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Relationship Between Food Insecurity and Functional Limitations in Older Adults from 2005–2014 NHANES

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Abstract

Background: Food insecurity refers to the physical, social, and economic inability to access and secure sufficient, safe and nutritious food. Food insecurity has been found to be associated with poor health status, obesity, and chronic disease. To date, a relationship between food insecurity and functional limitations has not been described in of older adults.

Methods: We examined 9,309 adults 60 years old from the 2005–2014 National Health and Nutrition Examination Surveys (NHANES). Food security was categorized as full, marginal, low, and very low. Functional limitations were assessed as having difficulty in physical, basic or instrumental activities of daily living.

Results: Of adults 60 years old (mean age: 70.5±0.08, 51% female), the prevalence of full, marginal, low, or very low food insecurity was 7,572 (81%), 717 (7%), 667 (8%), and 353 (4%), respectively. The prevalence of any functional limitations was 5,895 (66.3%). The adjusted odds (OR [95% CI]) of having any functional limitation in marginal, low, and very low food security levels compared to full food security are: 1.08 [1.02–1.13], 1.16 [1.10–1.22], 1.14 [1.07–1.21], respectively. The association between levels of food insecurity and functional limitation is modified by race/ethnicity.

Conclusions: Functional limitation is significantly associated with increasing food insecurity in older adults.

Keywords

Food insecurity; functional limitations; older adults

INTRODUCTION:

Food insecurity is commonly defined as having inconsistent physical, social, and economic ability to access and secure sufficient, safe and nutritious food.¹ Approximately 12.7% of United States households experienced food insecurity in 2015.² A relationship between food insecurity and poor health status including mental capacity, general health, hypertension, and diabetes has been well documented.^{3–10} In an attempt to mitigate food insecurity and its effects, Food Assistance programs such as the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) and the Supplemental Nutrition Assistance Program (SNAP) were created to mitigate food insecurity and its effects. Older adults are underrepresented in food assistance programs compared to their relative proportion of the US population.¹¹ Age and chronic conditions increase the risk of developing a functional limitation which could impact an individual's ability to leave the house and get support for food insecurity.¹² Having a limitation, physical or mental can make it more difficult and costly to determine eligibility, and get support to mitigate food insecurity.¹¹

Functional limitations are frequently used as indicators to assess progression from independence in daily activities to disability in older adults. A functional limitation is defined as having a restricted ability in performing tasks or activities that are fundamental to daily life. These tasks and abilities are broken up into three core domains: physical limitations (PL), basic activities of daily living (BADL), and instrumental activities of daily living (IADL). In the disablement process, functional limitations are thought to be a precursor to disability as moderate limitations predict future severe limitations and ultimately disability.^{12–14} Because food security is so influential in chronic disease and poor health status, there is reason to believe that change in food use may have a relationship with functional ability and limitations.^{3–6} Assessing the risk factors of functional limitations in older adults can help lead to policies that impact its development.

Research into the relationship between food insecurity and poor physical and mental health status has focused on children due to its large impact on infant and child development.^{9,15} Food insecurity and poor health in older adults has been explored to a lesser extent compared to mothers and children, and there is a lack of evidence in large, diverse populations.^{16–18} Studies have demonstrated an association between food insecurity and functional limitations using cross sectional datasets such as Health and Retirement Study (HRS)¹⁹, Health Care and Nutrition Study (HCNS)¹⁹, NHANES^{20–22}, and others^{23,24}. In older adult populations the importance of income has been demonstrated in the relationship between functional limitation and food insecurity²², along with participation in food assistance programs⁴. Additionally, food insecurity and functional limitations increases the

risk of obesity^{25–29} while there is also an association of diabetes and chronic disease with both food insecurity and functional limitations in older adults^{30,31}.

Although there has been increased awareness to food insecurity and food deserts³² and significant and meaningful impact that chronic disease, obesity, income, and food assistance have on food insecurity and functional status none have examined the differential role of race and ethnicity. The purpose of this analysis was to evaluate the association between food insecurity and functional limitations among older adults in a large population-based sample using contemporary epidemiological data. Additionally, we examine how the relationship between food insecurity and functional limitation changes when examining each sub-type of functional limitation and the impact of race/ethnicity. There is clear importance in understanding the impact that food insecurity has on health.

