

# UC Davis

## UC Davis Previously Published Works

### Title

Midlife vulnerability and food insecurity: Findings from low-income adults in the US National Health Interview Survey.

### Permalink

<https://escholarship.org/uc/item/17x7d6zj>

### Journal

PloS one, 15(7)

### ISSN

1932-6203

### Authors

Miller, Lisa M Soederberg  
Tancredi, Daniel J  
Kaiser, Lucia L  
[et al.](#)

### Publication Date

2020

### DOI

10.1371/journal.pone.0233029

Peer reviewed

## RESEARCH ARTICLE

# Midlife vulnerability and food insecurity: Findings from low-income adults in the US National Health Interview Survey

Lisa M. Soederberg Miller<sup>1\*</sup>, Daniel J. Tancredi<sup>2</sup>, Lucia L. Kaiser<sup>3</sup>, Jeffrey T. Tseng<sup>4</sup>

**1** Department of Human Ecology, University of California, Davis, CA, United States of America, **2** Center for Healthcare, Policy, and Research, UC Davis School of Medicine, Sacramento, CA, United States of America, **3** Nutrition Department, University of California, Davis, CA, United States of America, **4** Communication Department, University of California, Davis, CA, United States of America

\* [lmsmiller@ucdavis.edu](mailto:lmsmiller@ucdavis.edu)



## OPEN ACCESS

**Citation:** Miller LMS, Tancredi DJ, Kaiser LL, Tseng JT (2020) Midlife vulnerability and food insecurity: Findings from low-income adults in the US National Health Interview Survey. PLoS ONE 15(7): e0233029. <https://doi.org/10.1371/journal.pone.0233029>

**Editor:** Kenzie Latham-Mintus, Indiana University Purdue University at Indianapolis, UNITED STATES

**Received:** December 9, 2019

**Accepted:** April 27, 2020

**Published:** July 13, 2020

**Copyright:** © 2020 Miller et al. This is an open access article distributed under the terms of the [Creative Commons Attribution License](https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

**Data Availability Statement:** All relevant data is available at [https://www.cdc.gov/nchs/nhis/nhis\\_2014\\_data\\_release.htm](https://www.cdc.gov/nchs/nhis/nhis_2014_data_release.htm).

**Funding:** USDA National Institute of Food and Agriculture, project CA-D-HCE-7513-H. The opinions and conclusions expressed are solely those of the authors and should not be construed as representing the opinions or policies of the sponsoring agencies.

**Competing interests:** The authors have declared that no competing interests exist.

## Abstract

### Background

Food insecurity, limited access to adequate food, in adulthood is associated with poor health outcomes that suggest a pattern of accelerated aging. However, little is known about factors that impact food insecurity in midlife which in turn could help to identify potential pathways of accelerated aging.

### Methods

Low-income adults (n = 17,866; 2014 National Health Interview Survey), ages 18 to 84, completed a 10-item food security module and answered questions regarding health challenges (chronic conditions and functional limitations) and financial worry. We used multinomial logistic regression for complex samples to assess the association of health challenges and financial worry with food insecurity status and determine whether these associations differed by age group, while adjusting for poverty, sex, race/ethnicity, education, family structure, social security, and food assistance.

### Results

Food insecurity rates were highest in late- (37.5%) and early- (36.0%) midlife, relative to younger (33.7%) and older (20.2%) age groups and, furthermore, age moderated the relationship between food insecurity and both risk factors (interaction p-values < .05, for both). The effects of poor health were stronger in midlife relative to younger and older ages. Unlike younger and older adults, however, adults in midlife showed high levels of food insecurity regardless of financial worry.

### Conclusions

Findings suggest that food insecurity in midlife may be more severe than previously thought. Greater efforts are needed to identify those at greatest risk and intervene early to slow premature aging.

## Introduction

Food insecurity, defined as the inability to afford and access nutritious foods to eat, disproportionately affects those living in poverty and leads to poor health, higher healthcare costs, and increased risk of mortality [1–7]. Individuals living with food insecurity are at increased risk of poor quality diet and inadequate nutrient intake, which contribute to muscle mass loss, mobility problems, and frailty at earlier ages than those living with adequate access to nutritious food [8–15]. Older adults in the US often have lower rates of food insecurity than do working age (e.g., 25–61 years of age) and young adults, possibly because of social safety nets in the US such as social security [13, 16–24]. It is unclear, however, how food insecurity rates in the middle portion of adulthood compare to earlier and later ages. Some studies have shown a steady decline in food insecurity across adulthood [22, 24] while others have shown stability [23], or a curvilinear relationship with a peak at age 45 in a sample of 18 to 64 year olds [25]. There is some indication that chronic conditions and disability may impact food insecurity to a greater extent in midlife relative to other age groups [20], factors which may contribute to the ambiguity in the literature. Midlife or “middle-age” represents the life course position between young adulthood and old age. Although lacking a clear beginning or end, this period is often defined as beginning at age 40 or 45 and ending at age 60 or 64 [26, 27]. As described below, middle-aged adults experience changes in social, psychological, and biological factors that are unique to this portion of the lifespan [27, 28] and could increase the risk of food insecurity in midlife. In the present study, we explored two potential moderators of the relationship between age and food insecurity: health challenges and financial worry.

## Health challenges

Midlife is typically when the onset of chronic disease and functional limitations occurs [27]. Health challenges are more likely, in terms of number and severity, among low-income, relative to high-income, middle-aged adults [29, 30]. Poor health in midlife may be connected to food insecurity through several paths including reduced ability (e.g., mobility, strength, dexterity) to locate, access, and prepare inexpensive nutritious food. We hypothesized that the changes associated with midlife are likely to exacerbate the impact of health challenges on food insecurity. Still, it is unclear whether the presence of health challenges or another factor, in particular, financial worry, best captures the moderating effects of age on food insecurity.

## Financial worry

Another hallmark of midlife is an increase in the number of social roles (e.g., related to work, parenting, and other forms of caregiving) [26]. In particular, middle-aged adults often care for children and aging parents simultaneously, which has earned current cohorts the name *sandwich generation*, or more recently, *pivot generation* [31, 32]. Among low-income, middle-aged adults, additional roles may contribute to greater financial worry, defined as concerns regarding one’s ability to meet basic financial needs and obligations, and maintain a standard of living. Research has shown that financial worry is closely connected to stress and psychological well-being [33, 34], which in turn increase vulnerability to food insecurity [35]. As with research on physical health, evidence suggests that poor psychological health increases the risk of poor quality diet and food insecurity [36, 37]. Yet, few if any studies have examined associations between financial worry and food insecurity. We hypothesized that financial worry would moderate the relationship between age and food insecurity due middle-aged adults’ concerns surrounding their caregiving responsibilities and self-care needs relative to their financial concerns. In midlife, financial worry may reflect perceptions surrounding increasing risk of lost work time, reduced prospect of re-employment [7, 38], and few safety-net

opportunities (relative to parents of younger children or older adults) [20, 39]. Middle-aged adults may incur expenses associated with caring for adult children or aging parents that may not be factored into eligibility tests because care recipients reside outside, or transition in and out of, the household [40, 41]. Even when eligible, middle-aged adults may not be aware of benefits as evident in lower participation in food assistance programs, such as the Supplemental Nutrition Assistance Program (SNAP) [42].

