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Assessing and Monitoring Nutrition Security to Promote Healthy Dietary Intake and Outcomes in the United States

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Abstract

The US Department of Agriculture's Economic Research Service leads the federal government in data development and research on food security in US households. Nutrition security is an emerging concept that, although closely related, is distinct from food security. No standard conceptualization or measure of nutrition security currently exists. We review the existing research on nutrition security and how it is informed by the more robust literature on food security and diet quality. Based on this review, we propose a conceptual framework for understanding nutrition security and its relationship to food security. We identify two constructs (healthy diets and nutritional status) and multiple subconstructs that form the basis of nutrition security. The proposed framework and corresponding constructs are intended to provide (*a*) understanding of how nutrition security arises and how it differs from food security, (*b*) background on why assessment and monitoring of nutrition security is important, and (*c*) guidance for a research agenda that will further clarify the meaning of nutrition security and its measurement.

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FOOD SECURITY AND NUTRITION SECURITY IN THE UNITED STATES

Food consumption patterns in the United States are not optimal for the promotion of health and well-being, and the diets of most Americans do not meet federal nutrition recommendations (93). Average US scores on the Healthy Eating Index (HEI)—a measure of dietary quality that assesses adherence to Dietary Guidelines for Americans recommendations—reach only approximately 59 out of a possible 100 points. Further, more than 80% of Americans consume diets low in fruits, vegetables, and dairy (102). Unhealthy diets are responsible for almost half of cardiometabolic deaths from heart disease, stroke, and type 2 diabetes in the United States, creating a heavy burden for individuals and society (67).

The US Department of Agriculture (USDA) (96) defines food security as "access by all people at all times to enough food for an active, healthy life." People living in households that are food secure have healthier diets, in general, than people living in households that are food insecure. It is thus unsurprising that people in households that are food insecure and/or low income are disproportionately affected by diet-related diseases such as obesity, diabetes, and cardiovascular disease (39).

With limited exceptions, the USDA has released food security rates for the US population and subpopulations annually since 1995. Decades of consistent measurement of food security in the December supplement of the Current Population Survey (CPS), and the analysis and dissemination of these data from the USDA's Economic Research Service (ERS), have resulted in ongoing surveillance efforts that have deeply informed and accelerated policies, programs, and practices supporting food security in the United States (96).

The concept of nutrition security, recently introduced in the United States to build on the food security construct, emphasizes the role of nutrition in health and "the coexistence of food insecurity and diet-related diseases and disparities" (98). Although many have come to embrace the concept of nutrition security, others argue against this construct (82). Nutrition security is closely related to, yet distinct from, food security. This article reviews the extant literature on nutrition security; incorporates, where appropriate, evidence about food security that is relevant to nutrition security as well; and builds on the current understanding of nutrition security by proposing a conceptual framework that includes the well-studied construct of food security. Reviews of the food security literature have been published previously (39, 40, 54, 60, 88).

In March 2022, the USDA released documents highlighting policy and program priorities related to nutrition security with a stated aim of "taking an equity lens" to those efforts (see 94). For those activities and purposes, the USDA (98) defined nutrition security as "consistent access, availability, and affordability of foods and beverages that promote well-being, prevent disease, and, if needed, treat disease, particularly among racial/ethnic minority populations, lower income populations, and rural and remote populations including Tribal communities and Insular areas."

Development of measures of nutrition security is just beginning, and no broadly accepted measure of nutrition security exists, particularly one aligning with the emerging USDA definition (13). Further, without an accepted measure, nutrition security cannot be routinely measured or monitored nationally, the impact of policies and programs on nutrition security is less likely to be consistently assessed, and deep insights into the role of nutrition security in health and health disparities may be overlooked.

HISTORICAL CONTEXT

Early efforts to assess nutrition in the United States included the Ten-State Nutrition Survey, which was implemented between 1968 and 1970 (101). A formal nutrition monitoring system was first established in the United States with the passage of the Food and Agriculture Act in 1977 (11). Major legislative efforts to increase federal investments to coordinate nutrition surveys occurred in the late 1970s and 1980s and culminated in the passage of the National Nutrition Monitoring and Related Research Act in 1990. The act established several mechanisms to ensure the collaboration and coordination of federal agencies as well as state and local governments involved in nutrition monitoring. These included the formation of an interagency board to coordinate periodic scientific reports to describe the nutritional and related health status of the US population (11).

The Ten-Year Comprehensive Plan guided federal actions for nutrition monitoring during the period from 1992 to 2002 (11). To meet one of its research objectives, an 18-item food security measure (the USDA's Household Food Security Survey Module) was developed to monitor the prevalence of food insecurity in the population and high-risk subgroups (41). The food security questionnaire was administered as a single monthly supplement to the CPS in 1995, with some modifications to the screening and format of the questionnaire implemented with the final version used in the 1998 CPS (19). In 1998, the ERS assumed sponsorship of the Census Bureau's annual food security survey, responsibility for analyzing and reporting the data, and coordination of ongoing USDA research on food security and food security measurement. Annual reports on household food security in the United States were made available beginning with the 1999 CPS Food Security Supplement data (96; for a list of food security measurement publications, see also 97). The same food security measure is also used in national surveys, evaluation studies of nutrition assistance programs, and other research studies focused on low-income groups (11).

