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ABSTRACT

Supplemental Nutrition Assistance Program (SNAP) Participation and Cognitive Decline Among Older Americans

This study examines how SNAP participation may affect age-related cognitive decline among cognitively intact older adults over 10 years. Leveraging a longitudinal survey of SNAP-eligible participants in the Health and Retirement Study (HRS) collected biennially from 2010 to 2020, we estimate the relationship between SNAP participation and cognitive decline across different population groups. We show that SNAP participation is associated with a slower cognitive decline in global cognition, memory, and executive function. A significant three-way interaction among SNAP participation, race/ethnicity, and time indicates faster decline in global cognition among Non-Hispanic Black and Hispanic SNAP users. Our findings suggest that SNAP participation may help slow age-related cognitive decline. However, the benefits of SNAP vary across different population groups. Policies promoting equitable access to SNAP benefits have significant potential to improve cognitive health across diverse populations.

JEL Classification: H53, I38, J14, I18, H75

Keywords: Supplemental Nutrition Assistance Program (SNAP), cognitive decline, longitudinal study, disparity

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1. INTRODUCTION

Alzheimer's disease and related dementias (ADRD) are a growing public health concern, particularly as the population ages.[1] AD, the most common dementing illness, begins with prodromal / age-related cognitive changes that progress to mild cognitive impairment, which then often progresses to early-stage AD. Food security, *i.e.,* access to sufficient, safe, and nutritious food, impacts cognitive function in adults.[2] A healthy diet has been reported to delay cognitive decline and the onset of dementing illness, prolonging the prodromal stage.[3-5] Moreover, emerging studies show that food insecurity is associated with a faster rate of cognitive decline.[6,7] However, studies on food assistance programs such as the Supplemental Nutrition Assistance Program (SNAP) and age-related cognitive decline are limited. Furthermore, Non-Hispanic Black and Hispanic Americans are at increased AD risk,[8] and are more likely to experience food insecurity.[9] The intersection of food security, age-related cognitive function, and racial/ethnic disparities is a multifaceted issue. Consequently, a comprehensive approach is needed to understand the factors that cause these disparities, before addressing these disparities.

The SNAP, formerly known as the Food Stamp Program, is a cornerstone of the United States (U.S.) government efforts to combat food insecurity among low-income households. With over 40 million participants enrolled,[10] SNAP provides monthly financial benefits to purchase qualified food items, thereby enhancing food security and supporting nutritional intake.[11-13] The SNAP participation rate among older adults is relatively low, with only 4.8 million older adults enrolled in SNAP,[11] and SNAP participation's impact on age-related cognitive decline remains largely unexplored. Non-Hispanic Black and Hispanic Americans are more likely to meet SNAP eligibility criteria because they experience higher poverty rates. This situation is largely due to structural racism that affects housing, employment, and healthcare, and thus creating economic vulnerability.[14] In this study, we interpret these racial/ethnic differences as disparities, as they arise from systemic and avoidable inequities rather than random variation.[15] However, even among those eligible, Non-Hispanic Black and Hispanic individuals often face additional barriers that limit their participation. SNAP participation challenges are not only about eligibility. The cumbersome enrollment process and state-level variations in enrollment and recertification requirements impose

additional administrative burdens, and disproportionately affect Non-Hispanic Black and Hispanic households.[16] Given the complex relationship between food security and cognitive health, examining the association between SNAP participation and cognitive decline across racial/ethnic groups may offer insights into the magnitude of the benefits of nutrition assistance programming, and thus help motivate tailored public health initiatives to reduce cognitive decline risk in these populations.

So far, limited research has examined the association between SNAP participation and cognitive health, and the existing research findings are inconsistent.[17-19] For example, some studies found that SNAP participation can be a protective factor that slows cognitive decline, while others found no significant association between SNAP participation and cognitive decline. No previous study has specifically associated SNAP participation and cognitive decline across diverse racial/ethnic groups, and few studies have directly assessed the association between SNAP use and function across multiple cognitive domains, such as memory, and executive function, and global cognition in older adults. Moreover, several prior studies omitted key relevant covariates that may limit the generalizability of their findings. To address these gaps, our study utilizes longitudinal data from the Health and Retirement Study (HRS) to evaluate the long-term trajectories of cognitive outcomes such as global cognition, memory, and executive function associated with SNAP participation by racial/ethnic groups. We aim to understand the association between SNAP participation and cognitive decline among older adults and determine whether this association differs across diverse racial and ethnic groups. We hypothesize that SNAP participation is associated with a slower rate of age-related cognitive decline among older adults, with potentially stronger protective effects in socioeconomically vulnerable racial/ethnic groups, particularly Non-Hispanic Black and Hispanic older adults who face higher food insecurity and structural barriers, and thus may receive outsized benefit from supplemental nutrition.

2. METHODS

2.1 Data source

Original survey datasets from the HRS are publicly available to all registered

researchers. More information can be found on the website https://hrs.isr.umich.edu/.

All HRS participants provided verbal informed consent for study participation, and HRS data collection received approval from the Health Sciences and Behavioral Sciences Institutional Review Board at the University of Michigan. Additionally, this study was approved by the Institutional Review Board at the University of Georgia PROJECT00008358. The study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.

2.2 Study design and participants

The HRS is a longitudinal survey of a nationally representative sample of Americans aged 50 and older. HRS data has been collected every two years since 1992. More detailed information about HRS is available on the website: https://hrs.isr.umich.edu/about. We developed our dataset by integrating the raw Core HRS data with the longitudinal HRS data harmonized by the RAND Corporation.[21] In addition, we incorporated the Langa-Weir Classification of Cognitive Function, a dataset that provides summary scores based on measures from the core HRS interview.[22] We used wave 10 (i.e., 2010) as our baseline, following up with participants biennially through the examination years 2012, 2014, 2016, 2018, and 2020. Participants were followed up until they either withdrew from the study (death included) or completed the 2020 survey.

Among the 42,712 respondents who participated in the 2010 HRS survey, 5,068 participants were eligible for SNAP at baseline (*i.e.,* household income was ≤ 130% of the federal poverty threshold during the 2010 interview).[18,19] We also excluded those with missing cognitive (n=398), SNAP participation (n=0), and race/ethnicity (n=7) data. This study focuses on preventing age-related cognitive decline that can eventually progress to AD; consequently, we also excluded cognitively impaired individuals at baseline (global cognition score ≤ 11; n=1,827). Our final analytical sample (N=2,347) had at least two global cognition scores between 2010-2020 (Figure S1).

2.3 Cognition

Cognitive function was measured using the Telephone Interview for Cognitive Status (TICS-m).[23] Beginning in the 2018 interview, a web-based self-administered interview was introduced for some participants.[24] A global cognitive score (ranging from 0 –27) was computed by summing the scores from immediate word recall (0–10), delayed word recall (0–10), serial 7 subtraction (0–5), and backward counting (0–2). Scores between 7-11 indicate cognitive impairment, and scores <7 indicate likely dementia.[25] A composite memory score (0 –20) was computed from immediate and delayed word recall tasks. A composite executive function score (0 –7) was computed from serial 7 subtraction and backward counting.[26]

2.4 SNAP participation

There are two relevant questions in the HRS to assess if respondents participated in SNAP: 1) "Did you (or any other family members who were living here) receive government food stamps since the last interview?" and 2) "Are you (or other family members living here) still receiving food stamps?". An affirmative answer ("yes") to each question indicated that the household had participated in SNAP within the past two years. Otherwise, they were classified as SNAP non-users though eligible based on income.

2.5 Covariates

Our models accounted for potentially confounding factors including participants' age; Sex (Men, Women); race/ethnicity (Non-Hispanic-White/Caucasian [NHW], Non-Hispanic-Black/African American [NHB], Non-Hispanic-Other [NHO], Hispanic[HIS]); marital status (in a relationship, previously in a relationship, never in a relationship); total wealth; employment status (employed, unemployed, retired, disabled, not in labor force); education attainment (less than high-school, GED, high-school graduate, some college, college and above); insurance (uninsured, insured); depression (yes, no); smoke (never smoked, ever smoked, current smoker); drink (heavy drinker, others);[27] physical activity (0-17.6: low-vigorous intensity);[28] the number of chronic diseases (0-6: 1. high blood pressure or hypertension; 2. diabetes or high blood sugar; 3. cancer or a malignant tumor of any kind except skin cancer; 4.

chronic lung disease except asthma such as chronic bronchitis or emphysema; 5. heart attack, coronary heart disease, angina, congestive heart failure, or other heart problems; and 6. stroke or transient ischemic attack).

2.6 Empirical strategy

Mean ± standard deviation (SD) was computed for continuous variables, median (interquartile range: IQR) for total wealth due to its skewed distribution, and percentage (%) was used for categorical variables. Chi-square tests were used to compare categorical variables, and ANOVA was used to compare continuous variables. Then, we estimated the direct effect of SNAP participation on the decline in global cognition, memory, and executive function using linear mixed models with random intercepts and random slopes for time for each participant. The random intercepts account for the individual variability in baseline cognitive performance, and the random slopes capture individual variability in the rate of cognitive decline over time. The model includes fixed effects for the intercept, time, SNAP, and the interaction between time and SNAP (SNAP*time). The model adjusted for potential confounders mentioned above.

To test whether SNAP participation affects cognitive decline differently across racial/ethnic groups, we included the following interaction terms in the models: SNAP participation and race/ethnicity, race/ethnicity and time, SNAP participation and time, and the three-way interaction between time, race/ethnicity, and SNAP participation. Two-sided $p<0.05$ was considered statistically significant.

To examine potential racial/ethnic disparities, we first calculated mean differences with 95% confidence intervals in annual global cognition, memory, and executive function scores by race/ethnicity, stratified by SNAP use status (SNAP user versus SNAP non-user). To examine whether the association between SNAP use and decline in global cognition varied across specific subgroups, we conducted additional subgroup analyses stratified by covariates, this approach helped investigate whether SNAP's effect on cognitive decline was consistent or varied across these key sociodemographic and health-related factors. To address possible within-group heterogeneity within racial/ethnic groups and potential differences in characteristics between SNAP users and non-users, we conducted stratified analyses by race/ethnicity.

Finally, to assess the robustness of our findings, we conducted two sensitivity analyses. First, we utilized Propensity Score Matching (PSM) to reduce potential bias from confounding variables. SNAP users and non-users were matched on the SNAP propensity score, and matching was done using the nearest neighbor method with replacement, setting 1:3 matching and caliper to be 0.01. Second, we conducted a sensitivity analysis in which SNAP participation was treated as a time-varying variable and participants who become income-ineligible for SNAP at any point during follow-up were excluded, thereby limiting the analytic sample to individuals who were consistently eligible for SNAP from 2010 to 2020. All analyses used RStudio version 2024.09.1.

3. RESULTS

Among the 2010 SNAP-eligible population, our sample included 1,131 (48.19%) SNAP users and 1,216 (51.81%) SNAP-eligible non-users. The average baseline global cognitive score was 15.60 out of 27. The unadjusted annual rate of global cognitive decline was slower among SNAP users compared to non-users (SNAP users: -0.10, non-users: -0.36). The participants were more likely to be female (74.7%) than male (25.3%), with an average age of 62.74 ± 10.84 years. Most participants were Non-Hispanic White (43.2%) and Non-Hispanic Black (30.6%). Sample participants had a median total household income of $8,195 (IQR: $0-$83,842) and 1.57 ± 1.32 chronic diseases. Most of the participants had health insurance coverage (64.70%) and did not report symptoms of depression (78.6%). The SNAP users were more likely to be younger (mean ± SD=59.57 ± 9.31 years) than non-users (mean ± SD=65.69 ± 11.32 years). A higher proportion of Non-Hispanic Black participants were among SNAP users (35.6%) compared with non-users (25.9%). A higher percentage of SNAP users were current smokers (32.7%) compared to non-users (20.0%). SNAP users were more likely to attend some colleges (27.6%) than non-users (23.1%) (Table 1).

Table 2 shows the associations between SNAP participation and the decline in global cognition, memory, and executive function over time across three models with progressively adjusted covariates. In all three models, time was negatively associated with global cognition (β = -0.19; 95% CI: -0.22, -0.15; $p < 0.001$), and two domains (memory β = -0.12; 95% CI: -0.15, -0.09; $p < 0.001$; executive function β = -0.05; 95%

CI: -0.07, -0.04; $p < 0.001$), showing an overall decline in cognitive function over time. The interaction term of SNAP and time was positively significant in all cognitive outcomes, which indicates that SNAP participation was associated with a slower decline in global cognition ($\beta = 0.10$; 95% CI: 0.05, 0.14; $p < 0.001$), memory ($\beta = 0.07$; 95% CI: 0.03, 0.11; $p < 0.001$), and executive function ($\beta = 0.03$; 95% CI: 0.01, 0.04; $p = 0.004$). The PSM analysis (Table 4) revealed similar results, as presented by the positive interaction terms of SNAP and Time, indicating that SNAP participation was associated with delayed declines in global cognition, memory, and executive function. Results from the sensitivity analysis were consistent with the main analysis (Table S1). SNAP participation was associated with a significantly slower annual decline in global cognition ($\beta = 0.12$, 95% CI: 0.07, 0.17, $p < 0.001$), memory ($\beta = 0.08$, 95% CI: 0.04, 0.11, $p < 0.001$), and executive function ($\beta = 0.04$, 95% CI: 0.02, 0.06, $p < 0.001$).

