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OBESITY AND DIET (G. RAO, SECTION EDITOR)

Food Insecurity and its Impact on Body Weight, Type 2 Diabetes, Cardiovascular Disease, and Mental Health

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Abstract

Purpose of Review Food insecurity (FI) is a serious public health issue affecting 2 billion people worldwide. FI is associated with increased risk for multiple chronic diseases, including obesity, type 2 diabetes, cardiovascular disease, and mental health. We selected these four chronic diseases given their global prevalence and comorbid associations with each other. We evaluated the most recent literature published over the past 5 years and offer strategies for the screening of FI.

Recent Findings Recent systematic reviews and meta-analyses report an association between FI and obesity in adult women as well as adult men and women living in low- and middle-income countries. Gender differences also were observed between FI and type 2 diabetes, such that adult women showed an increased risk for type 2 diabetes. This association was influenced by social determinants of health. Very low food security (i.e., high FI) was associated with increased risk for cardiovascular disease and a higher risk for cardiovascular disease mortality. Finally, several studies showed an association between FI and adverse mental health outcomes, including increased risk for stress, depression, anxiety, sleep disorders, and suicidal ideation.

Summary FI and its negative association with body weight, type 2 diabetes, cardiovascular disease, and mental health provide a compelling rationale for identification of FI in clinical settings. Brief, well-validated screening measures are available in multiple languages. Despite the need for FI screening, many guidelines do not address its implementation. For this reason, more research and targeted interventions are needed to increase FI screening rates and close the loop in the coordination of resources.

Keywords Food insecurity · Obesity · Type 2 diabetes · Cardiovascular disease · Mental health

Food insecurity (FI) is defined as limited or uncertain access to adequate, nutritious food for an active and healthy lifestyle [1, 2]. The United States Department of Agriculture (USDA) classifies FI into four levels, ranging from "very low," "low," "marginal," to "high" food security (see Table 1) [3]. Globally, FI affects 25.9% of the world's population or approximately two billion people [4]. The total distribution of FI is highest in Africa, affecting 51.6% of the population, followed by Latin America and the Caribbean (31.7%), Asia (22.3%), and North America and Europe (7.9%) [4]. FI rates have increased steadily since 2014, with the most rapid increase observed in Latin America and the Caribbean, where FI rates have risen from 22.9% in 2014 to 31.7% in 2019 [4].

FI is a multi-faceted issue with numerous causes. FI is associated with limited income [5] as well as higher housing costs [6], higher rates of unemployment [7], and countries with grocery taxes [8]. Location also can affect access to adequate, nutritious food. For example, rural regions encounter additional barriers that contribute to FI, including reliance on transportation [9], distant proximity to grocery stores and markets [9], and increased cost of fresh, nutritious foods [10]. Importantly, social determinants of health are not the only factors that drive FI. Climate change (e.g., droughts, floods) [11], natural hazards (e.g., hurricanes, earthquakes) [12, 13], conflict and war [13, 14], market globalization and dominance [15], rapid population growth [16], and disease outbreaks [17] affect food production, distribution, and access. Most recently, the outbreak and spread of the novel coronavirus 19 (COVID-19) increased FI in nearly every country across the world [4] due to the economic recession [18], disruption of food supply chains [19], and increased consumer demands coupled with

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Table 1 United States Department of Agriculture (USDA) definitions of food security and insecurity with associated levels [2]

Term	Definition
High food security	No reported problems with food-access
Marginal food security	One to two reported problems with food access. Most common problem is anxiety over food sufficiency or shortage of food in the house. Minimal to no changes in diet or food intake
Low food security	Reported problems with reduced quality, variety, and/or desirability of diet. Minimal to no changes in food intake
Very low food security	Multiple reported problems with disrupted eating patterns and reduced food intake

labor shortages and higher food prices [20]. An additional 83 to 132 million people, who otherwise would not have been vulnerable, experienced FI in 2020 [4]. For example, in the USA, 10.5% of people reported FI in 2019 [3], whereas the estimates of FI more than tripled to 38.3% by April 2020 during the height of the state-mandated lockdowns [21]. While the long-term impact of the COVID-19 pandemic on FI and health outcomes will not be known for many years to come, we can learn from prior research about what to expect in the future [22].