Concurrently, the USDA developed a measure of how well American diets conformed to recommended healthy eating patterns: the HEI. The original HEI was developed in 1995 by the USDA Center for Nutrition Policy and Promotion, in cooperation with the USDA Food and Nutrition Service and the USDA Agricultural Research Service, to measure how well the diets of Americans align with the Dietary Guidelines for Americans and to monitor dietary patterns in the US population over time (99). Based on different aspects of a healthful diet, the index is designed to provide a measure of overall dietary quality, with scores ranging from 0 to 100 (99). The HEI has been revised several times since it was first developed, the most recent version being HEI-2015, with 13 components that reflect the different food groups and key recommendations in the 2015–2020 Dietary Guidelines for Americans for ages 2 years and older (100). The current

HEI measures components on a density basis (i.e., amount of a given nutrient or food component per 1,000 kcal), meaning it assesses some aspects of diet healthfulness but not food adequacy.

Since 2000, a major federal nutrition monitoring activity and accomplishment was related to the integration of the two national interagency nutrition surveys, the US Department of Health and Human Services' National Health and Nutrition Examination Survey (NHANES) and the USDA's Continuing Survey of Food Intakes by Individuals (75, 110). An expanded array of diet and health information resources, including specialized food composition, food environment, food safety, and food supply databases, were developed to support monitoring and research activities. The 1990 National Nutrition Monitoring and Related Research Act was not renewed in 2002, so monitoring activities are continuing without the formal, coordinated guidance of an interagency board or legislative mandate (11).

Although measures of food security and diet quality were conceived of and adopted in parallel, they have remained largely independent of one another. The components of each measure do not overlap, and the processes for monitoring them are separate. Food security measurement is conducted annually by the USDA and reported as a federal statistic. The HEI is not tracked as regularly, nor is there a mandate for any scheduled reporting of HEI. Although both diet quantity and healthfulness (i.e., quality) are critical to nutritional well-being, and both food insecurity and components of a healthful diet are tracked routinely as part of national Healthy People objectives, there have been no federal attempts to develop a unified measure or set of measures that could be used for national surveillance of dietary quantity and healthfulness (103).

A CONCEPTUAL FRAMEWORK FOR NUTRITION SECURITY

The USDA definition of food security specifically states that the food access to which it refers promotes an "active, healthy life" (96). Implicit in this definition is households' ability to access nutritionally adequate and safe foods. Despite this, the official definition of food security focuses on quantity ("enough food"), rather than quality, of food access, and measures of food security have also focused largely on assessing a household's ability to consistently access or afford a sufficient quantity of food and not its nutritional value (73). Although the USDA's Household Food Security Survey Module includes a single-item measure of agreement with a statement about the household's ability to consume a nutritious diet, this item—"We couldn't afford to eat balanced meals"—is focused primarily on the economic accessibility of being able to choose healthy food rather than the actual consumption of healthy food (96). Further, this item may not adequately account for other important factors such as cultural preferences, language differences, or access to healthy food purchasing options because of either distance, transportation, disability, or time (23, 43). There are valid criticisms of use of the term "balanced meals," but finding a simple replacement is difficult because of differing understandings of health and nutrition. The USDA ERS contracted with the US Census Bureau to conduct cognitive testing of the CPS Food Security Supplement, including the food security module items. The USDA considered replacing "balanced meals" with "healthy meals," but cognitive testing showed that for some respondents the term healthy was associated with unintended constructs, such as "organic," "more expensive name brands," and "fresh versus canned produce." Further, "balanced" and "healthy" did not appear to be measuring the same construct, so changing to "healthy" could cause a break in long-term national prevalence trends in food insecurity (51).

Further, there is a time window inconsistency between assessments of food insecurity and dietary quality. The food security module typically asks about households' experiences over the last 12 months; in its interpretation, both a brief, discrete occurrence of food inadequacy and a more chronic state of food inadequacy would classify a household as food insecure for the year,

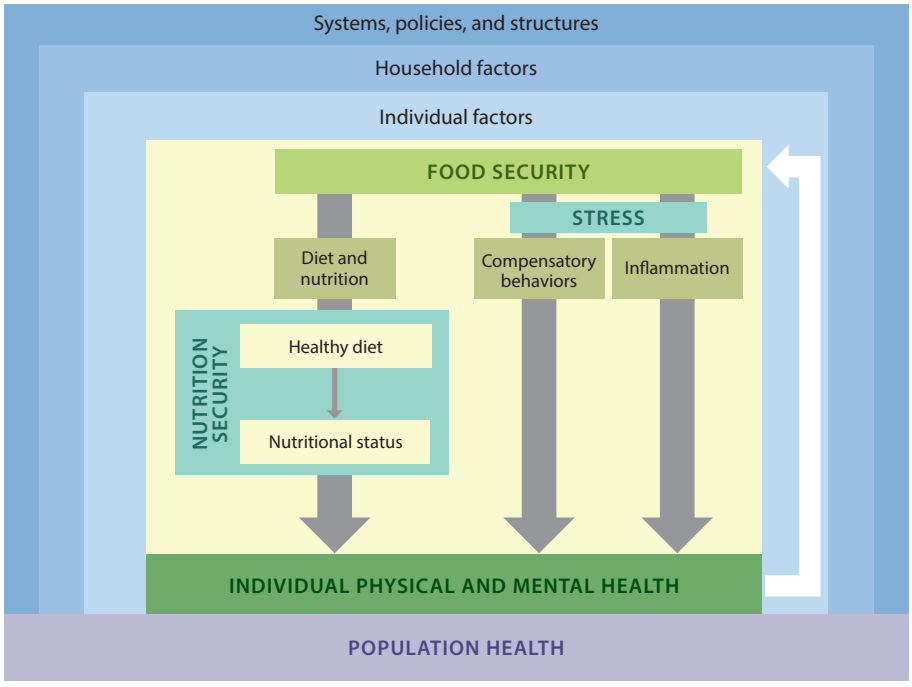

Figure 1

A proposed conceptual framework for exploring food security and nutrition security and their impacts on health.