METHODS:

Study Design:

Data was obtained through The National Health and Nutrition Examination Survey (NHANES) 2005–2014. These cross-sectional surveys are designed to assess the health and nutrition of a nationally representative sample of individuals using a complex, multistage probability sample of non-institutionalized US population through in-home interview in 2-year cycles.³³ The National Center for Health Statistics (NCHS) of the Centers for Disease Control (CDC) ethics review board reviewed and approved the survey. All participants provided written consent, and all interviews and examinations were carried out by trained technicians according to standard operation manuals (available at NHANES website: <http://www.cdc.gov/nchs/nhanes.htm>).

Study population:

Of the 9,352 recruited adults 60 years old, 9,309 completed data (Supplemental Figure 1). Complete data was defined as having non-missing information for all of the functional limitation questions. All of these individuals had complete data on food security.

Food insecurity:

Our primary exposure, food insecurity, was assessed through the United States Department of Agriculture Adult Food Security Survey Module (FSSM).³⁴ The 10-item adult FSSM is a validated survey developed by the USDA to measure the food insecurity over the past 12 months of adults. Questions assess how frequently an individual went without food, or consumed a reduced amount of food not due to choice.³⁵ Affirmative question responses indicate greater food insecurity per the NHANES scoring algorithm resulting in four mutually exclusive levels.³⁶ The degree of food insecurity was defined as full food security (no affirmative responses), marginal food security (1–2 affirmative responses), low food security (3–5 affirmative responses), and very low food security (6–10 affirmative responses).³⁴

Functional limitations:

Our primary outcome of interest, self-reported functional limitations, was assessed through 13 questions focusing on 3 different core domains; physical functioning, basic activities of daily living, and instrumental activities of daily living.³⁷ The response was dichotomized by presence of an affirmative response; “No Difficulty” as “No Limitation” and “Some Difficulty”, “Much Difficulty”, and “Unable to do” as “Limitation”. Having a limitation in a domain was defined as at least a single limitation response. Physical limitations were defined as having difficulty in: walking ¼ mile, walking up 10 steps, stooping, crouching, kneeling, lifting/carrying, walking between rooms on same floor, or standing from an armless chair. Basic activities of daily living limitation were defined as difficulty (any affirmative response) in: getting in and out of bed, using fork, knife, drinking from a cup, dressing yourself, or standing for long periods. Instrumental activities of daily living limitation were defined as difficulty (any affirmative response) in: managing money, house chores, preparing meals. Having difficulty in any of these three areas was defined as having any functional limitation.

Covariates:

Covariates were selected based on factors relevant to adult limitations and/or from past food insecurity literature such as the role of sex²⁵, age^{31,38}, race²⁵, education³⁹, body mass index^{25,27}, marital status⁴⁰, smoking³⁹, diabetes^{19,30}, participation in nutritional support²², and income^{8,22,41}. In addition, these are variables that the investigative team has used in their previous analyses using NHANES.^{42,43} Through the interview process, information on study participant’s age (at time of questionnaire), gender, highest achieved education level (non-high school graduate, high school graduate/GED, some college or associate degree, and college graduate or above), race/ethnicity (White, non-Hispanic Black, Hispanic, and Other), marital status (single, married or living with partner, widowed/divorced/separated), calculated body mass index (BMI; kg/m²) using measured weight and height, smoking status (never, current, former), diabetes (have you ever been told to have diabetes by a doctor; yes, no), participation in food stamps or SNAP, and income as a percent of the federal poverty level was gathered at the time of the interview. All covariates were gathered through the in-home questionnaire in concordance with the NHANES interview protocol.

