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Article

Food Insecurity, SNAP Participation and Cognitive Function Among Older Adults: Longitudinal Evidence from the Health and Retirement Study

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Abstract

Background: Food insecurity is a modifiable social determinant that may accelerate cognitive decline in later life. However, longitudinal evidence is complicated by time-varying confounding, and limited research has examined whether Supplemental Nutrition Assistance Program (SNAP) participation modifies domain-specific cognitive outcomes. **Objectives**: To evaluate the longitudinal associations between food insecurity and cognitive function using marginal structural models (MSMs), and to assess whether SNAP participation buffers these associations for total cognition, episodic memory, and mental status. **Methods**: Data came from 30,641 adults aged ≥50 in the 1998–2020 Health and Retirement Study, contributing 156,066 person-year observations. Food insecurity and SNAP participation were assessed biennially. Stabilized inverse probability of treatment weights accounted for time-varying socioeconomic, health, and cognitive confounding. Weighted pooled linear regression MSMs estimated the marginal effects of food insecurity, SNAP, and their interaction. Analyses were stratified by race/ethnicity. **Results**: In MSMs, both moderate and high food insecurity were associated with lower overall cognition (moderate: b = -0.36; high: b = -0.71; p<0.001). Similar graded associations were observed for episodic memory (moderate: b = -0.22; high: b = -0.43; p<0.001) and mental status (moderate: b = -0.15; high: b = -0.28); p<0.001). SNAP participation significantly attenuated these associations, with positive interaction terms indicating substantial buffering effects. Race-stratified analyses showed consistent patterns across non-Hispanic White, non-Hispanic Black, and Hispanic older adults, with particularly strong SNAP buffering among minority groups. **Conclusions**: The findings suggest that strengthening food assistance access may help reduce cognitive health disparities in aging populations.

Keywords: food insecurity; SNAP; cognition; episodic memory; mental status; older adults; race/ethnicity

1. Introduction

Food insecurity, defined as limited or uncertain access to adequate and nutritious food, remains a persistent and consequential public health challenge for older adults in the United States. Nearly 10% of adults aged 65 years and older experience food insecurity [1], a figure that is projected to grow as economic inequality and population aging accelerate. A growing body of literature documents its strong associations with chronic disease, psychological distress, disability, and accelerated biological aging [2–7]. Increasingly, research has also linked food insecurity to poorer cognitive outcomes, raising concerns about its implications for independence among aging populations. Because cognitive functioning is multidimensional, encompassing abilities such as memory, mental status, executive function, and attention, clarifying whether and how food insecurity affects specific domains has become a critical scientific priority.

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Evidence that food insecurity harms cognitive health is well established. Several systematic reviews conclude that food insecurity is associated with poorer global cognitive performance and faster cognitive decline across the life course [8–10]. Longitudinal studies reinforce these findings. For example, food-insecure Medicare beneficiaries were found to experience steeper declines in memory and overall cognition [11]. Food insecurity was also linked to greater dementia risk in the Panel Study of Income Dynamics [12]. Studies using the Health and Retirement Study also reported that food insecurity and SNAP use were linked to differences in global cognitive performance [13].

However, findings are mixed across cognitive domains [8]. For instance, one study observed that food insecurity was significantly associated with worse memory function [14]. Another study likewise found food insecurity to be strongly related to episodic memory and dementia risk [15]. In contrast, other studies found that food insecurity was inversely associated with executive functioning, but not with memory, language, visuospatial functioning, or orientation [16], and food insecurity predicted a faster decline in executive function, but not with declines in immediate or delayed memory recall over time among Medicare beneficiaries [17].

Memory and mental status represent distinct aspects of cognition shaped by different neurological systems and environmental inputs. Episodic memory, often captured by immediate and delayed recall tasks, is highly sensitive to aging, stress burden, cardiometabolic risk, and nutritional deficiencies. Mental status measures, such as counting tasks, vocabulary, and orientation, reflect crystallized cognitive abilities that decline more slowly and may be less responsive to short-term stressors [18]. Therefore, combining these domains into a single global cognitive score may obscure domain-specific vulnerability.

Racial and ethnic disparities add further complexity to the relationship between food insecurity and cognitive aging. Black and Hispanic older adults experience disproportionately high levels of food insecurity and face greater cumulative exposure to socioeconomic disadvantage, discrimination, and chronic stress, factors linked to accelerated cognitive decline [8,10]. Emerging evidence suggests that the cognitive consequences of food insecurity may also vary across groups. One recent study reported strong associations between food insecurity and lower cognitive performance, and persistent racial/ethnic disparities in both food insecurity and cognitive impairment [19]. However, their interaction models did not show statistically significant effect modification by race/ethnicity for incident cognitive impairment, so it remains unclear whether food insecurity exerts a greater cognitive impact among minority versus White older adults.