Table 3 shows the association between SNAP participation and declines in global cognition, memory, and executive function by race/ethnicity. The SNAP*NHB*Time ($\beta = -0.12$, 95% CI: -0.22, -0.01, $p = 0.04$) and SNAP*HIS*Time ($\beta = -0.12$; 95% CI: -0.23, -0.01; $p = 0.03$) interactions were significant, indicating that the Non-Hispanic Black and Hispanic participants among SNAP users have a slightly faster cognitive decline, compared with Non-Hispanic White. For memory and executive function, similar results were observed but did not reach statistical significance. Results from Table S2 also demonstrated the similar findings, SNAP participation was significantly associated with a slower rate of decline in global cognition ($\beta = 0.16$; 95% CI: 0.09, 0.23; $p < 0.001$), memory ($\beta = 0.12$; 95% CI: 0.06, 0.18; $p < 0.001$), and executive function ($\beta = 0.04$; 95% CI: 0.01, 0.07; $p = 0.006$) among Non-Hispanic White participants. However, the association was weaker and non-significant among Non-Hispanic Black and Hispanic participants.

Figure 1 further stratifies the association between SNAP participation and cognitive changes across different racial/ethnic groups over time. For global cognition, SNAP non-users exhibit accelerated cognitive decline than SNAP users across all racial/ethnic groups. The declines showed a greater variance across the racial/ethnic groups among SNAP non-users relative to SNAP users. Similar results are observed in the domains of memory and executive function.

To further test the association between SNAP participation and cognitive decline in

different population groups, we conducted subgroup analyses examining the association between SNAP participation and global cognitive decline, stratified by key covariates including depression status, education attainment, gender, insurance status, employment status, relationship status, and smoking status (Figure S2). The data shows that SNAP users have lower rates of annual cognitive decline than SNAP non-users among all subgroups. Additionally, the variance within each SNAP user's subgroup is smaller compared to that of SNAP non-users.

4. DISCUSSION

Our study examines the association between SNAP participation and decline in global cognition, memory, and executive function among older adults. The findings suggest that SNAP participation is associated with a slower decline in global cognition and the domains of memory and executive function, demonstrating a potential protective effect of SNAP participation on cognitive function. However, cognitive disparities across racial/ethnic groups exist. Non-Hispanic Black and Hispanic SNAP participants experience a faster decline in global cognition compared with Non-Hispanic White.

The results show that SNAP users had a slower rate of cognitive decline compared to SNAP non-users, suggesting SNAP participation could delay this cognitive decline. This trend was observed in global cognition and both domains, suggesting SNAP participation may play a comprehensive role in mitigating cognitive decline. Additionally, the PSM analysis demonstrated that the observed associations between SNAP participation and cognitive outcomes were robust to confound. Furthermore, sensitivity analyses that restricted the sample to participants who were consistently eligible for SNAP throughout the study period also showed similar results. These findings are consistent with previous research that has highlighted the positive impact of food security on cognitive function. Specifically, prior research has shown that improved nutritional intake associated with food assistance programs can improve brain health and delay cognitive decline.[6,18] Additionally, studies have found that food insecurity is linked to accelerated cognitive decline due to stress and nutritional deficiency.[29,30] Our results further expand upon this evidence by showing that the protective effect of SNAP is observed across global cognition as well as domain-specific measures of cognition, highlighting the role of food assistance programs in

supporting long-term cognitive health.

Although SNAP participation may offer cognitive protection and reduce variability in cognitive performance across racial/ethnic groups, racial/ethnic disparities still exist. While SNAP participation was generally associated with a slower rate of cognitive decline, this protective effect appeared weaker among Non-Hispanic Black and Hispanic participants, suggesting that the cognitive benefits of SNAP may be moderated by race/ethnicity. Hispanic and non-Hispanic Black SNAP users show slightly faster global cognition than non-Hispanic White participants. In other words, while SNAP participation is protective, it may not fully eliminate cognitive disparities among different racial/ethnic groups. This result is consistent with the context discussed in the introduction. Even Hispanic and Non-Hispanic Black population are eligible for SNAP enrollment, they have many barriers, such as troublesome application process, transportation challenges to farmer's markets, etc., to fully make use of SNAP benefits.[31-33] Future research is warranted to explore some potential unobservable variables contributing to these racial and ethnic disparities.

The subgroup analysis provides further evidence that SNAP participation may have a protective effect on cognitive health. In addition, it indicates that SNAP participation has the potential to reduce disparities in cognitive decline across different subgroups, which suggests that SNAP participation may contribute to promoting health equity in cognitive health.

The observed differences in cognitive decline across domains, such as executive function and memory, might reflect the fact that key nutrients and bioactives found in healthy foods can directly impact underlying brain structures that support cognitive function. For example, high-level executive function is influenced by dietary intake of nutrients such as protein, iron, and vitamins like B6 and B12.[36] Intake of dietary carotenoids lutein and zeaxanthin in dark green, leafy vegetables is associated with improved hippocampal white matter integrity, brain morphology, and memory function. These cognitive domains may respond differently to nutritional intervention, such as SNAP participation because they are influenced by different neurobiological processes.

Despite the significant findings, our study has some limitations. First, the use of self-reported data may introduce the potential for recall and social desirability bias. In particular, underreporting of SNAP participation is a well-documented concern in

survey data, with studies estimating false negative rates of 30% to 50%.[39,40] However, such underreporting could reduce our sample size, particularly if SNAP users are misclassified as non-users. Small sample size to get significant results, so we may see similar or even more pronounced result in a sample with accurate SNAP reporting. Second, although the HRS is nationally representative, the generalizability of our findings may be limited due to exclusions based on cognitive status, missing data, and follow-up availability. Also, we did not use sampling weights which may limit the generalizability. But this decision was made to prioritize model efficiency and minimize potential bias when estimating conditional associations between SNAP participation and cognitive outcomes. Third, there is some missing information about participants' cognitive status, SNAP participation status, and race/ethnicity, which might lead to bias. Fourth, unobserved factors such as enrollment motivation, social support, neighborhood and community factors, or unmeasured health conditions may differ between SNAP users and non-users, potentially influencing the observed associations. Fifth, the possibility of reverse causality cannot be entirely ruled out, as individuals experiencing cognitive decline may be more likely to enroll in SNAP. Although we excluded participants with cognitive impairment at baseline to reduce this risk, doing so may still have introduced selection bias if baseline cognitive status was associated with both SNAP participation and future cognitive trajectories.

Our study has some strengths that are worth noting. such as the fact that this is the first study to examine whether SNAP participation is associated with a slower rate of cognitive decline across racial/ethnic groups. This focus is important for identifying if food assistance programs can help reduce health inequalities. Given the fact that different nutrients and dietary bioactives impact cognitive function (and likely also risk for age-related cognitive decline) differently, this study provides groundwork for investigating the association between intake of nutrient-dense, higher quality diets and AD prevention in large, representative samples.

These results also have public health implications: expanding SNAP access may not only reduce food insecurity but may also help slow cognitive decline. AD is expected to cost the U.S. healthcare system more than $1trillion by 2050. To get more older adults at-risk for AD enrolled in SNAP (and ostensibly achieving the benefits we found for cognitive function), efforts to simplify application and recertification processes are

particularly important, and particularly important for Black and Hispanic adults, who are at higher risk for AD. Reducing administrative burdens, providing assistance with applications, offering online enrollment options, and ensuring culturally and linguistically appropriate outreach could help bridge participation gaps.

There are also clinical implications for our results. The baseline global cognition score was 15.6 (out of 27), indicating that most participants began the study cognitively intact. The average unadjusted annual cognitive decline was 0.36 points among non-SNAP users. Based on this rate, individuals in our study could be expected to progress to mild cognitive impairment (typically defined as a score <12) in approximately 10 years. In contrast, our adjusted regression model showed that SNAP participation was associated with a 0.10 point slower annual decline compared to non-users. If sustained, this slower rate could delay the onset of cognitive impairment by more than 35 years, highlighting a clinically meaningful protective effect. Consequently, SNAP advocacy from would facilitate providing a more comprehensive approach to managing cognitive health.

5. CONCLUSION

This study provides evidence that SNAP participation is associated with a slower decline in global cognition, memory, and executive function in older adults. These findings highlight the significance of food assistance programs in protecting cognitive health and reducing health disparities across racial/ethnic groups. Further research is warranted to explore the underlying mechanisms and to design interventions that can maximize the benefits of SNAP and other food assistance programs in improving cognitive outcomes for vulnerable populations. In addition, future work should aim to link self-reported survey datasets with administrative records to refine estimates of SNAP participation and thus provide more robust conclusions.[40]

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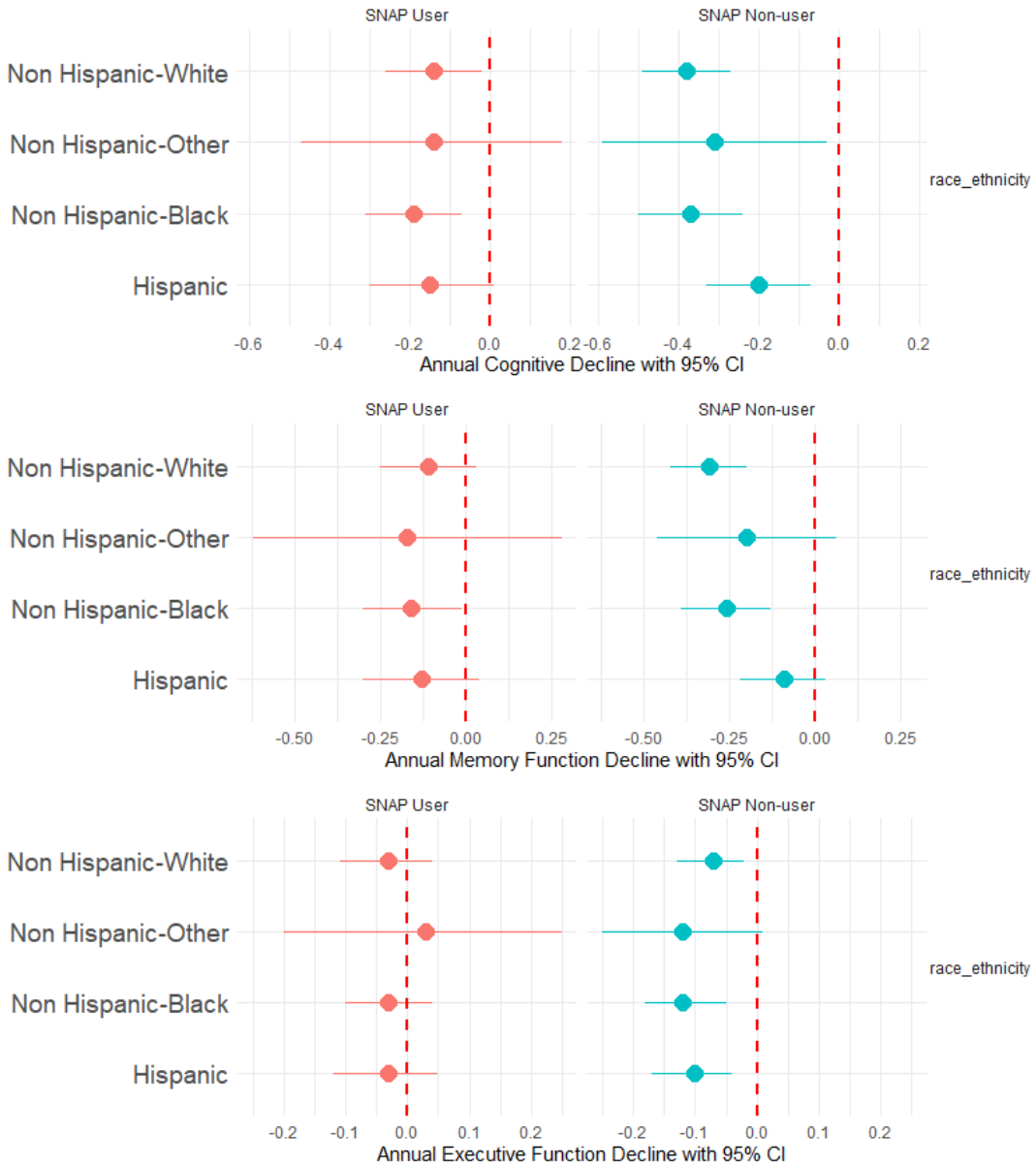