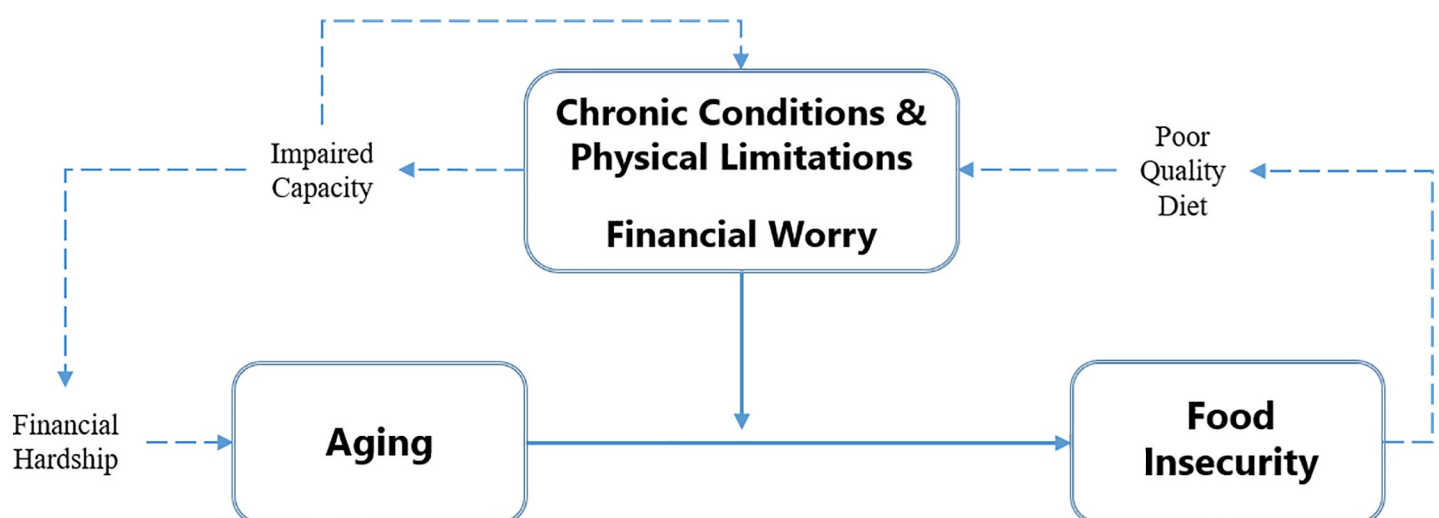
Thus, midlife represents the intersection of declining health, increasing financial uncertainty, and multiple roles which often include caregiving responsibilities. In the present study, we explored the possibility that health challenges and financial worry, independently moderate the relationship between age and food insecurity such that the relationships are most pronounced in midlife. The hypothesized relationships between health challenges, financial worry, and food insecurity are depicted in Fig 1 [6, 13, 35, 36, 43, 44].

## Methods

We analyzed cross-sectional data from the 2014 National Health Interview Survey (NHIS). The NHIS is a study conducted by the National Center for Health Statistics, Centers for Disease Control and Prevention designed to track health status and health care access since 1957 [45]. The 2014 NHIS contains a nationally representative sample ( $n = 34,798$ ) of US noninstitutionalized adults ages 20 to 84. Data were collected using a face-to-face interview format. In this study, we examined a subset of adults who were characterized as low income ( $n = 17,866$ ) using the poverty-to-income ratio (PIR), which is the ratio of income to the poverty threshold set by the US Census Bureau (adjusted for inflation and family size). The poverty threshold for a family of 4 in 2014 was \$23,850. Thus, income of this amount for a family this size would have a PIR = 1 (i.e., 100% of federal poverty threshold). We defined low-income as those with a PIR < 3, indicating less than three times the federal income threshold. This definition of low-income offers a good chance of including those with marginal food insecurity [21, 46].

## Measures

**Dependent variable.** Food insecurity was assessed using the US Department of Agriculture's 10-item, Adult Food Security Scale, which is a widely-used measure assessing the



**Fig 1. Conceptual model of accelerated aging and food insecurity in midlife: Cascading impact of poor diet quality, health challenges, financial hardship, and financial worry.**

<https://doi.org/10.1371/journal.pone.0233029.g001>

frequency with which adults experienced, for example, not having enough money to buy food or were unable to afford to eat balanced meals during the 30-day period prior to survey [25]. Responses, ranging from 0 to 10, were categorized into 4 levels: food secure (score of 0), marginal food secure (score of 1–2), low food secure (score of 3–5), and very low food secure (score of 6–10) [47].

**Independent variables.** Age, measured in years ranging from age 18 to 84, was stratified into four groups: young adults, ages 18–34; early midlife, ages 35–49; late midlife, ages 50–64; and older adults, ages 65–84. Because our focus was on midlife, we included an early- and late-midlife group. We defined the start of the early midlife group at age 35, based on recent evidence of increased health risks as young as 35 [48–50]. Age 50 marked the beginning of the late-midlife group, consistent with past work on midlife food insecurity [20]. The health challenges variable was constructed by crossing bivariate (yes/no) measures of chronic conditions with functional limitations. The chronic conditions variable was determined by scoring a “yes” if respondents had ever been told they had any of the following 13 chronic conditions, coronary heart disease, hypertension, angina pectoris, heart attack, heart condition/disease, hepatitis, cancer, stroke, COPD, asthma, kidney, diabetes, arthritis [51]. The functional limitations variable was similarly constructed based on a list of 12 activities. Respondents received a “yes” if they indicated difficulty performing any of the following activities without special equipment, walk 1/4 mile, climb 10 steps, stand 2 hours, sit 2 hours, stoop/bend or kneel, reach overhead, grasp small objects, lift/carry 10 lbs, push large objects, go out to events, participate in social activities, relax at home. The health challenges composite variable combined the two variables into 3 levels: 1 = neither a chronic condition nor a functional limitation; 2 = either one but not both; 3 = both (at least one chronic condition and at least one functional limitation) [23]. A financial worry was assessed using six questions pertaining to financial worry related to paying monthly bills, paying rent/ mortgage/ housing, and other costs. Responses were made on a scale of 1 (not worried at all) to 4 (very worried) and a composite score was formed by averaging across the 6 items.