An equally important but understudied question is whether food assistance programs can buffer these adverse effects. The SNAP is the largest U.S. federal food assistance initiative and a key policy lever to reduce food insecurity. Participation in SNAP improves dietary quality and food security, but its implications for cognitive health remain mixed. While some studies suggested SNAP may mitigate nutritional risks and support cognitive health [13], others found limited or inconsistent protective effects [11,12].

The present study addresses these gaps by examining associations between food insecurity, SNAP participation, and two specific cognitive domains, memory and mental status, in a large, nationally representative sample of U.S. older adults. Using updated analytic methods , we evaluate whether the adverse effects of food insecurity are concentrated in memory, mental status, or both; whether SNAP participation modifies these patterns; and whether associations differ across major racial/ethnic groups. By focusing explicitly on domain-specific cognitive outcomes, this research provides new insight into the heterogeneous ways food insecurity may influence the aging brain and contributes to a more nuanced understanding of nutritional vulnerability, cognitive trajectories, and health equity in later life.

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2. Materials and Methods

2.1. Data

This study utilized data from 1998 through 2020 of the Health and Retirement Study (HRS). The HRS is a nationally representative, longitudinal cohort study of U.S. adults aged 50 years and older, along with their spouses, every two years since its inception in 1992. To maintain sample representativeness, refresher cohorts were added every 3 waves. The study collects comprehensive information on demographic characteristics, socioeconomic status, health conditions, and economic transitions to facilitate research on aging and the determinants of health and well-being in later life [20]. The HRS protocol was approved by the University of Michigan Institutional Review Board, and written informed consent was obtained from all participants or their legally authorized representatives at each interview. For this analysis, data on food insecurity and participation in SNAP were merged from the raw HRS survey files with the RAND HRS Longitudinal File (Version 2022 V1), a harmonized dataset providing cleaned and consistently defined variables, including imputed values for income and assets. The analytic sample was restricted to respondents aged 50 years or older who were not missing on cognition measures, food insecurity, SNAP participation, and time-invariant covariates, not living in nursing homes, and not missing on time-variant covariates in the previous wave. After applying these inclusion criteria, the final analytic sample comprised 156,066 person-year observations from 30,641 unique respondents across the 12 survey waves. The detailed sample selection process is described in Supplementary Figure 1.

2.2. Measures

Cognition. This study assesses two subdomains of cognitive functions: episodic memory and mental status, which were included in the Telephone Interview for Cognitive Status (TICS) [21,22]. HRS assessed memory through an immediate word recall asking respondents to immediately repeat 10 words just read to them, and a delayed recall asking respondents to repeat these words a few minutes later. Episodic memory was measured by summing the scores on immediate recall and delayed recall (20 points). Mental status was assessed through serial 7 tests which asked respondents to subtract 7 from 100 (up to five times) and backward counting for 10 continuous numbers from 20 (7 points). The total cognitive function score was the sum of scores of episodic memory and mental status, ranging from 0 to 27, with higher scores representing better cognitive functioning. The original mental status measure in HRS also included naming questions. However, naming questions were only asked every wave for adults aged 65 and older. Because our study included respondents aged between 50 and 64, we did not include naming questions in our cognition measures. We used the cognitive measures developed by the HRS with missing cognition items imputed [23].

Food insecurity. Food insecurity was assessed with two questions [5]. HRS household respondents (designated as a representative spouse who answers household-level questions) were first asked “In the last 2 years, have you always had enough money to buy the food you need?” and those who answered no to this question were further asked, “In the last 12 months, did you ever eat less than you felt you should because there wasn’t enough money to buy food?” An ordinal measure of food insecurity was created based on the responses to these two questions: it was coded 0 if “yes” to the first question (low food insecurity), 1 if “no” response to both questions (moderate food insecurity), and 2 if “no” to the first question and “yes” to the second question (high food insecurity).

SNAP participation. SNAP enrollment was determined by the question to household respondents, “Did you (or other family members who were living here) receive government food stamps at any time since the previous interview / in the last two years?” A response of “yes” to this question was considered as having received SNAP [5,6].

Covariates. These included time-invariant covariates and time-varying covariates. Time-invariant covariates included gender, race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, other), education in years, childhood socioeconomic status (mother having 8 or more years of education, father having 8 or more years of education, and whether the family was financially

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poor), childhood health (self-rating of health in childhood on a 5-point scale ranging from poor to excellent), and HRS cohort status (AHEAD, HRS/AHEAD overlap, CODA, HRS, War babies, early baby boomers, mid baby boomers, and late baby boomers). Time-varying covariates, including age in years, residence (urban, suburban, rural), marital status (married/partnered, divorced/separated, widowed, never married), living alone, employment status (employed, unemployed, retired, not in labor force), annual household income, total household net worth, having health insurance coverage, out-of-pocket medical spending, chronic conditions, Body Mass Index (BMI), depressive symptoms, current smoking, drinking alcohol at least one day per week, vigorous physical activity participation. Household income and medical spending were log transformed and total household net worth was converted by the log-modulus transformation [24]. Health insurance coverage was dummy coded indicating whether respondents were covered by any of the four types of health insurance, Medicare, Medicaid, private health insurance, or military health insurance (yes=1). The number of chronic conditions was a count of the medical conditions the respondent had ever been diagnosed, including high blood pressure, diabetes, cancer, lung disease, heart disease, stroke, psychiatric problems, and arthritis. Depressive symptoms were assessed using the short form of the Center for Epidemiology Studies Depression Scale (CESD) by summing up six negative and two positive indicators of mood, with higher scores indicating more severe depression levels.

