Measuring food security in the U.S. for 25 years:

History, methods, findings, and opportunities

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Research Snapshot

Research Question: Reviewing the 25-year history of U.S. food security measurement, what lessons may guide future innovations using food security surveys to measure national progress and evaluate the effectiveness of federal nutrition assistance programs?

Key Findings: Sound measurement strategy involves a tension between focus and breadth. A single focused authoritative 12-mo measure may be used as a high-profile indicator of national progress toward food security goals and for cross-national comparisons. Alternatively, broader measures may be best for distinct populations with diverse experiences of food-related hardship or for evaluating particular interventions and programs that may influence specific dimensions of food security.

Abstract

As part of a conference on "25 Years of Food Security Measurement: Answered Questions and Further Research," with support from USDA's Economic Research Service (ERS), this paper sets the stage by providing some history of federal food security measurement, summarizing notable findings and reviewing selected special topics in analysis methods. The federal government uses food security surveys (a) to monitor national progress toward reducing food insecurity and (b) to evaluate federal nutrition assistance programs. For the monitoring purpose, there is a tension between focus (on a single authoritative measurement approach) and breadth (encompassing multiple tools or instruments suitable for diverse populations, contexts, and

applications). For the program evaluation purpose, challenges include coordination with study designs capable of real causal estimation in the face of strong self-selection effects and tailored reference periods in survey questions that match the timing of program participation. Some analysis methods treat the food security survey items as distinct experiences of hardship that can be summarized with a statistical measure, while others treat the food security survey items as windows on an underlying latent variable, a food insecurity score. As a consequence, the severity of food-related hardship may be assessed quantitatively by the number of distinct hardships reported, by the estimated value of a latent food insecurity score, or by the frequency of occurrence for sentinel hardships. Ongoing work investigates statistical approaches that are sufficiently simple for policy application and yet sufficiently flexible to accurately match the empirical survey evidence.

I. Introduction

For slightly more than 25 years, the U.S. Department of Agriculture (USDA) has used Census Bureau data to scientifically estimate the annual prevalence of household food insecurity, a measure of food-related hardship (1). This anniversary provides an opportunity to reflect on the achievements of the U.S. food security measurement, contemplate lessons learned, and consider potential changes going forward, to better serve the purposes of federal investment in this policy area.

The federal government uses the food security measure to monitor national progress toward reducing food insecurity and hunger and evaluate federal nutrition assistance programs that may be expected to improve food security.

- *Monitoring progress.* For 1998, USDA found that 11.8% of U.S. households were food insecure, with broad disparities by race/ethnicity: 8.3 % of Non-Hispanic White, 24.3% of Non-Hispanic Black, 25% of Hispanic and 13.5% of other non-Hispanic households were food insecure (2). Near that time, as part of a global initiative at the World Food Summit to set goals for hunger reduction, the United States adopted a target of halving household food insecurity to 6% by 2015 (3). Yet, for 2015, USDA found that 12.7% of U.S. households were food insecure, which was no progress at all. For 2020, the twenty-sixth year of U.S. food security statistics, 10.5% of U.S. households still were food insecure and disparities by race still persisted: 7.1% non-Hispanic White, 21.7%, non-Hispanic Black, 17.2% Hispanic, and 8.8% other non-Hispanic were food insecure (1). Moreover, other populations such as American Indians were not reported in annual USDA food security statistics, although research suggests that rates of food insecurity for this population is high (4).
- *Evaluating federal nutrition assistance programs.* A large literature finds that the Supplemental Nutrition Assistance Program (SNAP) improves household food security (5-11). Evaluation efforts are challenging, because people who participate in these programs may differ systematically from those who do not. SNAP is the nation's largest anti-hunger program and a key part of the social safety net, providing food spending support to 40 million people monthly in 2020. Among households with income below 130% of the federal poverty line (a gross income threshold used in SNAP eligibility determination), 45.4% of SNAP participants were food insecure and 24.8% of SNAP non-participants were food insecure (1). Cross-sectional comparison shows that SNAP

participants have high levels of food insecurity, while research that controls for self-selection into the program finds that SNAP improves household food security.

As part of a conference and journal special issue titled "25 Years of Food Security Measurement: Answered Questions and Further Research," with support from USDA's Economic Research Service (ERS), this paper sets the stage by providing some history of federal food security measurement, summarizing notable findings, and reviewing selected special topics in measurement methods that will come up again. We aim to include high-profile studies along with less famous and more idiosyncratic examples of recent research suggesting potential directions for further development.

A food security measure or measures should satisfy several criteria as well as possible:

- suitability for national progress monitoring;
- suitability for impact evaluation of federal nutrition assistance programs;
- appropriateness for diverse populations;
- closeness in meaning to the intended conceptual definition of household food security;
- sufficient simplicity to estimate and explain for high-impact government uses.

Emphasizing a single authoritative food security measure is useful for some purposes, while a broader array of multiple measures may be better for different contexts and diverse populations. This tension between focus and breadth reappears in subsequent sections on methods, monitoring progress, program evaluation, and conclusions. This paper sets the stage for considering methodological adaptations or modifications that have both research merit and practical suitability, keeping in mind the constraints and purposes of the federal food security measurement program.

II. History of the food security measure

The USDA food security measure was created after Congress passed the National Nutrition Monitoring and Related Research Act of 1990 (Figure 1). USDA's ten-year comprehensive plan developed under the act recommended a standardized instrument to measure food insecurity in the U.S. and at the state and local levels. Good sources for the history of the USDA household food security measure include (12-14), and others.