**Control variables.** We controlled for poverty level, sex, race/ethnicity, education level, presence of older adults in the home (other than self), presence of children in the home, household social security benefits, and household SNAP benefits. Poverty PIR was stratified into three groups: extreme poor- less than the poverty line (<1 PIR); very poor (1 to <2 PIR); and poor (2 to <3 PIR). Sex was a dichotomously coded as male/female. Race/ethnicity was assessed using four non-overlapping categories: White, Black, Hispanic, and other race. Education was coded into three groups: high school or lower; some college; and college graduate or more. To address the potential for caregiving responsibilities in the home, two family characteristics were assessed. First, presence of older adults in the home (other than self) was dichotomized into no/yes; and, second, presence of children in the home was categorized into three levels: no children; 1 child; and 2 or more children. Household social security and SNAP benefits were both dichotomized into no/yes.

## Analytic strategy

Analyses were conducted by using survey data analysis procedures in SPSS software (version 24), using the survey weight and study design variables provided by the 2014 NHIS [52], yielding inferences that represent the US civilian, noninstitutionalized adult population and design-adjusted variance estimates (for hypothesis testing and confidence interval estimation). Data were coded as missing for “refused,” “not ascertained,” “unsure,” and “don’t know” responses. First, we examined food insecurity prevalence, broadly defined, in terms of food secure (score of 0) and food insecure (scores of 1–10) using logistic regressions for complex

samples. In two models, we tested age effects before and after adjusting for health, financial worry, poverty, sex, race/ethnicity, education, elder and child presence, social security and SNAP support. Second, we used multinomial logistic regressions for complex samples to examine food security rates at marginal, low, and very low food security levels relative to food secure. Our dependent variable is ordered and could be analyzed by ordinal logistic regression under the strong assumption of proportional odds, but we opted to avoid this assumption and use multinomial logistic regression instead, given our goal to characterize the joint and separate effects of age and functional limitations on varying levels of food insecurity. To examine whether the effects for focal risk factors (i.e., health and financial worry) were modified by age, age-by-risk factor interaction terms were added to the model in separate analyses. Wald tests were used to examine main effects and interaction, with  $p < .05$ , to evaluate significance. Effect sizes from multinomial logistic regression models were reported as relative risk ratios, where the relative risk concerns the probability for each level of the dependent variable relative to the probability of the reference level.

### Ethics statement

NHIS is approved by the Research Ethics Review Board of the National Center for Health Statistics and the U.S. Office of Management and Budget. All NHIS respondents provided oral consent prior to participation. All data in the publicly available dataset are fully anonymized prior to release. All authors declare they have no competing interests.

### Results

Overall, 32.9% of low-income respondents ( $n = 17,866$ ) reported being food insecure in the 30 days prior to the survey. Food insecurity rates increased from young, 33.7%, to early-mid, 36.0%, and late-mid, 37.5%, representing a 10% increase in food insecurity rates from young adulthood to late midlife (Table 1). As presented in the top-left portion of Table 2, late middle-aged adults showed an increased risk of food insecurity (RRR = 1.18; 95% CI = 1.05, 1.33) relative to young adults. Older adults had the lowest rates, 20.2%, representing a significantly decreased risk (RRR = 0.50; 95% CI = 0.44, 0.57) relative to young adults.

We examined food insecurity in greater detail using four categories (secure, marginally secure, low secure, very low secure). Food insecurity rates decreased with increasing severity, 12.1%, 11.3%, 9.5%, for marginal, low, and very low food security levels, respectively (Table 1). We tested age differences and age moderation using multinomial logistic regression models, with food insecurity level as the dependent variable (with *food secure* as the reference level) and age group (with young adults as the reference group) as the independent variable. Fig 2 displays unadjusted food security means (i.e., ranging from 1 (food secure) to 4 (food very low secure) in small age increments (3–5 years) to illustrate the gradual change across the young, early-mid, late-mid, and older age groups.

In Model 1, the unadjusted relative risk ratios for marginal food security were nonsignificant among early- (RRR = 0.99; 95% CI = 0.83, 1.17) and late- (RRR = 0.93; 95% CI = 0.78, 1.11) middle-aged adults, indicating the relative risk of marginal food security (versus food security) for the midlife groups did not differ statistically from those of young adults (see bottom left portion of Table 2). On the other hand, the relative risk of very low food security was greater for both midlife groups (early-middle: RRR = 1.22; 95% CI = 1.00, 1.47; late-middle: RRR = 1.57; 95% CI = 1.30, 1.91) relative to younger adults. Very low food security increased 32.5% from young to late midlife (8.8% vs. 13.0%, see Table 1). Moreover, the late-midlife group was the only age group that did not decline from low- to very-low food security status (12.6% vs. 13.0%). Older adults, on the other hand, were less likely to be food insecure than

**Table 1. Characteristics of low-income adults by food security status (National Health Interview Survey, 2014; n = 17,866).**

Characteristic	Sample		Food Security Status				P value <sup>a</sup>
	n	Column %	Secure Row %	Marginal Row %	Low Row %	Very Low Row %	
Total	17866			12.1	11.3	9.5	
Age							<0.0001
Younger (18–34)	6026	0.383	0.663	0.135	0.114	0.088	
Early Middle (35–49)	4179	0.240	0.640	0.129	0.127	0.103	
Late Middle (50–64)	4011	0.214	0.625	0.119	0.126	0.130	
Older (65–84)	3650	0.162	0.798	0.075	0.076	0.051	
Poverty Level (PIR < 3)							<0.0001
Low (PIR < 1)	5360	0.300	0.531	0.154	0.162	0.153	
Mid (1 > = PIR < 2)	7111	0.398	0.664	0.125	0.120	0.091	
High (2 > = PIR < 3)	5396	0.302	0.820	0.082	0.056	0.042	
Health Challenges							<0.0001
Neither FL nor CC	7349	0.412	0.728	0.118	0.097	0.057	
One (either FL or CC)	5012	0.281	0.674	0.126	0.106	0.094	
Both (FL and CC)	5476	0.307	0.593	0.119	0.142	0.146	
Financial Worry (yes)	5401	0.309	0.465	0.155	0.189	0.191	<0.0001
Sex (female)	9612	0.538	0.656	0.124	0.120	0.100	<0.01
Race/Ethnicity							<0.0001
Non-Hispanic White	9558	0.535	0.717	0.103	0.089	0.091	
Non-Hispanic Black	2876	0.161	0.549	0.154	0.163	0.134	
Hispanic	4163	0.233	0.636	0.141	0.142	0.081	
Multirace/other	1251	0.070	0.713	0.115	0.096	0.076	
Education							
< = High School Diploma	7439	0.417	0.614	0.135	0.142	0.109	<0.0001
Some College	6993	0.392	0.669	0.124	0.105	0.102	
> = College Degree	3390	0.190	0.798	0.083	0.068	0.051	
Older Adults (yes)	2305	0.129	0.783	0.088	0.078	0.051	<0.0001
Children							<0.0001
None	10201	0.571	0.692	0.098	0.107	0.103	
One	2805	0.157	0.651	0.146	0.121	0.082	
Two or more	4860	0.272	0.638	0.153	0.123	0.086	
Social Security (yes)	5319	0.298	0.691	0.100	0.109	0.100	<0.0001
SNAP Benefits (yes)	5159	0.289	0.471	0.170	0.186	0.173	<0.0001

<sup>a</sup> based on Chi-Square tests

FL = Functional Limitation; CC = Chronic Condition; SNAP = Supplemental Nutrition Assistance Program

<https://doi.org/10.1371/journal.pone.0233029.t001>

young adults at all three levels of food security (marginal: RRR = 0.46; 95% CI = 0.38, 0.56; low: RRR = 0.55; 95% CI = 0.45, 0.68; very low: RRR = 0.48; 95% CI = 0.37, 0.63).