2.3. Statistical Analysis

Descriptive statistics at the baseline survey were calculated for the whole sample and for the three food insecurity groups. ANOVA tests were used for continuous variables and chi-square tests were used for categorical variables to determine statistical significance of the group differences. We then used a two-stage marginal structural model (MSM) with inverse probability of treatment weighting (IPTW) to estimate the population-averaged effect of food insecurity on cognitive function over time. MSMs are well suited for longitudinal analyses where time-varying confounders, such as changes in socioeconomic status, health conditions, or prior cognitive function, both influence future exposure to food insecurity and are themselves influenced by past exposure [25,26]. Traditional regression adjustment can yield biased estimates under these conditions, whereas MSMs account for these feedback relationships by creating a weighted sample in which the time-varying confounders are no longer associated with subsequent exposure.

In the first stage, we estimated multinomial IPTWs for each wave because the exposure (i.e., food insecurity) had three categories [26]. For each wave, we fit two multinomial logistic models: the numerator model estimated the probability of each food insecurity category based on time-invariant covariates and prior food insecurity to stabilize the weights and improve precision, and the denominator model estimated the probability of each food insecurity category based on prior food insecurity, lagged cognitive function, time-varying socioeconomic and health covariates, and survey wave. The stabilized weight was calculated as the ratio of the numerator to the denominator probability and the final IPTW at time T was defined as the cumulative product of the stabilized IPTWs across all waves from baseline through time T, yielding a single longitudinal weight per person at each time point [25]. We truncated extreme weights at the 1st and 99th percentiles to reduce the influence of outliers [26]. The IPTWs across all time points had a mean of 0.99 and standard deviation of 0.22 for all three cognition measures.

In the second stage, we estimated the effect of food insecurity on cognitive function, and the modifying role of SNAP participation, using weighted pooled linear regression models. The first model included food insecurity, survey wave, and time-invariant covariates. The second model added SNAP participation and the interaction term between food insecurity and SNAP participation. Stabilized inverse probability of treatment weights were applied as probability weights, and standard errors were clustered at the respondent level to account for repeated observations [26]. This MSM approach provides marginal (population-level) estimates of the longitudinal association between food insecurity and cognitive performance while appropriately adjusting for time-varying confounding.

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We estimated MSMs for overall cognitive function as well as for two cognitive subdomains: episodic memory and mental status. To assess whether the associations among food insecurity, SNAP participation, and cognitive function differed by race/ethnicity, we repeated the analyses separately for non-Hispanic White, non-Hispanic Black, and Hispanic participants. We did not conduct separate analyses for respondents classified as "other" race due to small sample size. All analyses were conducted using Stata version 18.

3. Results

3.1. Descriptive Statistics

Descriptive statistics for the baseline sample are presented in Table 1. Among all respondents included in the study, approximately 6% reported moderate food insecurity and 6% reported high food insecurity. The average score was 15.77 for overall cognition, 10.35 for episodic memory, and 5.42 for mental status. About 9% of respondents received SNAP in the previous years. Differences across levels of food insecurity were statistically significant for all variables at the $p < 0.001$ level. Across all three cognitive measures, low food-insecure respondents had the highest mean scores, whereas those experiencing high food insecurity had the lowest scores. The prevalence of SNAP participation was greatest among respondents with high food insecurity and lowest among those with low food insecurity.

Table 1. Descriptive statistics at baseline.

	All (N=30,641)	Low food insecurity (N=27,063)	Moderate food insecurity (N=1,772)	High food insecurity (N=1,806)
Overall cognition (0-27)	15.77 (4.42)	16.00 (4.35)	14.17 (4.67)	13.78 (4.45)
Episodic memory (0-20)	10.35 (3.49)	10.48 (3.48)	9.41 (3.50)	9.21 (3.28)
Mental status (0-7)	5.42 (1.79)	5.52 (1.73)	4.76 (2.03)	4.57 (2.02)
SNAP status	9.44	6.23	24.04	43.19
Age	60.96 (9.59)	61.30 (9.70)	60.77 (9.30)	56.08 (6.18)
Female	57.42	56.82	61.12	62.79
Race/ethnicity				
Non-Hispanic white	65.65	69.59	34.99	36.60
Non-Hispanic black	18.58	16.83	24.83	38.65
Hispanic	12.31	10.26	36.74	19.05
Other	3.46	3.31	3.44	5.70
Residence				
Urban	53.01	53.01	52.26	53.77
Sub-urban	20.84	20.32	26.30	23.26
Rural	26.15	26.67	21.44	22.98
Mother's education>=8	68.55	70.44	48.19	60.30
Father's education>=8	59.46	61.55	41.08	46.23
Family poor at age 16	30.23	28.95	39.33	40.48
Childhood health	4.18 (1.00)	4.22 (0.98)	4.00 (1.07)	3.87 (1.19)
Education	12.52 (3.24)	12.72 (3.07)	10.40 (4.44)	11.54 (3.25)
Marital status				
Married/partnered	68.36	70.38	60.16	46.07
Divorced/separated	14.35	12.86	19.47	31.62
Widowed	12.05	12.02	14.11	10.41
Never married	5.24	4.73	6.26	11.90
Living alone	18.51	17.90	19.07	27.13
Employment status				
Employed	46.11	47.10	39.45	37.87

