doi.org/10.1093/jn/136.5.1409S>.
- Frongillo, E.A., Wolfe, W.S., 2010. Impact of participation in Home-Delivered Meals on nutrient intake, dietary patterns, and food insecurity of older persons in New York state. *J. Nutr. Elder.* 29, 293–310. <https://doi.org/10.1080/01639366.2010.499094>.
- Frongillo, E.A., Nguyen, H.T., Smith, M.D., Coleman-Jensen, A., 2017. Food insecurity is associated with subjective well-being among individuals from 138 countries in the 2014 Gallup World Poll. *J. Nutr.* 147, 680–687. <https://doi.org/10.3945/jn.116.243642>.
- Frongillo, E.A., Baranowski, T., Subar, A.F., Toozé, J.A., Kirkpatrick, S.I., 2019a. Establishing validity and cross-context equivalence of measures and indicators. *J. Acad. Nutr. Diet.* 119, 1817–1830. <https://doi.org/10.1016/j.jand.2018.09.005>.
- Frongillo, E.A., Nguyen, P.H., Sanghvi, T., Mahmud, Z., Aktar, B., Alayon, S., Menon, P., 2019b. Nutrition interventions integrated into an existing maternal, neonatal, and child health program reduced food insecurity among recently delivered and pregnant women in Bangladesh. *J. Nutr.* 149, 159–166. <https://doi.org/10.1093/jn/149.2.159>.
- Frongillo, E.A., Fram, M.S., Escobar-Alegría, J.L., Pérez-Garay, M., Macaudo, M.M., Billings, D.L., 2019c. Concordance and discordance of the knowledge, understanding, and description of children's experience of food insecurity among Hispanic adults and children. *Fam. Community Health* 42, 237–244.
- Frongillo, E.A., Nguyen, H.T., Smith, M.D., Coleman-Jensen, A., 2019d. Food insecurity was more strongly associated with poor subjective well-being in more-developed countries than in less-developed countries. *J. Nutr.* 149, 240–248. <https://doi.org/10.1093/jn/149.2.240>.
- Frongillo, E.A., Bernal, J., Rampalli, K.K., Massey, E., Adams, E.J., Rosemond, T.N., Blake, C.E., 2021. Experiences and situations of shame among food-insecure adolescents in South Carolina and Oregon. *Ecol. Food Nutr.* <https://doi.org/10.1080/03670244.2021.1956484>.
- González, W., Jiménez, A., Madrigal, G., Muñoz, L.M., Frongillo, E.A., 2008. Development and validation of measure of household food insecurity in urban Costa Rica confirms proposed generic questionnaire. *J. Nutr.* 138, 587–592. <https://doi.org/10.1093/jn/138.3.587>.
- Grimaccia, E., Naccarato, A., 2019. Food Insecurity Individual Experience: a comparison of economic and social characteristics of the most vulnerable groups in the world. *Soc. Indic. Res.* 143, 391–410. <https://doi.org/10.1007/s11205-018-1975-3>.
- Grimaccia, E., Naccarato, A., 2020. Confirmatory factor analysis to validate a new measure of food insecurity: perceived and actual constructs. *Qual. Quantity* 54, 1211–1232. <https://doi.org/10.1007/s11135-020-00982-y>.
- Gunderson, C., Ziliak, J.P., 2015. Food insecurity and health. *Health Aff.* 34 (11), 1830–1839. <https://doi.org/10.3109/00016357.2012.743678>.
- Hamelin, A.M., Beaudry, M., Habicht, J.P., 2002. Characterization of household food insecurity in Québec: food and feelings. *Soc. Sci. Med.* 54 (1), 119–132. [https://doi.org/10.1016/S0277-9536\(01\)00013-2](https://doi.org/10.1016/S0277-9536(01)00013-2).