The likelihood of food insecurity changed, however, after adjusting for demographic characteristics and moderators (health challenges and financial worry) in Model 2. As shown in Table 2, the relative risk of food insecurity significantly declined (RRRs ranged from 0.25 to 0.80) in early-middle, late-middle, and older adulthood, relative to young adulthood (except for risk of low food security for early-middle aged adult, RRR = 0.84; 95% CI = 0.70, 1.01). Model 2 also showed that, after adjusting for demographic variables, health challenges, Wald

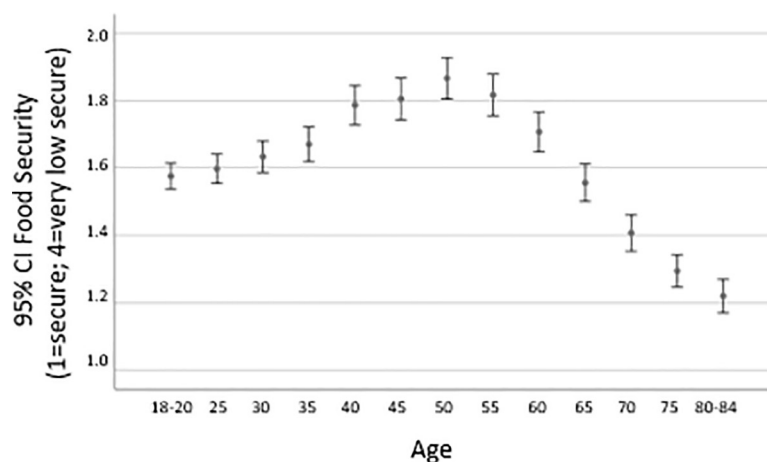
**Table 2. Effect size estimates of food security among young, early mid-, late mid-, and older adults, unadjusted and adjusted for demographic characteristics, health challenges, and financial worry (National Health Interview Survey, 2014; n = 17,866).**

Age	Food Security Status	Unadjusted Effect Size Estimates			Adjusted Effect Size Estimates		
		Preliminary Models					
Young vs:	Secure vs:	RRR	95% CI		RRR	95% CI	
Early Middle (35–49)	Insecure	1.11	0.99	- 1.24	0.81	0.71	- 0.92
Late Middle (50–64)	Insecure	1.18	1.05	- 1.33	0.69	0.59	- 0.80
Older (65–84)	Insecure	0.50	0.44	- 0.57	0.37	0.30	- 0.46
		Model 1			Model 2		
Young vs:	Secure vs	RRR	95% CI		RRR	95% CI	
Early Middle (35–49)	Marginal	0.99	0.84	- 1.17	0.80	0.67	- 0.97
	Low	1.16	0.98	- 1.37	0.84	0.70	- 1.01
	Very Low	1.22	1.00	- 1.47	0.75	0.61	- 0.93
Late Middle (50–64)	Marginal	0.93	0.78	- 1.11	0.76	0.61	- 0.94
	Low	1.17	0.98	- 1.39	0.68	0.55	- 0.84
	Very Low	1.57	1.30	- 1.91	0.59	0.47	- 0.75
Older (65–84)	Marginal	0.46	0.38	- 0.56	0.47	0.35	- 0.63
	Low	0.55	0.45	- 0.68	0.40	0.30	- 0.53
	Very Low	0.48	0.37	- 0.63	0.25	0.18	- 0.35

<https://doi.org/10.1371/journal.pone.0233029.t002>

F = 140.92, and financial worry, Wald F = 526.16, were significantly associated with food insecurity (Tables 2 and 3).

We tested age moderation of health challenges (Model 3) and financial worry (Model 4) on food insecurity after adjusting for demographic and moderator main effects (Model 2). Fig 3 shows predicted probabilities of marginal, low, and very low food security from Model 3 (top) and Model 4 (bottom). The Age x Health Challenges interaction term in Model 3 was significant, Wald F = 1.91 (Table 2). The top portion of Fig 3 indicates that the two middle-aged groups had the greatest risk of low and very low food security at the highest level of health challenges. When health challenges were lowest, the risk was comparable for young and late middle (low) and for young, early- and late- middle (very low food security). Marginal food security was largely unaffected by health.



**Fig 2. Food security means (unadjusted) by age (3- to 5-year increments).**

<https://doi.org/10.1371/journal.pone.0233029.g002>



**Table 3. Test statistic for age (Model 1), main effects (Model 2), and main effects plus moderation (Models 3 and 4) models (National health interview survey, 2014; n = 17,866).**

Model	Source	df		Wald F/Chi-Square	P-value
Model 1	Age	9		191.63	.000
Model 2	Age	9		95.86	.000
	Poverty Level (PIR < 3)	6		116.88	.000
	Health Challenges	6		140.92	.000
	Financial Worry	3		526.16	.000
	Sex	3		0.41	.938
	Race/Ethnicity	9		56.02	.000
	Education	6		37.72	.000
	Older Adults in HH	3		21.53	.000
	Children in HH	6		41.06	.000
	Social Security Benefits	3		8.17	.043
	SNAP Benefits	3		152.91	.000
Model 3	Age x Health Challenges	18	17401	1.91	.012
Model 4	Age x Financial Worry	9		39.21	.000

Note: PIR = Poverty Income Ratio; HH = Household; SNAP = Supplemental Nutrition Assistance Program