Figure 1 Annual decline in global cognition, memory, and executive function in SNAP users and non-users by race/ethnicity

Table 1 Baseline characteristics of SNAP Eligible participants by Participation Status: Health and Retirement Study, 2010-2020

Variables	**Total (N=2,347)**	**SNAP: No (N=1,216)**	**SNAP: Yes (N=1,131)**	**p-value**
Global Cognition (mean [SD])	15.60 (2.75)	15.52 (2.78)	15.67 (2.73)	0.185
Memory Score (mean [SD])	10.29 (2.40)	10.20 (2.42)	10.39 (2.38)	0.069
Executive Function Score (mean [SD])	5.30 (1.59)	5.32 (1.58)	5.29 (1.60)	0.647
Annual cognitive decline (mean [SD])	-0.27 (0.89)	-0.36 (1.06)	-0.10 (0.41)	<0.001
Age (mean [SD] in years)	62.74 (10.84)	65.69 (11.32)	59.57 (9.31)	<0.001
Race/Ethnicity (%)				<0.001
Non-Hispanic White	1013 (43.2)	554 (45.6)	459 (40.6)	
Non-Hispanic Black	718 (30.6)	315 (25.9)	403 (35.6)	
Non-Hispanic Other	81 (3.5)	42 (3.5)	39 (3.4)	
Hispanic	535 (22.8)	305 (25.1)	230 (20.3)	
Sex (%)				0.067
Mem	594 (25.3)	288 (23.7)	306 (27.1)	
Women	1753 (74.7)	928 (76.3)	825 (72.9)	
Marital Status (%)				<0.001
In a Relationship	683 (29.1)	302 (24.9)	381 (33.7)	
Previously in a Relationship	1391 (59.3)	776 (63.9)	615 (54.5)	
Never in a Relationship	270 (11.5)	137 (11.3)	133 (11.8)	
Total Wealth (median [IQR] in $)	8,195.00 (0.00-83,842)	23,766.50 (0.00-118,775)	2800.00 (0.00-49,375)	<0.001
Labor Status (%)				<0.001
Employed	539 (23.0)	229 (18.8)	310 (27.4)	
Unemployed	158 (6.7)	61 (5.0)	97 (8.6)	
Retired	1280 (54.5)	768 (63.2)	512 (45.3)	
Disabled	146 (6.2)	50 (4.1)	96 (8.5)	
Not in labor force	224 (9.5)	108 (8.9)	116 (10.3)	
Education (%)				<0.001
Less than High-school	666 (28.4)	362 (29.8)	304 (26.9)	
GED	162 (6.9)	61 (5.0)	101 (8.9)	
High-school graduate	725 (30.9)	410 (33.7)	315 (27.9)	
Some college	593 (25.3)	281 (23.1)	312 (27.6)	
College and above	200 (8.5)	101 (8.3)	99 (8.8)	
Insurance type (%)				<0.001
Medicare & Medicaid Dual-Eligible	1130 (48.1)	700 (57.6)	430 (43.6)	
Private	363 (15.5)	166 (13.7)	197 (17.4)	
CHAMPUS	25 (1.1)	14 (1.2)	11 (1.0)	
Uninsured	829 (35.3)	336 (27.6)	493 (43.6)	
Depression (%)				<0.001
No	1843 (78.6)	998 (82.2)	845 (74.8)	
Yes	501 (21.4)	216 (17.8)	285 (25.2)	
Smoke (%)				<0.001
Never smoking	958 (40.8)	564 (46.4)	394 (34.8)	
Ever smoking	775 (33.0)	408 (33.6)	367 (32.4)	
Current smoker	613 (26.1)	243 (20.0)	370 (32.7)	

Num of Chronic Diseases (mean [SD])	1.57 (1.32)	1.56 (1.30)	1.59 (1.34)	0.623
Drink (%)				0.864
Heavy drink	103 (4.4)	52 (4.3)	51 (4.5)	
Others	2235 (95.6)	1159 (95.7)	1076 (95.5)	
Physical Activity (mean [SD])	6.69 (4.07)	6.78 (4.14)	6.59 (4.00)	0.266

a) Abbreviations: SD: standard deviation; IQR: interquartile range; GED: General Educational Development; SNAP: the Supplemental Nutrition Assistance Program.

b) Non-Hispanic-Other: American Indian, Alaska Native, Asian, Native Hawaiian, Pacific Islander

c) The annual cognitive decline was calculated as the difference between the baseline and most recent cognitive scores divided by the number of follow-up years. (presented for reference)

Table 2 Association between SNAP and declines in global cognition, memory, and executive function

	Model1	Model2	Model3
Global Cognition			
SNAP*Time	0.09	0.10	0.10
95% CI	(0.05, 0.13)	(0.05, 0.14)	(0.05, 0.14)
p-value	<0.001	<0.001	<0.001
SNAP	-0.19	-0.10	-0.07
95% CI	(-0.36, 0.11)	(-0.35, 0.15)	(-0.33, 0.19)
p-value	0.29	0.43	0.85
Time	-0.19	-0.20	-0.19
95% CI	(-0.23, -0.16)	(-0.24, -0.17)	(-0.22, -0.15)
p-value	<0.001	<0.001	<0.001
Memory			
SNAP*Time	0.07	0.07	0.07
95% CI	(0.03, 0.10)	(0.03, 0.11)	(0.03, 0.11)
p-value	<0.001	<0.001	<0.001
SNAP	-0.20	-0.12	-0.10
95% CI	(-0.41, 0.01)	(-0.33, 0.08)	(-0.31, 0.11)
p-value	0.06	0.24	0.35
Time	-0.14	-0.13	-0.12
95% CI	(-0.17, -0.11)	(-0.16, -0.10)	(-0.15, -0.09)
p-value	<0.001	<0.001	<0.001
Executive Function			
SNAP*Time	0.03	0.03	0.03
95% CI	(0.01, 0.05)	(0.01, 0.05)	(0.01, 0.04)
p-value	<0.001	0.003	0.004
SNAP	-0.04	-0.02	0.00
95% CI	(-0.17, 0.09)	(-0.15, 0.11)	(-0.13, 0.13)
p-value	0.54	0.83	0.97
Time	-0.05	-0.05	-0.05
95% CI	(-0.07, -0.04)	(-0.07, -0.04)	(-0.07, -0.04)
p-value	<0.001	<0.001	<0.001

a) Note: Results are derived from linear mixed-effects models with random intercepts
b) Model 1 adjusted for time, age, race/ethnicity, gender, marital status.
c) Model 2 additionally adjusted for Total Wealth, Labor Status, Education, Insurance.
d) Model 3 additionally adjusted for Depression, Smoke, Drinking, Physical activity, and Number of Chronic Diseases.
e) CI: Confidence Interval, SNAP: the Supplemental Nutrition Assistance Program.

Table 3 The effect of SNAP on global cognition, memory, and executive function across different racial/ethnic groups

	Global Cognition β (95% CI)	**P-value**	**Memory** β (95% CI)	**P-value**	**Executive Function** β (95% CI)	**P-value**
SNAP	-0.06 (-0.43, 0.32)	0.77	0.05 (-0.25, 0.36)	0.73	-0.16 (-0.35, 0.04)	0.12
Non-Hispanic Black	-1.57 (-1.99, -1.15)	<0.001	-0.68 (-1.03, -0.33)	<0.001	-0.90 (-1.11, -0.68)	<0.001
Non-Hispanic Other	-1.06 (-1.96, -0.16)	0.02	-0.64 (-1.39, 0.11)	0.09	-0.47 (-0.94, 0.01)	0.05
Hispanic	-0.92 (-1.35, -0.49)	<0.001	-0.31 (-0.67, 0.05)	0.09	-0.64 (-0.87, -0.41)	<0.001
Time	-0.29 (-0.34, -0.24)	<0.001	-0.20 (-0.25, -0.16)	<0.001	-0.08 (-0.10, -0.05)	<0.001
SNAP*NHB	0.32 (-0.25, 0.88)	0.27	-0.04 (-0.51, 0.43)	0.87	0.36 (0.06, 0.66)	0.02
SNAP*NHO	-0.75 (-2.06, 0.56)	0.26	-0.99 (-2.08, 0.11)	0.08	0.22 (-0.47, 0.90)	0.54
SNAP*HIS	-0.21 (-0.82, 0.40)	0.51	-0.35 (-0.86, 0.16)	0.18	0.15 (-0.17, 0.48)	0.35
SNAP*Time	0.16 (0.09, 0.23)	<0.001	0.12 (0.06, 0.18)	<0.001	0.04 (0.01, 0.07)	<0.001
NHB*Time	0.15 (0.06, 0.23)	<0.001	0.10 (0.03, 0.17)	0.01	0.04 (0.00, 0.07)	0.05
NHO*Time	0.06 (-0.12, 0.25)	0.51	0.03 (-0.13, 0.18)	0.75	0.04 (-0.04, 0.12)	0.35
HIS*Time	0.19 (0.11, 0.27)	<0.001	0.14 (0.08, 0.21)	<0.001	0.04 (0.00, 0.07)	0.04
SNAP*NHB*Time	-0.12 (-0.22, -0.01)	0.04	-0.08 (-0.17, 0.01)	0.09	-0.03 (-0.08, 0.01)	0.15
SNAP*NHO*Time	0.08 (-0.18, 0.34)	0.55	0.14 (-0.08, 0.35)	0.22	-0.05 (-0.16, 0.06)	0.36
SNAP*HIS*Time	-0.12 (-0.23, -0.01)	0.03	-0.10 (-0.19, -0.00)	0.05	-0.02 (-0.07, 0.03)	0.42

Abbreviations: CI: confidence interval; NHW: Non-Hispanic-White/Caucasian; NHB: Non-Hispanic-Black/African American; NHO: Non-Hispanic-Other; HIS: Hispanic; SNAP: the Supplemental Nutrition Assistance Program.

Table 4 Propensity Score-matched model for association between SNAP and declines in global cognition, memory, and executive function (n= 6,244)

	Model1	**Model2**	**Model3**
Global Cognition			
SNAP*Time	0.09	0.07	0.07
95% CI	(0.03, 0.14)	(0.01, 0.12)	(0.01, 0.12)
p-value	<0.001	0.01	0.01
SNAP	-0.02	0.08	0.07
95% CI	(-0.30, 0.26)	(-0.18, 0.35)	(-0.21, 0.35)
p-value	0.89	0.54	0.64
Time	-0.19	-0.18	-0.18
95% CI	(-0.22, -0.16)	(-0.22, -0.15)	(-0.22, -0.15)
p-value	<0.001	<0.001	<0.001
Memory			
SNAP*Time	0.06	0.04	0.05
95% CI	(0.01, 0.10)	(0.00, 0.08)	(0.00, 0.09)
p-value	0.01	0.06	0.13
SNAP	-0.06	0.05	0.04
95% CI	(-0.29, 0.17)	(-0.18, 0.27)	(-0.14, 0.31)
p-value	0.60	0.67	1.00
Time	-0.13	-0.12	-0.12
95% CI	(-0.16, -0.10)	(-0.15, -0.09)	(-0.15, -0.09)
p-value	<0.001	<0.001	<0.001
Executive Function			
SNAP*Time	0.03	0.02	0.02
95% CI	(0.01, 0.05)	(0.00, 0.05)	(0.00, 0.04)

p-value	<0.001	0.03	0.07
SNAP	0.01	0.00	0.03
95% CI	(-0.14, 0.15)	(-0.14, 0.14)	(-0.11, 0.17)
p-value	0.92	0.97	0.65
Time	-0.06	-0.05	-0.05
95% CI	(-0.07, -0.04)	(-0.07, -0.04)	(-0.07, -0.04)
p-value	<0.001	<0.001	<0.001

a) Model 1 adjusted for time, age, race/ethnicity, gender, marital status.
b) Model 2 additionally adjusted for Total Wealth, Labor Status, Education, Insurance.
c) Model 3 additionally adjusted for Depression, Smoke, Drinking, Physical activity, and Number of Chronic Diseases.
d) CI: Confidence Interval, SNAP: the Supplemental Nutrition Assistance Program.

Table S1 Sensitivity analysis model for association between SNAP and declines in global cognition, memory, and executive function

	Global Cognition	Memory	Executive Function
SNAP*Time	0.12	0.08	0.04
95% CI	(0.07, 0.17)	(0.04, 0.11)	(0.02, 0.06)
p-value	<0.001	<0.001	<0.001
SNAP	0.06	-0.02	0.04
95% CI	(-0.24, 0.35)	(-0.26, 0.23)	(-0.12, 0.19)
p-value	0.71	0.88	0.65
Time	-0.19	-0.13	-0.05
95% CI	(-0.23, -0.16)	(-0.16, -0.10)	(-0.07, -0.04)
p-value	<0.001	<0.001	<0.001

a) Model adjusted for time, age, race/ethnicity, gender, marital status, Total Wealth, Labor Status, Education, Insurance, Depression, Smoke, Drinking, Physical activity, and Number of Chronic Diseases.