consistent with the definition of food security as "access at all times to enough food for an active, healthy life." At the same time, the HEI assesses diet quality over only a one- or two-day period but includes no measurement of quantity or consistency of consumption. These discrepancies between the two measures limit our capacity to monitor promotion of health and reduction of health disparities related to both constructs simultaneously or over long time periods.

To remedy this gap, a unified measurement tool or set of tools must be proposed, validated, and accepted for use in surveillance. The first step in this process is the development of a conceptual framework (**Figure 1**) describing the relationships between food security and nutrition security, and the physical and mental health consequences of both states. This framework, building on work by Weiser and colleagues (106), highlights the role nutrition security plays as a critical mediator of the relationship between food security and health. The framework also describes the context in which nutrition security arises and how it differs from food security. In addition to supporting the development of a measurement tool, it may be used to support development of a research agenda that focuses on reducing disparities in child health and development and the development and management of diet-related chronic diseases.

Both food security and nutrition security are profoundly influenced by the broader context and structures in which individuals and households live, work, and play (89). We group these into three socio-ecological levels represented in the framework (**Figure 1**) by the three blue-shaded sections framing food security. These broad factors influence both food security and nutrition security, so food and nutrition security are nested within those broader factors, but we do not focus explicitly on the linkages across those broad factors and structures and how they differentially impact food and nutrition security.

The broadest level includes the systems, policies, and structural factors that influence food security status by limiting household choice and resources (106). These include socioeconomic factors such as prices of foods and other essential goods, access to adequate health care and education, and access to affordable housing; geographic disparities, such as differences in food access in rural and urban communities; racism; and environmental factors, such as climate change and sanitation.

Household factors refer to the dynamics of food purchasing, preparation, distribution, and consumption within the household. Household resources for food are determined by social, economic, and demographic factors, such as employment, disability status, access to benefits, household size, incarceration of household members, and housing, kitchen, and transportation access [for reviews of this literature, see, for example, Gundersen et al. (38, 40)]. Food security typically is experienced at the household level, because households share access to resources (including food), even though individuals in households may differ in their experiences of food insecurity. For example, parents or caregivers may attempt to shield young children from the effects of food insecurity by limiting their own consumption even as they try to keep children's diets unchanged, whereas adolescents may seek strategies to feed themselves to reduce the burden on parents or caregivers to provide food (32).

Increasingly, there is recognition of the ways in which individual factors, including gender, sexuality, immigration status, and disability status, influence a household's food security (9). Age, education level, and family structure can also be important predictors of food security (68). For example, households with children (especially children under the age of 6), single-parent households, households of people of color, and households with low incomes all experience higher (and sometimes profoundly higher) rates of food insecurity than the national average (12). Although low household income is a strong driver of food insecurity, not all households with low incomes are food insecure. Approximately two-thirds (65%) of households with incomes below the federal poverty level are food secure (38). Conversely, approximately 5% of households with incomes greater than 185% of the federal poverty level experience food insecurity (38). Households with higher incomes may experience food insecurity when, for example, household medical bills or regional housing prices are high. Fluctuating income status also increases the likelihood of experiencing food insecurity, and access to liquid assets (for example, a savings account) may play an important role in protecting households from the destabilizing effects of income volatility, particularly for low-income households (38, 62). Medical debt is associated with food insecurity among low-income households with children (10). Financial literacy, financial coping behavior, and use of banks and alternative financial services may also play a role in food insecurity, especially for low- and moderate-income households or when there is volatility in household income or expenses (3, 15, 30).

In most cases, these same factors influence nutrition security—either directly or because food security itself increases the likelihood of nutrition security. Resource-constrained households may have trouble securing the right nutritional balance of foods because of monetary, time, and other nonmonetary costs. Inability to easily access or prepare healthy food items exacerbates food insecurity and may incentivize households to shift their dietary intake from more expensive healthy foods to less expensive, but more nutritionally poor, foods or to a less diverse diet. Other structural factors may influence nutrition security independent of the food security path, and some of these influences may promote nutrition security, whereas others may be detrimental. Examples include food marketing, nutrition education and promotion, and policy changes such as updated nutrition standards for USDA school meals and other child nutrition programs. These changes can have differing impacts on households and individuals, depending on factors such as race and income.

Such differences in impacts could result in disparities in nutrition security; understanding these differences is therefore an important focus of nutrition security research.

Physiologically, as represented by the gray arrows in **Figure 1**, food security shapes health through diet and nutrition and other nondietary mechanisms, including inflammation and compensatory behaviors. These relationships can also be circular or bidirectional, as physical and mental health also influence the capacity to bring resources into the household and therefore food security (52). The white arrow in **Figure 1** signifies this cyclical nature. Factors at different socioecological levels, including at the individual; household; and systems, policies, and structural levels, also influence these relationships. The compensatory behaviors and inflammatory paths are influenced by the stress caused by household food insecurity and the imperative it creates to devote time and effort toward securing food. Food insecurity can act as a toxic stressor, activating inflammatory paths that can trigger poor physical and mental health (35, 60). Together, these paths influence individual health, which forms the basis for overall population health.