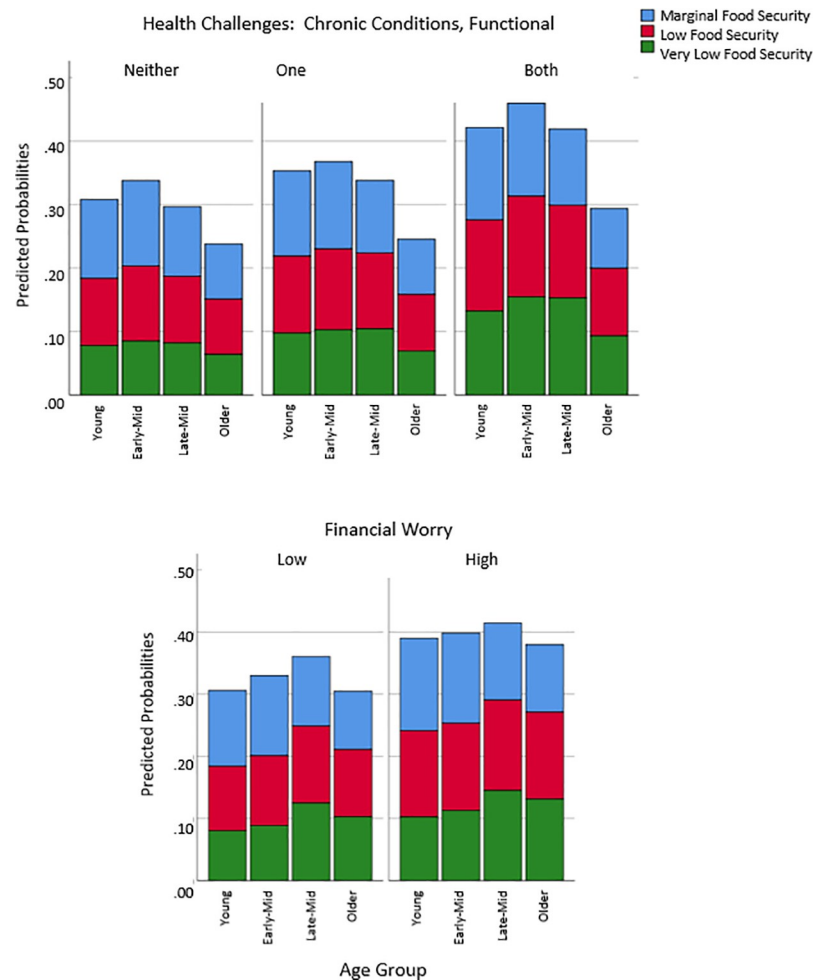
<https://doi.org/10.1371/journal.pone.0233029.t003>

In Model 4, the Age x Financial Worry interaction term was also significant, Wald  $F = 39.21$  (Table 3). As shown in bottom portion of Fig 3, predicted probabilities generally increased from low- to high- financial worry; however, increases in marginal food security rates were small for all groups but young adults. In addition, the effects of financial worry were greatest for very low food security rates for young, early-middle, and older adults; however, for late-middle aged adults, very low and low food security rates were comparable. Thus, the hypothesis that middle-age adults would show greater effects of financial worry than younger or older adults was not supported.

## Discussion

Overall food insecurity rates were highest for late- (37.5%) and early- (36.0%) middle-aged adults, followed by young (33.7%) and older (20.2%) adults. In addition, relative to younger adults, middle-aged adults had an increased risk of low and very low food security when health challenges were greatest and older adults had a decreased risk of marginal, low, and very low food security, across all three levels of health challenge. These findings are consistent with research showing that food insecurity is associated with functional limitations and poor health [6, 7, 21, 35, 53, 54] as well as with research showing that the impact of disability on food insecurity is stronger for working-age adults (ages 25–61) than it is for younger and older adults [16]. The findings add to past work by specifying that period in which disability and health challenges may pose the greatest vulnerable; specifically later, rather than earlier, within the working-age range.

We also found that financial worry was positively associated with food insecurity. Past studies have included measures of financial strain or worry that clearly overlapped with food insecurity measures (having enough money to pay for clothing or food) [55], making it difficult to distinguish between financial worry and food insecurity. Our findings indicate that concerns surrounding one's economic situation predict food insecurity even after adjusting for covariates and, furthermore, that the relationship between financial worry and food insecurity risk is moderated by age. Contrary to our expectations, however, food insecurity rates of younger



**Fig 3.** Predicted probabilities of food security (marginal, low, and very low) for age and health challenges (top) and age and financial worry (bottom) moderation models, by young adult (18–34 years), early midlife (35–49 years), late midlife (50–64 years) and older adults (65–84 years).

<https://doi.org/10.1371/journal.pone.0233029.g003>

and older adults, but not middle-aged adults, increased from low to high levels of financial worry. Food insecurity rates were high among middle-aged adults at both levels of financial worry.

When examined together, findings from the present study suggest that the negative effects of health challenges (chronic illness and functional limitations) on food insecurity are most pronounced among middle-aged adults nearing old age relative to other periods of adulthood. The findings are consistent with a pattern of midlife vulnerability found in studies examining stress, disease prevalence, and mortality rates [56–58]. There are several possible reasons why adults in late-midlife may be particularly vulnerable to food insecurity, especially in the presence of health challenges. Poor health may restrict employment which reduces the financial resources for food as well as the potential for engagement in the social world, which further decreases health [59]. Moreover, with few social welfare options, the need to remain in the work force places additional strain on financial well-being and, ultimately, increases the risk and severity of food insecurity [60, 61]. On the other hand, social safety nets may improve access to food in later life [20]. Another, less optimistic, reason why vulnerability may be less evident in later life is that life expectancy is markedly lower among those who experience

chronic economic, health, and food insecurity burdens [56, 57, 62]. Food insecurity has been linked to nutritional frailty, characterized by sudden loss of weight, strength, and muscle mass, which is a major risk factor for poor health (e.g., dementia, sarcopenia) [63, 64].

Although this study has several strengths including use of a nationally representative sample of adults, examination of midlife relative to both younger and older ages, and consideration of financial worry, it also has limitations. In particular, the findings are based on a cross-sectional survey with assessments of health challenges, financial worry, and food insecurity at only one point in time, precluding causal inferences. The food insecurity instrument, although widely used and validated in US populations, measures the respondent's perception of the adequacy of household food supplies but does not assess local food availability (e.g., presence of or distance to supermarkets) or "socially acceptable" availability [47].

## Conclusions

The present study contributes to the literature by showing that midlife appears to be a period of increased vulnerability to food insecurity, setting the stage for premature aging. Additional research is needed to further specify and test the mechanisms underlying food insecurity [44] and provide an empirical base for the hypothesized relationships in Fig 1 [6, 7, 13, 35, 36, 43, 44]. Such research would inform a growing literature on the cumulative effects of hardships across the life course [62, 65, 66] and their role in accelerating aging [8, 64, 67–71]. Further exploration of midlife vulnerability is needed to identify prevention and screening (e.g., primary care) strategies designed to halt or slow disease progression, promote rehabilitation, and increase wellness into later life [72, 73].

## Acknowledgments

The authors wish to thank the reviewers and the men and women who took time to participate in the NHIS survey.

## Author Contributions

**Conceptualization:** Lisa M. Soederberg Miller, Daniel J. Tancredi.

**Investigation:** Lisa M. Soederberg Miller, Jeffrey T. Tseng.

**Methodology:** Lisa M. Soederberg Miller, Daniel J. Tancredi.

**Resources:** Lucia L. Kaiser.

**Writing – original draft:** Lisa M. Soederberg Miller, Lucia L. Kaiser, Jeffrey T. Tseng.

**Writing – review & editing:** Lisa M. Soederberg Miller, Daniel J. Tancredi, Lucia L. Kaiser.

## References

1. Gundersen C, Tarasuk V, Cheng J, de Oliveira C, Kurdyak P. Food insecurity status and mortality among adults in Ontario, Canada. *PLOS ONE*. 2018; 13(8):e0202642. <https://doi.org/10.1371/journal.pone.0202642> PMID: 30138369
2. Walker RJ, Chawla A, Garacci E, Williams JS, Mendez C, Ozieh MN, et al. Assessing the relationship between food insecurity and mortality among U.S. adults. *Ann Epidemiol*. 2019.
3. Berkowitz SA, Basu S, Meigs JB, Seligman HK. Food Insecurity and Health Care Expenditures in the United States, 2011–2013. *Health services research*. 2018; 53(3):1600–20. <https://doi.org/10.1111/1475-6773.12730> PMID: 28608473
4. Gregory C, Coleman-Jensen A. Food Insecurity, Chronic Disease, and Health Among Working-Age Adults. Washington, DC: US Department of Agriculture, Economic Research Service, ERR-235; 2017.