In this review, we discuss the current literature on FI and chronic disease. Specifically, we examine the impact of FI on body weight [23, 24], type 2 diabetes [25, 26], cardiovascular disease [27, 28], and mental health [29]. We evaluate the literature published over the past 5 years on FI and the four selected chronic diseases. Next, we review guidelines and screening tools for FI in healthcare settings. Finally, we discuss strategies to support clinicians in the administration and facilitation of FI screening and resources.

Body Weight

The relationship between body weight and FI has been studied widely across the lifespan, with mixed findings by age and gender [30]. A 2020 systematic review and meta-analysis by Pourmotabbed and colleagues [31•] found no association between FI and risk for overweight/obesity in children under 18 years of age. However, the analysis did find a direct link between adolescents aged 12–18 years old living in developed countries but at lower economic levels and increased risk of overweight and obesity (OR=1.14; 95% CI: 1.02, 1.27) [31•]. Another study by Flórez and colleagues [32] observed an association between FI and obesity in Latinx children between the ages of 12 and 17 years, but only if the children were classified as a "2.5 generation" status (i.e., US-born with one US-born parent and one foreign-born parent) [22]. Research conducted by Bae and colleagues in 2021 [33] showed a positive association between FI and obesity risk among girls aged 2–17 years in Korea, but not boys, despite an overall low obesity rate among Korean children.

In the adult population, Farrell and colleagues [34] reviewed 13 studies conducted in low- and middle-income countries and observed a significant association between FI and obesity. Affordability and availability of processed foods were identified as the mechanism through which FI was associated with obesity, such that access to low-cost, energy-dense foods contributed to higher body mass index (BMI) levels [34]. A 2018 systematic review and meta-analysis by Moradi and colleagues [35•] examined associations between FI and body weight from 14 countries and found that FI was associated with a decreased in risk of overweight among men but not women [35•]. Further, Moradi and colleagues [35•] found a positive association between FI and obesity among adult women but not men. The positive association between FI and obesity in women was confirmed in research conducted by Rodriguez et al. [36], Testa and Jackson [37], Jones et al. [38], and Rasmusson et al. [39].

While most research has centered on FI and overweight/obesity, results from the 2018 systematic review and meta-analysis by Moradi and colleagues also showed that individuals with severe FI were more likely to be underweight than obese (49% vs 29% risk increase, respectively) [35•]. Conversely, Rasmusson and colleagues [39] found people with low and very low FI had increased odds for obesity as well as binge-eating disorder. Irregular eating patterns may explain the mechanism through which FI and overweight/obesity are associated. Specifically, people in food insecure households may experience periods of deprivation and/or underconsumption of food as well as periods of overconsumption to compensate for those periods when resources were limited [40]. Similarly, Nettle and colleagues proposed an evolutionary adaptive strategy they called the "insurance hypothesis" where the body stores additional fat during times of limited access to a stable food supply [41]. Further, Seligman and colleagues [42] suggest the "substitution" effect wherein higher-quality, less calorie dense foods are substituted for lower-quality, more calorie dense foods because they are cheaper and have a longer shelf-life. A combination of these theories and effects likely explain the relationship between FI and body weight. More well-designed longitudinal studies are necessary to determine temporal relationships between FI and

body weight to explore potential mechanisms underlying these relationships.

Type 2 Diabetes

A 2019 systematic review and meta-analysis of 18 studies by Abdurahman and colleagues [43•] showed that household FI was associated with increased odds for type 2 diabetes (OR=1.27, 95% CI: 1.11–1.42). Recent research by Strings and colleagues [44] observed gender and racial differences in FI and type 2 diabetes using the California Health Interview Survey dataset. They found an association between FI and increased risk for type 2 diabetes in Latinx women and White men and women, but not Latinx men or African American/Black men and women [44]. This finding lends support to prior research that suggested gender and race moderated the relationship between FI and type 2 diabetes [25, 28]. Another study by Schroeder and colleagues [45] documented differences in gender and race as well as comorbidity status and socioeconomic characteristics. Specifically, they found adults with type 2 diabetes identifying as women, minorities, single, current smokers, with multiple comorbidities, and/or a lower education level were more likely to experience FI [45]. Importantly, more research is needed to understand these observed differences by gender, race, and socioeconomic status in order to identify the root causes of these health disparities.