In this framework, we conceptualize nutrition security as influencing health primarily through food security, dietary behavior, and nutritional status. The extension of the nutrition security box beyond the food security box is intended to illustrate the possibility that nutrition security also influences health outside of food security paths. These paths are described in greater detail in forthcoming sections.

Diet and Nutrition

Nutrition security is the condition of achieving a healthy diet as well as optimal nutritional status to support health. It occurs when an individual (*a*) has access to both an adequate quantity and quality of food to promote health across the life span and (*b*) makes dietary choices that promote health and long-term well-being. Household food insecurity influences individual nutrition security by limiting access to nutrient-rich foods, which may be more expensive (or perceived to be more expensive) and less accessible than energy-dense, nutritionally poor foods. The result is decreased consumption of the essential components of a healthy diet that can lead to alterations in nutritional status even if energy intake is adequate.

Relationships between food security and diet quality have been studied among children and adults (42, 55, 63, 64, 72). Households experiencing food insecurity have lower fruit and vegetable intake and poorer diet quality overall. Cross-sectional studies have demonstrated that food-insecure adults have lower mean HEI scores than food-secure adults (37, 63, 64). A 2014 systematic review found that adults living in food-insecure households consumed fewer fruits, vegetables, and dairy products and had lower intakes of key vitamins and minerals (42). At the same time, studies have shown food insecurity to be associated with greater intakes of added sugars and sugar-sweetened beverages, empty calories, meat, and salty snacks (72). Among children, the evidence is more mixed, with the same systematic review finding that children living in food-insecure households consistently consumed only lower quantities of fruit. More limited evidence of food insecurity on diet quality among children is consistent with evidence that parents attempt to shield their children from some of the negative dietary impacts of food insecurity by limiting their own intake first (84). Parental perceptions that they are buffering their children from food insecurity, however, likely underestimate children's actual experiences with being food insecure (32, 59, 79). A cross-sectional study examining dietary intake among more than 9,000 US children found that overall, children had poor dietary quality and high intakes of sodium, added sugars, and saturated fats—regardless of food security status; children living in food-insecure households were at greater risk of inadequate vitamin D, magnesium, calcium (girls only), and choline intakes compared to children living in food-secure households (55).

In addition, both children and adults engage in less healthy eating behaviors in the face of economic constraints, such as substituting cheaper, lower-quality, more energy-dense foods in place of more expensive but higher-quality food items (63, 72, 78). Although food-insecure adults are likely to be more sensitive to food prices, a recent study by Ranjit et al. (85) found that food-insecure adults may also experience lower levels of self-efficacy and readiness to consume fruits and vegetables. Seligman & Berkowitz (88) previously outlined the multilevel coping strategies that individuals and households often employ in the face of food insecurity. Among low-income women, these include a decrease in food (energy) consumption and diet quality as food budgets and benefits are exhausted (46, 87). Over time, this pattern of inadequate energy followed by periods of adequate but poor-quality high-energy foods can contribute to increased risk of obesity and the development of cardiometabolic conditions such as diabetes (26). Further, individuals experiencing food insecurity are likely to report higher rates of binge eating as a coping mechanism (5). These complex relationships highlight the importance of considering food and nutrition security simultaneously as risk factors for poor health.

Nutritional status is complex and is often assessed using various anthropometric indices and biomarkers (33). Numerous studies have explored the complex relationship between food security and obesity (61, 72). There is evidence of a relationship between food insecurity and obesity, particularly among women. However, the underlying mechanisms that drive this relationship are less clear, evidence for an association among men and children is mixed, and the relationship even among women may be disappearing as obesity rates have climbed steadily in the US population as a whole (24, 72).

Few studies have examined associations between food security and nutritional biomarkers. A recent cross-sectional study among US children found no differences in vitamin or mineral biomarkers by food security status despite observing differences in dietary intake (55). Two prior US studies, however, have documented lower serum nutrient values among households experiencing food insecurity or food insufficiency (7, 25).

It is likely common in the United States for individuals to be simultaneously food secure and nutrition insecure. Although food insecurity, particularly among adults, is a strong predictor of inadequate nutrient intake, most Americans—regardless of food security and socioeconomic status—do not meet federal dietary recommendations outlined in the Dietary Guidelines for Americans (57). Cost may be one important barrier to consuming a healthy diet, but other barriers, such as taste and cultural preferences, marketing, time, ability to prepare food at home, local food environment, and transportation access, may influence an individual's nutritional intake, and thus their nutrition security (21, 74, 108). In **Figure 1**, nutrition security is illustrated as part of the diet and nutrition path leading from food security to health, but nutrition security also exists outside of the umbrella of food insecurity. As such, nutrition security can influence health in the absence of food insecurity, and nutrition security itself can be influenced by or result from a variety of factors across the individual; household; and system, policy, and structural levels.

The possibility of the opposite, that is, whether there can be simultaneous food insecurity and nutrition security, is less clear and should be the subject of future study. Simultaneous food insecurity and nutrition security hypothetically could exist in the context of easy availability of low-cost, healthy foods; capacity to invest additional time in preparing and cooking healthy foods; access to additional healthy food resources [such as WIC (the Special Supplemental Nutrition Program for Women, Infants, and Children) or fresh produce from a food pantry]; individual motivation to prioritize healthy food purchases over other expenditures (for example, in the context of a new diabetes diagnosis); and other factors. If this were the case, however, increasing severity of food insecurity likely would lead to increasing difficulty maintaining nutrition security.