Table S2 Association between SNAP and declines in global cognition, memory, and executive function among different races/ethnicities

	Global Cognition	Memory	Executive Function
Non-Hispanic White			
SNAP*Time	0.16	0.12	0.04
95% CI	(0.09, 0.23)	(0.06, 0.18)	(0.01, 0.07)
p-value	<0.001	<0.001	0.006
SNAP	-0.18	-0.07	-0.16
95% CI	(-0.58, 0.21)	(-0.41, 0.26)	(-0.35, 0.03)
p-value	0.36	0.67	0.10
Time	-0.29	-0.20	-0.08
95% CI	(-0.34, -0.24)	(-0.24, -0.16)	(-0.10, -0.05)
p-value	<0.001	<0.001	<0.001
Non-Hispanic Black			
SNAP*Time	0.05	0.05	0.01
95% CI	(-0.03, 0.14)	(-0.03, 0.12)	(-0.02, 0.05)
p-value	0.21	0.22	0.47
SNAP	0.33	0.09	0.21
95% CI	(-0.13, 0.78)	(-0.29, 0.47)	(-0.04, 0.46)
p-value	0.16	0.64	0.11
Time	-0.14	-0.10	-0.04
95% CI	(-0.21, -0.07)	(-0.16, -0.04)	(-0.07, -0.01)
p-value	<0.001	<0.001	0.006
Non-Hispanic Other			
SNAP*Time	0.24	0.27	-0.02
95% CI	(-0.07, 0.55)	(0.01, 0.53)	(-0.15, 0.11)
p-value	0.12	0.04	0.72
SNAP	-1.06	-1.19	0.08
95% CI	(-2.51, 0.38)	(-2.52, 0.15)	(-0.63, 0.79)
p-value	0.15	0.08	0.82
Time	-0.23	-0.18	-0.04
95% CI	(-0.45, 0.00)	(-0.37, 0.01)	(-0.13, 0.06)
p-value	0.04	0.07	0.43
Hispanic			
SNAP*Time	0.04	0.02	0.03
95% CI	(-0.04, 0.13)	(-0.05, 0.10)	(-0.01, 0.06)
p-value	0.33	0.57	0.14
SNAP	-0.11	-0.23	0.07
95% CI	(-0.61, 0.39)	(-0.63, 0.17)	(-0.22, 0.35)
p-value	0.68	0.26	0.64
Time	-0.11	-0.06	-0.04
95% CI	(-0.17, -0.05)	(-0.12, -0.01)	(-0.06, -0.01)
p-value	<0.001	0.01	0.002

a) Model adjusted for time, age, race/ethnicity, gender, marital status, Total Wealth, Labor Status, Education, Insurance, Depression, Smoke, Drinking, Physical activity, and Number of Chronic Diseases.

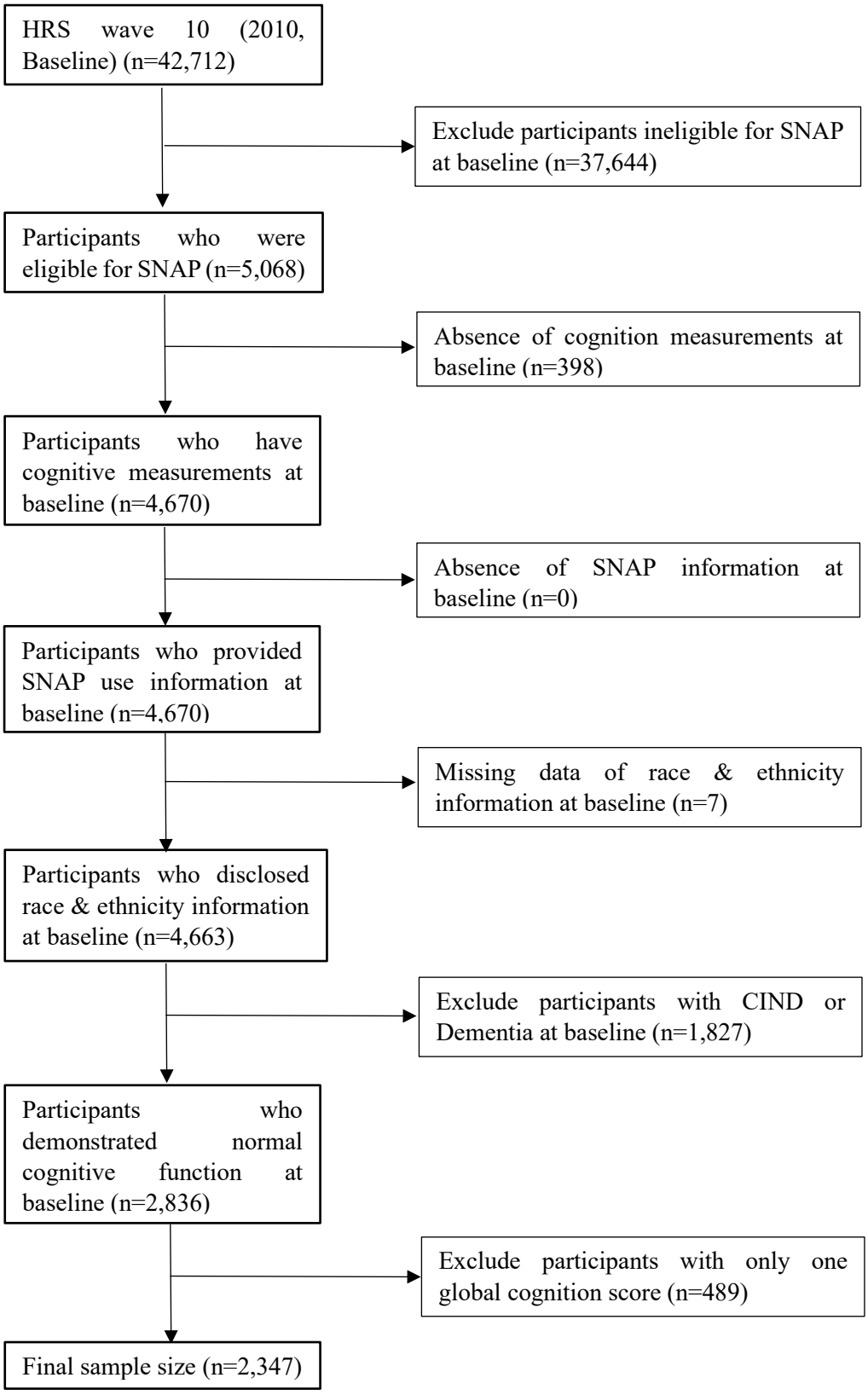

Figure S1 Participants selection diagram

Abbreviation: HRS: Health and Retirement Study; SNAP: Supplemental Nutrition Assistance Program; CIND: Cognitive impairment with no dementia)

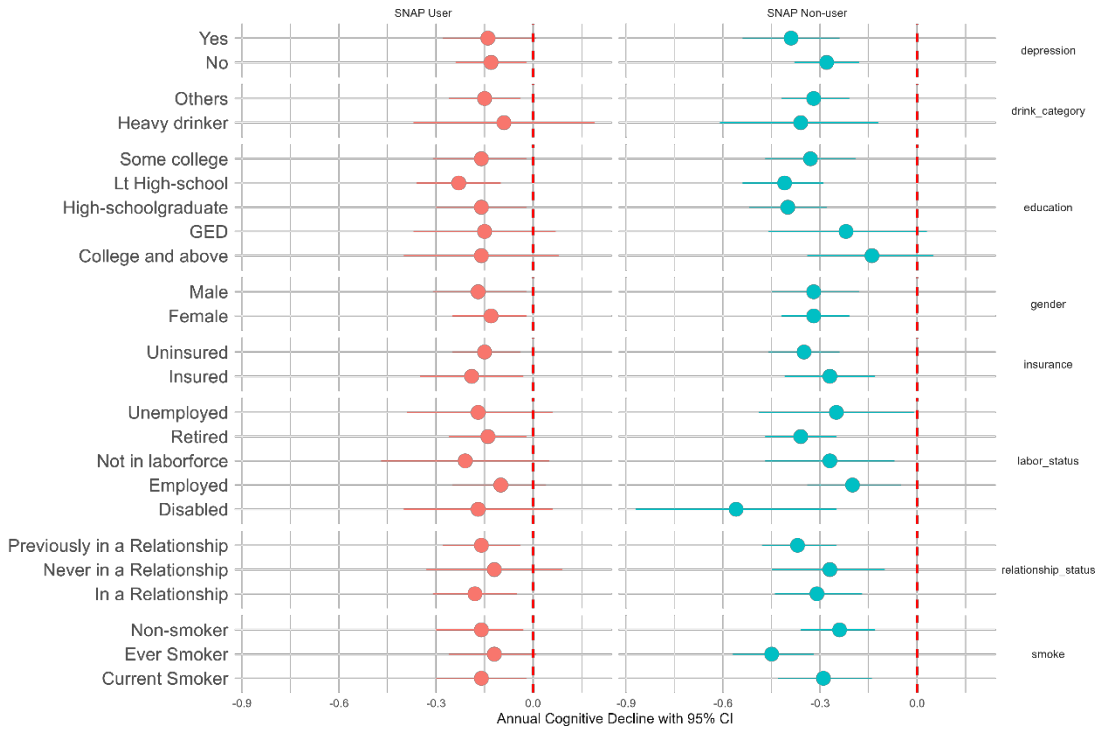

Figure S2 Subgroup analyses for association between SNAP and the annual decline in global cognition

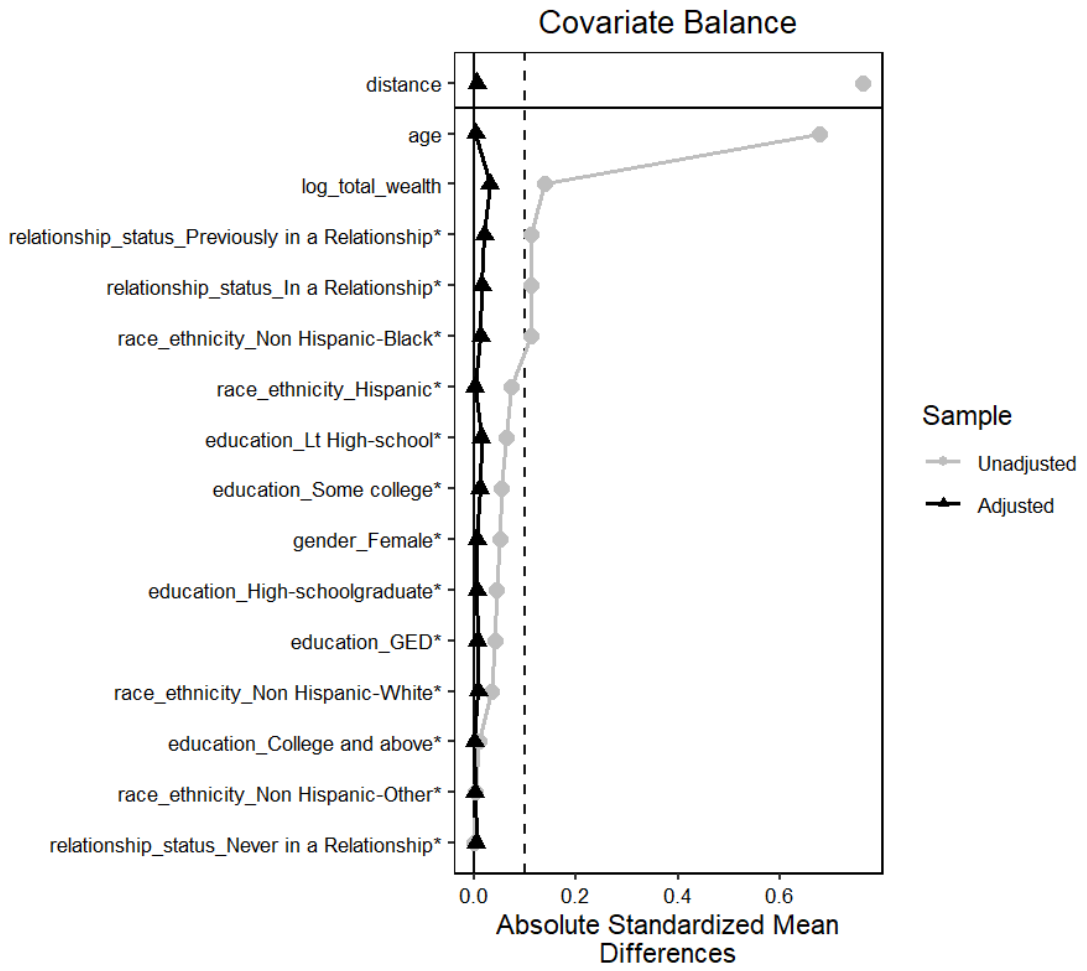

Figure S3 Standardized Mean Differences Before and After Propensity Score Matching

1. INTRODUCTION

Alzheimer's disease and related dementias (ADRD) are a growing public health concern, particularly as the population ages.[1] AD, the most common dementing illness, begins with prodromal / age-related cognitive changes that progress to mild cognitive impairment, which then often progresses to early-stage AD. Food security, *i.e.,* access to sufficient, safe, and nutritious food, impacts cognitive function in adults.[2] A healthy diet has been reported to delay cognitive decline and the onset of dementing illness, prolonging the prodromal stage.[3-5] Moreover, emerging studies show that food insecurity is associated with a faster rate of cognitive decline.[6,7] However, studies on food assistance programs such as the Supplemental Nutrition Assistance Program (SNAP) and age-related cognitive decline are limited. Furthermore, Non-Hispanic Black and Hispanic Americans are at increased AD risk,[8] and are more likely to experience food insecurity.[9] The intersection of food security, age-related cognitive function, and racial/ethnic disparities is a multifaceted issue. Consequently, a comprehensive approach is needed to understand the factors that cause these disparities, before addressing these disparities.