5. Seligman HK, Laraia BA, Kushel MB. Food insecurity is associated with chronic disease among low-income NHANES participants. *J Nutr*. 2010; 140(2):304–10. <https://doi.org/10.3945/jn.109.112573> PMID: 20032485
6. Seligman HK, Schillinger D. Hunger and socioeconomic disparities in chronic disease. *N Engl J Med*. 2010; 363(1):6–9. <https://doi.org/10.1056/NEJMp1000072> PMID: 20592297
7. Choi SK, Fram MS, Frongillo EA. Very Low Food Security in US Households Is Predicted by Complex Patterns of Health, Economics, and Service Participation. *The Journal of Nutrition*. 2017; 147(10):1992–2000. <https://doi.org/10.3945/jn.117.253179> PMID: 28855422
8. Perez-Zepeda MU, Castrejon-Perez RC, Wynne-Bannister E, Garcia-Pena C. Frailty and food insecurity in older adults. *Public Health Nutr*. 2016; 19(15):2844–9. <https://doi.org/10.1017/S1368980016000987> PMID: 27134079
9. Ryan-Ibarra S, Sanchez-Vaznaugh EV, Leung C, Induni M. The relationship between food insecurity and overweight/obesity differs by birthplace and length of US residence. *Public Health Nutr*. 2017; 20(4):671–7. <https://doi.org/10.1017/S1368980016002858> PMID: 27890021
10. Sattler EL, Lee JS, Bhargava V. Food insecurity and medication adherence in low-income older Medicare beneficiaries with type 2 diabetes. *J Nutr Gerontol Geriatr*. 2014; 33(4):401–17. <https://doi.org/10.1080/21551197.2014.959680> PMID: 25424513
11. Lee JS, Frongillo EA, Jr. Nutritional and health consequences are associated with food insecurity among U.S. elderly persons. *J Nutr*. 2001; 131(5):1503–9. <https://doi.org/10.1093/jn/131.5.1503> PMID: 11340107
12. Inzitari M, Doets E, Bartali B, Benetou V, Di Bari M, Visser M, et al. Nutrition in the age-related disablement process. *The journal of nutrition, health & aging*. 2011; 15(8):599–604.
13. Bishop NJ, Wang K. Food insecurity, comorbidity, and mobility limitations among older U.S. adults: Findings from the Health and Retirement Study and Health Care and Nutrition Study. *Prev Med*. 2018; 114:180–7. <https://doi.org/10.1016/j.ypmed.2018.07.001> PMID: 30003897
14. Vilar-Compte M, Gaitán-Rossi P, Pérez-Escamilla R. Food insecurity measurement among older adults: Implications for policy and food security governance. *Global Food Security*. 2017; 14:87–95.
15. Russell JC, Flood VM, Yeatman H, Wang JJ, Mitchell P. Food insecurity and poor diet quality are associated with reduced quality of life in older adults. *Nutrition & Dietetics*. 2016; 73(1):50–8.
16. Brucker DL, Coleman-Jensen A. Food Insecurity Across the Adult Life Span for Persons With Disabilities. *Journal of Disability Policy Studies*. 2017; 28(2):109–18.
17. Coleman-Jensen A, Rabbitt P, Gregory C, Singh A. Household Food Security in the United States in 2016. Washington, DC: US Department of Agriculture, Economic Research Service, ERR-237; 2017.
18. Jung SE, Kim S, Bishop A, Hermann J. Poor Nutritional Status among Low-Income Older Adults: Examining the Interconnection between Self-Care Capacity, Food Insecurity, and Depression. *J Acad Nutr Diet*. 2018.
19. Chang Y, Hickman H. Food Insecurity and Perceived Diet Quality Among Low-Income Older Americans with Functional Limitations. *J Nutr Educ Behav*. 2018; 50(5):476–84. <https://doi.org/10.1016/j.jneb.2017.09.006> PMID: 29107473
20. Ziliak JP, Gunderson C. Food Insecurity Among Older Adults: AARP Foundation; 2011 [Available from: [http://www.aarp.org/content/dam/aarp/aarp\\_foundation/pdf\\_2011/AARPFoundation\\_HungerReport\\_2011.pdf](http://www.aarp.org/content/dam/aarp/aarp_foundation/pdf_2011/AARPFoundation_HungerReport_2011.pdf).
21. Bergmans RS, Palta M, Robert SA, Berger LM, Ehrental DB, Malecki KM. Associations between Food Security Status and Dietary Inflammatory Potential within Lower-Income Adults from the United States National Health and Nutrition Examination Survey, Cycles 2007 to 2014. *J Acad Nutr Diet*. 2018; 118(6):994–1005. <https://doi.org/10.1016/j.jand.2017.12.003> PMID: 29452975
22. Saiz AM, Aul AM, Malecki KM, Bersch AJ, Bergmans RS, LeCaire TJ, et al. Food insecurity and cardiovascular health: Findings from a statewide population health survey in Wisconsin. *Preventive Medicine*. 2016; 93:1–6. <https://doi.org/10.1016/j.ypmed.2016.09.002> PMID: 27612573
23. Venci BJ, Lee S-Y. Functional limitation and chronic diseases are associated with food insecurity among U.S. adults. *Annals of Epidemiology*. 2018; 28(3):182–8. <https://doi.org/10.1016/j.annepidem.2018.01.005> PMID: 29482742
24. Shobe MA, Narcisse M-R, Christy K. Household Financial Capital and Food Security. *Journal of Poverty*. 2018; 22(1):1–22.
25. Coleman-Jensen A, Nord M, Singh A. Household Food Security in the United States in 2012. Washington, DC: US Department of Agriculture, Economic Research Service, ERR-155; 2013.
26. Ory MG, Anderson LA, Friedman DB, Pulczynski JC, Eugene N, Satariano WA. Cancer Prevention Among Adults Aged 45–64 Years: Setting the Stage. *American Journal of Preventive Medicine*. 2014; 46(3, Supplement 1):S1–S6.