FI negatively impacts type 2 diabetes outcomes, psychosocial well-being, and health expenditures. Schroeder and colleagues [45] showed FI in adults with type 2 diabetes increased the odds of emergency department visits (OR=1.40, 95% CI: 1.15–1.72) and hospitalizations (OR=1.41, 95% CI: 1.11–1.78) [33]. Walker and colleagues [46•] documented negative associations between FI and self-care behaviors, A1C levels, perceived stress, depression, diabetes distress, and diabetes fatalism. Further, structural equation modeling revealed FI was indirectly associated with [1] exercise through depression, [2] self-care through perceived stress and diabetes distress, and [3] A1C levels through diabetes distress [46•]; thus, identifying pathways through which FI influences diabetes self-care and A1C via psychosocial factors. Finally, Bermudez-Millan and colleagues [47] measured biomarkers of inflammation and stress to examine the association between FI and insulin resistance. They found that FI was associated with elevated insulin resistance and that this association was partially mediated by inflammation (i.e., cortisol) and stress hormones (i.e., hsCRP) [47]. In sum, the evidence establishing an association between FI and type 2 diabetes is considerable; however, a common limitation of this research is the use of cross-sectional study designs. Longitudinal research is needed to confirm causal associations between FI and type 2 diabetes and to identify potential mechanisms in this pathway to target areas for intervention.

Cardiovascular Disease

A 2021 literature review by Liu and colleagues [48], which included 14 studies in adults over 17 years of age, identified an unequal burden of CVD risk among individuals with the lowest food security levels [48]. Palakshappa and colleagues [49] found a similar association between coronary artery disease and very low food secure households (OR=2.0; 95% CI: 1.3, 3.0) using combined 2-year cycles of data from the 2007–2014 National Health and Nutrition Examination Survey (NHANES). Sun and colleagues in 2020 [50•] also observed individuals with very low food security had a higher risk of CVD mortality (HR=1.53, 95% CI, 1.04–2.26) when compared with those with high food security from participants in the US National Health and Nutrition Examination Survey from 1999–2014.

In 2021, Banerjee and colleagues [51] showed that people experiencing FI had a 58% higher risk of mortality compared to those not reporting FI. Mortality risk differed by level of FI, with very low food security (HR=2.00, CI:1.16, 3.44) showing the highest risk followed by marginal food security (HR=1.79, CI: 1.10, 2.93) and low food security (HR=1.21, CI:0.64, 2.29). When controlling for pre-existing CVD conditions (e.g., myocardial infarction, congestive heart failure), FI had an independent effect on CVD mortality, thereby demonstrating FI's importance in determining risk profiles for CVD mortality [51]. While most studies centered on FI and the risk of CVD, Charkhchi and colleagues [52] used the 2015 Behavioral Risk Factor Surveillance System (BRFSS) to establish a reverse relationship between CVD and increased odds of FI (OR=1.75, 95% CI: 1.12–2.73). Charkhchi and colleagues [52] attributed the direction of the association to reduced access to care (i.e., concerns about cost of healthcare) and poorer health status.

Isaura and colleagues [53] identified mediators influencing the relationship between FI and CVD. Specifically, they found that adults who were food insecure consumed high-calorie diets, which led to obesity, and in turn, less vigorous physical activity and higher systolic blood pressure [53]. These findings suggest prevention of CVD should target food consumption of high calorie diets in food insecure households, obesity, vigorous physical activity, and high blood pressure [53]. More longitudinal research is needed to understand all of the pathways by which FI and CVD influence each other.

Mental Health

Nine recent studies, two systematic reviews and meta-analyses [29, 54] and seven large-scale, cross-sectional studies [55–60], examined the relationship between FI and mental health. These broad examinations consistently showed that FI was associated with adverse mental health outcomes,

although the specific measures of mental health varied from subjective well-being to psychological distress to clinically defined measures of anxiety and depression. In a 2019 systematic review and meta-analysis of 57 cross-sectional studies, Arenas and colleagues [54•] found that FI was associated with increased risk for depression, anxiety, and sleep disorders, with the highest risk observed for depression. Another systematic review and meta-analysis of 19 studies by Pourmotabbed and colleagues in 2020 [29] showed that FI was associated with increased risk for depression and stress, but not anxiety.