- Heberlein, E., Frongillo, E.A., Picklesimer, A.H., Covington-Kolb, S., 2016. Effects of group prenatal care on food insecurity during late pregnancy and early postpartum. *Matern. Child Health J.* 20, 1014–1024. <https://doi.org/10.1007/s10995-015-1886-8>.
- Hussein, F.M., Ahmed, A.Y., Muhammed, O.S., 2018. Household food insecurity access scale and dietary diversity score as a proxy indicator of nutritional status among people living with HIV/AIDS, Bahir Dar, Ethiopia, 2017. *PLoS One* 13, e0199511. <https://doi.org/10.1371/journal.pone.0199511>.
- Jackson, D.B., Vaughn, M.G., 2017. Household food insecurity during childhood and adolescent misconduct. *Prev. Med.* 96, 113–117. <https://doi.org/10.1016/j.ypmed.2016.12.042>.
- Jiménez, S.A., Prada, G.G., Fernando Herrán, F., 2012. Scales for measuring food security in Colombia. Are they valid? *Rev. Chil. Nutr.* 39, 8–17.
- Jones, A.D., 2017. Food insecurity and mental health status: a global analysis of 149 countries. *Am. J. Prev. Med.* 53 (2), 264–273. <https://doi.org/10.1016/j.amepre.2017.04.008>.
- Kendall, A., Olson, C.M., Frongillo, E.A., 1995. Validation of the Radimer/Cornell measures of hunger and food insecurity. *J. Nutr.* 125, 2793–2801. <https://doi.org/10.1093/jn/129.2.506S>.
- Kendall, A., Olson, C.M., Frongillo, E.A., 1996. Relationship of hunger and food insecurity to food availability and consumption. *J. Am. Diet Assoc.* 96, 1019–1024. [https://doi.org/10.1016/S0002-8223\(96\)00271-4](https://doi.org/10.1016/S0002-8223(96)00271-4).
- Koyanagi, A., Stubbs, B., Oh, H., Veronese, N., Smith, L., Haro, J.M., Vancampfort, D., 2019. Food insecurity (hunger) and suicide attempts among 179,771 adolescents attending school from 9 high-income, 31 middle-income, and 4 low-income countries: a cross-sectional study. *J. Affect. Disord.* 248, 91–98. <https://doi.org/10.1016/j.jad.2019.01.033>.
- Leroy, J.L., Ruel, M., Frongillo, E.A., Harris, J., Ballard, T.J., 2015. Measuring the food access dimension of food security: a critical review and mapping of indicators. *Food Nutr. Bull.* 36, 167–195. <https://doi.org/10.1177/0379572115587274>.
- Marques, E.S., Reichenheim, M.E., de Moraes, C.L., Antunes, M.M.L., Salles-Costa, R., 2014. Household food insecurity: a systematic review of the measuring instruments used in epidemiological studies. *Publ. Health Nutr.* 18, 877–892. <https://doi.org/10.1017/S1368980014001050>.
- Maxwell, S., 1996. Food security: a post-modern perspective. *Food Pol.* 21, 155–170. [https://doi.org/10.1016/0306-9192\(95\)00074-7](https://doi.org/10.1016/0306-9192(95)00074-7).
- Maxwell, S., Frankenberger, T.R., 1992. *Household Food Security: concepts, Indicators, Measurements. A Technical Review*. UNICEF, International Fund for Agricultural Development (IFAD), New York, Rome.
- McIntyre, L., Williams, J.V.A., Lavorato, D.H., Patten, S., 2013. Depression and suicide ideation in late adolescence and early adulthood are an outcome of child hunger. *J. Affect. Disord.* 150 (1), 123–129. <https://doi.org/10.1016/j.jad.2012.11.029>.
- Melgar-Quinonez, H.R., Zubieta, A.C., Valdez, E., Whitelaw, B., Kaiser, L., 2005. Validation of an instrument to monitor food insecurity in Sierra de Manantlán, Jalisco. *Salud Publica Mex.* 47, 413–422. <https://doi.org/10.1590/s0036-36342005000600005>.