The SNAP, formerly known as the Food Stamp Program, is a cornerstone of the United States (U.S.) government efforts to combat food insecurity among low-income households. With over 40 million participants enrolled,[10] SNAP provides monthly financial benefits to purchase qualified food items, thereby enhancing food security and supporting nutritional intake.[11-13] The SNAP participation rate among older adults is relatively low, with only 4.8 million older adults enrolled in SNAP,[11] and SNAP participation's impact on age-related cognitive decline remains largely unexplored. Non-Hispanic Black and Hispanic Americans are more likely to meet SNAP eligibility criteria because they experience higher poverty rates. This situation is largely due to structural racism that affects housing, employment, and healthcare, and thus creating economic vulnerability.[14] In this study, we interpret these racial/ethnic differences as disparities, as they arise from systemic and avoidable inequities rather than random variation.[15] However, even among those eligible, Non-Hispanic Black and Hispanic individuals often face additional barriers that limit their participation. SNAP participation challenges are not only about eligibility. The cumbersome enrollment process and state-level variations in enrollment and recertification requirements impose

additional administrative burdens, and disproportionately affect Non-Hispanic Black and Hispanic households.[16] Given the complex relationship between food security and cognitive health, examining the association between SNAP participation and cognitive decline across racial/ethnic groups may offer insights into the magnitude of the benefits of nutrition assistance programming, and thus help motivate tailored public health initiatives to reduce cognitive decline risk in these populations.

So far, limited research has examined the association between SNAP participation and cognitive health, and the existing research findings are inconsistent.[17-19] For example, some studies found that SNAP participation can be a protective factor that slows cognitive decline, while others found no significant association between SNAP participation and cognitive decline. No previous study has specifically associated SNAP participation and cognitive decline across diverse racial/ethnic groups, and few studies have directly assessed the association between SNAP use and function across multiple cognitive domains, such as memory, and executive function, and global cognition in older adults. Moreover, several prior studies omitted key relevant covariates that may limit the generalizability of their findings. To address these gaps, our study utilizes longitudinal data from the Health and Retirement Study (HRS) to evaluate the long-term trajectories of cognitive outcomes such as global cognition, memory, and executive function associated with SNAP participation by racial/ethnic groups. We aim to understand the association between SNAP participation and cognitive decline among older adults and determine whether this association differs across diverse racial and ethnic groups. We hypothesize that SNAP participation is associated with a slower rate of age-related cognitive decline among older adults, with potentially stronger protective effects in socioeconomically vulnerable racial/ethnic groups, particularly Non-Hispanic Black and Hispanic older adults who face higher food insecurity and structural barriers, and thus may receive outsized benefit from supplemental nutrition.

2. METHODS

2.1 Data source

Original survey datasets from the HRS are publicly available to all registered

researchers. More information can be found on the website https://hrs.isr.umich.edu/.

All HRS participants provided verbal informed consent for study participation, and HRS data collection received approval from the Health Sciences and Behavioral Sciences Institutional Review Board at the University of Michigan. Additionally, this study was approved by the Institutional Review Board at the University of Georgia PROJECT00008358. The study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.

2.2 Study design and participants

The HRS is a longitudinal survey of a nationally representative sample of Americans aged 50 and older. HRS data has been collected every two years since 1992. More detailed information about HRS is available on the website: https://hrs.isr.umich.edu/about. We developed our dataset by integrating the raw Core HRS data with the longitudinal HRS data harmonized by the RAND Corporation.[21] In addition, we incorporated the Langa-Weir Classification of Cognitive Function, a dataset that provides summary scores based on measures from the core HRS interview.[22] We used wave 10 (i.e., 2010) as our baseline, following up with participants biennially through the examination years 2012, 2014, 2016, 2018, and 2020. Participants were followed up until they either withdrew from the study (death included) or completed the 2020 survey.

Among the 42,712 respondents who participated in the 2010 HRS survey, 5,068 participants were eligible for SNAP at baseline (*i.e.,* household income was ≤ 130% of the federal poverty threshold during the 2010 interview).[18,19] We also excluded those with missing cognitive (n=398), SNAP participation (n=0), and race/ethnicity (n=7) data. This study focuses on preventing age-related cognitive decline that can eventually progress to AD; consequently, we also excluded cognitively impaired individuals at baseline (global cognition score ≤ 11; n=1,827). Our final analytical sample (N=2,347) had at least two global cognition scores between 2010-2020 (Figure S1).

2.3 Cognition

Cognitive function was measured using the Telephone Interview for Cognitive Status (TICS-m).[23] Beginning in the 2018 interview, a web-based self-administered interview was introduced for some participants.[24] A global cognitive score (ranging from 0 –27) was computed by summing the scores from immediate word recall (0–10), delayed word recall (0–10), serial 7 subtraction (0–5), and backward counting (0–2). Scores between 7-11 indicate cognitive impairment, and scores <7 indicate likely dementia.[25] A composite memory score (0 –20) was computed from immediate and delayed word recall tasks. A composite executive function score (0 –7) was computed from serial 7 subtraction and backward counting.[26]

2.4 SNAP participation

There are two relevant questions in the HRS to assess if respondents participated in SNAP: 1) "Did you (or any other family members who were living here) receive government food stamps since the last interview?" and 2) "Are you (or other family members living here) still receiving food stamps?". An affirmative answer ("yes") to each question indicated that the household had participated in SNAP within the past two years. Otherwise, they were classified as SNAP non-users though eligible based on income.

2.5 Covariates

Our models accounted for potentially confounding factors including participants' age; Sex (Men, Women); race/ethnicity (Non-Hispanic-White/Caucasian [NHW], Non-Hispanic-Black/African American [NHB], Non-Hispanic-Other [NHO], Hispanic[HIS]); marital status (in a relationship, previously in a relationship, never in a relationship); total wealth; employment status (employed, unemployed, retired, disabled, not in labor force); education attainment (less than high-school, GED, high-school graduate, some college, college and above); insurance (uninsured, insured); depression (yes, no); smoke (never smoked, ever smoked, current smoker); drink (heavy drinker, others);[27] physical activity (0-17.6: low-vigorous intensity);[28] the number of chronic diseases (0-6: 1. high blood pressure or hypertension; 2. diabetes or high blood sugar; 3. cancer or a malignant tumor of any kind except skin cancer; 4.

chronic lung disease except asthma such as chronic bronchitis or emphysema; 5. heart attack, coronary heart disease, angina, congestive heart failure, or other heart problems; and 6. stroke or transient ischemic attack).

2.6 Empirical strategy

Mean ± standard deviation (SD) was computed for continuous variables, median (interquartile range: IQR) for total wealth due to its skewed distribution, and percentage (%) was used for categorical variables. Chi-square tests were used to compare categorical variables, and ANOVA was used to compare continuous variables. Then, we estimated the direct effect of SNAP participation on the decline in global cognition, memory, and executive function using linear mixed models with random intercepts and random slopes for time for each participant. The random intercepts account for the individual variability in baseline cognitive performance, and the random slopes capture individual variability in the rate of cognitive decline over time. The model includes fixed effects for the intercept, time, SNAP, and the interaction between time and SNAP (SNAP*time). The model adjusted for potential confounders mentioned above.

To test whether SNAP participation affects cognitive decline differently across racial/ethnic groups, we included the following interaction terms in the models: SNAP participation and race/ethnicity, race/ethnicity and time, SNAP participation and time, and the three-way interaction between time, race/ethnicity, and SNAP participation. Two-sided $p<0.05$ was considered statistically significant.

To examine potential racial/ethnic disparities, we first calculated mean differences with 95% confidence intervals in annual global cognition, memory, and executive function scores by race/ethnicity, stratified by SNAP use status (SNAP user versus SNAP non-user). To examine whether the association between SNAP use and decline in global cognition varied across specific subgroups, we conducted additional subgroup analyses stratified by covariates, this approach helped investigate whether SNAP's effect on cognitive decline was consistent or varied across these key sociodemographic and health-related factors. To address possible within-group heterogeneity within racial/ethnic groups and potential differences in characteristics between SNAP users and non-users, we conducted stratified analyses by race/ethnicity.

Finally, to assess the robustness of our findings, we conducted two sensitivity analyses. First, we utilized Propensity Score Matching (PSM) to reduce potential bias from confounding variables. SNAP users and non-users were matched on the SNAP propensity score, and matching was done using the nearest neighbor method with replacement, setting 1:3 matching and caliper to be 0.01. Second, we conducted a sensitivity analysis in which SNAP participation was treated as a time-varying variable and participants who become income-ineligible for SNAP at any point during follow-up were excluded, thereby limiting the analytic sample to individuals who were consistently eligible for SNAP from 2010 to 2020. All analyses used RStudio version 2024.09.1.

3. RESULTS

Among the 2010 SNAP-eligible population, our sample included 1,131 (48.19%) SNAP users and 1,216 (51.81%) SNAP-eligible non-users. The average baseline global cognitive score was 15.60 out of 27. The unadjusted annual rate of global cognitive decline was slower among SNAP users compared to non-users (SNAP users: -0.10, non-users: -0.36). The participants were more likely to be female (74.7%) than male (25.3%), with an average age of 62.74 ± 10.84 years. Most participants were Non-Hispanic White (43.2%) and Non-Hispanic Black (30.6%). Sample participants had a median total household income of $8,195 (IQR: $0-$83,842) and 1.57 ± 1.32 chronic diseases. Most of the participants had health insurance coverage (64.70%) and did not report symptoms of depression (78.6%). The SNAP users were more likely to be younger (mean ± SD=59.57 ± 9.31 years) than non-users (mean ± SD=65.69 ± 11.32 years). A higher proportion of Non-Hispanic Black participants were among SNAP users (35.6%) compared with non-users (25.9%). A higher percentage of SNAP users were current smokers (32.7%) compared to non-users (20.0%). SNAP users were more likely to attend some colleges (27.6%) than non-users (23.1%) (Table 1).

Table 2 shows the associations between SNAP participation and the decline in global cognition, memory, and executive function over time across three models with progressively adjusted covariates. In all three models, time was negatively associated with global cognition (β = -0.19; 95% CI: -0.22, -0.15; $p < 0.001$), and two domains (memory β = -0.12; 95% CI: -0.15, -0.09; $p < 0.001$; executive function β = -0.05; 95%

CI: -0.07, -0.04; $p < 0.001$), showing an overall decline in cognitive function over time. The interaction term of SNAP and time was positively significant in all cognitive outcomes, which indicates that SNAP participation was associated with a slower decline in global cognition ($\beta = 0.10$; 95% CI: 0.05, 0.14; $p < 0.001$), memory ($\beta = 0.07$; 95% CI: 0.03, 0.11; $p < 0.001$), and executive function ($\beta = 0.03$; 95% CI: 0.01, 0.04; $p = 0.004$). The PSM analysis (Table 4) revealed similar results, as presented by the positive interaction terms of SNAP and Time, indicating that SNAP participation was associated with delayed declines in global cognition, memory, and executive function. Results from the sensitivity analysis were consistent with the main analysis (Table S1). SNAP participation was associated with a significantly slower annual decline in global cognition ($\beta = 0.12$, 95% CI: 0.07, 0.17, $p < 0.001$), memory ($\beta = 0.08$, 95% CI: 0.04, 0.11, $p < 0.001$), and executive function ($\beta = 0.04$, 95% CI: 0.02, 0.06, $p < 0.001$).