A 2017 study by Frongillo and colleagues [43•] analyzed data from the 2014 Gallup World Poll and showed that FI explained lower subjective well-being in a global sample of 147 countries. A second study by Frongillo and colleagues in 2019 [55] expanded on their previous findings and found that FI was more strongly associated with lower subjective well-being in more-developed countries. In 2017, Jones [56•] also analyzed data from the 2014 Gallup World Poll and observed a dose-like response between FI and mental health scores via the Negative Experience and Positive Experience Indices. Similarly, Jessiman-Perreault and McIntyre [59] documented a dose-response relationship between household FI and adverse mental health outcomes (i.e., depressive symptoms, major depressive disorder, anxiety disorder, mood disorder, fair/poor mental health, suicidal ideation) in Canadian adults, in which the highest risk for adverse outcomes was observed among those reporting severe household FI. Kolovos and colleagues in 2020 [60] also showed a dose-like response with "mild," "moderate," and "severe" FI and increased odds for high depressive symptoms as well as depression in a representative Mexican population. Most recently, Smith and colleagues in 2021 [57] analyzed data from the World Health Organization Study on Global AGEing and Adult Health (SAGE) Study and found that severe FI was associated with 2.4 times higher odds for depression compared to those with no FI. Finally, the positive association between FI and mental health in adults holds true for children and adolescents. Burke and colleagues in 2016 [58] demonstrated that severity of household FI increased the odds of children and adolescents having a mental disorder. Longitudinal research with larger, more heterogeneous samples is needed to confirm the association between FI and mental health over time.

Screening for Food Insecurity

The need to screen for FI in a healthcare setting has been recognized for more than 20 years, with the first such recommendation from the Committee on Health Care for Underserved Women of the American College of Obstetricians and Gynecologists (ACOG) [61]. Specifically, ACOG recommended that obstetricians and gynecologists inquire about and document a patient's access to food and safe drinking water, in addition to other social determinants of health, to improve patient-centered care and decrease inequities in reproductive healthcare [61]. While initial FI screening recommendations focused on the psychosocial issues facing pregnant women, widespread attention to address social determinants of health across all population groups [62, 63] has led many organizations to incorporate FI screening in their recommended guidelines across the lifespan, from children [64–67] to older adults [68]. Further, federal resources in the USA have expanded to include FI screening tools and resources among Medicare and Medicaid recipients [69] and families with children [70]. Recently, one of the five goals of US Healthy People 2030 focused on social determinants of health, with a specific community objective aimed at reducing household FI [71]. In addition to social determinants of health, FI screening is important because FI can mask underlying health conditions [72], lead to medical misdiagnoses [72], decrease medication adherence in chronic disease management [73], increase emergency department use [74], prolong hospital stays [74], and increase healthcare expenditures [75]. Thus, the reasons for incorporating FI screening into a medical visit are numerous. The following sections address the challenges noted by clinicians in screening for FI as well as opportunities to provides resources and support for those who screen positive.

Despite the recognized need and interest in addressing FI as part of the clinical experience, most guidelines do not address implementation or impact [76]. A 2019 systematic review by De Marchis and colleagues [77] yielded only 25 peer-reviewed articles on FI screening, acceptability, and implementation in a healthcare setting, most conducted in pediatric settings and all within the USA [77]. While physician acceptability of FI screening was found to be quite high, 85–90% [78, 79], physicians noted time burden as a key barrier to incorporating screening practices within the medical encounter [77]. In addition to time constraints and lack of guidance on the optimal staffing resources to dedicate to FI screening [69, 77, 80], physicians also experienced a fear of "not having the answers" if a patient disclosed FI in the appointment [81]. Specifically, there was a disconnect in the acknowledgement of FI and the knowledge of resources and community organizations that offer programs and services to address FI [69, 81]. A recent study by Runkle and Nelson in 2021 [81] found family medicine and pediatric physicians expressed concern over the stigma associated with discussing FI in the clinic; however, another study by Kopparapu and colleagues in 2020 [82] showed that 83.9% of primary care patients stated that asking about FI was important and 82.7% felt it demonstrated that the clinic cared about their well-being. Another important consideration is a patient's preferences for FI screening. Kopparapu and colleagues [82] also identified that primary care patients preferred having a nurse ask the

screening questions, and Palakshappa and colleagues [83] found that patients preferred a written questionnaire versus a face-to-face screening method [82, 83]. These challenges represent opportunities for future research to design interventions that target FI training, screening uptake, and closed-loop referral management with tracking of local resources