27. Lachman ME, Teshale S, Agrigoroaei S. Midlife as a Pivotal Period in the Life Course: Balancing Growth and Decline at the Crossroads of Youth and Old Age. *International journal of behavioral development*. 2015; 39(1):20–31. <https://doi.org/10.1177/0165025414533223> PMID: 25580043
28. Yaffe MJ, Stewart MA. The Problems and Concerns of Middle Age. *Canadian Family Physician*. 1984; 30:1089–93. PMID: 21278990
29. Willson AE, Shuey KM. Life Course Pathways of Economic Hardship and Mobility and Midlife Trajectories of Health. *Journal of health and social behavior*. 2016; 57(3):407–22. <https://doi.org/10.1177/0022146516660345> PMID: 27601413
30. Walker KA, Gottesman RF, Walston J, Palta P, Kucharska-Newton A, Windham BG. Midlife Systemic Inflammation Is Associated With Frailty in Later Life: The ARIC Study. *The Journals of Gerontology: Series A*. 2018; 74(3):343–9.
31. Chassin L, Macy JT, Seo D-C, Presson CC, Sherman SJ. The Association between Membership in the Sandwich Generation and Health Behaviors: A Longitudinal Study. *Journal of applied developmental psychology*. 2010; 31(1):38–46. <https://doi.org/10.1016/j.appdev.2009.06.001> PMID: 20161605
32. Friedman EM, Park SS, Wiemers EE. New Estimates of the Sandwich Generation in the 2013 Panel Study of Income Dynamics. *The Gerontologist*. 2017; 57(2):191–6. <https://doi.org/10.1093/geront/gnv080> PMID: 26672020
33. Sturgeon JA, Arewasikporn A, Okun MA, Davis MC, Ong AD, Zautra AJ. The Psychosocial Context of Financial Stress: Implications for Inflammation and Psychological Health. *Psychosomatic medicine*. 2016; 78(2):134–43. <https://doi.org/10.1097/PSY.0000000000000276> PMID: 26569541
34. Abeyta AA, Routledge C, Kersten M, Cox CR. The existential cost of economic insecurity: Threatened financial security undercuts meaning. *The Journal of Social Psychology*. 2017; 157(6):692–702. <https://doi.org/10.1080/00224545.2016.1270892> PMID: 27960633
35. Tarasuk V, Mitchell A, McLaren L, McIntyre L. Chronic physical and mental health conditions among adults may increase vulnerability to household food insecurity. *J Nutr*. 2013; 143(11):1785–93. <https://doi.org/10.3945/jn.113.178483> PMID: 23986364
36. Bruening M, Dinour LM, Chavez JBR. Food insecurity and emotional health in the USA: a systematic narrative review of longitudinal research. *Public Health Nutr*. 2017; 20(17):3200–8. <https://doi.org/10.1017/S1368980017002221> PMID: 28903785
37. Parletta N, Zarnowiecki D, Cho J, Wilson A, Bogomolova S, Villani A, et al. A Mediterranean-style dietary intervention supplemented with fish oil improves diet quality and mental health in people with depression: A randomized controlled trial (HELFIMED). *Nutritional Neuroscience*. 2019; 22(7):474–87. <https://doi.org/10.1080/1028415X.2017.1411320> PMID: 29215971
38. Pool LR, Burgard SA, Needham BL, Elliott MR, Langa KM, Mendes de Leon CF. Association of a Negative Wealth Shock With All-Cause Mortality in Middle-aged and Older Adults in the United States. *Jama*. 2018; 319(13):1341–50. <https://doi.org/10.1001/jama.2018.2055> PMID: 29614178
39. Bor J, Cohen GH, Galea S. Population health in an era of rising income inequality: USA, 1980–2015. *Lancet*. 2017; 389(10077):1475–90. [https://doi.org/10.1016/S0140-6736\(17\)30571-8](https://doi.org/10.1016/S0140-6736(17)30571-8) PMID: 28402829
40. Dennerstein L, Dudley E, Guthrie J. Empty nest or revolving door? A prospective study of women's quality of life in midlife during the phase of children leaving and re-entering the home. *Psychol Med*. 2002; 32(3):545–50. <https://doi.org/10.1017/s0033291701004810> PMID: 11989999
41. Horner-Johnson W, Dobbertin K, Kulkarni-Rajasekhara S, Beilstein-Wedel E, Andresen EM. Food Insecurity, Hunger, and Obesity Among Informal Caregivers. *Preventing Chronic Disease*. 2015; 12:E170. <https://doi.org/10.5888/pcd12.150129> PMID: 26447547
42. Lopez-Landin H. SNAP Access Barriers Faced by Low Income 50–59 Year Olds: AARP Foundation; 2013 [Available from: [https://www.aarp.org/content/dam/aarp/aarp\\_foundation/2013-pdfs/SNAP\\_White\\_Paper\\_Mar\\_2013.pdf](https://www.aarp.org/content/dam/aarp/aarp_foundation/2013-pdfs/SNAP_White_Paper_Mar_2013.pdf)].
43. Banerjee T, Crews DC, Wesson DE, Dharmarajan S, Saran R, Rios Burrows N, et al. Food Insecurity, CKD, and Subsequent ESRD in US Adults. *American journal of kidney diseases: the official journal of the National Kidney Foundation*. 2017; 70(1):38–47.
44. Brown AGM, Esposito LE, Fisher RA, Nicastro HL, Tabor DC, Walker JR. Food insecurity and obesity: research gaps, opportunities, and challenges. *Translational Behavioral Medicine*. 2019; 9(5):980–7. <https://doi.org/10.1093/tbm/ibz117> PMID: 31570918
45. National Center for Health Statistics. National Health Interview Survey, 2014. Public-use data file and documentation. 2015 [Available from: [http://www.cdc.gov/nchs/nhis/quest\\_data\\_related\\_1997\\_forward.htm](http://www.cdc.gov/nchs/nhis/quest_data_related_1997_forward.htm)].
46. Leung CW, Epel ES, Ritchie LD, Crawford PB, Laraia BA. Food insecurity is inversely associated with diet quality of lower-income adults. *J Acad Nutr Diet*. 2014; 114(12):1943–53.e2. <https://doi.org/10.1016/j.jand.2014.06.353> PMID: 25091796

