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Food Insecurity Is Associated with Lower Cognitive Functioning in a National Sample of Older Adults

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ABSTRACT

Background: Food insecurity, a social and economic condition of inadequate food resources, is known to affect cognitive development in children. However, research is sparse among adult populations, particularly older adults who may be more susceptible to accelerated cognitive decline.

Objective: The aim of this study was to examine the associations between food insecurity and cognitive functioning among older adults.

Methods: Data came from 1823 older adults (≥60 y) with incomes ≤300% of the federal poverty level (FPL) from the 2011–2014 NHANES. Food security was measured using the 10-item Adult Food Security Survey Module. Cognitive function was measured using the Consortium to Establish a Registry for Alzheimer's Disease (CERAD) word learning subtest and delayed word recall, the Animal Fluency Test (AFT), and the Digit Symbol Substitution Test (DSST). The cognitive assessments were then standardized and an overall cognitive function *z* score was created by averaging across all cognitive assessments. Associations with food insecurity were examined using multivariate linear regression models, adjusting for sociodemographic and health characteristics.

Results: In the analytic population, the prevalence of food insecurity was 23.7%. Across all cognitive assessments, the mean scores among food-insecure adults was significantly lower than the mean scores among food-secure adults. After adjusting for sociodemographic and health characteristics, food insecurity was associated with lower scores on the CERAD word learning subtest ($\beta = -0.14$, 95% CI: −0.26, −0.01), the AFT ($\beta = -0.13$, 95% CI: −0.25, −0.002), and the DSST ($\beta = -0.24$, 95% CI: −0.33, −0.15). Food insecurity was also associated with a lower score on the overall cognitive function *z* score ($\beta = -0.15$, 95% CI: −0.26, −0.05).

Conclusions: In this national sample of 1823 adults aged ≥60 y, food insecurity was inversely associated with cognitive function, which may translate into higher risk of cognitive impairment over time. *J Nutr* 2019;149:1812–1817.

Keywords: food insecurity, cognitive function, cognitive impairment, NHANES, elderly

Introduction

Food insecurity, defined as the lack of consistent access to food, has been a persistent concern for older adults in the US. In 2016 ∼4.9 million older adults were food insecure and another 3.7 million older adults experienced marginal food security (1). Food insecurity is more prevalent among older adults living below the poverty line, of African American or Hispanic race/ethnicity, and living with grandchildren in the home (1).

Food insecurity is an important social determinant of health, independent of other socioeconomic factors (2). Extensive literature has shown that food insecurity is associated with several health conditions in adulthood, including hypertension (3–5), diabetes (3–6), and cardiovascular disease (4, 7). There have been fewer studies on the health consequences and underlying mechanisms of food insecurity among older adults, despite the higher burden of diseases related to aging and subsequent healthcare expenditures (8). To date, studies have demonstrated that older adults with multiple chronic diseases are at higher risk of food insecurity (9), and that food insecurity subsequently predicts poorer disease management through cost-related medication nonadherence (10, 11), leading to greater healthcare costs over time (12).

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Abbreviations used: AFT, Animal Fluency Test; CERAD, Consortium to Establish a Registry for Alzheimer's Disease; DSST, Digit Symbol Substitution Test; FPL, federal poverty level; MEC, mobile examination center.

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In addition to physical health, food insecurity has also been known to impact cognitive function and mental health (13–18). Much of the current research on food insecurity and cognitive function has been conducted in children (19, 20). Aging is also a risk factor for cognitive decline and cognitive impairment, which may be exacerbated by the experience of food insecurity and deficiencies in dietary intake (21) or increases in psychological stress (22). Only a few studies have explored the relation between food insecurity and cognitive function among middle-aged and older adults, 2 of which are from the Boston Puerto Rican Health Study cohort, a longitudinal cohort study of health disparities among 1500 Puerto Rican adults. In 2009, Gao et al. found that compared to food-secure adults, adults with very low food security had lower scores on a global assessment of a cognitive performance test (the Mini-Mental State Examination), and several tasks measuring executive function (23). In 2016, Wong et al. repeated this analysis using longitudinal measures (24). Their findings showed that food insecurity was associated with greater cognitive decline over a 2-y period using a composite score of cognitive assessments. The results of these studies mirror those from studies of children's cognitive development and academic achievement (2, 19, 20). However, more research is needed to determine whether the results observed from Puerto Rican adults are generalizable to the larger population of older adults at risk of food insecurity. Thus, the objective of the present study was to examine the associations between food insecurity and cognitive function in a national sample of older adults.

