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## The Relationship between Food Insecurity, Dietary Patterns, and Obesity

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### Abstract

Food insecurity is a major public health concern, and refers to the uncertainty, lack of, or inability to acquire nutritious food in a safe and socially acceptable manner. Food insecurity has been associated with obesity and unhealthy dietary patterns, both of which can have negative health consequences. A review of the current literature revealed an adverse association between food insecurity and dietary patterns is well supported. The association between food insecurity and obesity is strongest for women, with results for men and children being mixed. Evidence for long-term effects is limited due to a lack of longitudinal studies. Results from interventional studies have mostly yielded mixed results, and it is presently unclear how to best help food insecure individuals improve diet and weight.

### Keywords

Food Insecurity; Obesity; Overweight; Dietary Patterns

### Introduction

Poor diet and unhealthy weight place an individual at risk for an array of health consequences, including cardiovascular diseases. Food insecurity is the “limited or uncertain availability of nutritionally adequate and safe foods, or limited or uncertain ability to acquire acceptable foods in socially acceptable ways”. [1] Currently in the United States, 35% of adults and 17% of youth are obese, and 14% of households are food insecure. [1, 2]

Food insecurity may be associated with both poor diet and unhealthy weight, but the relationship between food insecurity, dietary patterns, and weight gain is not fully understood. A better understanding of this relationship may be particularly useful in creating and implementing effective behavioral and lifestyle interventions for at-risk populations. Previous research on the relationship between food insecurity and dietary patterns has linked food insecurity with a lower consumption of healthy food groups and poor diet quality, particularly with regard to fruit and vegetable intake. [3, 4] Past work on food insecurity and

obesity has yielded mixed evidence of associations, especially for children and adult men[5, 6], while stronger evidence for an adverse association has been noted in women.[6] For nutritional support programs, there is some evidence that long-term SNAP benefits are associated with increased risk of obesity, more so for women than for children or adult men. [6] [7]Results from studies that have explored the relationship between WIC participation and child obesity, and food insecurity and gestational weight gain, have also been mixed.[6, 8]

With growing interest in the role of food insecurity as a social determinant of health, there has been a major increase in the number of studies that have explored the relationship between food insecurity, dietary patterns, and obesity in recent years. In this review article we summarize the current literature on food insecurity, obesity, and dietary patterns. We focused on studies conducted in 2012 and onward. We included studies of cross-sectional, longitudinal, and interventional design.

## Food Insecurity and Dietary Patterns

A major hypothesis regarding food insecurity and diet is that food insecurity can lead to a ‘substitution’ effect where higher-quality and/or less calorie dense foods (such as produce and lean sources of protein), are replaced with more energy dense foods (often high in simple carbohydrates and fat) that are cheaper on a per-calorie basis.[9] Several cross-sectional studies provide support for this hypothesis in both children and adults. In a study of 3,605 children in 4<sup>th</sup>–5<sup>th</sup> grade, Fram et al. found that child food insecurity was associated with a lower Healthy Eating Index (HEI) vegetable subscale score and a higher intake of energy, fat, sugar, and fiber.[10] Child food insecurity was not associated with fruit intake, total HEI score, or any other HEI subscale score.[10] In a sample of 2,084 children aged 13–17, Belachew et al. found that food insecurity was associated with a lower intake of animal source food, protein rich food, dairy products, and fruit. Food insecurity was also associated with a lower diet diversity score and food variety score.[11] Nackers and Appelhans [24021456] found that food insecurity is associated with greater access to unhealthy foods in the kitchen, more microwavable or quick-cook frozen foods.[12] Another study found food insecurity to be associated with an increased intake of fat plus added sugar as a percentage of total calories.[13] However, a study by Trapp et al. found no association between food insecurity and any dietary measure.[14]

There have been few longitudinal studies examining food insecurity and diet. One of the few that has done this, however, was a study of 5,670 children followed prospectively for 3 years.[15] This study found that food insecurity was associated with a higher fruit intake for both girls and boys. Food insecurity was not associated with the consumption of green salad or vegetables. When analysis was stratified based on the severity of food insecurity, low food security was associated with a higher fruit intake and very low food security was associated with a higher intake of potatoes and carrots. However, these findings were limited by the somewhat restricted food frequency questionnaires used, and survey dates in the spring and summer, which may not have captured seasonal variation in consumption.