Table 3 shows the association between SNAP participation and declines in global cognition, memory, and executive function by race/ethnicity. The SNAP*NHB*Time ($\beta = -0.12$, 95% CI: -0.22, -0.01, $p = 0.04$) and SNAP*HIS*Time ($\beta = -0.12$; 95% CI: -0.23, -0.01; $p = 0.03$) interactions were significant, indicating that the Non-Hispanic Black and Hispanic participants among SNAP users have a slightly faster cognitive decline, compared with Non-Hispanic White. For memory and executive function, similar results were observed but did not reach statistical significance. Results from Table S2 also demonstrated the similar findings, SNAP participation was significantly associated with a slower rate of decline in global cognition ($\beta = 0.16$; 95% CI: 0.09, 0.23; $p < 0.001$), memory ($\beta = 0.12$; 95% CI: 0.06, 0.18; $p < 0.001$), and executive function ($\beta = 0.04$; 95% CI: 0.01, 0.07; $p = 0.006$) among Non-Hispanic White participants. However, the association was weaker and non-significant among Non-Hispanic Black and Hispanic participants.

Figure 1 further stratifies the association between SNAP participation and cognitive changes across different racial/ethnic groups over time. For global cognition, SNAP non-users exhibit accelerated cognitive decline than SNAP users across all racial/ethnic groups. The declines showed a greater variance across the racial/ethnic groups among SNAP non-users relative to SNAP users. Similar results are observed in the domains of memory and executive function.

To further test the association between SNAP participation and cognitive decline in

different population groups, we conducted subgroup analyses examining the association between SNAP participation and global cognitive decline, stratified by key covariates including depression status, education attainment, gender, insurance status, employment status, relationship status, and smoking status (Figure S2). The data shows that SNAP users have lower rates of annual cognitive decline than SNAP non-users among all subgroups. Additionally, the variance within each SNAP user's subgroup is smaller compared to that of SNAP non-users.

4. DISCUSSION

Our study examines the association between SNAP participation and decline in global cognition, memory, and executive function among older adults. The findings suggest that SNAP participation is associated with a slower decline in global cognition and the domains of memory and executive function, demonstrating a potential protective effect of SNAP participation on cognitive function. However, cognitive disparities across racial/ethnic groups exist. Non-Hispanic Black and Hispanic SNAP participants experience a faster decline in global cognition compared with Non-Hispanic White.

The results show that SNAP users had a slower rate of cognitive decline compared to SNAP non-users, suggesting SNAP participation could delay this cognitive decline. This trend was observed in global cognition and both domains, suggesting SNAP participation may play a comprehensive role in mitigating cognitive decline. Additionally, the PSM analysis demonstrated that the observed associations between SNAP participation and cognitive outcomes were robust to confound. Furthermore, sensitivity analyses that restricted the sample to participants who were consistently eligible for SNAP throughout the study period also showed similar results. These findings are consistent with previous research that has highlighted the positive impact of food security on cognitive function. Specifically, prior research has shown that improved nutritional intake associated with food assistance programs can improve brain health and delay cognitive decline.[6,18] Additionally, studies have found that food insecurity is linked to accelerated cognitive decline due to stress and nutritional deficiency.[29,30] Our results further expand upon this evidence by showing that the protective effect of SNAP is observed across global cognition as well as domain-specific measures of cognition, highlighting the role of food assistance programs in

supporting long-term cognitive health.

Although SNAP participation may offer cognitive protection and reduce variability in cognitive performance across racial/ethnic groups, racial/ethnic disparities still exist. While SNAP participation was generally associated with a slower rate of cognitive decline, this protective effect appeared weaker among Non-Hispanic Black and Hispanic participants, suggesting that the cognitive benefits of SNAP may be moderated by race/ethnicity. Hispanic and non-Hispanic Black SNAP users show slightly faster global cognition than non-Hispanic White participants. In other words, while SNAP participation is protective, it may not fully eliminate cognitive disparities among different racial/ethnic groups. This result is consistent with the context discussed in the introduction. Even Hispanic and Non-Hispanic Black population are eligible for SNAP enrollment, they have many barriers, such as troublesome application process, transportation challenges to farmer's markets, etc., to fully make use of SNAP benefits.[31-33] Future research is warranted to explore some potential unobservable variables contributing to these racial and ethnic disparities.

The subgroup analysis provides further evidence that SNAP participation may have a protective effect on cognitive health. In addition, it indicates that SNAP participation has the potential to reduce disparities in cognitive decline across different subgroups, which suggests that SNAP participation may contribute to promoting health equity in cognitive health.

The observed differences in cognitive decline across domains, such as executive function and memory, might reflect the fact that key nutrients and bioactives found in healthy foods can directly impact underlying brain structures that support cognitive function. For example, high-level executive function is influenced by dietary intake of nutrients such as protein, iron, and vitamins like B6 and B12.[36] Intake of dietary carotenoids lutein and zeaxanthin in dark green, leafy vegetables is associated with improved hippocampal white matter integrity, brain morphology, and memory function. These cognitive domains may respond differently to nutritional intervention, such as SNAP participation because they are influenced by different neurobiological processes.

Despite the significant findings, our study has some limitations. First, the use of self-reported data may introduce the potential for recall and social desirability bias. In particular, underreporting of SNAP participation is a well-documented concern in

survey data, with studies estimating false negative rates of 30% to 50%.[39,40] However, such underreporting could reduce our sample size, particularly if SNAP users are misclassified as non-users. Small sample size to get significant results, so we may see similar or even more pronounced result in a sample with accurate SNAP reporting. Second, although the HRS is nationally representative, the generalizability of our findings may be limited due to exclusions based on cognitive status, missing data, and follow-up availability. Also, we did not use sampling weights which may limit the generalizability. But this decision was made to prioritize model efficiency and minimize potential bias when estimating conditional associations between SNAP participation and cognitive outcomes. Third, there is some missing information about participants' cognitive status, SNAP participation status, and race/ethnicity, which might lead to bias. Fourth, unobserved factors such as enrollment motivation, social support, neighborhood and community factors, or unmeasured health conditions may differ between SNAP users and non-users, potentially influencing the observed associations. Fifth, the possibility of reverse causality cannot be entirely ruled out, as individuals experiencing cognitive decline may be more likely to enroll in SNAP. Although we excluded participants with cognitive impairment at baseline to reduce this risk, doing so may still have introduced selection bias if baseline cognitive status was associated with both SNAP participation and future cognitive trajectories.

Our study has some strengths that are worth noting. such as the fact that this is the first study to examine whether SNAP participation is associated with a slower rate of cognitive decline across racial/ethnic groups. This focus is important for identifying if food assistance programs can help reduce health inequalities. Given the fact that different nutrients and dietary bioactives impact cognitive function (and likely also risk for age-related cognitive decline) differently, this study provides groundwork for investigating the association between intake of nutrient-dense, higher quality diets and AD prevention in large, representative samples.

These results also have public health implications: expanding SNAP access may not only reduce food insecurity but may also help slow cognitive decline. AD is expected to cost the U.S. healthcare system more than $1trillion by 2050. To get more older adults at-risk for AD enrolled in SNAP (and ostensibly achieving the benefits we found for cognitive function), efforts to simplify application and recertification processes are

particularly important, and particularly important for Black and Hispanic adults, who are at higher risk for AD. Reducing administrative burdens, providing assistance with applications, offering online enrollment options, and ensuring culturally and linguistically appropriate outreach could help bridge participation gaps.

There are also clinical implications for our results. The baseline global cognition score was 15.6 (out of 27), indicating that most participants began the study cognitively intact. The average unadjusted annual cognitive decline was 0.36 points among non-SNAP users. Based on this rate, individuals in our study could be expected to progress to mild cognitive impairment (typically defined as a score <12) in approximately 10 years. In contrast, our adjusted regression model showed that SNAP participation was associated with a 0.10 point slower annual decline compared to non-users. If sustained, this slower rate could delay the onset of cognitive impairment by more than 35 years, highlighting a clinically meaningful protective effect. Consequently, SNAP advocacy from would facilitate providing a more comprehensive approach to managing cognitive health.

5. CONCLUSION

This study provides evidence that SNAP participation is associated with a slower decline in global cognition, memory, and executive function in older adults. These findings highlight the significance of food assistance programs in protecting cognitive health and reducing health disparities across racial/ethnic groups. Further research is warranted to explore the underlying mechanisms and to design interventions that can maximize the benefits of SNAP and other food assistance programs in improving cognitive outcomes for vulnerable populations. In addition, future work should aim to link self-reported survey datasets with administrative records to refine estimates of SNAP participation and thus provide more robust conclusions.[40]

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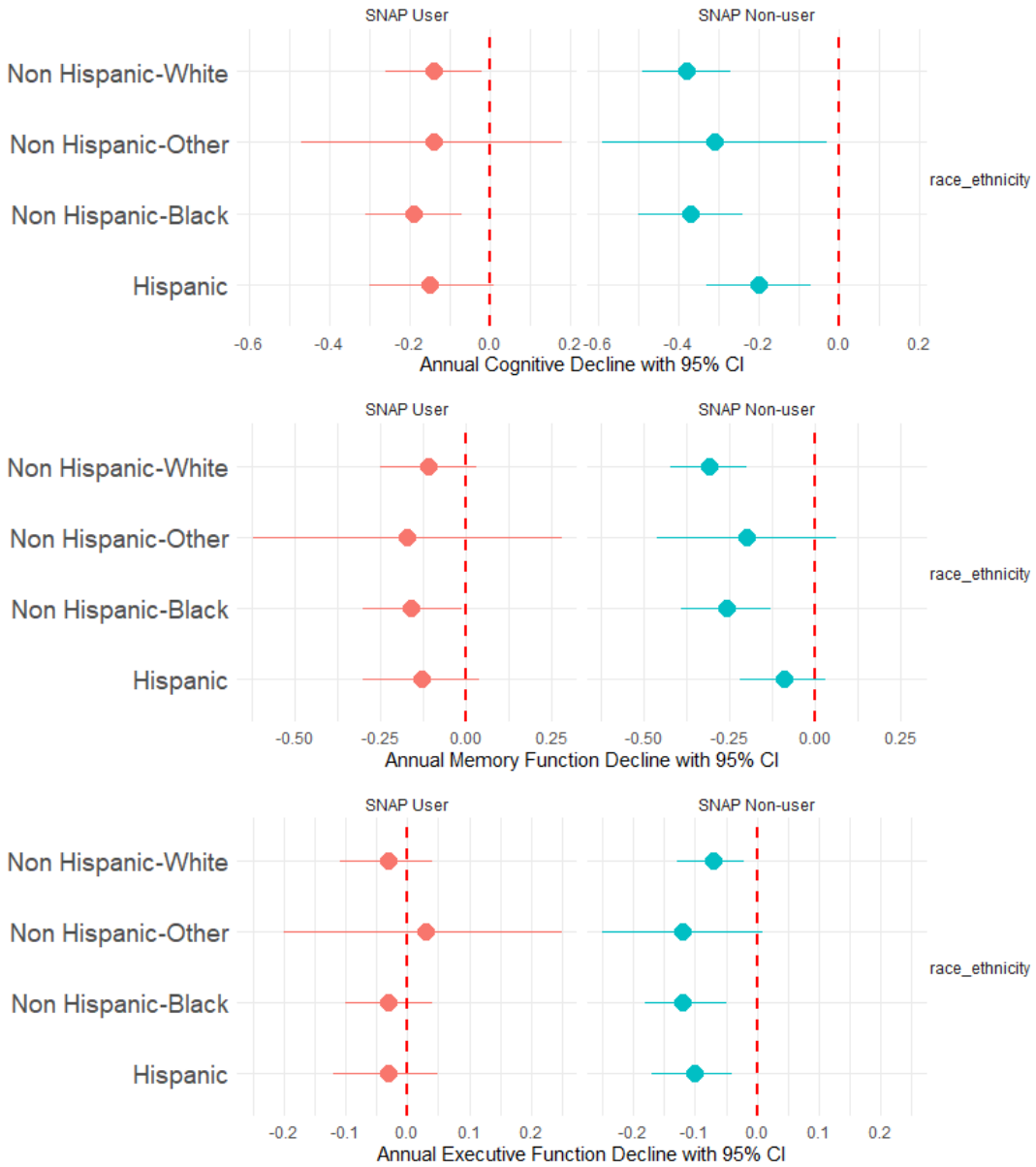

Figure 1 Annual decline in global cognition, memory, and executive function in SNAP users and non-users by race/ethnicity

Table 1 Baseline characteristics of SNAP Eligible participants by Participation Status: Health and Retirement Study, 2010-2020