Previously, food-related measures of hardship were based on anthropometrics (wasting or stunting), household income (poverty), growth of emergency food services (food banks and food pantries), or a simple food insufficiency survey question, none of which met the need for a representative validated survey-based measure of food security. The USDA food sufficiency question predates the official household food security measure. It has remained as a screener question on federal surveys and has received increased attention in 2020 during the COVID-19 pandemic due to its adaptation for the Census Bureau's high-frequency Household Pulse Survey, discussed in the next section (see Methods).

In January 1994, the Food and Nutrition Service (FNS) of USDA and the National Center for Health Statistics of the U.S. Department of Health and Human Services (DHHS) sponsored the National Conference on Food Security Measurement and Research. Participants at that conference were academic experts that led nutrition and hunger projects, private researchers from Abt Associates, Mathematica Policy Research and similar organizations, as well as staff from federal agencies that studied and collected data related to food insecurity and insufficiency. The participants conceptually defined food security and recommended an approach to scientifically measure food insecurity using a national survey.

In April 1995, the first nationally representative food insecurity survey was administered by the U.S. Census Bureau, via a supplemental module to the CPS. Abt Associates analyzed the data from the 1995 survey; Mathematica Policy Research had a contract with FNS to determine the stability of the food security measure for the period 1995-1997. Thereafter, CPS annually collected food security data as part of a supplemental module. The 1995 technical report led by Abt Associates found that scaling techniques justified three thresholds and four food security categories: food secure, food insecure with hunger not evident, food insecure with moderate hunger, and food insecure with severe hunger.

One group of questions in the first CPS Food Security Supplement addressed coping or resource augmentation, including actions that households might take to deal with scarce food resources. Examples of these questions are sending children to eat at a friend's, putting off paying other bills in order to buy food, or obtaining meals from soup kitchens or food banks. The report concluded that these questions did not meet the statistical criteria for inclusion in the scale (15).

The wording of food security questions has not changed much since 1995. From the beginning, CPS had a battery of 18 questions to measure food insecurity for households with children and 10 questions to measure food insecurity for households without children (CPS-FSS). In 1998, ERS assumed responsibility for analyzing food insecurity measures, as well as sponsorship of the annual household food security survey module in the Current Population Survey. Since then, small changes have occurred, mainly related to the screening questions and ordering of items rather than the actual content of the questionnaire. USDA has conducted "split ballot" tests of variations in the wording of some questions, including child-referenced items and a "balanced" meals question. In addition, shorter 6-item and 2-item survey instruments were developed for particular uses, discussed in the Methods section.

In 2006, USDA consulted with the Committee on National Statistics of the National Academies on a high-profile review: *Food Insecurity and Hunger in the United States: An Assessment of the Measure*. Based on one recommendation from that report, the labels of the four food security status categories were changed to: (1) high food security, (2) marginal food security, (3) low food security and (4) very low food security. The first two categories indicate food security, while the last two indicate food insecurity. The term "hunger" was removed from the category labels. The expert committee explained that hunger might result from food insecurity, and measuring hunger required detailed and extensive information on physiological experiences of each household member.

Following another recommendation from the National Academies review, the ordering of items was changed for households with children, so that all adult-referenced items would precede all child-referenced items. Engelhard et al. (16) estimate measures of statistical fit for food security items, with attention to the order in which questions were asked. The National Academies review made other recommendations about the statistical models used to assess household food security measures, as will be discussed further in the Methods section

The USDA questions are used on most U.S. national surveys, including but not limited to CPS, Panel Study of Income Dynamics (PSID), National Longitudinal Survey of Youth (NLSY), Early Childhood Longitudinal Survey Birth Cohort (ECLS-B) and Kindergarten Cohort (ECLS-K), National Health Interview Survey (NHIS), National Health and Nutrition Examination Survey (NHANES), and the Medical Expenditure Panel Survey (MEPS) (USDA Economic Research Service, 2020).

The use of sound statistical methods to validate the USDA food security instrument and scale has motivated other countries and organizations to use the survey in its current form (e.g. Young

Lives), or to adapt it (17-19). Moreover, the USDA food security instrument has influenced the way we measure food security around the world. For example, in 2014 the United Nations, Food and Agriculture Organization's (FAO) Voices of the Hungry project developed a measure of food insecurity, the Food Insecurity Experience Scale (FIES). It was modeled after the USDA food security survey module and consists of eight questions. FIES is a standardized measure of individuals' direct experiences of food insecurity and is used to compare food insecurity around the globe (20). It is currently used by 146 countries.

[Figure 1 about here]

III. Methods

The methods for federal household food security measurement are described in multiple sources, including USDA's annual food security report series (21), ERS web pages on food security in the United States (22), a guide to measuring household food security(23), the National Academies report *Food Insecurity in the United States: An Assessment of the Measure* (14), and an ERS technical report in response to the National Academies report (24). Reviewing these sources on measurement methods may suggest ideas for modification or improvement in the future. This section discusses conceptual definitions, the food security survey items and category thresholds that determine federal food insecurity prevalence statistics in the past 12 months, an alternate measure with 30-day in place of 12-month reference period, alternate measures for food insecurity in households with children, and item response theory (IRT) models used for several statistical purposes.

III.1. Conceptual definitions

USDA defines household food security as having "access at all times to enough food for an active, healthy life for all household members." Households that are not food secure may be called "food insecure." These food-insecure households may be subclassified as having "low" or "very low" food security. USDA defines very low food security as "the more severe range of food insecurity where one or more household members experienced reduced food intake and disrupted eating patterns at times during the year because of limited money and other resources for obtaining food" (21).