Among adults, several studies have also supported the idea that food insecurity can lead to substitution of more healthy food with less healthy ones. Examining participants from the 2003–2010 NHANES, Nguyen et al. found that food insecurity was associated with a lower total HEI score and a higher intake of added sugars and empty calories.[16] In a study of participants in low-income households (< 300% FPL) from the 1999–2008 NHANES, Leung et al. found that food insecurity was associated with a higher intake of high-fat dairy products, sugar sweetened beverages, meat, and salty snacks.[17•] Food insecurity was also associated with lower HEI and Alternative Healthy Eating Index (AHEI) scores and a lower intake of vegetables, sweets, and bakery desserts.[17•] Food insecurity was not associated with fruit, fish, or grain intake.

In a study of 4,009 adults aged 74 and up, Ford et al. found that food insufficiency was associated with a poor diet quality.[18] Berkowitz et al. found that food insecurity in diabetes patients was associated with a lower intake of fruits and vegetables, and a lower total HEI score.[19] No association was found between food insecurity and grain, meat, or dairy intake. Robaina and Martin found that food insecurity was associated with a lower consumption of fruits, vegetables, and fiber among food pantry participants.[20] Several other studies noted that food insecurity was associated with a lower intake of fruits and vegetables[21], and lower intake of fruit.[22] In contrast, Ramsey et al. found no association between food insecurity and fruit, vegetable, or meat consumption, but the study was limited by the use of a mail-in survey that may have differentially excluded more vulnerable participants.[23]

While studies have not found that food insecurity is associated with whether meals are prepared at home or in restaurants[24], the composition of those meals can vary. Bruening et al. found that food insecurity is associated with more sugar-sweetened drinks and less salad, fruit, and vegetables being served at family meals, more fast food being served, and more binge eating.[25] Burns et al. [26] found that having run out of money to buy food was associated with increased likelihood of purchasing fast-food from chain restaurants on a weekly basis.

## Food Insecurity and Obesity

The relationship between food insecurity and body weight is complicated. While food insecurity may be obesogenic due to its relationship with unhealthy dietary patterns, food insecurity could also lead to weight loss, especially in its most extreme form—hunger. Perhaps because of these competing influences, the evidence to date regarding an association between food insecurity and obesity, particularly in cross-sectional studies, remains mixed. In children and adolescents, a study examining a sample of 590 students in 4<sup>th</sup>–6<sup>th</sup> grade on the Mexican border with the U.S. found that child food insecurity was associated with an increased risk for obesity.[27] In a study of 4,060 Métis children in Canada, having experienced hunger was associated with a higher likelihood of being obese among boys aged 6–10, but not girls.[28]

In a study of 28,353 children followed prospectively from the 1<sup>st</sup> infancy visit to the last child visit as part of the Special Supplemental Nutrition Program for Women, Infants, and

Children (WIC), Metallinos-Katsaras et al. found that persistent food insecurity without hunger was associated with a greater risk of obesity at the last child visit.[29•] When analysis was stratified by maternal pre-pregnancy weight, associations persisted only for children whose mothers were either overweight/obese or underweight pre-pregnancy. The results of this study suggest that maternal pre-pregnancy weight modifies the relationship between food insecurity and child obesity. Following 1,589 mother-child pairs prospectively for 2 years, Suglia et al. found that the cumulative social risk score was associated with obesity at the age of 5 for girls, but not boys.[30] Food insecurity was one of the 6 risk factors that made up the cumulative social risk score. Other factors included housing insecurity, maternal substance use, maternal depressive symptoms, incarceration of the father, and domestic violence reports. A third study also found increased BMI associated with past exposure to food insecurity.[31] While these studies shed important light on the issue, studies exploring the temporal relationship between food insecurity, obesity, and dietary patterns remain limited.