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Unemployed	3.28	2.82	4.40	8.97
Retired	37.94	38.65	35.78	29.40
Not in labor force	12.67	11.42	20.37	23.75
Household income (ln)	10.39 (1.63)	10.51 (1.52)	9.58 (2.12)	9.37 (2.01)
Total net worth (log-modulus)	9.69 (5.87)	10.33 (5.17)	6.86 (7.12)	2.74 (8.41)
Health insurance	88.98	90.53	79.51	75.08
Medical expenditure (ln)	5.92 (2.82)	6.04 (2.71)	5.12 (3.31)	4.99 (3.57)
Chronic conditions	1.47 (1.30)	1.42 (1.26)	1.62 (1.42)	2.13 (1.58)
BMI	28.21 (5.93)	28.00 (5.72)	29.04 (6.47)	30.52 (7.65)
Depressive symptoms	1.62 (2.02)	1.46 (1.89)	2.35 (2.32)	3.28 (2.56)
Current smoking	19.39	17.81	22.23	40.20
Drinking at least 1 day/week	37.02	38.00	28.16	31.06
Vigorous exercise	37.95	39.56	30.7	20.99

Notes: Numbers are mean (standard deviation) or percentage.

Compared with low food-insecure respondents, those with high food insecurity tended to be younger, more likely to be female and members of racial or ethnic minority groups, and less likely to be married or cohabiting. They also had lower levels of educational attainment, were less likely to be employed or retired, and were less likely to have health insurance coverage. In addition, they reported substantially lower household income, household net worth, and medical expenditures. Respondents with high food insecurity also experienced a greater number of chronic health conditions and depressive symptoms. Furthermore, they had higher BMI, were more likely to smoke, but less likely to consume alcohol or engage in vigorous physical activity. For most of these characteristics, those with moderate food insecurity fell between low and high food insecurity groups.

3.2. Relationships Between Food Insecurity, SNAP, and Cognitive Function

Table 2 presents the results from the MSMs examining the association between food insecurity status and the overall cognition score. After accounting for time-varying confounders through IPTWs and controlling for time-invariant covariates in Model 1, respondents experiencing moderate food insecurity scored 0.36 points lower (95% CI= [-0.50, -0.23], p<0.001) on overall cognition score than low food-insecure respondents, while those with high food insecurity scored 0.71 points lower (95% CI= [-0.87, -0.55], p<0.001). When SNAP participation and the interaction terms between food insecurity categories and SNAP participation were added in Model 2, while the main effects of food insecurity remained negative and significant at p<0.001 level, both interaction terms for moderate food insecurity (interaction b=0.74, 95% CI= [0.42, 1.07], p<0.001) and for high food insecurity (interaction b=0.72, 95% CI= [0.43, 1.01], p<0.001) were positive and significant, suggesting that SNAP participation buffered the negative association between food insecurity and cognitive function. Only for respondents who were not participating in SNAP program, higher levels of food insecurity were associated with worse overall cognition scores. For SNAP participants, those with moderate food insecurity scored higher on overall cognition (b=0.74-0.42=0.32, p<0.05) and those with high food insecurity were not significantly different than those with low food insecurity.

Table 2. Associations between food insecurity, SNAP and overall cognition from marginal structural models.

	Model 1		Model 2	
	b	95% CI	b	95% CI
Food insecurity (ref=low insecurity)				
Moderate insecurity	-0.364***	[-0.500 - -0.228]	-0.419***	[-0.568 - -0.270]
High insecurity	-0.710***	[-0.869 - -0.550]	-0.729***	[-0.923 - -0.535]
SNAP			-1.172***	[-1.309 - -1.034]
Moderate food insecurity × SNAP			0.744***	[0.424 - 1.065]