Statistical analysis:

Summary statistics are presented as counts with weighted percentages for categorical data, and weighted mean value and standard error for continuous data, stratified by 4 levels of food security. All data was combined at the person level and the primary analysis examined the association between the exposure (ordinal - 4 levels of food insecurity) and experiencing the primary outcome (binary - any functional limitation). The first subgroup analysis examined the association between level of food insecurity (ordinal - 4 levels of food insecurity) and type of function limitation (binary – for each type of functional limitation). The second subgroup analysis examined the association between level of food insecurity (ordinal - 4 levels of food insecurity) and functional limitation was (binary – any functional limitation) separate for each race/ethnicity. All linear associations between food insecurity and functional limitation were measured using multivariate logistic regressions, following

the procedures outlined by the Centers for Disease Control (CDC) and Prevention (<https://www.cdc.gov/nchs/nhanes/index.htm>). We accounted for the NHANES complex survey design using the CDC recommended weighting schema and accounting for stratified clustered sampling using the Survey package.⁴⁴ Baseline univariate association was assessed with the same method. Partially adjusted models included age, education level, ethnicity, marriage status, BMI, smoking status, diabetes, and income to poverty ratio. The fully adjusted model included all covariates of the partially adjusted model along with currently receiving food stamps or SNAP. Two-sided p-values with $\alpha = 0.05$ were used for all analysis. Analysis was conducted using R (version 3.4.1).

RESULTS:

Adults 60 years old in this study had a mean age of 70.1 ± 0.13 years (55% female). In the population, 88% had full food security ($n = 7,572$), 5.3% experienced marginal food security ($n = 717$), 4.2% experienced low food security ($n = 667$), and 2.3% experienced very low food security ($n = 353$) (Table 1). We identified 62.9% ($n = 6,196$) with a functional limitation of any kind. Of the study participants 55.1% ($n = 5,438$) had at least one physical limitation, 43.7% ($n = 4,440$) had at least one BADL limitation, and 30.2% ($n = 3,248$) had at least one instrumental ADL limitation. Rates of having any functional limitation increases as food security decreased; full food security (63.6%), marginal food security (77.3%), low food security (80.5%), and very low food security (81.3%) ($p < 0.001$) (Table 2).

When adjusting for gender, age, race/ethnicity, education, BMI, marital status, smoking status, diabetes, and income, increasing food insecurity is associated with functional limitation. The odds of having a functional limitation for older adults with marginal food security is 1.08 (95% CI: 1.02–1.14) when compared to participants with full security. This relationship is exacerbated as food insecurity increases; the odds that an older adult with low food security or very low food security has a functional limitation is 1.16 (1.10–1.22) & 1.14 (1.07–1.21), respectively, compared to participants with full food security (Table 3). The fully adjusted model mitigates the effect size of food insecurity by about 1% for marginal food security and by 2% for both low and very low food security (OR[95% CI]: 1.07[1.01–1.12], 1.14[1.08–1.20], 1.12[1.06–1.19], respectively), but all relationships remain statistically significant.

Functional limitations subgroup analysis:

Each subgroup of functional limitation was examined separately, each model adjusted for the same covariates above. Older adults who experience marginal, low, or very low food security, the odds of having a physical limitation is 1.08 (1.08–1.13), 1.14 (1.07–1.20), 1.12 (1.05–1.20), respectively. In study participants who experience marginal, low, or very low food security, the odds of having a BADL is 1.10 (1.04–1.16), 1.11 (1.11–1.27), 1.18 (1.10–1.28), respectively. For older adults who experience marginal, low, or very low food security, the odds of having an IADL is 1.09 (1.03–1.14), 1.15 (1.10–1.21), 1.18 (1.09–1.28), respectively. (Figure 1)

Racial/ethnic discrepancies subgroup analysis:

The relationship between food insecurity and functional limitation is modified by race/ethnic in our fully adjusted models (Table 4). Older adults who identify as non-Hispanic white had significantly higher odds of functional limitation when experiencing low food security. Self-identified non-Hispanic black older adults had significantly higher odds when experiencing very low food security. Finally, self-identified Hispanic older adults have significant higher odds of functional limitation when experiencing low and very low food security (Supplemental Figure 2).