In contrast, several studies have not found an association between food insecurity and obesity in children and adolescents. In an analysis of participants aged 2–11 from the 2001 to 2010 National Health and Nutrition Examination Surveys (NHANES), Kaur et al. found that child-level food insecurity was not associated with obesity.[32] Personal food insecurity, which is a measure of food insecurity at the individual level, was associated with obesity for children aged 6–11, but not children aged 2–5. Findings from this study suggest that the level at which food insecurity is measured can alter results. In a sample of 1,529 females aged 15–19 set in Brazil, Kac et al. found that only female adolescents from severely food insecure households were at an increased risk of being overweight or obese.[33] No association was found for female adolescents living in households with mild or moderate food insecurity. Weigel and Armijos found no association between food insecurity and obesity for adolescent females in Ecuador, but did find evidence of an association with short adult stature, another important nutritional outcome.[34]

In adults, there is also a mixed pattern of findings in a number of largely cross-sectional studies. In a study of 35,747 low-income adults, Leung et al. found that very low food security was associated with a higher risk of obesity and a higher BMI.[35•] When analysis was stratified by race and ethnicity, this association persisted for male and female Hispanics, and female Asians. For multi-racial men, low food security was associated with a higher BMI and a higher risk of obesity. Similarly, Nguyen et al. found that food insecurity was associated with a higher risk of obesity and a higher BMI.[16] In a study of 13,720 adults, Gooding et al. found an association between food insecurity and higher BMI for young women, but not young men.[36] Similarly several other studies have found that food insecurity was associated with obesity for women, but not men.[37–40] In a study of 7,931 adults, Martin and Lippert found that food insecure mothers are at a higher risk of being overweight or obese, compared to food insecure fathers and child-free women (regardless of food insecurity status).[41] Mohammadi et al. found that moderate food insecurity was associated with a lower likelihood of being overweight while severe food insecurity was associated with a higher risk of obesity among women.[42]

In contrast, Shariff et al. found that food insecurity was associated with a lower likelihood of being obese for women in Malaysia,[43] and several studies found no association between food insecurity and obesity.[20, 22, 44] Many of the studies that found no association between food insecurity and obesity were relatively small, which may have reduced their power to detect an association, and set outside the US, which may indicate overall food environment is an effect modifier of the association between food insecurity and weight.

In the only longitudinal study of food insecurity and BMI in adults we are aware of, food insecurity was associated with greater increase in BMI among adults in a community health center over approximately 3 years of follow-up.[45]

## Nutrition Support Interventions

Increasing recognition of the prevalence of food insecurity and its possible effects has led to interest in addressing it as a way to improve health. The largest program to combat food insecurity in the US is the Supplemental Nutrition Assistance Program (SNAP).[46] Currently the effects of SNAP participation on diet quality and weight status are not well understood.

In a study of 16,553 children aged 5–18, Schmeiser found that long-term SNAP participation was associated with a lower BMI percentile and a lower risk of being overweight or obese for boys aged 12–18, and boys and girls aged 5–11.[47] Examining data of participants aged 4–17 in low-income families (< 200% FPL) from the 2007–2008 NHANES, Kohn et al. found that participation in food assistance programs was associated with increased body size in low-income, food secure youth, but not for youth who remained food insecure despite program participation.[48] Thus food insecurity status after program enrollment may mediate the association between assistance programs and body size.