Methods

Study population

Data for this study was derived from the 2011–2014 NHANES (25), which is an ongoing, multistage cross-sectional survey administered by the National Center for Health Statistics. The 2011–2012 and 2013–2014 surveys represent the most recent years in which cognitive assessments were available at the time of the present study. The study population was comprised of 2127 adults aged ≥60 y with household incomes ≤300% federal poverty level (FPL). Individuals with missing data on food security ($n = 1$), cognitive assessments ($n = 299$), and other covariates, such as educational attainment ($n = 2$) and smoking status ($n = 2$), were further excluded leaving an analytic sample size of 1823 adults. Similar to prior studies, a threshold on household income was applied because food insecurity is relatively uncommon among higher-income households and restricting the analytic population to lower-income households may reduce confounding of the primary association by household income (6, 26–28).

Food insecurity

Food insecurity was measured with the 10-item US Adult Food Security Survey Module. This module includes the same questions used in the US Household Food Security Survey Module but omits questions pertaining to children in the household. The questions assess experiences or behaviors related to insufficient resources to purchase food over the past 12 mo. A score ranging from 0–10 was created by summing the affirmative responses, with a higher score denoting greater food insecurity. The score was categorized into full food security (0), marginal food security (1, 2), low food security (3–5), and very low food security (6–10). Similar to prior studies, marginal food-secure adults ($n = 219$) were combined with low ($n = 219$) and very low food-secure adults ($n = 130$) in the present study to create a combined "food-insecure" category (29, 30).

Cognitive function assessments

Starting in 2011, multiple assessments of cognitive functioning were administered to study participants aged ≥60 y in the mobile examination center (MEC) by trained examiners (31). These tasks were conducted in the study participant's preferred language (English, Spanish, Korean, Vietnamese, or Chinese) and were audio recorded. The cognitive assessments included: The Consortium to Establish a Registry for Alzheimer's Disease (CERAD) word learning subtest and delayed word recall, the Animal Fluency Test (AFT), and the Digit Symbol Substitution Test (DSST).

CERAD word learning subtest assesses the ability to immediately learn new verbal information (32). In a series of 3 trials, NHANES participants first read aloud 10 unrelated words, and were then asked to recall as many of the 10 words as possible. The order of the 10 words was changed in the subsequent trials. Each trial was scored from 0 (no words recalled) to 10 (all words recalled). For the present analysis, the average of the 3 trials was computed. The CERAD delayed word recall was conducted after the AFT and DSST (~8–10 min after the CERAD word learning subtest), assessing the ability for delayed learning of new information. The CERAD delayed word recall score is the number of words the participant was able to recall from the earlier CERAD word learning subtest, and is scored from 0–10. The AFT, which assesses verbal fluency, asks participants to name as many animals as they can in 1 min (33). The AFT score is the total number of animals named. The DSST assesses processing speed, sustained attention, and working memory, and is a component of the Wechsler Adult Intelligence Scale (WAIS III) (34). The psychometric properties of these tasks have been established in prior studies (35–38). In this paper-based test, participants are provided a key of 9 numbers matched to symbols. They are then instructed to copy the corresponding symbols into 133 boxes next to the adjacent numbers. The DSST score is the total number of correct matches.

All cognitive assessment scores were further converted to z scores to facilitate interpretation and to accommodate the different maximum scores across the various cognitive assessments. An overall cognitive function score was also created by averaging the 4 z scores, with a higher score denoting higher cognitive functioning. Creation of the overall cognitive function score also helps to minimize floor and ceiling effects across cognitive function tasks in a population of older adults (39).

Study covariates

Covariates included age, sex, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, or non-Hispanic other race/ethnicities), highest education level (<12 y, high school graduate or General Education Diploma equivalent, or any college), marital status (married or living with partner, and never married/widowed/divorced/separated), poverty income ratio (0–100% FPL, 100.1–200% FPL, 200.1–300% FPL), and smoking status (never smoker, and former smoker/current smoker). Age was modeled as a continuous and quadratic (i.e. squared) term to account for a potential curvilinear relation with cognitive functioning. These variables were selected because it was hypothesized that they were related to both food insecurity and cognitive functioning among older adults.

Statistical analysis

Statistical analyses were conducted using Stata SE 12.1 (StataCorp LLC) with the SVY commands to account for the complex survey design of NHANES. Survey weights from the MEC were recalculated to reflect the probability of being selected across the 4-y period, and were used in all analyses to account for differential patterns of selection and nonresponse. First, differences in covariates of interest were examined by food insecurity levels and the significance of these differences were examined by chi-squared tests. Next, differences in mean raw scores and mean z scores of the 4 cognitive assessments by food insecurity groups were examined and significance was determined by univariate linear regression models.