In operational practice, the classifications used for estimating food security prevalence using survey data are related to, but not precisely the same as, the conceptual definitions (Wilde, 2004b). USDA notes, "This operational measure does not specifically address whether the household members' food intake was sufficient for active, healthy lives—the conceptual definition of food security" (21).

III.2. Instruments

Food security items and category thresholds

The empirical categories are based on the number of affirmative responses to survey questions, so it is useful to become familiar with the specific survey items and their response frequencies. The food security classification system used in the high-profile statistics for monitoring national progress, cited previously in the introduction, is based on 18 survey items ((21), p. 5). These 18 items are referred to as the U.S. Household Food Security Survey Module.

Ten of the items use survey questions asked of all households (Table 1). The first 3 most frequently affirmed of these 10 items are "household items." The remaining 7 of the 10 items asked of all households are "adult items," describing the experience of the respondent or other

adults in the household. The final 8 of the 18 items are "child items," based on questions asked only of households with children (Table 2).

The original survey questions provide much information about how frequently hardships occur. For most of the items, the survey asks whether the household experienced the hardship never, sometimes, or often (Table 3). For later statistical analysis, the survey questions may be condensed into binary survey items that are affirmed (the hardship is sometimes or always experienced) or not affirmed (never experienced). At times, as discussed later in this section, researchers have explored using statistical models that treat the survey questions as "polytomous," with 3 separate classifications for never, sometimes, or often.

Food security modules in federal surveys are administered with internal screeners: any household that does not affirm the initial screeners or one of the first three items is not administered any of the remaining (household) items, and these non-administered items are counted as non-affirmations. Similarly, for any household administered the fourth through the eighth item, any household that does not affirm at least one of those is not administered the final two. Similar screeners are present for households with children. Initial screeners are also used, including an income screener. This mode of administration operationalizes an important assumption of the underlying model: namely, that households that affirm items indicating severe hardship should also have affirmed some subset of less-severe items.

The raw score is the number of affirmative responses to the binary survey items. There are at least two commonly used ways of interpreting the survey items and raw score:

- Summary interpretation. The survey items may be interpreted as multiple food-related hardships that households experience. The raw score is a way of summarizing the collection of experiences.
- Latent variable interpretation. The survey items may be interpreted as multiple windows on a single underlying latent food insecurity variable, using statistical tools from the field of item response theory, which are described further below. In one such IRT model commonly used in U.S. food security research, the Rasch model, the raw score is a "sufficient statistic" that contains all of the information needed to estimate the latent food insecurity variable.

Based on the raw score, households are classified into food security categories. Official prevalence estimates for the categorical variables are widely cited. In some cases, the threshold for a particular category differs for households with and without children (Table 4). The intent of USDA's approach is to have the categories represent approximately equal levels of severity in households with and without children, so that a single food security status classification can be used for all households.

Food security status for households with children

USDA researchers have explored separate classifications for households with and without children, as an alternate experimental approach (25, 26). Adult food security status may be determined by responses to the 10 household- and adult-referenced items, while child food security status may be determined by response to the 8 child-referenced items.

Under this alternate approach, a question arises about how to classify the overall food security status of the household. In households with children, the household could be considered food

insecure if either adults or children or both were classified as food insecure. Or, one could simply classify household food security status based on the 10 household- and adult-referenced items in all households. USDA research into experimental food-security classification methods discusses indications of internal and external validity, with some strengths and weaknesses for each option (26, 27).

12-month and 30-day measures(25)

The food security measures described above reference the previous 12 months. Because participants enter and exit federal nutrition assistance programs from month to month, an alternative measure with a shorter reference time period is more useful for program evaluation purposes. The statistical supplement to USDA's annual report provides estimates of food security during the 30 days prior to interview, in households with and without participation in federal nutrition assistance programs (1). This measure has been validated. The hardship described in a survey item is more likely to have occurred in the past 12 months than in the past 30 days.

Shorter instruments

Shorter instruments for food security measurement, including a 2-item and a 6-item survey, have been used to assess household food insecurity (28). Both versions have been validated as screeners (29). The advantages of these short instruments are the decreased respondent burden and minimal bias compared to longer versions. The disadvantages are that they do not measure the most severe levels of food insecurity, they are less precise than the 18-item instrument, and they do not ask questions regarding children in the household. Shorter 2-item instruments may also be more feasible in clinical healthcare settings.

For the 2-item survey, the Hunger Vital Signs, the following two questions have been used:

- "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 in the last 12 months?
- "The food we bought just didn't last and we didn't have money to get more." Was that often true, sometimes true, or never true for your household in the last 12 months?"

At least one alternative question would be needed for a 2-item survey that aimed at assessing hunger.

The 6-item short form of the food security survey module has had minor technical improvements to wording since the 1995 module. Blumberg (29)found that the 6-item survey was useful not only in a clinical setting but had applications for national survey use as well.

The Household Pulse Survey administered during the COVID-19 pandemic is a 19-item questionnaire assessing employment status, food sufficiency, housing security, education disruptions, and physical and mental wellbeing (30). Food-related hardship is assessed using several questions, including a version of the long-standing USDA food sufficiency question:

- Getting enough food can also be a problem for some people. Which of these statements best describes the food eaten in your household?
    - Enough of the kinds of food (I/we) wanted to eat
    - Enough, but not always the kinds of food (I/we) wanted to eat
    - Sometimes not enough to eat
    - Often not enough to eat

The current Household Pulse Survey provides a unique example of a shorter household food sufficiency measurement instrument, with a short 7-day reference period, incorporated into a larger more general survey, with relatively specific questions in the context of the pandemic and the need for recent data in order to feel the "pulse" of the nation during a national emergency (30).