Compensatory Behaviors

Food insecurity may also influence an individual's physical and mental health through other paths. Through compensatory behaviors, households may make trade-offs between food and other basic needs, such as medical expenses, housing costs, education, or utilities (6, 49). Multiple studies have shown that food-insecure adults with chronic disease have worse disease control than their food-secure counterparts (36, 60). For example, people with diabetes who experience food insecurity have poorer blood sugar control, which increases their risk for diabetes-related complications (4). One potential mechanism for this is the association between food insecurity and cost-related medication underuse; many chronically ill, food-insecure individuals cannot simultaneously meet their food and medical needs due to competing demands (6, 49). In addition to poor physical health outcomes, these hardships can also take a toll on mental health, leading to increased stress, anxiety, and depression (1). Trade-offs between food and other basic needs are associated with parental stress and poor mental health that in turn negatively affect children's health and development (58). Although many parents try to shield their children from the consequences of food insecurity, the stress accompanied by trade-offs is often felt by the entire household (58). Competing demands and shifts in dietary patterns can also strain cognitive capacity, influencing decision-making and hindering an individual's ability to manage disease (8, 44). A study among food pantry clients with diabetes found that those who were more food insecure had higher rates of medication nonadherence, more trade-offs between food and diabetes medication and supplies, greater diabetes distress (a measure of the emotional burden an individual associates with managing disease), lower rates of disease self-efficacy, and more depressive symptoms than participants with less severe food insecurity (50). Increased stress can also lead to metabolic dysfunction and changes in eating behaviors, which can increase the risk of obesity and other health conditions (90).

Inflammation

Food insecurity is also likely to function as a toxic stressor that can increase risk for adverse health outcomes by elevating inflammatory markers (35). Few studies have directly examined the connection between food insecurity, inflammation, and health; however, two cross-sectional studies among a representative national sample of adults found that food insecurity is associated with higher markers of inflammation (31, 35). Further, one of those studies found that food-insecure individuals had lower serum concentrations of folate, which has been associated with a greater risk of infection and disease. In a cohort study of older adults, food insecurity was associated with higher allostatic load through physiologic and metabolic dysregulation, and this effect was mitigated by SNAP (Supplemental Nutrition Assistance Program) enrollment (80). Inflammation may also be a mediator by which other paths lead to poor health (35). For example, stress-induced shifts in dietary behaviors and some coping strategies for food insecurity (such as shifting dietary intake toward less expensive or a more limited range of foods) may result in inflammation, and research has established an association between food insecurity and increased inflammation (35). Diet alone has also been associated with changes to the inflammatory response through changes to the gut microbiota and increased oxidative stress (91). Both overconsumption and underconsumption of specific dietary components promote inflammation and lead to metabolic alterations that influence health (91).

ASSESSMENT AND MONITORING

To achieve nutrition security, households and individuals must consistently access and consume a healthy diet that provides adequate energy (calories) and optimal amounts of nutrients and other dietary constituents (e.g., dietary fiber) required for good nutritional status, as assessed by

physiological measures. From the perspective of assessing and monitoring whether individuals or populations achieve nutrition security, therefore, two important constructs of nutrition security are healthy diets and nutritional status (**Figure 1**). Knowing what and ultimately how to assess and monitor means knowing the subconstructs that make up each of these two constructs.

In the remaining sections, we (*a*) identify the constructs that form the basis of nutrition security and then, given the constructs, the subconstructs of each construct; (*b*) identify data systems that could be used to provide data to assess subconstructs of nutrition security; and (*c*) illustrate currently used measures that may be useful for assessing these constructs and subconstructs.

Constructs and Subconstructs of Nutrition Security

We conducted searches using the keywords "nutrition security" and "food and nutrition security" in Google Scholar and PubMed databases to identify articles with existing definitions of nutrition security. The five identified were from both white and gray literature from US and global sources (20, 73, 81, 83, 105). These definitions of nutrition security were extracted from the identified articles. The two important constructs of nutrition security implied in this literature were healthy diets (that is, the nutritional content of foods consumed) and nutritional status (a physiologic assessment of the adequacy of nutrient intake).

To guide assessment and monitoring efforts, identifying the subconstructs that make up each of the two constructs of nutrition security—healthy diets and nutritional status—is crucial. To identify the subconstructs of healthy diets, we focused on what constitutes healthy diets (i.e., what they are) and not on what healthy diets are supposed to accomplish (e.g., prevent disease). Reyes et al. (86) highlight recommended actions from global nutrition initiatives. We reviewed nutrition policy documents from this article for content relevance and identified 12 papers published in the English language from 2016 to 2020. These articles were reviewed to identify the subconstructs that were captured in the definitions and descriptions of healthy diets or healthy diet quality.

