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Alternate Healthy Eating Index is Positively Associated with Cognitive Function Among Middle-Aged and Older Hispanics/Latinos in the HCHS/SOL

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ABSTRACT

Background: Diet quality may be an important area of focus for promoting cognitive health; however, the association between diet quality and cognitive function among Hispanics/Latinos remains largely unexamined. We hypothesized that a healthier diet quality will be associated with better cognitive function in middle-aged and older Hispanics/Latinos.

Objective: The objective of this study was to examine associations between the Alternate Healthy Eating Index (AHEI-2010), a measure of diet quality, and cognitive function in middle-aged and older Hispanics/Latinos.

Methods: Data from the Hispanic Community Health Study/Study of Latinos (HCHS/SOL) Visit 1 (2008–2011) were used ($n = 8461$; ages 45–74 y). Cognitive function was assessed with tests of verbal learning and memory, verbal fluency, and processing speed; a global cognition score was derived by summing the *z* scores of individual tests. Dietary intake was assessed via two 24-h recalls. Total AHEI-2010 score was categorized into quintiles (higher quintiles indicating healthier diet). Linear regression models were used to examine associations between AHEI-2010 quintiles and cognitive function adjusting for sociodemographic characteristics, daily energy intake, type 2 diabetes, smoking, and depressive symptoms.

Results: Compared with the lowest quintile, in the second to fourth AHEI-2010 quintiles, global cognition scores were significantly higher by 0.28, 0.52, and 0.48 units (P-trend = 0.042). In the second to fifth AHEI-2010 quintiles, verbal learning scores were significantly higher by 0.60, 0.62, 0.92, and 0.88 units, and verbal memory scores were higher by 0.33, 0.40, 0.52, and 0.46 units (P-trend = 0.020 and 0.007, respectively). No associations were observed between the AHEI-2010 and verbal fluency or processing speed (P-trend = 0.49 and 0.84, respectively). Among AHEI-2010 components, adequate consumption of vegetables, alcohol, and whole fruits were each associated with better cognitive function.

Conclusions: An overall healthier diet quality was associated with better global cognition, verbal learning, and verbal memory in middle-aged and older Hispanics/Latinos. *J Nutr* 2020;150:1478–1487.

Keywords: cognitive function, diet quality, dietary pattern, AHEI-2010, Hispanics, Latinos, minority health, HCHS/SOL

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Introduction

Diet quality is an understudied potential target for promoting cognitive health among middle-aged and older Hispanics/Latinos, a growing segment of the population in the United States (1) at high risk for accelerated cognitive decline (2). Overall diet quality refers to a pattern of food and nutrient consumption reflecting the complexity of nutritional adequacy for optimal health (3). Diet quality is a potentially modifiable lifestyle factor that may play a role in cognitive health through indirect [e.g., lower burden of cardiovascular disease risk factors (CVD-RFs) such as hypertension, obesity, and hypercholesterolemia] (4–6) and direct mechanisms (e.g., lower inflammation) (7, 8). It is possible that these mechanisms exert their effects on cognitive health by limiting oxidative stress in nervous cells and increasing protection against the adverse effects of developing neuropathology (9). In fact, a growing body of evidence has associated an overall healthier diet quality with better brain and aging-related outcomes (6, 10–12).

The Alternate Healthy Eating Index-2010 (AHEI-2010) represents adherence to overall healthy dietary pattern recommendations. The AHEI-2010 is an empirically based measure of diet quality based on items known to be predictive of major chronic disease risk, particularly CVD, stroke, diabetes, and cancer (13). It emphasizes high intake of vegetables, whole fruits, whole grains, nuts and legumes, ω-3 fats, and PUFA, while limiting intake of red and processed meats, *trans* fat, sodium, sugary beverages, and alcohol (13). Research has shown good validity and reproducibility of the AHEI-2010 across US racial/ethnic populations (14); however, studies on the associations between AHEI-2010 and cognitive function are surprisingly sparse. To date, available studies have reported no association between AHEI-2010 and cognitive function outcomes among US adults aged $\geq$65 y including non-Hispanic white women in the Nurses' Health Study (15), Women's Health Initiative Memory Study (16), and non-Hispanic white women and men in the Rancho Bernardo Study of Healthy Aging (17). Further, it was recently shown that higher AHEI-2010 during mid-life does not protect against Alzheimer disease in late-life among non-Hispanic whites in the Whitehall II study (18). In contrast, higher AHEI-2010 in mid-life was associated with lower risk of cognitive impairment in late-life among older Chinese adults (19). Among Puerto Ricans adults living in Boston, higher AHEI-2010 was associated with higher 2-y memory function among those without type 2 diabetes but not among participants with type 2 diabetes (20). Notably, the generalizability of the current evidence on the associations between AHEI-2010 and cognitive function to middle-aged and older US Hispanics/Latinos of diverse backgrounds, many of whom are of relatively lower household income and educational attainment, remains unclear.