TABLE 1 Characteristics of food-secure and food-insecure older adults with household incomes ≤300% of the federal poverty level: NHANES 2011–2014

	Food secure ($n = 1255$)		Food insecure ($n = 568$)		
	n	%	*n*	%	*P* value[1]
Age, y					<0.001
60–69	569	43.4	355	59.7	
70–79	392	32.4	159	30.9	
≥80	294	24.1	54	9.4	
Sex					0.51
Male	585	39.9	254	38.7	
Female	670	60.1	314	61.3	
Race/ethnicity					<0.001
Non-Hispanic white	616	76.1	163	55.2	
Non-Hispanic black	235	8.3	182	20.3	
Hispanic	283	9.5	187	19.9	
Non-Hispanic other	121	6.2	36	4.7	
Education level					<0.001
<12 y	406	22.7	262	41.5	
High school graduate	334	30.4	149	25.3	
Any college	515	46.9	157	33.2	
Marital status					0.02
Married or living with partner	653	48.4	322	57.2	
Single or formerly partnered	602	51.6	246	42.8	
Household income (as ratio to federal poverty line)					<0.001
<100%	268	13.6	267	41.5	
100–200%	628	48.7	240	45.5	
>200–300%	359	37.7	61	13.1	
Smoking status					0.047
Never smoker	624	48.8	246	42.1	
Current or former smoker	631	51.2	322	57.9	

[1]From chi-squared tests.

Lastly, multivariate linear regression models were fit for each of the standardized cognitive assessment outcomes and the overall cognitive function score to examine adjusted differences by food insecurity. Models were first adjusted for age and sex, and then all covariates were included in the final model. Statistical tests were 2-sided and statistical significance was considered at $P < 0.05$.

Results

In our analytic sample of 1823 older adults, 23.7% reported food insecurity during the past 12 mo. Sociodemographic and health characteristics of study participants by food insecurity levels are shown in Table 1. Food insecurity was more prevalent among adults aged 60–69 y, of minority racial/ethnic backgrounds, with lower levels of education, not married or living with a partner, and with lower household incomes ($P < 0.05$). There was no significant difference in food insecurity by participant's sex.

Table 2 describes the mean scores of the cognitive assessments by food insecurity status. Across all cognitive assessments, the mean raw and standardized scores among food-insecure adults were significantly lower than the scores among food-secure adults. With respect to overall cognitive function *z* score, food-insecure adults had a 0.19-point lower unadjusted mean *z* score than food-secure adults ($P = 0.002$).

Multivariate-adjusted associations between food insecurity and cognitive assessment *z* scores are shown in Table 3. After adjusting for age and sex, food insecurity was significantly associated with lower *z* scores for each individual cognitive test and the overall cognitive function score. After adjusting for all sociodemographic and health characteristics, food insecurity was associated with a lower overall cognitive function score

TABLE 2 Mean scores on cognitive function assessments by food insecurity status among 1823 older adults with household incomes ≤300% of the federal poverty level: NHANES 2011–2014[1]

	Raw score (SE)		*z* score (SE)	
	Food secure ($n = 1255$)	Food insecure ($n = 568$)	Food secure ($n = 1255$)	Food insecure ($n = 568$)
CERAD word learning subtest	6.2 ± 0.09	6.0 ± 0.07*	0.02 ± 0.05	−0.13 ± 0.04*
CERAD delayed word recall	5.8 ± 0.11	5.6 ± 0.12	0.004 ± 0.05	−0.07 ± 0.05
Animal Fluency Test	16.7 ± 0.28	15.7 ± 0.41*	0.07 ± 0.05	−0.11 ± 0.07*
Digit Symbol Substitution Test	47.0 ± 0.69	40.0 ± 1.17*	0.09 ± 0.04	−0.31 ± 0.07*
Overall cognitive function score	—	—	0.04 ± 0.04	−0.15 ± 0.04*

[1]Values are means ± SEs. * Different from food secure, $P < 0.05$. CERAD, Consortium to Establish a Registry for Alzheimer's Disease.

TABLE 3 Associations between food insecurity status and cognitive function assessment *z* scores among 1823 older adults with household incomes ≤300% of the federal poverty level: NHANES 2011–2014[1]

	β (95% CI)	
	Age and sex adjusted	Multivariate adjusted[2]
CERAD word learning subtest	−0.28 (−0.40, −0.17)	−0.14 (−0.26, −0.01)
CERAD delayed word recall	−0.22 (−0.36, −0.08)	−0.10 (−0.25, 0.05)
Animal Fluency Test	−0.31 (−0.49, −0.13)	−0.13 (−0.25, −0.002)
Digit Symbol Substitution Test	−0.55 (−0.68, −0.42)	−0.24 (−0.33, −0.15)
Overall cognitive function score	−0.36 (−0.48, −0.24)	−0.15 (−0.26, −0.05)

[1] CERAD, Consortium to Establish a Registry for Alzheimer's Disease.
[2] Models adjusted for age, age as a quadratic term, sex, race/ethnicity, highest education level, marital status, household income (as a ratio to poverty guidelines), and smoking status.