DISCUSSION:

We demonstrate that food insecurity in older adults is significantly associated with functional limitation. This relationship becomes greater with increased food insecurity and is most pronounced for individuals who have basic activities of daily living and instrumental activities of daily living limitations. Additionally, these results provide new insight into the differential impact that race has on the relationship that food security has on functional limitations in older Americans. These results highlight the need to enhance awareness and potentially provide assistance for food insecurity among older adults with functional limitations, in particular those with BADL or IADL.

In adults 60 years old, the adjusted prevalence odds of having a functional limitation increases by 7%, 14%, and 12% when their food security level is marginal, low and very low, respectively. To generalize to the US population, if we use the NHANES sample weights and the 15.3 million older Americans with food insecurity in 2016⁴⁵ – 12.8 million older Americans are food insecure with a functional limitation. The slight non-linearity in this relationship suggests that there might be some additional support mechanisms that exist for individuals with very low food security that act to mitigate the likelihood of co-occurrence – in effect preventing the onset of a functional limitation. Additionally, older adults whose functional limitation requires them to live at long-term care facilities or are not ambulatory may not be included in the sampled NHANES population, reducing the power that such a group might have on any study examining more severe functional limitation. The observational nature of the NHANES survey does not allow us to evaluate the underlying reason that experiencing very low food security increases the odds of having a functional limitation less than experiencing low food security.

In 2016 13.6% of seniors were marginally food secure, 7.7% had low security, and 2.9% had very low food security, while the absolute number of seniors facing hunger was 90%, 113%, and 200% higher relative to 2001.⁴⁵ These individuals can receive help from several federal and state programs that help to mitigate food insecurity, yet the funding for these programs have been decreasing over time per individual.^{46,47} This is important in the context of the conceptual model of developing a disability in older adults; disability develops from a chronic medical condition to impairments to functional limitation and finally to disability.¹⁴ Because food insecurity is associated with functional limitation, helping increase food security in older adults could impact not only functional limitations but disability as well. With an expanding older population, it is critical to understand the impact and relationship

between food insecurity and functional limitation as food insecurity can potentially be influenced through policy and social systems.

This analysis demonstrates that a general relationship exists between food insecurity across different types of limitations. Because we are assessing the presence of any limitation and not the intensity or quantity we might be simplifying the relationship that food insecurity and functional limitations have. Despite this simplification we are still able to see a differential relationship when examining each limitation domain by food insecurity level. This could be due to the kinds of institutional and non-institutional support that exist for older adults with food insecurity and the impact that food insecurity can have on health.

Our results highlight how older adults who identify as being part of different racial groups have different odds of having a functional limitation for each level of food insecurity. Non-Hispanic white older adults have the highest adjusted odds of having a functional limitation when they experience low food insecurity. This is different for non-Hispanic blacks, who only have increased odds when very low food secure and Hispanics, who have high rates of functional limitations in both low and very low. Older adults who reported being part of a different racial or ethnic group there was an increased association of having a functional limitation when experiencing low food security. These differences could be due to how different racial and ethnic groups support older adults, inherent institutional discrimination, or other discriminatory mechanisms and should be further explored. Previous studies have identified social economic status as accounting for as much as 60% of the racial differences in all-cause mortality⁴⁸, and additionally, when examining the racial differences in ADL in older adults physical limitations have been identified as the strongest predictor⁴⁹. Here we demonstrate the role of race in functional limitations and food insecurity and through controlling for economic status suggest that there are underlying social and societal biases driving these relationships.

Other factors that are associated with both limitations and food insecurity that may explain this relationship are poor living conditions⁵⁰, driving cessation⁵¹ and limited transportation⁵², along with the importance of supporting social activities and social support^{53–55}, and access to healthcare.⁵⁶ All of these factors have been demonstrated to be associated with food insecurity or functional limitation and help give context to the complicated relationship between the two.