We used baseline data from the Hispanic Community Health Study/Study of Latinos (HCHS/SOL) to examine the cross-sectional associations between AHEI-2010 and cognitive function in middle-aged and older Hispanics/Latinos of diverse backgrounds, independent of sociodemographic characteristics, daily energy intake, type 2 diabetes, smoking, and depressive symptoms, all of which could be confounders in the diet–cognition association. We also tested whether sex, Hispanic/Latino background, or presence of type 2 diabetes—some of which have been the target of previous work studying the AHEI-2010 and cognition association (15–17, 20)—modify the AHEI-2010 and cognitive function associations. In secondary analyses, we examined the associations of individual AHEI-2010 components with statistically significant cognitive function tests (to assess the role of each dietary component). A better understanding of these AHEI-2010 and cognitive function associations among Hispanics/Latinos may help to inform culturally appropriate approaches to promote cognitive health in this rapidly growing but understudied segment of the US population.

Methods

Study population

The HCHS/SOL is a community-based prospective cohort study of Hispanic/Latino adults who were aged 18–74 y at recruitment (21). The cohort includes 16,415 participants who self-identified as having Cuban, Central American, Dominican, Mexican, Puerto Rican, or South American backgrounds (21, 22). Baseline (Visit 1) study enrollment was conducted from 2008 to 2011 in 4 designed community areas with field centers located in the Bronx, NY; Chicago, IL; Miami, FL; and San Diego, CA. The goals of the HCHS/SOL are to describe the prevalence of risk and protective factors for chronic conditions and diseases over time. Baseline data were used in the current study. The probability-based sampling designed used in HCHS/SOL allows estimation of the prevalence of chronic conditions and their putative antecedent factors in the target population (22). The Institutional Review Boards of all affiliated institutions approved the study. All participants provided written informed consent.

This study focused on 9705 participants aged 45–74 y who were eligible to complete the cognitive function module. We excluded 522 participants with self-reported heart attack, stroke, mini-stroke, or transient ischemic attack because of potential confounding effects on cognitive function. We also excluded 540 participants with missing data on any of the cognitive function variables, 159 participants with missing data on AHEI-2010, and 363 participants with missing data on any of the model covariates. The final analytic sample comprised 8461 participants of the baseline HCHS/SOL examination.

Data collection

Detailed methodology for data collection was previously described (18, 21). Briefly, the baseline examination included a comprehensive array of biological (e.g., anthropometrics, blood draw, and oral glucose tolerance test), lifestyle (e.g., physical activity, tobacco use, and alcohol use), and sociodemographic (e.g., income, education, and employment status) assessments. All assessments were conducted in the field centers by trained bilingual personnel in the preferred language of the participant (i.e., English or Spanish). Fasting blood samples were collected soon after arrival and shipped to the central laboratory for analysis. A Roche Modular P Chemistry Analyzer was used to analyze plasma glucose (Roche Diagnostics). All field center procedures and laboratory protocols have been previously posted to the HCHS/SOL website (23).

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Supplemental Tables 1–3 are available from the "Supplementary data" link in the online posting of the article and from the same link in the online table of contents at https://academic.oup.com/jn/.

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Abbreviations used: AHEI-2010, Alternate Healthy Eating Index-2010; CVD-RF, cardiovascular disease risk factor; HCHS/SOL, Hispanic Community Health Study/Study of Latinos.