- Melgar-Quinonez, H.R., Zubieta, A.C., McKnelly, B., Nteziyaremye, A., Gerardo, M.F.D., Dunford, C., 2006. Household food insecurity and food expenditure in Bolivia, Burkina Faso, and the Philippines. *J. Nutr.* 136, 1431S–1437S. <https://doi.org/10.1093/jn/136.5.1431S>.
- Melgar-Quinonez, H.R., Alvarez Uribe, M.C., Fonseca Centeno, Z., Bermúdez, O., Palma de Fulladolsa, P., Fulladolsa, P., Parás, P., Pérez-Escamilla, R., 2010. Características psicométricas de la escala de seguridad alimentaria ELCSA aplicada en Colombia,

- Guatemala y México. *Segurança Aliment. e Nutr. Campinas* 17, 48–60. <https://doi.org/10.20396/san.v17i1.8634799>.
- Mendoza, J.A., Haaland, W., D'Agostino, R.B., Martini, L., Pihoker, C., Frongillo, E.A., Mayer-Davis, E.J., Liu, L.L., Dabelea, D., Lawrence, J.M., Liese, A.D., 2018. Food insecurity is associated with high risk glycemic control and higher health care utilization among youth and young adults with type 1 diabetes. *Diabetes Res. Clin. Pract.* 138, 128–137. <https://doi.org/10.1016/j.diabres.2018.01.035>.
- Naja, F., Hwalla, N., Fossian, T., Zebian, D., Nasreddine, L., 2014. Validity and reliability of the Arabic version of the household food insecurity access scale in rural Lebanon. *Publ. Health Nutr.* 18, 251–258. <https://doi.org/10.1016/j.jdiabres.2018.01.035>.
- Nanama, S., Frongillo, E.A., 2012. Altered social cohesion and adverse psychological experiences with chronic food insecurity in the non-market economy and complex households of Burkina Faso. *Soc. Sci. Med.* 74, 444–451. <https://doi.org/10.1016/j.socscimed.2011.11.009>.
- National Research Council, 2006. Panel to review U.S department of agriculture's measurement of food insecurity and hunger. In: *Food Insecurity and Hunger in the United States: an Assessment of the Measure*. The National Academies Press, Washington, D.C. <https://doi.org/10.17226/11578>.
- Pelletier, D.L., Olson, C.M., Frongillo, E.A., 2012. Food insecurity, hunger and undernutrition. In: Erdman, J., Macdonald, I., Zeisel, S.I. (Eds.), *Present Knowl. Nutr. Tenth Ed.* International Life Sciences Institute Press, Washington D.C.
- Pérez-Escamilla, R., Segall-Corrêa, A.M., Kurdian Maranhã, L., Sampaio Md M de, F.A., Marín-León, L., Panigassi, G., 2004. An adapted version of the U.S. Department of Agriculture Food Insecurity module is a valid tool for assessing household food insecurity in Campinas, Brazil. *J. Nutr.* 134, 1923–1928. <https://doi.org/10.1093/jn/134.8.1923>.
- Pérez-Escamilla, R., Pinheiro de Toledo Vianna, R., 2012. Food insecurity and the behavioral and intellectual development of children: a review of the evidence. *J. Appl. Res. Child* 3 (1), Article 9. <https://digitalcommons.library.tmc.edu/cgi/viewcontent.cgi?article=1071&context=childrenatrisk>.
- Pinheiro de Toledo Vianna, R., Hromi-Fiedler, A.J., Segall-Correa, A.M., Pérez-Escamilla, R., 2012. Household food insecurity in small municipalities in Northeastern Brazil: a validation study. *Food Secur* 4, 295–303. <https://doi.org/10.1007/s12571-012-0181-4>.