Due to our model, these results can also be interpreted as the having the reverse directional relationship; functional limitation could be leading to some degree of food insecurity. This study is unable to determine the directionality or causality of this relationship. To simplify our modeling and interpretation, we chose our outcome to be a binary variable of functional limitations rather than an ordinal variable of food security. Using the latter would require complex ordinal logistic regression modeling which can be difficult for clinicians to interpret in practical terms. It is possible this relationship could be a positive feedback loop where both functional limitation and food insecurity increase the likelihood of the other due to societal and individual reasons such as access, public policy such as SNAP or meals on wheels, and individual capacity. Such a model has been previously described.³⁸ Future research should attempt to determine a temporal and causal relationship between food

insecurity and functional limitations. This work could impact the scope and importance of senior meal services as a preventative measure against functional limitation development and ultimately disability.

There are several potential policy and service implications based on these results. Older adults with functional limitations are at increased risk of having food insecurity. Services for older adults that promote healthy aging and prevent development of functional limitations should also address food insecurity, specifically in those with BADL or IADL. Due to the association between food insecurity and functional limitation, policies that focus on helping those with functional limitations should also try to address the increased odds that participants will experience food insecurity. Because these associations are highest for minority racial/ethnic groups there should be specific outreach programs to minorities to address the increased odds. Policies that focus on providing seniors with meal services or that support those with functional limitations could potentially impact the development of the other. The Older Americans Act (OAA) is a national policy initiative that is actively trying to support food security. State programs funded by the OAA and the Administration for Community Living (ACL) provide Congregate Nutrition Programs, that can help to serve the void of food insecurity. In addition, Meals On Wheels is a program that specifically helps older adults by providing some level food security to older adults who may have decreased functionality addressing these two associated needs. Such programs act to mitigate the impact of any functional limitation might have on food security, though, as these programs have been around in one form or another since 1965 is it important to recognize that they do not fully address the need still exists as demonstrated here. Another program, the Senior Farmers Market Nutrition Program (SFMNP) is a national grant program for states to provide low-income seniors with coupons that can be exchanged at farmers markets. While it can be used for Community Supported Agriculture (CSA) boxes, based on this work it would be important for these to be mailed to participating older adults as they may have a co-occurrence of functional limitation and food insecurity. Again, the potential bi-directionality of this association would have to be addressed in any policy or program by supporting both food insecurity and functional limitation.

We acknowledge several limitations to this study. First, the cross-sectional nature of the data collection does not allow us to make any conclusions on causality and we are unable to determine any temporal relationships between food insecurity and functional limitations. Our results are also specific to the older population in the U.S. (60 years of age). Second, functional status was self-reported, which could be subject to some recall bias and misclassification. Third, the assessment of limitations might not be able to capture all aspects of limitations that an individual might face. Finally, the NHANES questionnaire does not survey all the components of BADLs or IADLs. This would mean that some individuals who we determined to be free of functional limitations may in fact be adversely affected by a limitation. Any such misclassification would bias our results towards the null.

There are several strengths to this study. We confirm results of a positive association between functional impairments and food insecurity.^{19–24} These results are also consistent with previous that found an association between food security and mental cognition follows a similar non-linear relationship with increasing food insecurity.¹⁸ Our subgroup analysis,

incremental modeling, and partial models (data not shown) demonstrate the robustness of these results. Our analysis expand on these results in two major ways. We examine the different relationships that the level of food insecurity has on the type of functional limitation experienced. Finally, we examine how a differential relationship exists between food insecurity and functional limitation for different racial groups. These results could help identify older adult populations that might be at risk of a functional limitation and justify the need to expand nutritional programs that serve these older adults with functional limitations.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations:

NHANES	National Health and Nutrition Examination Surveys
WIC	Special Supplemental Nutrition Program for Women, Infants, and Children
SNAP	Supplemental Nutrition Assistance Program
PL	Physical Limitations
BADL	Basic Activities Of Daily Living
IADL	Instrumental Activities Of Daily Living
HRS	Health and Retirement Study
HCNS	Health Care and Nutrition Study
NCHS	The National Center for Health Statistics
CDC	Centers for Disease Control
FSSM	United States Department of Agriculture Adult Food Security Survey Module
BMI	Body Mass Index
OAA	The Older Americans Act
ACL	Administration for Community Living

SFMNP	Senior Farmers Market Nutrition Program
CSA	Community Supported Agriculture

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TAKE AWAY:

- There is a relationship between food insecurity and functional limitation in older adults
- The relationship between food insecurity and functional limitation in older adults is modified by functional limitation type
- The relationship between food insecurity and functional limitation in older adults is modified by racial/ethnic groups.