($\beta = -0.15$, 95% CI: −0.26, −0.05). Associations were also observed between food insecurity and the DSST *z* score ($\beta = -0.24$, 95% CI: −0.33, −0.15), AFT *z* score ($\beta = -0.13$, 95% CI: −0.25, −0.002), and the CERAD word learning subtest *z* score ($\beta = -0.14$, 95% CI: −0.26, −0.01). The association between food insecurity and CERAD delayed word recall was no longer significant after further adjustment of additional covariates.

Discussion

In this national sample of older adults, food insecurity was inversely associated with cognitive function, independent of sociodemographic factors. The cognitive skills most strongly associated with food insecurity were processing speed, sustained attention, verbal fluency, working memory, and immediate learning ability—all processes related to executive function. This study builds on the previous findings from the Boston Puerto Rican Health Study (23, 24), demonstrating that the associations between food insecurity and cognitive function are observed with varying measures of executive functions and extending the association to individuals beyond one particular ethnic group or geographic region. This study also corroborates a prior analysis by Frith and Loprinzi of food insecurity and cognitive function (40). Using data from 1999–2002 NHANES, the authors found that food insecurity was associated with lower DSST scores among older adults, and that the magnitude of the association was greater at more extreme levels of food insecurity. Results of the present study are consistent with studies that have focused on variations in adult cognitive function by poverty (41) or educational attainment (42–45). In the present study, the associations with food insecurity and cognitive function were observed even after the adjustment of education and income, suggesting food insecurity is another social determinant that may contribute to cognitive impairment in older adults.

Proposed mechanisms for the observed associations include inadequate dietary intake and increased psychological stress. Previous research has found that food-insecure adults have lower intakes of important food groups (e.g. fruits, vegetables) (21), key nutrients (46), and lower diet quality than food-secure adults (47). Consuming a healthy diet has been shown to be important for maintaining cognitive health in later life (48, 49). A second mechanism is the role of stress and allostatic load. Food insecurity is an inherently stressful experience that has been associated with poor mental health (13, 50). In a prior study of older adults, food insecurity was associated with dysregulation of the allostatic load system (22). This repeated "wear and tear" on the body's systems has been associated with brain changes that dampen one's ability to cognitively respond to psychological stress, subsequently leading to cognitive decline (51, 52). The evidence to date suggests that the direction of association is likely food insecurity influencing cognitive function. This prospective finding has been observed in 2 studies. One of these was the Boston Puerto Rican Health Study, which showed that food insecurity among older adults was associated with cognitive decline over a 2-y period (24). The other study was conducted among Malaysian older adults and found that food insufficiency during childhood was predictive of dementia in later life (53). No studies have shown the reverse association—that cognitive impairment contributes to food insecurity among older adults. However, the study of food insecurity among older populations is sparse and it is plausible that cognitive impairment could exacerbate food insecurity through a strain on one's finances, inability to adopt healthy behaviors, and a lack of social support. Although more research is needed to establish the direction and magnitude of the observed association, the present study also highlights the need for programs and policies that address the concurrent burden of food insecurity and cognitive impairment among older adults.

This study has several strengths: *1*) a large and recent national sample of adults, *2*) the creation of an overall cognitive function *z* score to avoid floor or ceiling effects of individual cognitive tasks, and *3*) the ability to control for the effects of multiple sociodemographic and health confounders in the model. In addition to the cross-sectional design of the study, another limitation is the potential for unmeasured confounding by psychosocial factors (e.g. social support), environmental factors (e.g. urban compared with rural neighborhood, neighborhood socioeconomic status), or other unknown factors that could bias the association, as these data were not available from NHANES. The sociodemographic covariates included in the present analysis were considered the strongest known confounders for the association between food insecurity and cognitive function. There may also be independent differential measurement error if individuals with undiagnosed mild cognitive impairment or Alzheimer's disease misreport their food security status and have poorer performance on the cognitive tasks, which could have biased the observed results. Further research is needed with populations across broader age ranges and with repeated measures of food insecurity and cognitive function to better understand the nature of these associations over time and life stages, and to better account for undiagnosed cognitive impairment over time. This study was also not designed to test potential mediating pathways, primarily due to the cross-sectional nature of the data. Prospective cohort studies are needed to better understand the extent to which health behaviors, psychological stress, and chronic disease burden mediate the pathways between food insecurity and cognitive function in older adults.

In conclusion, this study shows that food insecurity is associated with lower cognitive function among older adults, which may translate into higher risk of cognitive impairment over time. Programs and policies that improve the availability of nutritious food are needed to alleviate both food insecurity and maintain cognitive health in this vulnerable population.

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