Considering these challenges to FI screening, several nonprofit organizations have developed recommendations for screening in a clinical setting [72, 84–86]. Collectively, these recommendations endorse universal screening using the 2-item FI screen [87] to ensure that no patients who are food insecure are missed [72, 84–86] (see Table 2, a list of brief validated FI screening tools with language translations). If practices do not want to incorporate universal screening, key populations to screen include young children, pregnant and breastfeeding women, older adults, and individuals with diet-related chronic diseases [86]. These documents recommend including the FI screen on the EMR home page to remind clinicians and staff to ask the questions as well as to log the responses from each patient. These recommendations advocate that all clinical staff are trained in FI screening as well as how to respond to a positive screen. The decision for who screens patients is made by individual practices and healthcare systems. For patients who screen positive, these organizations recommend a variety of resources, including written materials with local nutrition resources, referrals to community-based organizations, active referrals and warm handoffs to community-based organizations, vitamin supplementation, and on-site food assistance with emergency food boxes and access to a food pantry. Also, clinical staff buy-in is critical to guarantee the success of FI screening and resource support. Further, maintaining a patient's dignity, privacy, and confidentiality throughout the screening process is of utmost importance.

The following case study illustrates an example of universal screening using the 2-item FI screen at a small endocrine clinic located in the rural Midwestern USA. This case study demonstrates the impact of FI screening with an older adult

Table 2 Brief, validated measures to assess food insecurity

Instrument	Number of items	Language	Food insecurity level	Outcome measure	Reliability and validity
Food Insecurity Screen [87]	2	English	Household	Dichotomous outcome with categorization of "food secure" or "food insecure"	Sensitivity=97%, Specificity=83% [70]
Household Food Security Survey Module (HFSSM) [88]	18	English Spanish Portuguese French Aymara Mòoré Tagalog Tamil Afro-Asiatic Nilo-Saharan Thai Urdu	Household or Individual	Continuous with raw score ranges categorized as "high food security," "marginal food security," "low food security," or "very low food security"	α=.91, test-retest r=.75
Household Food Security Survey Module—Short Version (HFSSM-SF) [89]	6	English Portuguese Spanish Farsi Luganda Lusoga Bengali	Household or Individual	Continuous with raw score ranges categorized as "high food security," "marginal food security," "low food security," or "very low food security"	α=.87 [73]; sensitivity=92.0%, specificity=99.4% [89]
Radimer/Cornell Scale [90]	12	English Russian Korean Malaysian	Household or Individual	Dichotomous outcome with categorization of "food secure" or "food insecure"	α= .84 (household); α=.86 (individual) [91]
Community Childhood Hunger Identification Project (CCHIP) [92]	8	English	Household	Categorical outcomes with "food secure," "at risk of hunger," and "experience hunger"	α= .86
Self-Perceived Household Food Security Scale [93]	12	Spanish	Household	Categorical outcomes with food "secure," "middly secure," "moderately insecure," and "severely insecure"	α= .92

Table 3 Post-screening considerations to address food insecurity [68]

Recommendation	Examples
Refer patients to existing local food access programs	Distribute information on local resources that provide food access: food banks, hot meal services, and free food delivery services
Connect patients with long term benefits	Share knowledge on federal nutrition programs, which can address long-term needs
	In the US:
	• SNAP: Supplemental Nutrition Assistance Program (SNAP) | USDA-FNS
	• WIC: Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) | USDA-FNS
	• Temporary Assistance for Needy Families (TANF): Summer Food Service Program | USDA-FNS
	Globally:
	• WPF: United Nations World Food Programme (WFP) - WFP.org
Dedicate on-site staff	Consider having a champion staff member to help patients navigate referrals to resources and manage relationships with community organizations

with a diet-related chronic disease as well as utilization of community resources to address FI.