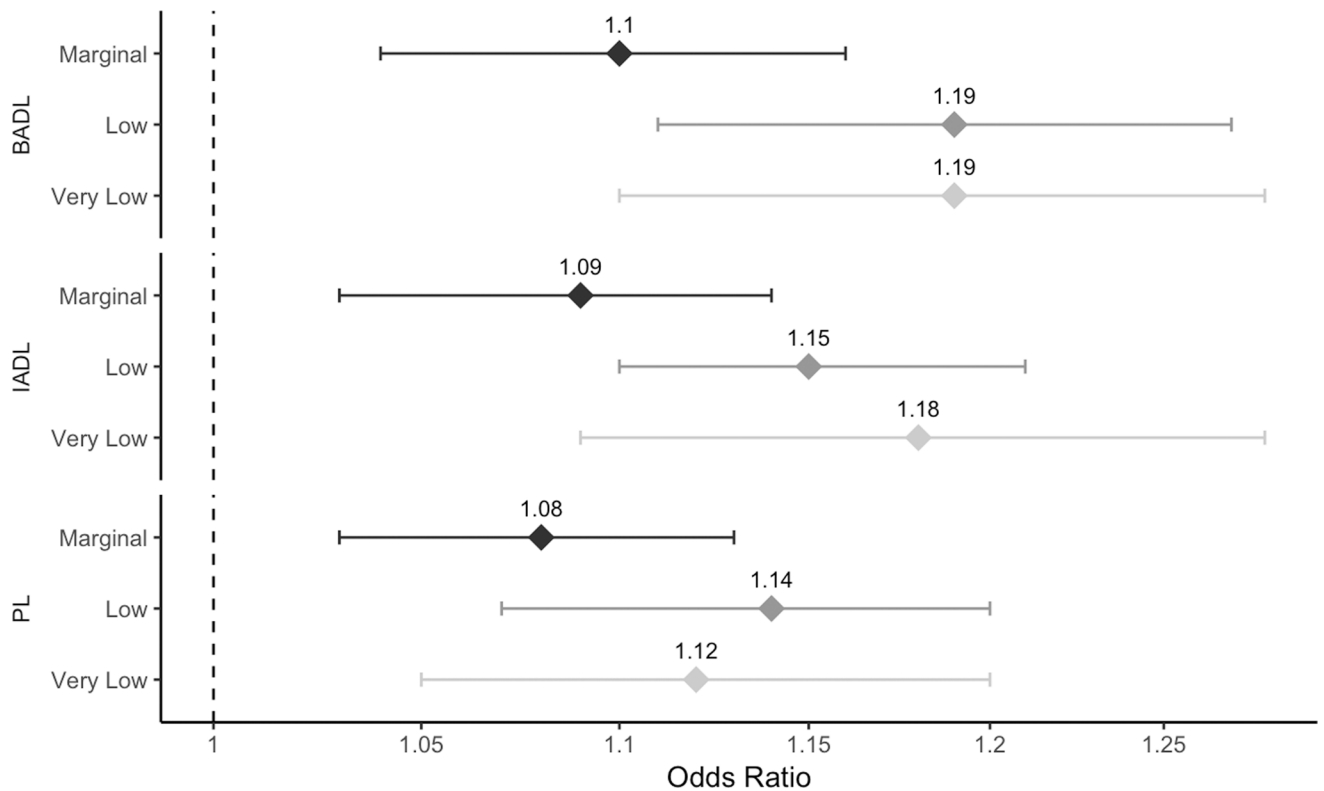


Figure 1: Functional limitation subgroups and association with food insecurity levels. Subgroup analysis of the odds of each type of functional limitation (basic activities of daily living [BADL], instrumental activities of daily living [IADL], physical limitations [PL]) for each food security level (marginal, low, and very low food security). All associations are significant, the across the largest effect is seen in low food security, followed by very low food security, and finally marginal food security. All odds ratios were adjusted for sex, age, race, education level, body mass index, marital status, smoking status, diabetic status, SNAP, and income to poverty ratio.