- Radimer, K.L., Olson, C.M., Greene, J.C., Campbell, C.C., Habicht, J.-P., 1992. Understanding hunger and developing indicators to assess it in women and children. *J. Nutr. Educ.* 24, 36S–44S. [https://doi.org/10.1016/S0022-3182\(12\)80137-3](https://doi.org/10.1016/S0022-3182(12)80137-3).
- Sharkey, J.R., Nalty, C., Johnson, C.M., Dean, W.R., 2012. Children's very low food security is associated with increased dietary intakes in energy, fat, and added sugar among Mexican- origin children (6–11 y) in Texas border Colonias. *BMC Pediatr.* 12 (1), 16. <https://doi.org/10.1186/1471-2431-12-16>.
- Smith, M.D., Kassa, W., Winters, P., 2017a. Assessing food insecurity in Latin America and the caribbean using FAO's food insecurity experience scale. *Food Pol.* 71, 48–61. <https://doi.org/10.1016/j.foodpol.2017.07.005>.
- Smith, M.D., Rabbitt, M.P., Coleman- Jensen, A., 2017b. Who are the world's food insecure? New evidence from the food and agriculture organization's food insecurity experience scale. *World Dev.* 93, 402–412. <https://doi.org/10.1016/j.worlddev.2017.01.006>.
- Studdert, L.J., Frongillo, E.A., Valois, P., 2001. Household food insecurity was prevalent in Java during Indonesia's economic crisis. *J. Nutr.* 131, 2685–2691. <https://doi.org/10.1093/jn/131.10.2685>.
- To, Q.G., Frongillo, E.A., Gallegos, D., Moore, J.B., 2014. Household food insecurity is associated with less physical activity among children and adults in the U.S. population. *J. Nutr.* 144 (11), 1797–1802. <https://doi.org/10.3945/jn.114.198184>.
- Wambogo, E.A., Ghattas, H., Leonard, K.L., Sahyoun, N.R., 2018. Validity of the food insecurity experience scale for use in sub-Saharan Africa and characteristics of food-insecure individuals. *Curr. Dev. Nutr.* 2, nzy062. <https://doi.org/10.1093/cdn/nzy062>.
- Weaver, L.J., Hadley, C., 2009. Moving beyond hunger and nutrition: a systematic review of the evidence linking food insecurity and mental health in developing countries. *Ecol. Food Nutr.* 48 (4), 263–284. <https://doi.org/10.1080/03670240903001167>.
- Wehler, C.A., Scott, R.I., Anderson, J.J., 1992. The community childhood hunger identification project: a model of domestic hunger—demonstration project in Seattle, Washington. *J. Nutr. Educ.* 24, 29S–35S. [https://doi.org/10.1016/S0022-3182\(12\)80135-X](https://doi.org/10.1016/S0022-3182(12)80135-X).
- Weiser, S.D., Bukusi, E.A., Steinfeld, R.L., Frongillo, E.A., Weke, E., Dworkin, S.L., Pusateri, K., Shiboski, S., Scow, K., Butler, L.M., Cohen, C.R., 2015. Shamba Maisha: randomized control trial of an agricultural and finance intervention to improve HIV health outcomes in Kenya. *AIDS* 29, 889–1894. <https://doi.org/10.1097/QAD.0000000000000781>.
- Wolfe, W.S., Frongillo, E.A., 2001. Building household food security measurement tools from the ground up. *Food Nutr. Bull.* 22, 5–12. <https://doi.org/10.1177/156482650102200102>.
- Wolfe, W.S., Olson, C.M., Kendall, A., Frongillo, E.A., 1998. Hunger and food insecurity in the elderly. Its nature and measurement. *J. Aging Health* 10, 327–350. <https://doi.org/10.1177/089826439801000304>.
- Wolfe, W.S., Frongillo, E.A., Valois, P., 2003. Understanding the experience of elderly food insecurity suggests ways to improve its measurement. *J. Nutr.* 133, 2762–2769.