Ms. H. is 76-year-old woman with type 2 diabetes. She has a fasting glucose of 227, a BMI of 38, high triglycerides, and a history of neuropathy. During a medical visit, her diabetologist asked Ms. H the 2-item FI screen questions [87]. Ms. H responded that the food she buys does not last and she does not have enough money to buy more because of the high costs of her diabetes medications. Ms. H explained that she wanted to enroll in Medicare Part D but had pay a large penalty. At the time, she was paying for all of her medications out of pocket. Previously, she applied for a medical card three times and was denied each time. She also mentioned she did not have a support system to help her with these issues. Based on the positive screen, her diabetologist referred her to the local diabetes patient navigator. The role of a patient navigator is to help patients overcome barriers and help them navigate the health care system. The patient navigator was available to all providers in the county via a federally funded initiative to support chronic disease management in rural regions in the US. The patient navigator met with her multiple times and identified Ms. H's most emergent needs. The navigator was able to increase her Supplemental Nutrition Assistance Program (SNAP; federal nutrition assistance program) benefits from $16/month to $169/month. In addition, the navigator enrolled her in the Social Security Extra Help program that provided Medicare Part D coverage at no cost. Now, Ms. H's monthly medications cost $7 each saving her $800 a month. Finally, the navigator worked with three different agencies to grant Ms. H a 100% discount on medical bills saving her $300. Over the next three months, Ms. H increased her physical activity, lowered her Hemoglobin A_{1c} by 0.4%, decreased her triglycerides, and improved her total cholesterol.

Conclusion

Despite the established need to screen for FI in a healthcare setting, practical barriers remain. Clinicians need guidance on implementation as well as tools to address stigma for both the patient and clinician. Some resources to aid clinicians with implementation have been developed. Table 3 represents key considerations for implementation, as adapted from a toolkit created by Humana and Feeding America [94]. Beyond screening measures, clinicians need to have information on resources available for their patients and a referral system in place. They should consider how FI may impact medication management and other implications for the patient's health and follow up with patients accordingly [94].

While language guidelines have been developed surrounding stigma related to other conditions (i.e., obesity, diabetes, substance abuse, mental health), we did not find such guidelines specific for talking to patients about FI. As a starting point, clinicians may consider using language suggestions for people with obesity, diabetes, or other health conditions when communicating with patients experiencing FI. For example, Pont and colleagues [95] recommend nonbiased behaviors and language to reduce weight-related stigma. These recommendations from the American Academy of Pediatricians and The Obesity Society recommend people-first language such as referring to a "person with obesity" instead of saying an "obese patient" [95]. In recommendations from the American Diabetes Association and Association of Diabetes Education and Care Specialists, Dickinson and colleagues [96] recommend the five following language recommendations to minimize diabetes stigma: [1] use nonjudgmental, fact-based language; [2] use stigma-free language; [3] use inclusive, strengths-based language; [4] use collaborative

language; and [5] use person-centered language [96]. When applying these concepts to FI, clinicians should avoid using stereotypes around people who receive food assistance benefits or labeling individuals who are food insecure. Clinicians can focus on patient strengths surrounding how they are approaching their FI or health conditions and ask questions to gain cooperation as opposed to telling patients what they should or should not do or labeling a choice as good or bad.

In summary, the links between FI and adverse health outcomes are well-established. Screening in healthcare settings is instrumental in the fight to reduce FI and improve cardiovascular and mental health outcomes. The impact of the COVID-19 pandemic on FI accentuate the need for this to be addressed. Local contexts and resources need to be considered in this implementation. Clinicians need not only guidance on the process of implementation but also on how to best address the topic with patients experiencing FI to avoid reinforcing or introducing stigma associated with the experience of not being able to access or provide sufficient food.

Abbreviations FI, food insecurity; CI, confidence interval; COVID-19 , novel coronavirus 19; CVD, cardiovascular disease; OR , odds ratio

Declarations

Conflict of Interest The authors declare no competing interests.

Human and Animal Rights and Informed Consent This narrative review does not contain any studies with human participants or animals performed by any of the authors.

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