Table 1:

Characteristics of study population by food security (FS) level

	Full FS	Marginal FS	Low FS	Very low FS
n	7572	717	667	353
Male n (%)	3769 (45.3)	321 (37.6)	285 (37.7)	173 (42.5)
Age mean (SE)	70.2 (0.1)	69.3 (0.3)	68.7 (0.4)	67.5 (0.4)
Race n (%)				
Non-Hispanic White	4369 (82.5)	239 (60.5)	162 (49.1)	97 (51.5)
Non-Hispanic Black	1473 (7.6)	210 (18.5)	169 (18.5)	105 (20.1)
Hispanic	1249 (5.3)	222 (15.7)	291 (24.9)	136 (21.9)
Other	481 (4.7)	46 (5.3)	45 (7.5)	15 (6.5)
Education n (%)				
12th grade	2166 (18.9)	350 (39.8)	387 (50.5)	205 (48.5)
High school graduate/GED	1659 (28.0)	50 (9.1)	29 (6.7)	12 (5.7)
Some college or AA degree	1849 (25.3)	155 (24.4)	142 (22.7)	70 (24.7)
College graduate or above	1880 (27.8)	160 (26.7)	108 (20.2)	64 (21.0)
Body Mass Index kg/m² mean (SE)	28.8 (0.1)	29.8 (0.4)	30.1 (0.5)	30.4 (0.6)
Marital Status n (%)				
Married or living with partner	4504 (65.3)	335 (46.4)	302 (43.7)	132 (37.6)
Single	333 (3.6)	45 (5.1)	44 (6.1)	30 (6.2)
Widowed, divorced, or separated	2725 (31.1)	337 (48.5)	321 (50.2)	191 (56.2)
Smoking Status n (%)				
Current smoker	3738 (49.2)	328 (43.1)	306 (44.4)	151 (40.0)
Former smoker	803 (9.9)	134 (20.5)	130 (19.2)	98 (28.7)
Never smoker	3022 (40.9)	254 (36.4)	231 (36.4)	104 (31.3)
Diabetes n (%)	1597 (17.5)	212 (27.9)	190 (25.9)	113 (34.3)
Income to poverty level ratio mean (SE)	3.2 (<0.01)	1.7 (0.1)	1.4 (0.1)	1.2 (0.1)

n: respondent counts

%: all percentages are weighted using NHANES defined weighting method

mean: all means are weighted using NHANES defined weighting method

SE: standard error

Table 2:

Prevalence of functional limitations in older adults by food security (FS) level

	Full FS		Marginal FS		Low FS		Very low FS		p-value*
n	7572		717		667		353		
Any Limitation n (%)	4818	(60.7)	9554	(76)	537	(81.5)	287	(81.6)	<0.001
Basic Activities of Daily Living n (%)	3371	(41.1)	417	(58.3)	414	(66.5)	238	(68.7)	<0.001
Instrumental Activities of Daily Living n (%)	2392	(27.8)	334	(44.6)	331	(48.5)	191	(54.2)	<0.001
Physical Limitations n (%)	4189	(52.7)	507	(70.3)	485	(74.7)	257	(75.2)	<0.001

n: respondent counts

%: all percentages are weighted using NHANES defined weighting method

* Pearson's χ^2 : Rao & Scott adjustment

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Table 3:

Univariate, partial, and fully adjusted regression models for any functional limitation