III.3. Cognitive testing

Cognitive interviews are widely used to pretest survey instruments by identifying comprehension and response problems (31). This approach is used to create new survey questions and to understand and interpret existing survey instruments. For the original USDA food security module, researchers pretested survey items (15, 32). A decade later, researchers also used cognitive testing when improving their children's food security measure (33), and in 2019 USDA's Economic Research Service contracted with Census to conduct cognitive testing of the entire CPS Food Security Supplement questionnaire (Office of Management and Budget, undated).

Several items in the food security module have been a special focus for cognitive testing. "Running out of food" and "balanced meals" might not be clearly understood or might have different meaning for different populations (34). Studies from Hawaii, India, and Indonesia show that the term "balanced meals" depends on cultural contexts. Suggested variations of that phrase based on cognitive testing are: "healthy and varied diet" or "nutritious meal" (35-37). Cognitive testing may suggest alternative answers when questions have multiple choices. Cognitive testing in the US with Latino immigrant mothers suggests that the option "hardly ever" should be used instead of "never" (38).

There has been limited cognitive testing of the U.S. food security module in languages other than English. About 42 million people five and older speak Spanish at home in the U.S. Chinese languages (Mandarin, Cantonese, and others) are spoken by about 3 million people in the U.S. While formal cognitive testing has not been conducted for the Spanish version of the CPS-FSS food security items, researchers at USDA-ERS have validated the Spanish version using Rasch analysis (Rabbitt & Coleman-Jensen, 2017). In the past, a lack of standardized Spanish translation led to the use of different Spanish variants of the CPS-FSS module. For example, the "balanced meals" item was translated variously as "comida balanceada" (balanced meals) and "comida nutritiva" (nutritious meals) (39), while the new USDA standardized Spanish module now uses "comida variada y nutritiva" (40). However, for the Chinese version of the CPS-FSS module, no cognitive testing or Rasch analysis has been conducted to date. In Chinese no equivalent words are found for "balanced meals" or "eat less than you felt you should" (38, 41).

Among areas for future research, formal cognitive testing of the Spanish and Chinese versions of the USDA food security instrument can use Hispanic and Chinese subjects from different parts of the country and who speak different dialects. There is limited research on whether a shorter version of items is more convenient for certain populations. Harrison (42) and Connell et al. (43) found that low-income Spanish speakers and children prefer shorter versions of the items because they can easily understand them. Cognitive testing can also be used to examine the appropriate age when a child can start reporting their own food security.

III.4. Analysis tools

Some decisions in federal measurement methods, including decisions about the raw score thresholds for food security status classification, draw on scaling tools from item response theory (IRT), a field of statistics with long-standing applications in educational testing and psychometrics. The National Academies report mentioned above describes several potential IRT methods, including the Rasch Model, which was originally used to develop the federal food security measurement approach, and several alternatives (14).

The Rasch model is akin to a logistic regression model showing the log-odds of affirmative response to the survey items as a function of the "severity" of the item and a food security scale score for the household. With the Rasch model, the raw score (the number of affirmative responses, an integer variable) is a "sufficient statistic" for the underlying food security scale score (a continuous variable). This means one can use the raw score to determine the food security scale score without needing other information about which questions were answered affirmatively. The Rasch model is unidimensional, which means that the survey items are taken to provide information about a single underlying latent variable. USDA chose to develop a unidimensional measure of food security that captures the central dimension of food security, food sufficiency. As a result, respondents to the household food security survey model are assumed to formulate their responses to the food-security questions based on the food available to them relative to their subjective needs (23).

Because the raw score is a sufficient statistic for the scaled Rasch score, the official food security status classifications are based on raw score thresholds – which are straightforward to interpret -- rather than direct estimates from an IRT model. In this sense, the IRT models do not directly determine household food security prevalence estimates. The IRT models do help determine what thresholds should count as equivalent for households that are asked different questions,

most notably households with and without children (44), and these models are heavily used in validation research.

Previous research has found that Rasch model estimates for the severity of survey items differ in households with and without children, which violates one of the model's technical assumptions and complicates efforts to use the Rasch model for setting equivalent raw score thresholds among these groups (14, 26, 45, 46). Formally, the Rasch model rules out differential item functioning (DIF), which is differences across populations in the frequency of affirming items when the underlying food security score is held constant. Noting other evidence of this type of differential item functioning with respect to several household characteristics, the National Academies report investigated more general statistical models in the IRT family (14).

However, these alternate IRT models each present additional difficulties in estimation and ease of explanation to policy-makers. For example, the alternatives do not permit one to estimate an underlying scale score directly from the raw score as the Rasch model does. Nord (24) reviewed multiple technical suggestions from the National Academies, finding in most cases that they would provide only minor statistical benefits and would not greatly influence food security prevalence estimates. For example, the most complex model he explored would make three changes: (a) two coefficients would be used to describe the severity of each survey item (instead of one coefficient per item in the Rasch model), (b) the survey questions would be treated as polytomous with 3 categories for never, sometimes, or often experiencing hardship (instead of a binary outcome in the current approach), and (c) household food security scores would be assigned probabilistically (instead of determined based on the raw score). After estimating food security models with and without these changes, Nord concluded: "The extent of improvement in precision that might be realized is not likely to justify the loss of transparency, simplicity, and

communicability that would result from use of the more complex model" (24). The alternatives were not adopted for official use.