Among adults, evidence regarding a SNAP effect on dietary quality is mixed. While one study using 2003–2010 NHANES data found that SNAP participation is associated with a higher total HEI score for food insecure adults[16•], another found that SNAP participation was associated with a lower total HEI score and lower HEI subscale scores for fruits and vegetables, seafood and plant protein, and empty calories.[49•] When analysis was stratified by food insecurity status, the association persisted only for food secure adults, which suggests that benefit levels may be insufficient for participants to both reach food security and afford healthier foods. In an analysis of low-income (< 130% FPL) adult participants from the 1999–2008 NHANES, Leung found that SNAP participation was associated with a lower intake of whole grains and a higher intake of 100% fruit juice, potatoes, and red meat.[50] SNAP participation was also associated with lower total AHEI score, but not total HEI score.[50] In sum, we agree with the findings of a recent systematic review, which concluded that while SNAP is effective in combating food insecurity, the effect of participation on improving dietary quality is currently unclear.[51] Because income eligible non-participants are likely to be in less severe circumstances than participants, it is unclear whether comparing the groups cross-sectionally shed much light on the effects of the SNAP intervention.

An interesting study examined dietary changes as a function of time since receiving the SNAP benefit. Among a sample of 244 African American SNAP participants[52], total energy intake and HEI dairy subscale score decreased as time since SNAP distribution (TSSD) increased for participants that received SNAP benefits 15 days before completing the dietary recall survey. Among participants that received benefits >15 days before taking the survey, total energy, total fat, saturated fat, and protein intake increased as TSSD increased. The results of this study suggest that one's position in the SNAP cycle can impact their diet. Unlike SNAP, the Special Supplemental Nutrition Assistance Program for Women, Infants, and Children (WIC), is specifically designed to promote both healthy eating and health.[53] Odoms-Young et al. report that the 2009 WIC food package revisions led to an increase in fruit intake for Hispanic mothers, increase in low-fat dairy intake for Hispanic mothers and children, and African American children, and saturated fat decreases for Hispanic mothers and children.[54]

Other studies explored the effects of smaller scale interventions. Wordell et al. reported on the impact of having only bottled water in vending machines, only milk and fruit on the à la carte menu, and a seasonal fruit and vegetable bar in middle schools.[55] A total of 2,292 7<sup>th</sup> and 8<sup>th</sup> graders participated at the 3-year follow up. Students in the intervention group were more likely to consume milk outside of school and less likely to consume pastries or juice in school. No significant difference was found in regards to fruit and vegetable intake. Lindsay et al. reported on the impact of providing 7,298 adults, who were currently receiving government nutrition assistance (SNAP, WIC, SSI), with monetary incentives to buy produce at farmers markets. Fruit and vegetable intake was significantly higher at the 12-month follow up.[56] Miewald et al. reported on the impact of a food box program, in which participants were able to purchase an \$8 food box containing 45–50 servings of fruits and vegetables each month. Program participation was associated with improved intake of vegetables.[57] A home delivered meals program for elderly participants was effective in reducing food insecurity and improving nutritional status.[58]

There has been interest in combating 'food deserts' (areas with limited access to fresh food for purchase).[59] However, there is little evidence that opening new stores in these areas improved dietary intake. In a study where opening a new neighborhood grocery store served as the intervention, no significant difference was observed between residents of the intervention and control neighborhoods in regards to BMI or fruit and vegetable intake 6 months after the store opened.[60] Similarly, Sadler et al. reported on the impact of adding a new neighborhood grocery store on residents' diet and weight status.[61] Residents of the control and intervention neighborhoods did not differ in the intake of healthy foods, such as fruits and vegetables. In addition, the prevalence of food insecurity and overweight/obesity did not differ pre- and post- intervention among residents of the intervention neighborhood.

### **Special Considerations: Pregnancy, Infants, and Toddlers**

Because early life, both prior to and immediately after birth, serves as a critical window for human development, nutrition in the period of pregnancy and infant- and toddlerhood is of special interest. In a longitudinal study, in which 550 pregnant women were followed until 12 months postpartum, Laraia et al. found that food insecurity during pregnancy and