We also reviewed the report from a technical consultation on the measurement of healthy diets by the World Health Organization, UNICEF, and the Food and Agriculture Organization (FAO) to unpack the subconstructs that were captured by the various existing measures of diet quality that have been developed and validated globally (109). Other relevant articles and publications from US and global sources suggested by coauthors and colleagues were subsequently reviewed as well. Dietary guideline documents for several countries were obtained from the FAO website to capture and compare the subconstructs of healthy diets that were described in the guidelines (29). We reviewed selected work from the US and global scientific literature, international agency reports, dietary guidance documents from the United States and other countries, and tools for assessing healthy diets or dietary quality. Both white and gray literature were reviewed for definitions, descriptions, and subconstructs of healthy diets or diet quality, including reports and technical consultations from international organizations.

The subconstructs of healthy diets were derived from three categories of sources:

- Global reports: The subconstructs of healthy diets were derived from global reports that attempted to define the components of healthy diets or healthy diet quality.
- Country dietary guidelines: The subconstructs of healthy diets were derived from dietary guidelines and recommendations from multiple countries that attempted to define the components of healthy diets or healthy diet quality. The dietary guidelines for selected countries apart from the United States were derived from a compilation on the FAO website (29). A global review by Herforth et al. (48) confirmed that most countries were consistent regarding the subconstructs of healthy diets as reflected in the guidelines, although differences were observed with guidelines on a few subconstructs.

- Measurement tools: The subconstructs of healthy diets were inferred from articles and reports that described measurement tools that aimed to capture and assess healthy diets or diet quality at individual and population levels. That is, we identified the subconstructs that measures were intended to reflect.

To identify the subconstructs of nutritional status, we relied mostly on Gibson's (33) textbook, which gave a comprehensive layout of the subconstructs of nutritional status, and a report by Quisumbung et al. (83), which included a definition of nutrition security that outlined the subconstructs of nutritional status (83).

To organize the findings on the subconstructs of healthy diets from the articles reviewed, we developed a matrix to list the subconstructs of healthy diets and to compare the subconstructs derived from different sources. Arimond & Deitchler (2) provided a comprehensive elaboration of subconstructs for healthy diets (which they labeled diet quality). They described six subconstructs of healthy diets, which we then used to help organize the subconstructs from other literature sources and definitions (2) (**Table 1**). Dietary Guidelines for Americans identified one additional subconstruct (102). Many of these six subconstructs appear in dietary guidelines from the United States and other countries (**Table 2**) and are consistent with the subconstructs derived from the measurement tools (**Table 3**). Several sources, including Dietary Guidelines for Americans, identified the importance of dietary patterns favorable to health, but favorable dietary patterns result from achieving the other six subconstructs rather than being a subconstruct of healthy diets (27, 73, 77, 86, 102). Three other subconstructs (i.e., sociocultural acceptability, sustainability, and stability) were initially considered for inclusion in the matrix but were later excluded upon further consideration and based on expert consultation and feedback. Sociocultural acceptability is important for understanding food choice decision-making, and unsustainability and stability are important for understanding continuance of healthy diets over time, but these subconstructs do not constitute what makes diets healthy from biological and nutritional perspectives.

Healthy diets are adequate in amounts of food energy (calories) and nutrients relative to requirements without excess, nutrient dense, balanced in composition of energy-yielding nutrients, diverse, moderate in intake of dietary components associated with detrimental health, and safe (**Table 1**). That is, the subconstructs of healthy diets are (*a*) nutrient adequacy, (*b*) nutrient density, (*c*) macronutrient balance, (*d*) diversity, (*e*) moderation, and (*f*) safety. The subconstructs of nutritional status are having optimal amounts in body tissues of (*a*) energy, (*b*) protein, (*c*) essential fats, (*d*) vitamins, and (*e*) minerals.

Available Data Systems and Currently Used Measures

Assessing and monitoring nutrition security requires marshalling existing or additional data systems to collect data on current or additional measures of the important subconstructs of healthy diets and nutritional status. To that end, we enumerate existing data systems and current measures.

NHANES, conducted by the National Center on Health Statistics, is designed to monitor the nation's health and nutritional status. It is the primary and most comprehensive source of nutrition data in the United States (65) (**Table 4**). NHANES obtains information on anthropometry, dietary intake of foods and nutrients using dietary recall, food security, diet behavior, nutrition knowledge of individuals, and biochemical indicators of nutrient levels in the body (18). Although NHANES is the most comprehensive of the existing data systems on nutrition measures, inconsistencies in the frequency of data collection for some nutrition measures occur, especially nutritional biomarkers that are obtained at irregular time intervals or discontinued after some data collection cycles (16). This inconsistency in the assessment of nutrition measures limits effective monitoring and surveillance of these nutrition measures over time.