III.5 Analysis tools and measures for subpopulations

The prevalence of household food insecurity varies greatly across subgroup populations (21). One reason is that some populations experience higher poverty rates and greater symptoms of food-related hardship than others do. Another possible reason is that response frequencies to food security items might vary across subgroup populations even when food insecurity is held constant. This possibility has been the focus of a substantial body of validation research.

While early validation of the USDA Household Food Security Measure (HFSM) and scaling found similar patterns of responses by race/ethnicity, income and household composition (47), similar analysis was not conducted by gender groups. A few years later, using CPS data from 1995, 1997 and 1999 and a generalized linear model, researchers tested the validity of the USDA food security measure. Although their overall results validated the HFSM, the study also found evidence that responses vary among subpopulation groups. Specifically, their findings suggested that minority respondents, Spanish speaking respondents, male respondents and those living in metropolitan areas respond to questions differently than other households (48). Research by Mark Nord (24), described earlier in the Methods section, noted some evidence of differential item functioning (DIF), but found that it may not strongly affect food security prevalence estimates. Engelhard, Rabbitt and Engelhard (16) tested the item fit and overall fit of the food security measure using household model-data fit. Findings suggests that higher levels of misfit are predicted by gender, educational attainment, Spanish as the only language for adults, and participation in SNAP in the last 12 months. The population share has risen from 1995 to 2019

for one-parent only male-headed householders (an increase of 4 percentage points), Hispanic households (6 percentage points), and people living in metropolitan areas (6 percentage points) (US Census Bureau, 1995, 1998, 2019), so this issue may grow in importance.

When response frequencies vary across populations, even holding constant the level of food insecurity, the validation literature sometimes has interpreted these findings as evidence that different populations understand the meaning of the questions differently (for example, they might have different understandings of "balanced meals"). However, another possibility is that different populations actually experience food-related hardships with different relative frequencies in the real world (for example, one population may be comparatively more likely to have difficulty acquiring balanced meals and comparatively less worry about running out of food). One of the assumptions of the Rasch model is that response frequencies are the same across populations when the food security score is held constant, so the validation research finding differences across populations indicates a potential difficulty for either the validity of the questions, or the Rasch model, or both.

Interestingly, studies from other countries suggest different responses to food security questions for different subpopulations. A study from Canada suggests differences in response frequencies in similar married or cohabiting households, where women tend to report higher levels of food insecurity than men (49). A more recent study that explored gender differences in food insecurity globally using a modified Oaxaca-Blinder decomposition gap approach found that a nontrivial share of the gender gap remained unexplained; the authors suggest that the willingness to report food security experiences might vary by gender (50). Similar gender differences examining the United Nations food insecurity experience scale (FIES) with a multilevel explanatory Rasch model was found by Wang et al.(51).

Prior studies have also explored differences by geographic areas and race and ethnicity. For example, Quandt et al. (52) examined food insecurity for rural elders in North Carolina using quantitative and qualitative approaches and their findings suggest that self-sufficiency and pride might lead them to underreport their levels of food security.

There is a consensus among researchers who study food insecurity in indigenous populations that by using the USDA food security module, there is underreport of the levels of food insecurity for the indigenous population (53). Indigenous populations require specific household food security measurement methods, which have increased in use in the United States and globally in the last two decades. Researchers have noted that such measures should include unique cultural and traditional aspects of food consumption, agricultural production, and community-developed tools (53-55).

IV. Monitoring progress

A large body of research has focused on monitoring progress at the national level. Since 1995, food security data have been consistently and scientifically collected in the US every year. USDA's annual household food security report presents many findings about the prevalence and severity of household food insecurity by year and the correlates of food insecurity, such as income, race/ethnicity, region of the country, and household size (21).

Beyond descriptive studies, food security research has addressed important policy questions. For example, studies on the effects of the American Recovery and Reinvestment Act on food security (7) and specifically on the changes of SNAP benefit sizes on food security and other health outcomes (56, 57) have guided the federal response to the COVID-19 pandemic that included over $2 billion per month in emergency SNAP supplements to take all participating

households up to the maximum amount. Moreover, with the majority of schools closed in 2020 due to the pandemic, SNAP or a SNAP-like benefit card have also been used to distribute money to families to replace meals that children would have received through the National School Lunch Program (NSLP). Such studies build on decades of research into the effects of food assistance programs on food security and health outcomes by academic researchers, health experts and physicians (58).

Since the creation of the food security measure in 1995, researchers have also examined food security for vulnerable populations such as elderly, immigrants, children, and more recently women. In the case of seniors, food security is associated with adverse health outcomes including health status, self-reported health, depression, anxiety, and disabilities (59-64). Research on food insecurity and immigrants have focused on Hispanic/Latino subjects (65). Food insecurity is associated with weight increase with longer US residence for immigrant women (66). Relative to Hispanic natives, Hispanic immigrant households and children are more likely to be food insecure (67-69). While SNAP has been found to be a protective factor for food insecurity, with the passage of the Personal Responsibility, Work, and Reconciliation Act, non-citizens became ineligible for food assistance programs and mixed families reduced their allotment of SNAP, which contributed to an increase of food security (70). Recent high levels of food insecurity among immigrants can be explained by level of acculturation, and economic stress (71), maternal education, and household size (69), as well as the Great Recession, language barriers to get access or keep access to food assistance programs, and increasing anti-immigrant sentiment(72).