postpartum were both associated with greater disordered eating and fat intake postpartum. [62••] Food insecurity during pregnancy was also adversely associated with pre-pregnancy weight status, duration of breastfeeding, and BMI at 12 months postpartum. When analysis was stratified by pre-pregnancy weight status, the association between food insecurity during pregnancy and BMI at 12 months postpartum persisted only for women who were overweight or obese pre-pregnancy. Another study examining 1,041 pregnant women, found that marginal food insecurity was associated with lower gestational weight gain and weight gain ratio for participants with a history of low dietary restraint. Among pregnant women with a past experience of high dietary restraint, marginal food insecurity was associated with a higher gestational weight gain and weight gain ratio.[63] Overall this suggests that food insecurity plus a history of dieting issues can have important health implications for pregnant women. In a study of 1,522 mother-toddler pairs, Cunningham et al. found that maternal food insecurity was associated with a lower weekly intake of fruits and vegetables and a higher weekly intake of soda for toddlers.[64] Nguyen et al. found that food insecurity was adversely associated with maternal diet diversity among mothers with children 2 years old or younger.[65] No association was found for child diet diversity.

## Conclusion

An explosion of interest in food insecurity research in recent years has greatly expanded the evidence base available. However, many studies have important limitations, and critical questions remain unanswered. We believe that the current literature provides a substantial amount of evidence for an adverse association between food insecurity and diet. Food insecure children and adults tend to consume diets of lower quality, have less healthy eating behaviors, and have lower intakes of produce. With regard to obesity, while there is increasingly strong evidence that food insecurity is associated with obesity among women, the evidence in adult males and children remains mixed.

It is important to remember that food insecurity incorporates a range of situations, including frank hunger, but also including the worry that food will run out. Because of this, it is plausible that food insecurity can lead to reduced calorie and nutrient intake, increased calorie and nutrient intake, or no change in calorie and nutrient intake, in different circumstances, and in different times in an individual's life. The apparently conflicting results seen when considering several studies may in fact simply indicate the heterogeneous circumstances of food insecure individuals. A more clinically relevant question than 'does food insecure cause poor diet or unhealthy weight?' may be 'is food insecurity affecting this individual's diet and health?'.

Evidence from longitudinal studies to support causality and the long-term effects of food insecurity on diet and weight and diet is quite limited. Because of the complex relationship between food insecurity, diet, and weight, including countervailing influences towards both consumption of obesogenic foods and decreased consumption of calories, further cross-sectional studies are unlikely to shed much light on these relationships. Purpose-designed longitudinal studies with methods that permit the elucidation of pathways and mechanisms are a research priority in this area.

Data regarding the effectiveness of nutrition support programs has also been limited. A major challenge to the interpretation of results has been non-random entry into government assistance programs. It is not clear that comparing enrollees to eligible non-enrollees provides a valid comparison due to potential ‘confounding by indication’ among those with dire enough circumstances to seek enrollment in programs that are often stigmatized and complicated. Comparing those who are food secure after program enrollment to those who remain food insecure may also obscure differences in social circumstances. Finally, only a few studies focused on pregnant women and children below the age of 2, despite the fact that these populations are very vulnerable to the effects of food insecurity.

There are a number of possible explanations for some of the contradictory findings noted in this review. The relationship between food insecurity and health is likely complex and bidirectional. Food insecurity may worsen diet quality and health. At the same time, worsening health may decrease the ability to work and increase medical expenses, leading to food insecurity. Households often cycle in and out of food insecurity over time, and the timing, duration, and severity of exposure to food insecurity can be difficult to quantify. There is also variation in how food insecurity was measured across the literature. While a majority of studies use instruments traceable to the USDA Food Security Survey Module, the instruments used ranged from a single question to all 18 items. In addition, many studies on children and adolescents measured food insecurity at the household level, which may not accurately reflect the degree of food insecurity children experience. Children may be shielded from food shortages and thus feel food insecurity to a different extent compared with adults in the household. Even among food insecure participants, variation in the severity of experienced food insecurity may also explain contradictory findings.

It is an exciting time for food insecurity research, but much work is left to be done. High quality etiologic studies and innovative interventions may lead us closer to the day when food insecurity no longer represents a health threat for so many Americans.

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