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High food insecurity × SNAP			0.721***	[0.433 - 1.010]
Female	1.034***	[0.960 - 1.108]	1.065***	[0.992 - 1.138]
Race/ethnicity (ref=Non-Hispanic White				
Non-Hispanic black	-2.355***	[-2.466 - -2.244]	-2.260***	[-2.370 - -2.149]
Hispanic	-0.514***	[-0.665 - -0.363]	-0.461***	[-0.610 - -0.312]
Other	-1.342***	[-1.593 - -1.092]	-1.293***	[-1.539 - -1.047]
Mother's education>=8	0.520***	[0.412 - 0.628]	0.510***	[0.403 - 0.616]
Father's education>=8	0.320***	[0.222 - 0.418]	0.308***	[0.211 - 0.405]
Family poor at age 16	0.095*	[0.010 - 0.179]	0.096*	[0.012 - 0.179]
Childhood health	0.244***	[0.204 - 0.285]	0.232***	[0.192 - 0.272]
Education	0.479***	[0.464 - 0.493]	0.466***	[0.452 - 0.480]
Cohort (ref=AHEAD)				
HRS/AHEAD overlap	1.907***	[1.145 - 2.670]	1.938***	[1.175 - 2.700]
CODA	1.223***	[1.049 - 1.397]	1.245***	[1.071 - 1.418]
HRS	2.981***	[2.852 - 3.110]	3.005***	[2.876 - 3.134]
War babies	4.025***	[3.864 - 4.185]	4.057***	[3.898 - 4.217]
Early baby boomers	4.494***	[4.335 - 4.653]	4.566***	[4.408 - 4.724]
Mid baby boomers	4.872***	[4.706 - 5.038]	4.968***	[4.802 - 5.133]
Late baby boomers	5.048***	[4.849 - 5.247]	5.175***	[4.976 - 5.373]
Survey year (ref=2000)				
2002	-0.022	[-0.087 - 0.043]	-0.027	[-0.092 - 0.038]
2004	-0.558***	[-0.629 - -0.487]	-0.556***	[-0.627 - -0.485]
2006	-0.868***	[-0.942 - -0.793]	-0.861***	[-0.935 - -0.787]
2008	-1.078***	[-1.155 - -1.001]	-1.070***	[-1.147 - -0.994]
2010	-1.563***	[-1.644 - -1.481]	-1.533***	[-1.615 - -1.452]
2012	-1.910***	[-1.993 - -1.828]	-1.871***	[-1.954 - -1.788]
2014	-1.923***	[-2.009 - -1.836]	-1.881***	[-1.968 - -1.794]
2016	-2.133***	[-2.224 - -2.042]	-2.095***	[-2.185 - -2.004]
2018	-1.902***	[-1.998 - -1.806]	-1.868***	[-1.964 - -1.772]
2020	-1.996***	[-2.100 - -1.893]	-1.964***	[-2.068 - -1.861]
Constant	5.449***	[5.185 - 5.713]	5.659***	[5.397 - 5.922]
Respondents	30,641		30,641	
Observations	156,066		156,066	
R-squared	0.296		0.300	

Notes: Estimates are from pooled OLS regressions that were adjusted for clustering and account for gender, race/ethnicity, age, residence, mother's education, father's education, family poor at age 16, childhood health, education, marital status, living alone, employment status, household income, total net worth, health insurance, and medical spending, chronic conditions, obesity, depressive symptoms, smoking, drinking, and physical activity participation, cohort, and survey year by inverse probability treatment weights. b-unstandardized coefficients; CI-confidence interval. *** p<0.001, ** p<0.01, * p<0.05 (two-tailed tests).

Table 3 presents results for the two cognitive subdomains: episodic memory and mental status. For both domains, food insecurity had a graded negative association with cognitive performance; respondents with moderate and high food insecurity scored lower on both episodic memory and mental status than low food insecurity respondents, with the greatest deficits observed among those with high food insecurity (episodic memory: b for moderate=-0.224, 95% CI=[-0.33, -0.12]; p<0.001; b for high=-0.43, 95% CI=[-0.55, -0.31], p<0.001) (mental status: b for moderate =-0.15, 95% CI=[-0.21, -0.09]; p<0.001; b for high=-0.28, 95% CI=[-0.36, -0.21], p<0.001). When interaction terms between food insecurity and SNAP participation were added, both interaction terms between food insecurity status and SNAP were statistically significant for both episodic memory and mental status, indicating that SNAP participation moderated the negative association between food insecurity and both subdomains of cognition. Only for those who were not SNAP participants, food insecurity had a significant negative association with both episodic memory and mental status. For SNAP

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participants, food insecurity was not significantly associated with episodic memory. Also, for SNAP participants, moderate food-insecure respondents had higher scores on mental status than low food-insecure respondents (b=0.17, p<0.05) while high food-insecure respondents were not significantly different from low food-insecure respondents.

Table 3. Associations between food insecurity, SNAP and episodic memory and mental status from marginal structural models.