Just recently, research in the U.S. has focused on examining the relationship between gender and sexuality, food insecurity and health outcomes and found that women of color, elderly women

and the LGBTQ+ population experience disproportional rates of food insecurity (73). Key variables that explain food insecurity for women are domestic violence (74) and the way they shop and make their meals (75). In addition, social capital and geographical location explain food security experiences for elderly women (76, 77). Transgender and gender nonconforming people experience high rates of food insecurity largely due to lack of steady employment opportunities and layered discrimination (78).

V. Evaluation of federal nutritional assistance programs

Prior literature has studied the effects of safety net programs on food insecurity (79) including the effects on the Supplemental Nutrition Assistance Program (SNAP), the Supplemental Nutrition for Women, Infants, and Children program (WIC), the National School Lunch Program (NSLP), among others.

- SNAP. Analyses of the relationship between SNAP and food security have produced mixed results and largely attribute difficulties identifying the relationship to endogeneity, due to selection into program participation, and participant reporting error. Studies using simultaneous equation models (80), fixed effects models (81), and propensity score matching (82) have found unclear evidence regarding the relationship between SNAP and food security, often reporting positive but not statistically significant estimates. These older studies shed light on the nature of confounding factors suggesting that unobserved factors are probably time—varying, and affect from time to time. More recent studies have found that SNAP participation reduces the severity or incidence of household food security. These studies use instrumental variables approaches (6, 10), fixed effects (83),

485 and partial identification bounding methods (84), regression discontinuity design (85),
486 among others. A study by Gregory, Rabbitt & Ribar (86)replicates the modeling
487 strategies used in the literature and finds that SNAP reduces food insecurity, but effects
488 might vary across sub-populations and are not always statistically significant.

489 • WIC. There is a small number of studies examining the relationship between WIC
490 participation and food insecurity. While earlier studies are not causal and find mixed
491 results, more recent studies find WIC participation associated with lower risk of food
492 insecurity. Using a small sample size of around 300 pregnant, first-time participants in
493 WIC, Hernan et al. (2006) found that WIC makes a significant contribution to reducing
494 food insecurity. A few studies used logistical regression analysis. Oberholzer and Tuttle
495 (2004) found a positive association between food security status and WIC participation
496 but did not find a relationship between number of months receiving WIC and food
497 security status. Metallinos-Katsaras and co-authors (87), report a positive association
498 between WIC participation and food security for most subgroups, except for the
499 households that were categorized as food secure at WIC entry, where a negative
500 association was found. Additionally Black and colleagues (2004) observe a higher but not
501 statistically significant rate of reports of food insecurity among WIC-eligible non
502 participants than WIC participants. More recently and using quasi-experimental designs,
503 researchers have found that WIC increases food security or that aging out of WIC
504 increases food insecurity. Using regression discontinuity design, Arteaga, and
505 collaborators(88) and Cho (89) found that ageing out of WIC increases food insecurity in
506 households with children. Using partial identification methods to jointly account for

unobserved counterfactual outcomes and underreporting of WIC participation, Kreider, Pepper & Roy (90) found that WIC reduces the prevalence of child food insecurity.

- NSLP. There is limited literature on the effects of the National School Lunch program (NSLP) on food security and its results are mixed. Arteaga & Heflin(91) used an instrumental variable approach and found that NSLP reduces food insecurity at school entry. Huang, Kim & Barnidge (92) uses seasonal difference in NSLP participation to examine the effects of the program on food security and found that additional participation in the program increases food security. Burke et al. (93) used a randomized control trial of three school meals and weekend backpack reduced the most severe form of food insecurity in children, but increased less severe form in children, adults, and households.

Prior research also examines the effects of food programs not only on food security, but also on health outcomes, as well study take-up and administrative burden during the certification process. SNAP participation is found to mitigate the negative association between food insecurity and health outcomes (59). In addition, research suggests that states that require schools to offer school breakfast programs have reduced food security for young children (94). This body of research points to the importance of policy action such as increase take-up rates for WIC and SNAP, and to making changes to the recertification process in terms of administration and length (95)

VI. Discussion

528 This review provides just an introduction to the lively and energetic body of research on
529 household food security measurement in the United States, while also communicating a sense of
530 how much remains to do. At this 25th anniversary of this area of work, several interesting
531 questions may be contemplated looking forward.

532 *What are the comparative merits of focusing on a primary authoritative food security measure*
533 *versus using more varied measures for distinct populations and purposes?* A primary
534 authoritative 12-mo measure may be used for a high-profile indicator of national progress toward
535 food security goals and for cross-national comparisons. Alternatively, more varied measures may
536 be best for distinct populations with diverse experiences of food-related hardship or for
537 evaluating particular interventions and programs that may influence some dimensions of food
538 security more than others. A substantial challenge with more varied measures is comparability of
539 the level of hardship. The threshold for being classified as "food insecure" may be difficult to
540 interpret when different measures are based on different underlying survey questions.

541 *How much should the definition of food security be broadened to address additional dimensions?*
542 Broadening the definition of food security in one direction, Mozaffarian et al. (96) proposed
543 greater emphasis on "nutrition security," focusing on experiences that are associated with risk of
544 chronic disease, with implied policy responses offering more specific nutrition benefits.
545 Broadening the definition in another direction, Chilton and Rose(97) suggest an approach to food
546 security that engages a human right framework, with implied policy responses addressing deeper
547 social challenges such as "lack of adequate education and living wages, lack of access to health
548 care and health information, and exposure to unsafe living conditions such as unsafe water, poor
549 housing, and dangerous neighborhood environments." It is comparatively more feasible to
550 address broader dimensions of food security if the measurement program encompasses an array

551 of different tools for different purposes (the second approach in the previous paragraph). By
552 contrast, if the official measurement approach focuses on one primary authoritative measure,
553 then these additional dimensions, such as nutrition-related chronic disease risk or poverty-related
554 structural violence, may be too much for a single measure to handle; they may best be seen
555 merely as external correlates of food insecurity rather than dimensions that are part of the
556 definition of food insecurity.