Table 1 Subconstructs of healthy diets derived from global reports

Subconstruct	Arimond & Deitchler (INTAKE, 2019) (2)	FAO (State of Food Security, 2020) (28)	FAO & WHO (Sustainable Healthy Diets, 2019) (27)	FAO (Committee on World Food Security, 2012) (92)	Mozaffarian et al. 2021 (73)	Neufeld et al. (Food Systems Summit, 2021) (77)	GLOPAN 2016 (34)	Willett et al. 2019 (107)
Nutrient adequacy: nutrient intake relative to requirements without excess	Adequacy: nutrient intake relative to requirements	Adequacy: sufficiency of nutrients or food groups compared with requirement	NR	Sufficient quantity and quality to meet dietary needs and food preferences	NR	Adequacy	NR	Nutritional adequacy: includes micronutrient adequacy
Nutrient density: unit of nutrient per 100 kcal	Nutrient density: unit of nutrient per 100 kcal	NR	NR	NR	NR	NR	NR	NR
Macronutrient balance: balance of carbohydrates, proteins, and fats	Macronutrient balance: balance of carbohydrates, proteins, and fats	Overall balance: composition of macronutrient intake	NR	NR	NR	No excess of nutrients	NR	NR
Diversity: diets composed of a variety of foods derived from diverse food groups	Diversity and proportionality: diets composed of a variety of foods derived from diverse food groups	Variety or diversity within and across food groups	Variety: balance of food groups	Variety and diversity	NR	NR	Diversity of diets	Balance and diversity of food groups
Moderation: restriction of food and nutrients related to chronic diseases	Moderation: in intake of red and processed meats, avoidance of trans fats, etc.	Moderation: foods and nutrients that should be consumed with restraint	Moderation in salt intake	NR	NR	Avoidance of health-harming substances in food or diets	Minimizing the intake of saturated and trans fats, free sugars, and salt	NR
Safety: food is free of microbial pathogens, foodborne macroparasites, toxins, and chemicals	Safety: food is free of microbial pathogens, foodborne macroparasites, toxins, and chemicals	Safety: no exposure to food safety hazards	Safety: contains minimal levels of pathogens, toxins, or agents that can cause foodborne disease	Safety	NR	Avoidance of health-harming substances in food and diets	Safety	NR

Abbreviation: NR, subconstruct not reported.

Table 2 Subconstructs of healthy diets derived from dietary guidelines from countries

Subconstruct	Sources					
	United States (2020) (102)	Canada (2019) (45)	Kenya (2017) (69)	Thailand (2007) (70)	Australia (2013) (76)	South Africa (2013) (104)
Nutrient adequacy: nutrient intake relative to requirements without excess	Meets nutrient recommendation	NR	Adequacy	NR	NR	NR
Nutrient density: unit of nutrient per 100 kcal	Nutrient-dense foods and beverages	NR	Nutrient density	NR	NR	Nutrient density
Macronutrient balance: balance of carbohydrates, proteins, and fats	Balance of calorie-yielding foods	Energy balance	Energy control	NR	NR	NR
Diversity: diets composed of a variety of foods derived from diverse food groups	Variety: different foods and beverages from each food group Meets food group recommendations	NR	Variety	Variety	Variety	Variety of foods
Moderation: restriction of food and nutrients related to chronic diseases	Limited intake of refined grains, red and processed meats, sugar-sweetened foods, and beverages	Moderation	Moderation, minimally processed foods	Moderation: avoid sweet and salty foods	Moderation	Moderation in intake of salt and foods high in salt, fat, and sugar
Safety: food is free of microbial pathogens, foodborne macroparasites, toxins, and chemicals	Follow food safety recommendations to reduce the risk of foodborne illness	NR	Safety in production, preparation, and storage	Safety	Safety	NR

Abbreviation: NR, subconstruct not reported.

Other existing data systems mostly assess food security using the USDA's Household Food Security Survey Module, in either the full 18-item form, a briefer 10-item form that references only household adults, or briefer screening forms. Data on individual and household experiences of food insecurity are obtained from these data systems: NHANES, Behavioral Risk Factor Surveillance System (BRFSS), American Housing Survey, Current Population Survey–Food Security Supplement, Household Pulse Survey, National Health Interview Survey (NHIS), Medical Expenditure Panel Survey, Panel Study of Income Dynamics, Survey of Income and Program Participation, Early Childhood Longitudinal Study, National Household Food Acquisition and Purchase Survey, and National Survey of Children's Health (for information on some of these sources, see 95). In addition to assessing food security, some surveys, such as BRFSS and NHANES, capture other diet and nutrition measures, such as frequency of consumption of specific food groups and brief instruments to measure intake of fruit and vegetables and salt/sodium (**Table 4**). BRFSS includes measures of fruit and vegetable intake and of salt/sodium intake. As a potential means to capture consequences of nutrition insecurity, NHIS data can be linked to information on health care use, expenditures, sources of payment, and health insurance coverage in the Medical Expenditure Panel Survey (17).

Table 3 Subconstructs of healthy diets reflected in measurement tools

Subconstruct	Health Eating Index 2015 (US Dep. Agric. Food Nutr. Serv. 2015) (100)	Minimum Dietary Diversity for Women (Martin-Prevel 2021) (66)	Diet Quality Questionnaire (Herforth 2021) (47)	Global Diet Quality Score (Deitchler 2021) (22)	Nova Score for Ultra-Processed Foods (Monteiro 2021) (71)	Diet Quality Index-International (Kim et al. 2003) (56)
Nutrient adequacy: nutrient intake relative to requirements without excess	Adequacy (from 9 food groups)	Micronutrient adequacy	Nutrient adequacy	Nutrient adequacy	NR	Adequacy of nutrients relative to requirements
Nutrient density: unit of nutrient per energy content	Nutrient density per 1,000 kcal	NR	Nutrient density	NR	Nutrient density: energy density and micronutrient content of foods	NR
Macronutrient balance: balance of carbohydrates, proteins, and fats	NR	NR	NR	NR	NR	Overall balance of energy-yielding macronutrients
Diversity: diets composed of a variety of foods derived from diverse food groups	NR	Diversity across food groups	Diversity across food groups	Variety and diversity across food groups	NR	Variety and diversity across and within food groups
Moderation: restriction of food and nutrients related to chronic diseases	Moderation (from 4 food groups)	NR	Moderation in intake of ultraprocessed foods	Moderation in intake of red and processed meat, high-fat dairy products, sugar-sweetened beverages	Moderation in intake of ultraprocessed foods, foods high in trans and saturated fats and free sugars	Moderation: restriction of food and nutrients related to chronic diseases
Safety: food is free of microbial pathogens, foodborne macroparasites, toxins, and chemicals	NR	NR	NR	NR	NR	NR

Abbreviation: NR, subconstruct not reported.