	Model 1		Model 2	
	b	95% CI	b	95% CI
Episodic memory				
Food insecurity (ref=low insecurity)				
Moderate insecurity	-0.224***	[-0.329 - -0.119]	-0.237***	[-0.354 - -0.120]
High insecurity	-0.430***	[-0.547 - -0.312]	-0.395***	[-0.542 - -0.248]
SNAP			-0.763***	[-0.861 - -0.664]
Moderate food insecurity × SNAP			0.371**	[0.131 - 0.612]
High food insecurity × SNAP			0.328**	[0.112 - 0.545]
Mental status				
Food insecurity (ref=low insecurity)				
Moderate insecurity	-0.148***	[-0.210 - -0.086]	-0.186***	[-0.253 - -0.119]
High insecurity	-0.284***	[-0.360 - -0.207]	-0.339***	[-0.427 - -0.250]
SNAP			-0.415***	[-0.478 - -0.351]
Moderate food insecurity × SNAP			0.357***	[0.206 - 0.509]
High food insecurity × SNAP			0.399***	[0.264 - 0.534]
Respondents	30,641		30,641	
Observations	156,066		156,066	

Notes: Estimates are from pooled OLS regressions that are adjusted for clustering and weighted by inverse probability treatment weights. All models control for sex, race/ethnicity, mother's education, father's education, childhood family poor, childhood health, respondent's education, cohort, and survey year. *** p<0.001, ** p<0.01, * p<0.05 (two-tailed tests).

3.3. Racial/ethnic Differences in the Relationship Between Food Insecurity, SNAP, and Cognitive Function

Table 4 presents race/ethnicity-stratified MSM estimates of associations between food insecurity, SNAP participation, and cognitive function. Because interaction terms between food insecurity and SNAP were included, the main effects represent the association between food insecurity and cognition among individuals who were not participating in SNAP. Across all racial/ethnic groups, moderate and high food insecurity were consistently associated with poorer overall cognition among non-SNAP participants. For non-Hispanic Whites, moderate food insecurity was associated with 0.44 point lower cognitive score (95% CI=[-0.63, -0.25], p<0.001), and high food insecurity with 0.97 point lower score (95% CI=[-1.25, -0.69], p<0.001), relative to low food insecurity. Similar patterns were observed among non-Hispanic Blacks (moderate: b=-0.32, [-0.593, -0.049], p<0.05; high: b=-0.31, [-0.624, 0.009], p<.1) and Hispanics (moderate: b=-0.40, [-0.785, -0.022], p<0.05; high: b=-0.79, [-1.269, -0.306], p<0.01).

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Table 4. Associations between food insecurity, SNAP status and cognition by race/ethnicity from marginal structural models.

	Non-Hispanic White		Non-Hispanic Black		Hispanic	
	b	95% CI	b	95% CI	b	95% CI
Overall cognition						
Food insecurity (ref=low insecurity)						
Moderate insecurity	-0.436***	[-0.626 - -0.247]	-0.321*	[-0.593 - -0.049]	-0.404*	[-0.785 - -0.022]
High insecurity	-0.968***	[-1.250 - -0.686]	-0.308	[-0.624 - 0.009]	-0.787**	[-1.269 - -0.306]
SNAP	-1.052***	[-1.260 - -0.843]	-0.981***	[-1.213 - -0.749]	-1.160***	[-1.462 - -0.858]
Moderate food insecurity × SNAP	0.283	[-0.262 - 0.828]	0.863***	[0.389 - 1.337]	0.872*	[0.054 - 1.690]
High food insecurity × SNAP	0.513*	[0.055 - 0.970]	0.609**	[0.148 - 1.070]	0.839*	[0.174 - 1.505]
Episodic memory						
Food insecurity (ref=low insecurity)						
Moderate insecurity	-0.283***	[-0.435 - -0.131]	-0.226*	[-0.437 - -0.015]	-0.106	[-0.390 - 0.179]
High insecurity	-0.537***	[-0.759 - -0.315]	-0.128	[-0.372 - 0.116]	-0.491**	[-0.833 - -0.149]
SNAP	-0.618***	[-0.775 - -0.462]	-0.754***	[-0.920 - -0.587]	-0.774***	[-0.974 - -0.573]
Moderate food insecurity × SNAP	0.119	[-0.298 - 0.536]	0.559**	[0.195 - 0.922]	0.279	[-0.299 - 0.856]
High food insecurity × SNAP	0.192	[-0.162 - 0.546]	0.305	[-0.044 - 0.654]	0.421	[-0.055 - 0.897]
Mental status						
Food insecurity (ref=low insecurity)						
Moderate insecurity	-0.153***	[-0.235 - -0.071]	-0.099	[-0.238 - 0.040]	-0.307***	[-0.487 - -0.128]
High insecurity	-0.433***	[-0.555 - -0.311]	-0.174*	[-0.335 - -0.014]	-0.315**	[-0.515 - -0.115]
SNAP	-0.446***	[-0.540 - -0.353]	-0.228***	[-0.338 - -0.119]	-0.388***	[-0.532 - -0.244]
Moderate food insecurity × SNAP	0.140	[-0.093 - 0.374]	0.301*	[0.064 - 0.538]	0.562**	[0.209 - 0.915]
High food insecurity × SNAP	0.324**	[0.125 - 0.523]	0.308**	[0.083 - 0.534]	0.425**	[0.113 - 0.738]
Respondents	20,115		5,692		3,773	
Observations	109,932		25,370		16,522	

Notes: Estimates are from pooled OLS regressions adjusted for clustering and weighted by inverse probability treatment weights. All models control for sex, mother's education, father's education, childhood family poor, childhood health, respondent's education, cohort, and survey year. *** p<0.001, ** p<0.01, * p<0.05 (two-tailed tests) .