557 *Are high-profile prevalence statistics best interpreted as summaries of experiences of food-*
558 *related hardship or as estimated values for a latent variable within an IRT framework?* Some
559 widely read and influential sources on U.S. household food security, including the annual USDA
560 food security reports, make little reference to IRT models. When prevalence statistics are
561 interpreted as summaries of the food security survey items, the estimates do not depend on
562 specific assumptions of statistical models used for analysis. Other sources consider estimated
563 scores for a latent food security variable to be the fundamental objective of food security
564 measurement. Such latent variable estimates may be derived from comparatively simple and easy
565 to communicate statistical models such as the Rasch model (which depend on comparatively
566 strict assumptions that may not be empirically corroborated) or from more complex models
567 within the broader IRT family of models (which may be more correct statistically but more
568 difficult to explain in policy applications).

569 *What are options for assessing the severity or depth of food insecurity?* One approach
570 emphasizes the raw score, the number of binary survey items that is affirmed by respondents. A
571 larger raw score indicates more severe food insecurity. This approach works equally well
572 whether analysts interpret the raw score as merely a summary of several survey items or within a
573 Rasch model framework as a representation of the underlying food security latent variable.

Another approach is to directly focus on the latent food insecurity variable, within the framework either of the Rasch model or a more complex IRT model, each of which has strengths and limitations. A third approach, which would involve more change from current practice, would give greater emphasis to the frequency and timing of experiences of hardship, for example making greater use of questions about whether the hardship was experienced never, sometimes, or often.

In what ways can survey instruments be shortened for effective use in time-constrained interview settings? The methods section earlier reviewed a variety of 2-item and 6-item food security survey instruments. Furthermore, the much older USDA food sufficiency question received new attention in 2020-2022 due to high-profile adaptation with a short 7-day reference period to monitor short-term hardship in the Household Pulse Survey during the pandemic. Heavier use of a short food security or food sufficiency instrument would have implications for the three preceding questions in this section: it goes well with a narrow focus rather than broadening the concept of food security to encompass new issues, with thinking of prevalence statistics as a simple summary of experiences of hardship rather than accurate measures of a latent variable in an IRT framework, and with using frequency of experiences of hardship (rather than range of items affirmed) as the best way of assessing severity.

We have high hopes that these questions and many others will motivate a fascinating discussion at this conference recognizing the 25th anniversary of the U.S. household food security measurement program.

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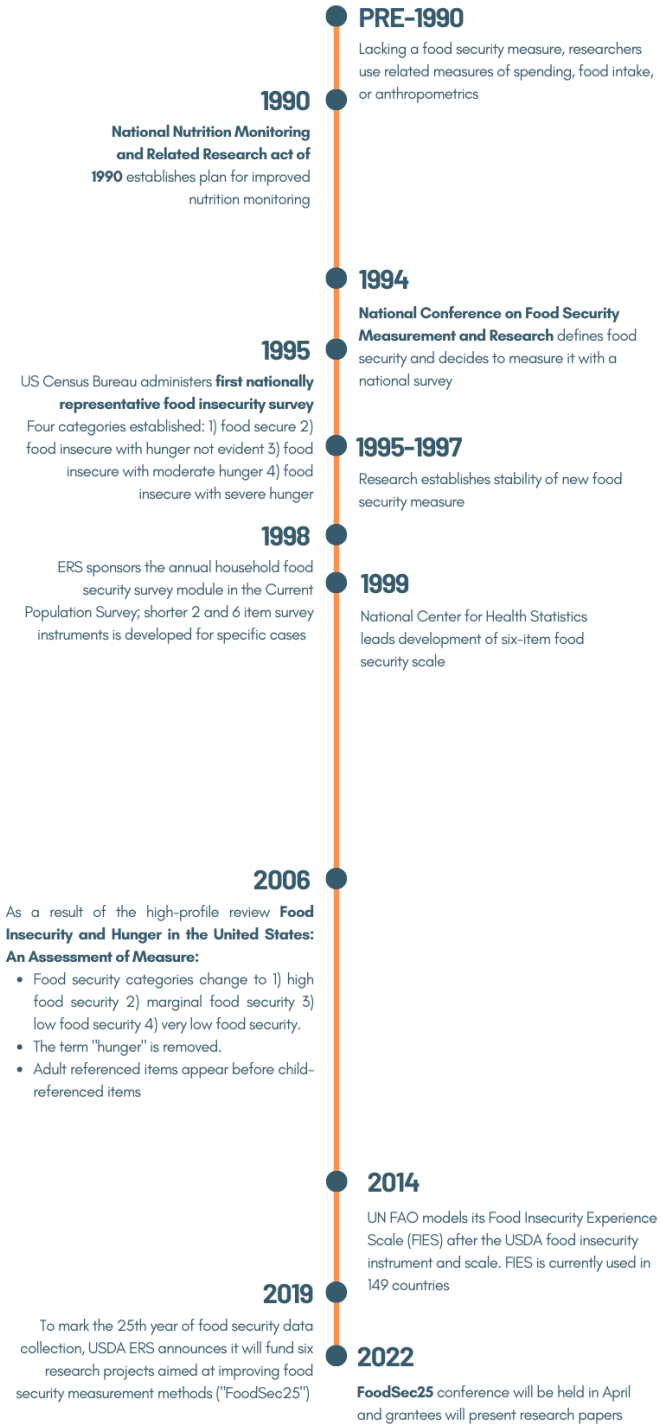

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839 **Figure 1.** Selected events in the history of U.S. food security measurement.