Table 4 Available data systems and currently used food security, diet, and nutrition measures in the United States

Available data systems	Currently used nutrition measures
National Health and Nutrition Examination Survey (NHANES)	Adequacy of intake for macronutrients (energy, proteins, fats, and micronutrients), vitamins, and minerals, derived from two 24-h recalls Diet quality measured using the Healthy Eating Index Levels of certain nutrient biomarkers Anthropometry: height, weight, body mass index, waist circumference, abdominal diameter Body composition measures: bone mineral density, fat mass, lean mass, and percent body fat Food security status derived from the household food security module Self-assessed diet quality and diet-related behaviors
National Health Interview Survey (NHIS)	Food security from household food security questionnaire
Behavioral Risk Factor Surveillance System (BRFSS)	Frequency of intake of foods from specific food groups: fruits, green leafy vegetables, fried foods Sodium/salt consumption behavior
Youth Risk Behavior Surveillance System	Anthropometry: measures of adiposity, obesity Frequency of intake of specific foods: fruits, vegetables, sugar-sweetened beverages
Early Childhood Longitudinal Study Program (ECLS)	Anthropometry: height, weight Frequency of food consumption for children, measuring food and nutrient intake Food security status for households and children, derived from the 18-item household food security survey module and children's food security scale
Current Population Survey Food Security Supplement	Food security status of households Food spending and use of nutrition assistance programs including community food assistance
Pediatric Nutrition Surveillance System (PedNSS)	Anthropometry: weight Nutritional biomarkers for anemia
Total Diet Study	Food safety, food contaminants: pesticide residues, industrial chemicals, and levels of toxic elements in food
American Housing Survey	Food security status, derived from the 10-item adult food security survey module Availability of kitchen cooking appliances and housing quality
Household Pulse Survey	Food insufficiency Food spending and use of nutrition assistance programs
National Household Food Acquisition and Purchase Survey (FoodAps)	Food security status, derived from the 10-item adult food security survey module Household food purchases and acquisitions from all sources Dietary knowledge and behaviors
Panel Study of Income Dynamics	Food security status, derived from the 18-item household food security survey module
Survey of Income and Program Participation (SIPP)	Food security status, derived from the 6-item household food security survey module

SIGNIFICANCE FOR CONTEMPORARY UNITED STATES

In the United States, concerns regarding poor nutrition have prevailed for decades. Poor nutrition has led to rising rates of diet-related diseases, such as diabetes, obesity, hypertension, and heart disease, which result in more than half a million deaths annually (94). Although the consequences of unhealthy diets affect the entire US population, Black, Latino, and Native American households

as well as households with lower socioeconomic status are at increased risk for diet-related diseases (14, 53). These same disparities exist for households experiencing food insecurity.

To make progress in assessment and monitoring, we must not only recognize the inextricable link between food security and nutrition security but also understand how they co-occur in the population. Our current measurement of food insecurity does not include, and was not intended to include, information to assess healthfulness of diets; nutritional status; or the nutritional, behavioral, and inflammatory paths (73). To effectively address key drivers of conditions such as diabetes and obesity, developing measures of nutrition security that build on and complement the measure of food security is essential. A monitoring system that allows for concurrent measurement of food security and nutrition security will be important for understanding the different factors that drive nutrition insecurity and the extent to which food insecurity is one of those driving forces. A more nuanced understanding of the inputs that affect food and nutrition security and ultimately health can allow us to create more targeted and effective interventions to address diet-related disparities. Further, just as we need a mechanism for understanding the drivers and prevalence of nutrition security, estimating the consequences of nutrition insecurity is important, by observing the association between nutrition security and diet-related health outcomes such as diabetes, obesity, and cardiovascular disease.

Several steps must be undertaken to further assessment and monitoring of nutrition security. Conceptual clarity about nutrition security and delineation of its constructs and subconstructs are essential to form a basis from which to determine what measures are needed as well as the existing data systems and currently used measures. The conceptual framework we propose is intended to guide research to better understand the determinants of nutrition security. Going forward, empirical studies should examine measures that reflect the subconstructs of nutrition security and how these measures relate to assumed determinants of nutrition security (e.g., food security and household characteristics), consequences of nutrition security (e.g., physical and mental health), and paths connecting these constructs and subconstructs with determinants and consequences (**Figure 1**). As we develop a better understanding of nutrition security and the relevant measurement needs, gaps in existing data systems and current measures should be identified. A plan for alleviating these gaps and implementing the required research should be developed. The research should specify the inputs necessary for measuring healthy diets and nutritional status for monitoring of nutrition security, accounting for its multiple subconstructs and any differences across subpopulations. Identifying measures at a population level that reflect important subconstructs of nutritional status is a complex and nuanced task that has yet to be explored fully. We have begun work on this important research topic, with the intention of informing nutrition security measurement needs.

DISCLOSURE STATEMENT

The authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review. The findings and conclusions in this publication are those of the authors and should not be construed to represent any official US Department of Agriculture or US Government determination or policy.

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