Variables	**Total (N=2,347)**	**SNAP: No (N=1,216)**	**SNAP: Yes (N=1,131)**	**p-value**
Global Cognition (mean [SD])	15.60 (2.75)	15.52 (2.78)	15.67 (2.73)	0.185
Memory Score (mean [SD])	10.29 (2.40)	10.20 (2.42)	10.39 (2.38)	0.069
Executive Function Score (mean [SD])	5.30 (1.59)	5.32 (1.58)	5.29 (1.60)	0.647
Annual cognitive decline (mean [SD])	-0.27 (0.89)	-0.36 (1.06)	-0.10 (0.41)	<0.001
Age (mean [SD] in years)	62.74 (10.84)	65.69 (11.32)	59.57 (9.31)	<0.001
Race/Ethnicity (%)				<0.001
Non-Hispanic White	1013 (43.2)	554 (45.6)	459 (40.6)	
Non-Hispanic Black	718 (30.6)	315 (25.9)	403 (35.6)	
Non-Hispanic Other	81 (3.5)	42 (3.5)	39 (3.4)	
Hispanic	535 (22.8)	305 (25.1)	230 (20.3)	
Sex (%)				0.067
Mem	594 (25.3)	288 (23.7)	306 (27.1)	
Women	1753 (74.7)	928 (76.3)	825 (72.9)	
Marital Status (%)				<0.001
In a Relationship	683 (29.1)	302 (24.9)	381 (33.7)	
Previously in a Relationship	1391 (59.3)	776 (63.9)	615 (54.5)	
Never in a Relationship	270 (11.5)	137 (11.3)	133 (11.8)	
Total Wealth (median [IQR] in $)	8,195.00 (0.00-83,842)	23,766.50 (0.00-118,775)	2800.00 (0.00-49,375)	<0.001
Labor Status (%)				<0.001
Employed	539 (23.0)	229 (18.8)	310 (27.4)	
Unemployed	158 (6.7)	61 (5.0)	97 (8.6)	
Retired	1280 (54.5)	768 (63.2)	512 (45.3)	
Disabled	146 (6.2)	50 (4.1)	96 (8.5)	
Not in labor force	224 (9.5)	108 (8.9)	116 (10.3)	
Education (%)				<0.001
Less than High-school	666 (28.4)	362 (29.8)	304 (26.9)	
GED	162 (6.9)	61 (5.0)	101 (8.9)	
High-school graduate	725 (30.9)	410 (33.7)	315 (27.9)	
Some college	593 (25.3)	281 (23.1)	312 (27.6)	
College and above	200 (8.5)	101 (8.3)	99 (8.8)	
Insurance type (%)				<0.001
Medicare & Medicaid Dual-Eligible	1130 (48.1)	700 (57.6)	430 (43.6)	
Private	363 (15.5)	166 (13.7)	197 (17.4)	
CHAMPUS	25 (1.1)	14 (1.2)	11 (1.0)	
Uninsured	829 (35.3)	336 (27.6)	493 (43.6)	
Depression (%)				<0.001
No	1843 (78.6)	998 (82.2)	845 (74.8)	
Yes	501 (21.4)	216 (17.8)	285 (25.2)	
Smoke (%)				<0.001
Never smoking	958 (40.8)	564 (46.4)	394 (34.8)	
Ever smoking	775 (33.0)	408 (33.6)	367 (32.4)	
Current smoker	613 (26.1)	243 (20.0)	370 (32.7)	

Num of Chronic Diseases (mean [SD])	1.57 (1.32)	1.56 (1.30)	1.59 (1.34)	0.623
Drink (%)				0.864
Heavy drink	103 (4.4)	52 (4.3)	51 (4.5)	
Others	2235 (95.6)	1159 (95.7)	1076 (95.5)	
Physical Activity (mean [SD])	6.69 (4.07)	6.78 (4.14)	6.59 (4.00)	0.266

a) Abbreviations: SD: standard deviation; IQR: interquartile range; GED: General Educational Development; SNAP: the Supplemental Nutrition Assistance Program.

b) Non-Hispanic-Other: American Indian, Alaska Native, Asian, Native Hawaiian, Pacific Islander

c) The annual cognitive decline was calculated as the difference between the baseline and most recent cognitive scores divided by the number of follow-up years. (presented for reference)

Table 2 Association between SNAP and declines in global cognition, memory, and executive function

	Model1	Model2	Model3
Global Cognition			
SNAP*Time	0.09	0.10	0.10
95% CI	(0.05, 0.13)	(0.05, 0.14)	(0.05, 0.14)
p-value	<0.001	<0.001	<0.001
SNAP	-0.19	-0.10	-0.07
95% CI	(-0.36, 0.11)	(-0.35, 0.15)	(-0.33, 0.19)
p-value	0.29	0.43	0.85
Time	-0.19	-0.20	-0.19
95% CI	(-0.23, -0.16)	(-0.24, -0.17)	(-0.22, -0.15)
p-value	<0.001	<0.001	<0.001
Memory			
SNAP*Time	0.07	0.07	0.07
95% CI	(0.03, 0.10)	(0.03, 0.11)	(0.03, 0.11)
p-value	<0.001	<0.001	<0.001
SNAP	-0.20	-0.12	-0.10
95% CI	(-0.41, 0.01)	(-0.33, 0.08)	(-0.31, 0.11)
p-value	0.06	0.24	0.35
Time	-0.14	-0.13	-0.12
95% CI	(-0.17, -0.11)	(-0.16, -0.10)	(-0.15, -0.09)
p-value	<0.001	<0.001	<0.001
Executive Function			
SNAP*Time	0.03	0.03	0.03
95% CI	(0.01, 0.05)	(0.01, 0.05)	(0.01, 0.04)
p-value	<0.001	0.003	0.004
SNAP	-0.04	-0.02	0.00
95% CI	(-0.17, 0.09)	(-0.15, 0.11)	(-0.13, 0.13)
p-value	0.54	0.83	0.97
Time	-0.05	-0.05	-0.05
95% CI	(-0.07, -0.04)	(-0.07, -0.04)	(-0.07, -0.04)
p-value	<0.001	<0.001	<0.001

a) Note: Results are derived from linear mixed-effects models with random intercepts
b) Model 1 adjusted for time, age, race/ethnicity, gender, marital status.
c) Model 2 additionally adjusted for Total Wealth, Labor Status, Education, Insurance.
d) Model 3 additionally adjusted for Depression, Smoke, Drinking, Physical activity, and Number of Chronic Diseases.
e) CI: Confidence Interval, SNAP: the Supplemental Nutrition Assistance Program.

Table 3 The effect of SNAP on global cognition, memory, and executive function across different racial/ethnic groups

	Global Cognition β (95% CI)	**P-value**	**Memory** β (95% CI)	**P-value**	**Executive Function** β (95% CI)	**P-value**
SNAP	-0.06 (-0.43, 0.32)	0.77	0.05 (-0.25, 0.36)	0.73	-0.16 (-0.35, 0.04)	0.12
Non-Hispanic Black	-1.57 (-1.99, -1.15)	<0.001	-0.68 (-1.03, -0.33)	<0.001	-0.90 (-1.11, -0.68)	<0.001
Non-Hispanic Other	-1.06 (-1.96, -0.16)	0.02	-0.64 (-1.39, 0.11)	0.09	-0.47 (-0.94, 0.01)	0.05
Hispanic	-0.92 (-1.35, -0.49)	<0.001	-0.31 (-0.67, 0.05)	0.09	-0.64 (-0.87, -0.41)	<0.001
Time	-0.29 (-0.34, -0.24)	<0.001	-0.20 (-0.25, -0.16)	<0.001	-0.08 (-0.10, -0.05)	<0.001
SNAP*NHB	0.32 (-0.25, 0.88)	0.27	-0.04 (-0.51, 0.43)	0.87	0.36 (0.06, 0.66)	0.02
SNAP*NHO	-0.75 (-2.06, 0.56)	0.26	-0.99 (-2.08, 0.11)	0.08	0.22 (-0.47, 0.90)	0.54
SNAP*HIS	-0.21 (-0.82, 0.40)	0.51	-0.35 (-0.86, 0.16)	0.18	0.15 (-0.17, 0.48)	0.35
SNAP*Time	0.16 (0.09, 0.23)	<0.001	0.12 (0.06, 0.18)	<0.001	0.04 (0.01, 0.07)	<0.001
NHB*Time	0.15 (0.06, 0.23)	<0.001	0.10 (0.03, 0.17)	0.01	0.04 (0.00, 0.07)	0.05
NHO*Time	0.06 (-0.12, 0.25)	0.51	0.03 (-0.13, 0.18)	0.75	0.04 (-0.04, 0.12)	0.35
HIS*Time	0.19 (0.11, 0.27)	<0.001	0.14 (0.08, 0.21)	<0.001	0.04 (0.00, 0.07)	0.04
SNAP*NHB*Time	-0.12 (-0.22, -0.01)	0.04	-0.08 (-0.17, 0.01)	0.09	-0.03 (-0.08, 0.01)	0.15
SNAP*NHO*Time	0.08 (-0.18, 0.34)	0.55	0.14 (-0.08, 0.35)	0.22	-0.05 (-0.16, 0.06)	0.36
SNAP*HIS*Time	-0.12 (-0.23, -0.01)	0.03	-0.10 (-0.19, -0.00)	0.05	-0.02 (-0.07, 0.03)	0.42

Abbreviations: CI: confidence interval; NHW: Non-Hispanic-White/Caucasian; NHB: Non-Hispanic-Black/African American; NHO: Non-Hispanic-Other; HIS: Hispanic; SNAP: the Supplemental Nutrition Assistance Program.

Table 4 Propensity Score-matched model for association between SNAP and declines in global cognition, memory, and executive function (n= 6,244)

	Model1	**Model2**	**Model3**
Global Cognition			
SNAP*Time	0.09	0.07	0.07
95% CI	(0.03, 0.14)	(0.01, 0.12)	(0.01, 0.12)
p-value	<0.001	0.01	0.01
SNAP	-0.02	0.08	0.07
95% CI	(-0.30, 0.26)	(-0.18, 0.35)	(-0.21, 0.35)
p-value	0.89	0.54	0.64
Time	-0.19	-0.18	-0.18
95% CI	(-0.22, -0.16)	(-0.22, -0.15)	(-0.22, -0.15)
p-value	<0.001	<0.001	<0.001
Memory			
SNAP*Time	0.06	0.04	0.05
95% CI	(0.01, 0.10)	(0.00, 0.08)	(0.00, 0.09)
p-value	0.01	0.06	0.13
SNAP	-0.06	0.05	0.04
95% CI	(-0.29, 0.17)	(-0.18, 0.27)	(-0.14, 0.31)
p-value	0.60	0.67	1.00
Time	-0.13	-0.12	-0.12
95% CI	(-0.16, -0.10)	(-0.15, -0.09)	(-0.15, -0.09)
p-value	<0.001	<0.001	<0.001
Executive Function			
SNAP*Time	0.03	0.02	0.02
95% CI	(0.01, 0.05)	(0.00, 0.05)	(0.00, 0.04)

p-value	<0.001	0.03	0.07
SNAP	0.01	0.00	0.03
95% CI	(-0.14, 0.15)	(-0.14, 0.14)	(-0.11, 0.17)
p-value	0.92	0.97	0.65
Time	-0.06	-0.05	-0.05
95% CI	(-0.07, -0.04)	(-0.07, -0.04)	(-0.07, -0.04)
p-value	<0.001	<0.001	<0.001

a) Model 1 adjusted for time, age, race/ethnicity, gender, marital status.
b) Model 2 additionally adjusted for Total Wealth, Labor Status, Education, Insurance.
c) Model 3 additionally adjusted for Depression, Smoke, Drinking, Physical activity, and Number of Chronic Diseases.
d) CI: Confidence Interval, SNAP: the Supplemental Nutrition Assistance Program.

Table S1 Sensitivity analysis model for association between SNAP and declines in global cognition, memory, and executive function

	Global Cognition	Memory	Executive Function
SNAP*Time	0.12	0.08	0.04
95% CI	(0.07, 0.17)	(0.04, 0.11)	(0.02, 0.06)
p-value	<0.001	<0.001	<0.001
SNAP	0.06	-0.02	0.04
95% CI	(-0.24, 0.35)	(-0.26, 0.23)	(-0.12, 0.19)
p-value	0.71	0.88	0.65
Time	-0.19	-0.13	-0.05
95% CI	(-0.23, -0.16)	(-0.16, -0.10)	(-0.07, -0.04)
p-value	<0.001	<0.001	<0.001

a) Model adjusted for time, age, race/ethnicity, gender, marital status, Total Wealth, Labor Status, Education, Insurance, Depression, Smoke, Drinking, Physical activity, and Number of Chronic Diseases.