47. Bickel G, Nord M, Price C, Hamilton W, Cook J. Guide to measuring household food security. Revised 2000. Alexandria, VA: US Department of Agriculture, Food and Nutrition Service, Office of Analysis, Nutrition, and Evaluation; 2000.
48. Wright JS, Wall HK, Ritchey MD. Million hearts 2022: Small steps are needed for cardiovascular disease prevention. *JAMA*. 2018.
49. Jennings JR, Muldoon MF, Ryan C, Gach HM, Heim A, Sheu LK, et al. Prehypertensive Blood Pressures and Regional Cerebral Blood Flow Independently Relate to Cognitive Performance in Midlife. *Journal of the American Heart Association: Cardiovascular and Cerebrovascular Disease*. 2017; 6(3): e004856.
50. Vaughan AS, Ritchey MD, Hannan J, Kramer MR, Casper M. Widespread recent increases in county-level heart disease mortality across age groups. *Annals of epidemiology*. 2017; 27(12):796–800. <https://doi.org/10.1016/j.annepidem.2017.10.012> PMID: 29122432
51. Goodman RA, Posner SF, Huang ES, Parekh AK, Koh HK. Defining and Measuring Chronic Conditions: Imperatives for Research, Policy, Program, and Practice. *Preventing Chronic Disease*. 2013; 10:E66. <https://doi.org/10.5888/pcd10.120239> PMID: 23618546
52. National Center for Health Statistics. Survey Description, National Health Interview Survey, 2014. Hyattsville, Maryland 2015.
53. Chang Y, Chatterjee S, Kim J. Household Finance and Food Insecurity. *Journal of Family and Economic Issues*. 2014; 35(4):499–515.
54. Jih J, Stijacic-Cenzer I, Seligman HK, Boscardin WJ, Nguyen TT, Ritchie CS. Chronic disease burden predicts food insecurity among older adults. *Public Health Nutr*. 2018; 21(9):1737–42. <https://doi.org/10.1017/S1368980017004062> PMID: 29388533
55. Prayogo E, Chater A, Chapman S, Barker M, Rahmawati N, Waterfall T, et al. Who uses foodbanks and why? Exploring the impact of financial strain and adverse life events on food insecurity. *Journal of public health (Oxford, England)*. 2017:1–8.
56. Case A, Deaton A. Rising morbidity and mortality in midlife among white non-Hispanic Americans in the 21st century. *Proc Natl Acad Sci U S A*. 2015; 112(49):15078–83. <https://doi.org/10.1073/pnas.1518393112> PMID: 26575631
57. Woolf SH, Chapman DA, Buchanich JM, Bobby KJ, Zimmerman EB, Blackburn SM. Changes in midlife death rates across racial and ethnic groups in the United States: systematic analysis of vital statistics. *BMJ*. 2018; 362:k3096. <https://doi.org/10.1136/bmj.k3096> PMID: 30111554
58. Gomez-Bernal F, Madva EN, Puckett J, Amonoo HL, Millstein RA, Huffman JC. Relationships Between Life Stressors, Health Behaviors, and Chronic Medical Conditions in Mid-Life Adults: A Narrative Review. *Psychosomatics*. 2019; 60(2):153–63. <https://doi.org/10.1016/j.psych.2018.12.007> PMID: 30691935
59. Nersesian PV, Han H-R, Yenokyan G, Blumenthal RS, Nolan MT, Hladek MD, et al. Loneliness in middle age and biomarkers of systemic inflammation: Findings from Midlife in the United States. *Social Science & Medicine*. 2018; 209:174–81.
60. Hagger-Johnson G, Carr E, Murray E, Stansfeld S, Shelton N, Stafford M, et al. Association between midlife health behaviours and transitions out of employment from midlife to early old age: Whitehall II cohort study. *BMC Public Health*. 2017; 17(1):82. <https://doi.org/10.1186/s12889-016-3970-4> PMID: 28095887
61. Wickrama K, O'Neal CW, Lorenz FO. The decade-long effect of work insecurity on husbands' and wives' midlife health mediated by anxiety: A dyadic analysis. *Journal of Occupational Health Psychology*. 2018; 23(3):350–60. <https://doi.org/10.1037/ocp0000084> PMID: 28358574
62. Miller GE, Chen E, Parker KJ. Psychological stress in childhood and susceptibility to the chronic diseases of aging: Moving toward a model of behavioral and biological mechanisms. *Psychological Bulletin*. 2011; 137(6):959–97. <https://doi.org/10.1037/a0024768> PMID: 21787044
63. Yannakoulia M, Ntanasi E, Anastasiou CA, Scarmeas N. Frailty and nutrition: From epidemiological and clinical evidence to potential mechanisms. *Metabolism*. 2017; 68:64–76. <https://doi.org/10.1016/j.metabol.2016.12.005> PMID: 28183454
64. Shlisky J, Bloom DE, Beaudreault AR, Tucker KL, Keller HH, Freund-Levi Y, et al. Nutritional Considerations for Healthy Aging and Reduction in Age-Related Chronic Disease. *Advances in Nutrition*. 2017; 8(1):17–26. <https://doi.org/10.3945/an.116.013474> PMID: 28096124
65. Dannefer D. Cumulative advantage/disadvantage and the life course: cross-fertilizing age and social science theory. *J Gerontol B Psychol Sci Soc Sci*. 2003; 58(6):S327–37. <https://doi.org/10.1093/geronb/58.6.s327> PMID: 14614120

66. Surachman A, Wardecker B, Chow SM, Almeida D. Life Course Socioeconomic Status, Daily Stressors, and Daily Well-Being: Examining Chain of Risk Models. *J Gerontol B Psychol Sci Soc Sci*. 2019; 74(1):126–35. <https://doi.org/10.1093/geronb/gby014> PMID: 29669043
67. Lorenzo-Lopez L, Maseda A, de Labra C, Regueiro-Folgueira L, Rodriguez-Villamil JL, Millan-Calenti JC. Nutritional determinants of frailty in older adults: A systematic review. *BMC geriatrics*. 2017; 17(1):108. <https://doi.org/10.1186/s12877-017-0496-2> PMID: 28506216
68. Marsman D, Belsky DW, Gregori D, Johnson MA, Low Dog T, Meydani S, et al. Healthy ageing: the natural consequences of good nutrition—a conference report. *Eur J Nutr*. 2018; 57(Suppl 2):15–34. <https://doi.org/10.1007/s00394-018-1723-0> PMID: 29799073
69. Smit E, Winters-Stone KM, Loprinzi PD, Tang AM, Crespo CJ. Lower nutritional status and higher food insufficiency in frail older US adults. *The British journal of nutrition*. 2013; 110(1):172–8. <https://doi.org/10.1017/S000711451200459X> PMID: 23113895
70. Brunner EJ, Shipley MJ, Ahmadi-Abhari S, Valencia Hernandez C, Abell JG, Singh-Manoux A, et al. Midlife contributors to socioeconomic differences in frailty during later life: a prospective cohort study. *The Lancet Public Health*. 2018; 3(7):e313–e22. [https://doi.org/10.1016/S2468-2667\(18\)30079-3](https://doi.org/10.1016/S2468-2667(18)30079-3) PMID: 29908857
71. Pooler JA, Hartline-Grafton H, DeBor M, Sudore RL, Seligman HK. Food Insecurity: A Key Social Determinant of Health for Older Adults. *J Am Geriatr Soc*. 2018.
72. Seals DR, Justice JN, LaRocca TJ. Physiological geroscience: targeting function to increase health-span and achieve optimal longevity. *The Journal of physiology*. 2016; 594(8):2001–24. <https://doi.org/10.1113/jphysiol.2014.282665> PMID: 25639909
73. Aspinall F, Glasby J, Rostgaard T, Tuntland H, Westendorp RGJ. New horizons: Reablement—supporting older people towards independence. *Age and Ageing*. 2016; 45(5):574–8.