	Univariate		Partially adjusted [§]		Fully adjusted*	
	Odds Ratio	(95% CI)	Odds Ratio	(95% CI)	Odds Ratio	(95% CI)
Food security level						
Full	(REF)		(REF)		(REF)	
Marginal	1.16	(1.11–1.22)	1.08	(1.02–1.14)	1.07	(1.01–1.12)
Low	1.23	(1.18–1.29)	1.16	(1.10–1.22)	1.14	(1.08–1.20)
Very low	1.23	(1.16–1.31)	1.14	(1.07–1.21)	1.12	(1.06–1.19)
Male vs. female	0.92	(0.90–0.94)	0.94	(0.92–0.97)	0.95	(0.92–0.97)
Age						
60–69	(REF)		(REF)		(REF)	
70–79	1.13	(1.09–1.17)	1.11	(1.07–1.15)	1.11	(1.07–1.15)
80+	1.33	(1.29–1.37)	1.34	(1.29–1.39)	1.35	(1.30–1.40)
Race						
Non-Hispanic White	(REF)		(REF)		(REF)	
Non-Hispanic Black	1.03	(1.00–1.06)	0.95	(0.92–0.98)	0.94	(0.92–0.97)
Hispanic	1.05	(1.02–1.09)	0.98	(0.94–1.01)	0.97	(0.94–1.01)
Other	1.01	(0.96–1.06)	1.04	(0.98–1.09)	1.03	(0.98–1.09)
Education						
12th grade	(REF)		(REF)		(REF)	
High school graduate/GED	0.93	(0.89–0.96)	0.97	(0.94–1.01)	0.98	(0.94–1.01)
Some college or AA degree	0.90	(0.87–0.93)	0.97	(0.93–1.00)	0.97	(0.94–1.01)
College graduate or above	0.77	(0.74–0.80)	0.89	(0.85–0.93)	0.89	(0.85–0.93)
Body Mass Index kg/m²						
<18.5	1.02	(0.90–1.16)	0.96	(0.85–1.09)	0.96	(0.85–1.08)
18.5–24.9	(REF)		(REF)		(REF)	
25–29.9	1.03	(0.99–1.07)	1.05	(1.01–1.10)	1.05	(1.01–1.10)
30	1.18	(1.13–1.22)	1.19	(1.15–1.23)	1.19	(1.15–1.23)
Marital Status						
Married or living with partner	(REF)		(REF)		(REF)	
Single	1.06	(1.00–1.13)	1.01	(0.95–1.08)	1.00	(0.94–1.07)
Widowed, divorced, or separated	1.14	(1.11–1.17)	1.02	(0.99–1.05)	1.01	(0.99–1.04)
Smoking Status						
Never smoker	(REF)		(REF)		(REF)	
Current smoker	1.07	(1.04–1.11)	1.12	(1.07–1.16)	1.11	(1.07–1.16)
Former smoker	1.04	(1.01–1.07)	1.05	(1.01–1.08)	1.05	(1.01–1.08)
Diabetes vs. No Diabetes	1.18	(1.14–1.22)	1.12	(1.07–1.16)	1.11	(1.07–1.16)
SNAP participation	1.21	(1.17–1.26)	NA		1.08	(1.04–1.13)
Income to poverty level ratio	0.94	(0.93–0.95)	0.98	(0.97–0.99)	0.98	(0.97–0.99)

[§] Adjusted for food security level, sex, age, race, education level, body mass index, marital status, smoking status, diabetic status, and income to poverty ratio

* Adjusted for partially adjusted covariates and SNAP participation

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Table 4:

Adjusted relationship between any functional limitation and food security level modified by race/ethnicity

	Non-Hispanic White Odds Ratio (95%CI)	Non-Hispanic Black Odds Ratio (95%CI)	Hispanic Odds Ratio (95%CI)	Other Odds Ratio (95%CI)
Full	(Ref)	(Ref)	(Ref)	(Ref)
Marginal	1.06 (0.99–1.14)	1.07 (0.99–1.15)	1.07 (1.00–1.15)	1.07 (0.86–1.32)
Low	1.17 (1.09–1.25)	1.01 (0.91–1.11)	1.16 (1.10–1.23)	1.21 (1.08–1.36)
Very low	1.09 (1.00–1.20)	1.15 (1.06–1.24)	1.17 (1.08–1.28)	1.07 (0.88–1.29)

Adjusted for sex, age, education level, body mass index, marital status, smoking status, diabetic status, SNAP, and income to poverty ratio

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