Table 1. Response frequencies for binary household food security items (Household and adult referenced)

Scale item	All households	Households without children	Households with children
Household items		Percent	
Worried food would run out before (I/we) got money to buy more	14.2	11.9	19.9
Food bought didn't last, and (I/we) didn't have money to get more	11.4	9.9	15.0
Couldn't afford to eat balanced meals	11.3	10.5	13.2
Adult items			
Adult(s) cut size of meals or skipped meals	6.2	5.8	7.2
Respondent ate less than felt he/she should	6.3	5.7	7.4
Adult(s) cut size or skipped meals in 3 or more months	4.7	4.5	5.1
Respondent hungry but didn't eat because couldn't afford food	3.2	3.1	3.7
Respondent lost weight	2.1	2.1	2.1
Adult(s) did not eat for whole day	1.2	1.2	1.2
Adult(s) did not eat for whole day in 3 or more months	0.9	0.9	0.8

Source: U.S. Department of Commerce Current Population Survey (CPS) Food Security Survey Supplement, 2020, archived at IPUMS. Notes: USDA/ERS (2021)[note]. Questions refer to resource limitation (e.g., "... because (I was/we were) running out of money…"). Weighted estimates, omitting non-responders.

Table 2. Response frequencies for binary household food security items (Child referenced)

Scale item	Households with children
	Percent
Child items	
Relied on few kinds of low-cost food to feed child(ren)	12.9
Couldn't feed child(ren) balanced meals	7.7
Child(ren) were not eating enough	3.6
Cut size of child(ren)'s meals	1.9
Child(ren) were hungry	0.9
Child(ren) skipped meals	0.6
Child(ren) skipped meals in 3 or more months	0.5
Child(ren) did not eat for whole day	0.1

Source: U.S. Department of Commerce Current Population Survey (CPS) Food Security Survey Supplement, 2020, archived at IPUMS. Notes: USDA/ERS (2021)[note]. Questions refer to resource limitation (e.g., "... because (I was/we were) running out of money…"). Weighted estimates.

Table 3. Response frequencies for never/sometimes/often items

Scale item	All households			Households without children			Households with children		
	Percent			Percent			Percent		
	Never	Sometimes	Often	Never	Sometimes	Often	Never	Sometimes	Often
Household items									
Worried food would run out before (I/we) got money to buy more	85.5	11.2	3.1	87.9	9.1	2.8	79.8	16.1	3.7
Food bought didn't last, and (I/we) didn't have money to get more	88.3	9.2	2.2	89.8	7.7	2.2	84.7	12.7	2.3
Couldn't afford to eat balanced meals	88.4	8.6	2.6	89.2	7.7	2.8	86.4	10.8	2.3
Child items									
Relied on few kinds of low-cost food to feed child(ren)							86.2	10.4	2.4
Couldn't feed child(ren) balanced meals							91.4	6.5	1.1
Child(ren) weren't eating enough							95.4	3.0	0.5

Source: U.S. Department of Commerce Current Population Survey (CPS) Food Security Survey Supplement, 2020, archived at IPUMS. Notes: USDA/ERS (2021)[note]. Questions refer to resource limitation (e.g., "... because (I was/we were) running out of money…"). Weighted estimates, omitting non-responders.

Table 4. Response frequencies for almost every month/some months but not every month/in only 1 or 2 months items ("not at all" and "at least once" excluded)

	All households			Households without children			Households with children		
	Percent			Percent			Percent		
Scale item	Every month	Some months	1 or 2 months	Every month	Some months	1 or 2 months	Every month	Some months	1 or 2 months
Adult items									
Adult(s) cut size of meals or skipped meals	1.9	2.8	1.5	1.9	2.6	1.3	1.8	3.3	2.2
Respondent ate less than felt he/she should	1.8	2.8	1.6	1.9	2.6	1.4	1.6	3.5	2.3
Respondent hungry but didn't eat because couldn't afford food	1.0	1.4	0.8	1.1	1.3	0.7	0.8	1.7	1.1

Source: U.S. Department of Commerce Current Population Survey (CPS) Food Security Survey Supplement, 2020, archived at IPUMS.

Table 5. Frequency of raw score for adult-referenced items

Raw score	All households	Households without children	Households with children
	Frequency (percent)	Frequency (percent)	Frequency (percent)
0	82.5	84.8	76.8
1	4.2	3.5	5.9
2	3.3	2.7	4.6
3	3.1	2.5	4.5
4	1.5	1.3	2
5	1.3	1.1	1.7
6	1.5	1.4	1.7
7	1.1	1.1	1.15
8	0.7	0.7	0.7
9	0.3	0.3	0.2
10	0.5	0.5	0.5

Source: U.S. Department of Commerce Current Population Survey (CPS) Food Security Survey Supplement, 2020, archived at IPUMS.

Table 6. Frequency of raw score for child-referenced items

Raw score	Households with children
	Frequency (percent)
0	85.6
1	6.6
2	4
3	2
4	0.7
5	0.5
6	0.1
7	0.2
8	0.1

Source: U.S. Department of Commerce Current Population Survey (CPS) Food Security Survey Supplement, 2020, archived at IPUMS.