Table S2 Association between SNAP and declines in global cognition, memory, and executive function among different races/ethnicities

	Global Cognition	Memory	Executive Function
Non-Hispanic White			
SNAP*Time	0.16	0.12	0.04
95% CI	(0.09, 0.23)	(0.06, 0.18)	(0.01, 0.07)
p-value	<0.001	<0.001	0.006
SNAP	-0.18	-0.07	-0.16
95% CI	(-0.58, 0.21)	(-0.41, 0.26)	(-0.35, 0.03)
p-value	0.36	0.67	0.10
Time	-0.29	-0.20	-0.08
95% CI	(-0.34, -0.24)	(-0.24, -0.16)	(-0.10, -0.05)
p-value	<0.001	<0.001	<0.001
Non-Hispanic Black			
SNAP*Time	0.05	0.05	0.01
95% CI	(-0.03, 0.14)	(-0.03, 0.12)	(-0.02, 0.05)
p-value	0.21	0.22	0.47
SNAP	0.33	0.09	0.21
95% CI	(-0.13, 0.78)	(-0.29, 0.47)	(-0.04, 0.46)
p-value	0.16	0.64	0.11
Time	-0.14	-0.10	-0.04
95% CI	(-0.21, -0.07)	(-0.16, -0.04)	(-0.07, -0.01)
p-value	<0.001	<0.001	0.006
Non-Hispanic Other			
SNAP*Time	0.24	0.27	-0.02
95% CI	(-0.07, 0.55)	(0.01, 0.53)	(-0.15, 0.11)
p-value	0.12	0.04	0.72
SNAP	-1.06	-1.19	0.08
95% CI	(-2.51, 0.38)	(-2.52, 0.15)	(-0.63, 0.79)
p-value	0.15	0.08	0.82
Time	-0.23	-0.18	-0.04
95% CI	(-0.45, 0.00)	(-0.37, 0.01)	(-0.13, 0.06)
p-value	0.04	0.07	0.43
Hispanic			
SNAP*Time	0.04	0.02	0.03
95% CI	(-0.04, 0.13)	(-0.05, 0.10)	(-0.01, 0.06)
p-value	0.33	0.57	0.14
SNAP	-0.11	-0.23	0.07
95% CI	(-0.61, 0.39)	(-0.63, 0.17)	(-0.22, 0.35)
p-value	0.68	0.26	0.64
Time	-0.11	-0.06	-0.04
95% CI	(-0.17, -0.05)	(-0.12, -0.01)	(-0.06, -0.01)
p-value	<0.001	0.01	0.002

a) Model adjusted for time, age, race/ethnicity, gender, marital status, Total Wealth, Labor Status, Education, Insurance, Depression, Smoke, Drinking, Physical activity, and Number of Chronic Diseases.

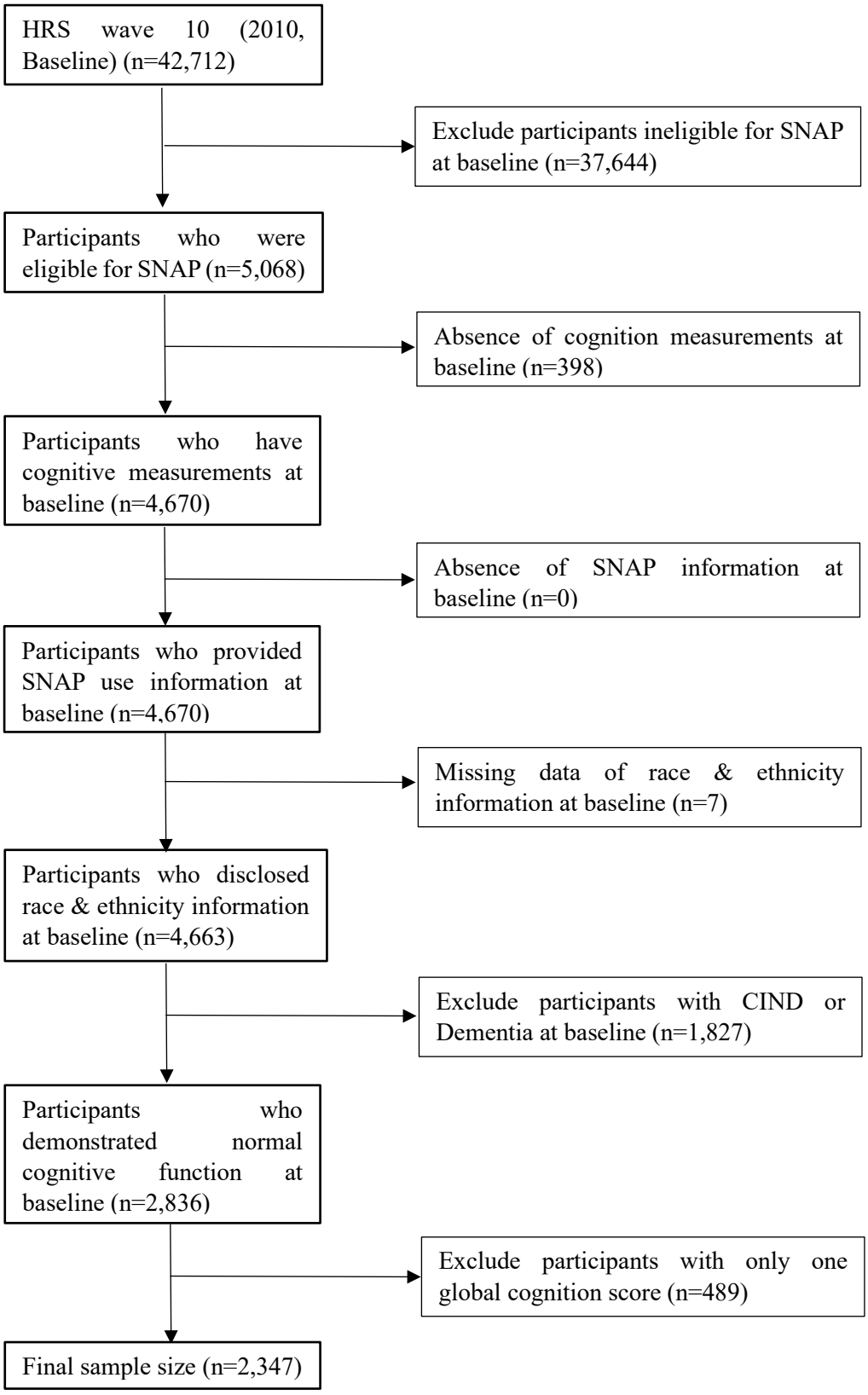

Figure S1 Participants selection diagram

Abbreviation: HRS: Health and Retirement Study; SNAP: Supplemental Nutrition Assistance Program; CIND: Cognitive impairment with no dementia)

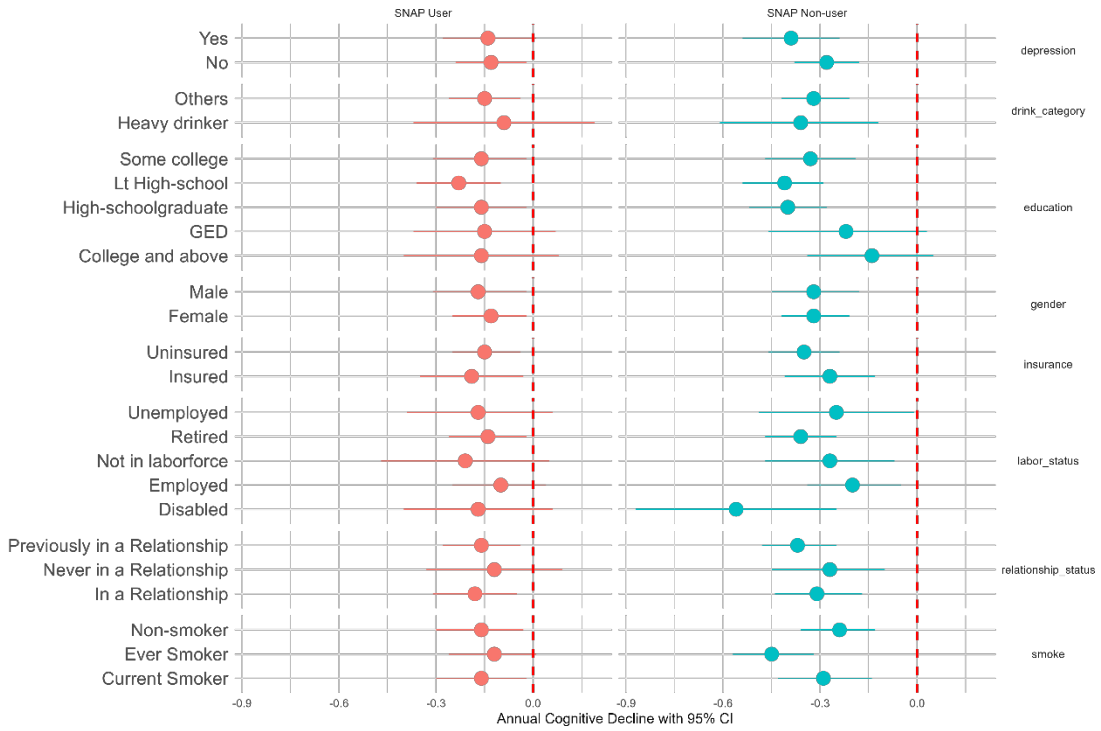

Figure S2 Subgroup analyses for association between SNAP and the annual decline in global cognition

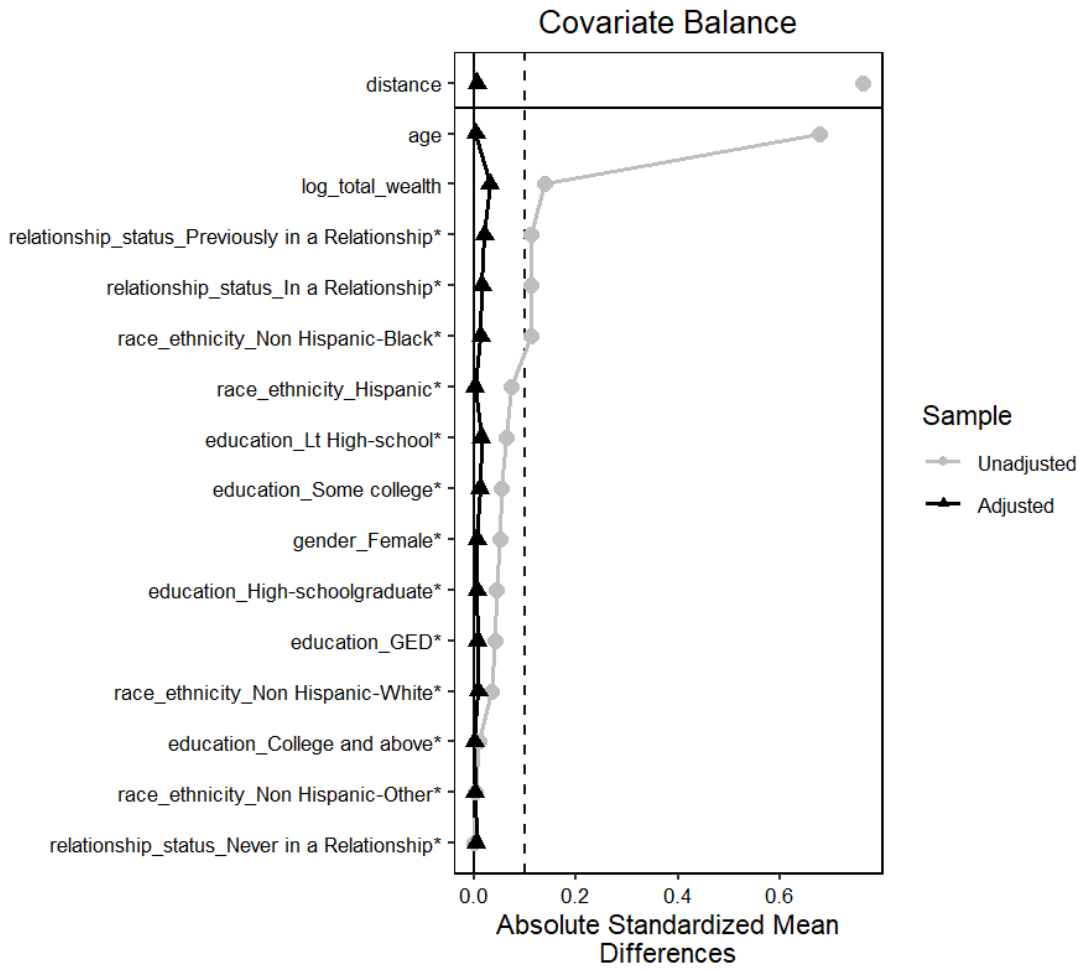

Figure S3 Standardized Mean Differences Before and After Propensity Score Matching