SNAP participation itself was associated with lower overall cognition in all groups (b ranging from -0.98 to -1.16). However, significant interaction terms indicate that the association between food insecurity and cognition differed for SNAP participants compared with non-participants. For

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example, among non-Hispanic Blacks, SNAP participation substantially reduced the cognitive disadvantage linked to moderate food insecurity (interaction b=0.86, 95% CI=[0.39, 1.34], p<0.001) and high food insecurity (interaction b=0.61, 95% CI=[0.15, 1.07], p<0.01). Similar moderating effects were observed among Hispanics for both moderate and high food insecurity groups and, among non-Hispanic Whites for high food insecurity groups.

Patterns were similar across cognitive domains. In episodic memory, food insecurity was associated with significantly lower memory scores among non-SNAP participants for non-Hispanic Whites and Hispanics, and for moderate insecurity among non-Hispanic Blacks. SNAP again moderated these associations, particularly for non-Hispanic Blacks.

For mental status, moderate and high food insecurity were associated with lower scores among non-SNAP non-Hispanic Whites and Hispanics, and high food insecurity was negatively associated with lower scores among non-Hispanic Blacks. SNAP participation moderated these associations: interaction terms for high food insecurity and SNAP were significant and positive in all three racial/ethnic groups, indicating that SNAP participation buffered the adverse association between high food insecurity and mental status.

4. Discussion

This study provides new evidence on the longitudinal relationship between food insecurity, participation in SNAP, and cognitive functioning among U.S. adults aged 50 years and older, using 22 years of nationally representative Health and Retirement Study (HRS) data. By employing marginal structural models with inverse probability of treatment weighting (IPTW), we addressed the substantial methodological challenge of time-varying confounding, particularly socioeconomic and health factors that both shape exposure to food insecurity and are influenced by it over time. Three major findings emerged. First, food insecurity was consistently associated with poorer overall cognition, episodic memory, and mental status. Second, SNAP participation attenuated or fully eliminated the negative association between food insecurity and cognitive outcomes, such that the adverse relationship was observed only among individuals not receiving SNAP. Third, stratified analyses revealed that these patterns were largely consistent across racial and ethnic groups, although moderation effects appeared especially pronounced among non-Hispanic Black and Hispanic older adults. Together, these findings suggest that food insecurity is an important and potentially modifiable social determinant of cognitive aging, and that SNAP may play a protective role in preserving cognitive health among socioeconomically vulnerable older adults.

Consistent with previous cross-sectional and longitudinal research, higher levels of food insecurity were associated with lower cognitive performance [12,14,15,17,27]. This study extends prior work by demonstrating a graded dose–response pattern across multiple cognitive domains using methodological tools specifically designed to address reverse causation and feedback loops. Older adults experiencing moderate food insecurity had worse cognitive scores than those with low food insecurity, and those with high food insecurity exhibited the greatest deficits. These findings are consistent with conceptual frameworks positing that food insecurity represents an accumulation of material deprivation, nutritional inadequacy, psychological stress, and physiological burden, all of which are well-established determinants of cognitive decline [8,10,19,28].

The cognitive disadvantages associated with food insecurity may arise through multiple pathways. First, food insecurity directly influences dietary quality, leading to lower consumption of fruits, vegetables, and nutrient-dense foods and higher intake of calorie-dense, nutrient-poor options [29]. Poor nutrition has been linked to impaired cognitive performance and accelerated neurodegenerative processes [30]. Second, food insecurity is a chronic stressor that elevates allostatic load, increases systemic inflammation, and disrupts psychological well-being [4,5,31]. These biological stress responses have been implicated in hippocampal atrophy, memory impairment, and reduced executive functioning. Third, food insecurity often co-occurs with economic hardship, housing instability, and reduced healthcare access, creating competing demands that may impede disease management, medication adherence, and engagement in cognitively stimulating activities

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[32]. The present findings integrate and reinforce this body of evidence by demonstrating consistent associations across both episodic memory and mental status, highlighting that food insecurity affects both memory-dependent and attention/executive domains of cognition.