Dependent variables: cognitive function

Detailed methods describing the HCHS/SOL neurocognitive assessments were previously published (24). Briefly, cognitive function tests were conducted during face-to-face interviews by trained research staff in the preferred language of the participant. Cognitive function measures, which assess important daily activities associated with aging including learning, memory, and attention/executive functioning, administered in the HCHS/SOL were chosen because they have been shown to be adequate for use among Hispanics/Latinos and Spanish speakers. Verbal learning and verbal memory were assessed using the abbreviated version of the Brief Spanish-English Verbal Learning Test (25, 26). The verbal learning score is the sum of the number of items correctly recalled across 3 learning trials (range: 0–45) and the verbal memory score is the sum of the number of items correctly recalled post-interference (range: 0–15). Verbal fluency was assessed through an adapted version of the Word Fluency test of the Multilingual Aphasia Examination (27, 28). Participants were asked to generate as many words as possible in 60 s that began with the letter *F* in the first trial and the letter *A* in the second trial; the verbal fluency score is the sum of the correctly generated words across both trials (range: 0–50). Processing speed was assessed using the Digit Symbol Subtest of the Wechsler Adult Intelligence Scale Revised (29). Participants were asked to write the corresponding symbol under each digit. Processing speed score is the sum of the number of correctly identified symbols in 90 s (range: 0–90). From the individual cognitive function tests, we created a global cognitive function score by summing the *z* scores [i.e., (individual value − mean value)/standard deviation] for performance across these 4 cognitive indices (i.e., verbal learning, verbal memory, verbal fluency, and processing speed). All cognitive function indices were treated as continuous variables with higher scores representing better cognitive function.

Independent variable: diet quality

Detailed methods for dietary data collection in the HCHS/SOL have been previously published (30, 31). Briefly, diet quality was assessed using data from two 24-h dietary recalls administered by trained interviewers in the participant's language of preference. The first recall was administered in-person at the baseline examination and the second recall was administered over the telephone about 5–90 d after the baseline visit (with only 5% administered more than 46 d after). Food models (in-person) and a food-amount booklet (telephone) were used by the participants to estimate portion sizes. Recalls were conducted using the Nutrition Data System for Research dietary analysis software application (version 2011), which contains over 18,000 foods, about 8000 brand name products, and has applicability across Hispanic/Latino backgrounds (as it includes a variety of ethnic and regional foods). Dietary recalls were excluded if daily energy intake was below the sequence sex-specific 1st percentile or above the 99th percentile, or if the interviewer determined it was unreliable because the participant could not recall food intake. The AHEI-2010 score was computed, if a participant had at least one 24-h dietary recall after exclusions. Among the HCHS/SOL participants, 97% and 91% had the 1st and 2nd dietary recall considered reliable, respectively.

In the present study, diet quality was defined based on the AHEI-2010 scoring criteria proposed by Chiuve et al. (13) and operationalized in accordance with a previous HCHS/SOL study (31) as shown in **Supplemental Table 1**. The National Cancer Institute method (32) was used to estimate the usual intake amounts for each AHEI-2020 component. For each dietary component, score ranges from 0 to 10 based on minimal to maximal observance of recommended intake amount (reflecting either current dietary guidelines or associations previously reported in the literature). Intermediate intakes were scored proportionately between 0 and 10 (33). There are 6 components for which highest intake is considered the healthiest [i.e., vegetables without potatoes, whole fruits without fruit juice, whole grains, nuts and legumes, long-chain ω-3 fatty acids, and PUFA (excluding long chain n-3)], 1 component for which low-to-moderate intake is considered the healthiest (i.e., alcohol), and 4 components for which avoidance or lowest intake is considered the healthiest (i.e., sugar-sweetened beverage and fruit juice, red and processed meats, *trans* fat, and sodium). Whole grains and alcohol intake had sex-specific recommendations. The total AHEI-2010 score is computed as the sum of the 11 dietary components (range 0–110) with higher scores representing healthier diet quality based on the extent to which recommended intakes of each item are met. To capture the presence of fine gradations and/or nonlinear associations, the AHEI-2010 score and its components were categorized according to quintiles of roughly equal size based on the overall sample. The first AHEI-2010 quintile represents the unhealthiest diet quality while the fifth quintile represents the healthiest diet quality. In secondary analyses, AHEI-2010 was also treated as a continuous variable to assess the robustness of the associations.

Covariates

Our covariates included self-reported sociodemographic factors: age, sex, Hispanic/Latino background, education (<high school, high school graduate, or >high school), annual household income (<$20,000, $20,000–$50,000, >$50,000, or not reported), and language preference for baseline examination. Participants who declined to report their household income were included as a category to avoid deleting those observations. In analysis of effect modification by Hispanic/Latino background, those in the "other or more than one Hispanic/Latino background" category were excluded from analysis to allow for conceptually meaningful comparisons across backgrounds. Total daily energy intake was also included as a covariate. According to the American Diabetes Association (34), type 2 diabetes was defined as fasting plasma glucose ≥126 mg/dL, 2-h-postload plasma glucose ≥200 mg/dL, and hemoglobin A1c ≥6.5%, or use of type 2 diabetes medication. Current smoking status was self-reported. Depressive symptoms were ascertained with the 10-item version of the Center for Epidemiologic Studies Depression scale (35).