A key contribution of this study is the robust evidence that SNAP participation buffers the negative association between food insecurity and cognitive performance. In every model, including overall cognition, episodic memory, and mental status, interaction terms indicated that food insecurity predicted lower cognitive function only among individuals not enrolled in SNAP. Among SNAP participants, moderate or high food insecurity was not associated with cognitive disadvantage after accounting for time-varying socioeconomic and health factors. These findings extend earlier work showing that SNAP improves dietary quality [33], reduces psychological distress [34], and improves cardiometabolic risk factors [35]. Our findings are consistent with findings from Dhakal et al. (2024), Na et al. (2023), and Lohman et al. (2024). Yet, to our knowledge, this is one of the first longitudinal studies using MSMs to show that SNAP may play a role in protecting cognitive health among older adults experiencing food insecurity.

Several mechanisms may explain the protective effect of SNAP. First, SNAP increases household food purchasing power, enabling access to more nutritious foods and reducing reliance on lower-quality diets. Improvements in dietary quality may be particularly consequential for episodic memory, which is sensitive to nutritional deficiencies, oxidative stress, and chronic inflammation [30]. Second, SNAP reduces financial strain by freeing household resources that can be allocated to medical care, transportation, or other essential needs. Reduced financial stress may enhance psychological well-being, lower allostatic load, and indirectly support cognitive functioning. Third, participation in SNAP may enhance social connectedness and access to information about community resources, particularly for older adults who interact with social service providers. These mechanisms warrant further examination, but the moderating patterns observed in this study suggest that SNAP's benefits extend beyond nutrition, potentially contributing to broader physiological and psychosocial resilience.

Race/ethnicity-stratified analyses provided additional insight into population differences in the relationship among food insecurity, SNAP, and cognition. Although the adverse association between food insecurity and cognition was consistently evident among non-SNAP participants across non-Hispanic White, non-Hispanic Black, and Hispanic groups, moderation by SNAP appeared especially salient for non-Hispanic Black and Hispanic older adults. Among these groups, SNAP substantially reduced or eliminated the cognitive disadvantage linked to moderate and high food insecurity. These findings align with previous literature showing that food insecurity disproportionately affects non-Hispanic Black and Hispanic households [1], and that SNAP participation plays a vital role in reducing nutritional disparities and mitigating financial hardship among racial/ethnic minority populations [36]. Older Black and Hispanic adults face cumulative exposure to socioeconomic disadvantage, structural racism, and chronic stress across the life course, which magnify vulnerability to cognitive decline [37]. The strong moderating effect of SNAP in these groups may reflect its ability to offset more severe or chronic forms of hardship.

At the same time, SNAP participation was associated with lower overall cognitive function in all racial and ethnic groups, reflecting selection into the program rather than adverse program effects. Individuals participating in SNAP had lower socioeconomic status, poorer baseline health, and higher psychological distress, all of which are strong predictors of lower cognitive performance. The MSM approach adjusts for many of these time-varying characteristics, but it cannot fully eliminate selection effects. The interaction patterns, rather than the main effect of SNAP, therefore, provide more meaningful insight into the program's impact.

Several strengths enhance the robustness of this study. The analysis leveraged more than two decades of nationally representative data from the HRS, capturing long-term exposure to food insecurity and repeated cognitive assessments. The use of MSMs with IPTW allowed us to properly address time-varying confounding, which is essential in understanding the interplay between food insecurity, socioeconomic conditions, health status, and cognitive trajectories. Including episodic

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memory and mental status as distinct domains enabled domain-specific inference and revealed consistent patterns across both memory and executive functioning. Finally, stratified analyses offered important perspectives on racial and ethnic disparities in food insecurity and its cognitive consequences.

Despite these strengths, several limitations should be acknowledged. Food insecurity was measured using two household-level items and may not fully capture the multidimensional nature of food access or individual-level experience. Cognitive assessments were primarily based on the Telephone Interview for Cognitive Status, which, while validated, may not capture finer-grained cognitive deficits. Although MSMs address many forms of confounding, unobserved confounding cannot be completely ruled out. Additionally, information on SNAP benefit amounts or duration of participation was not assessed. Finally, some observed racial/ethnic differences may reflect unmeasured cultural, social, or structural factors that influence food security, coping strategies, or cognitive aging pathways, which warrants further investigation.

5. Conclusions

The findings highlight the importance of food insecurity as a modifiable determinant of cognitive health in later life and underscore the critical role of SNAP as a protective resource for older adults. As the aging U.S. population becomes increasingly diverse, public health and policy efforts should prioritize improving access to food assistance, reducing barriers to SNAP enrollment, and ensuring adequate benefit levels, particularly for racial and ethnic minority older adults. Future research should examine how SNAP benefit generosity, dietary quality, stress physiology, and social support interact to influence cognitive trajectories over time. Continued investment in nutrition assistance programs may represent a valuable strategy for promoting healthy cognitive aging and reducing socioeconomic and racial disparities in later-life cognitive health.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org, Figure S1: Flow chart of sample selection process.

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Abbreviations

The following abbreviations are used in this manuscript:

BMI	Body Mass Index
HRS	Health and Retirement Study
OLS	Ordinary Least Squares
SNAP	Supplemental Nutrition Assistance Program
U.S.	United States

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