Statistical analysis

Five major steps were followed to conduct the statistical analysis of this study. First, we estimated the weighted means and SEs of the AHEI-2010 total score and its components for the target population. Second, descriptive statistics of all covariates were estimated for the target population and according to AHEI-2010 quintiles. Differences in covariates across AHEI-2010 quintiles were examined using chi-square tests for categorical variables and F-tests for continuous variables.

Third, in our main analyses, survey-weighted adjusted linear regression models were used to evaluate the associations of AHEI-2010 (with first quintile defined as referent) with each of the cognitive function outcomes. The base model was adjusted for age, sex, education, and log of daily total energy intake (i.e., Model 1). The fully adjusted model also included Hispanic/Latino background, annual household income, language preference for baseline interview, type 2 diabetes, smoking, and depressive symptoms (i.e., Model 2). Further adjustment for hypertension, hypercholesterolemia, C-reactive protein, BMI, or physical activity did not change our results (data not shown); thus, these factors were not considered confounders in the current study. Tests of linear trend across increasing AHEI-2010 quintiles were conducted by assigning the medians to each quintile and treating it as a continuous variable. Main analyses were repeated treating AHEI-2010 as continuous to assess robustness of findings. Fourth, to explore whether sex, Hispanic/Latino background, or type 2 diabetes modified the association between AHEI-2010 and cognitive function, we included each interaction term separately in the fully adjusted model using survey-weighted linear regression analysis. Finally, secondary analyses were conducted to identify whether statistically significant associations might be attributable to specific dietary components. These secondary models examined the associations between AHEI-2010 components and cognitive function adjusting for all covariates and each of the other dietary components.

Data management was performed using SAS 9.4 software (SAS Institute) and all statistical analyses were performed using Stata Statistical Software Release 15 (Stata Corp LP). All analyses accounted for the complex study design. All reported values are weighted, except sample size which are unweighted. Significance level of $P < 0.05$ was used.

Results

Descriptive statistics

Table 1 presents descriptive statistics for the overall target population and by quintile of AHEI-2010. The mean age of the target population was 56 y and 56% were female. The mean AHEI-2010 score for the overall target population was 50.2 ± 0.2 (Supplemental Table 1). Compared to those in the lowest AHEI-2010 quintile, those in the highest quintile tended to be older, male, of Mexican heritage, and reported higher annual household income (all $P < 0.001$). As AHEI-2010 quintiles increased, we observed lower depressive symptoms scores, higher percentage of type 2 diabetes, and lower percentage of current smokers (all $P < 0.001$). In addition, higher AHEI-2010 quintiles were generally associated with lower levels of C-reactive protein and BMI, and meeting the 2008 US physical activity guidelines, whereas the opposite was observed for hypercholesterolemia and no differences were observed in hypertension across AHEI-2010 quintiles (data not shown). Finally, as AHEI-2010 quintiles increased, we observed higher verbal learning, verbal memory, and verbal fluency scores.

Association between diet quality and cognitive function

Table 2 displays results of the adjusted associations between AHEI-2010 quintiles and cognitive function. In base models (Model 1), the highest AHEI-2010 quintile was significantly associated with higher global cognition (Q5: β: 1.32; 95% CI: 1.05, 1.59), verbal learning (Q5: B: 2.38; 95% CI: 1.34, 2.92), verbal memory (Q5: B: 1.40; 95% CI: 1.11, 1.69), verbal fluency (Q5: B: 2.33; 95% CI: 1.57, 3.10), and processing speed (Q5: B: 1.34; 95% CI: 0.09, 2.59), compared to the lowest AHEI-2010 quintile. There was evidence of a linear trend in all of these relations; specifically, global cognition, verbal learning, verbal memory, verbal fluency, and processing speed scores were each significantly higher across the second to fourth AHEI-2010 quintiles (P-trend ≤ 0.010).

In fully adjusted models (Model 2), the association between the highest AHEI-2010 quintile and global cognition was no longer significant (Q5: β: 0.32; 95% CI: -0.01, 0.65). In contrast, the associations of the second to fourth AHEI-2010 quintiles (versus first) with global cognition remained significant. The associations of second to fourth quintiles of AHEI-2010 with verbal learning and verbal memory remained significant although attenuated. We observed evidence of a linear trend in these associations of AHEI-2010 with global cognition, verbal learning, and verbal memory (i.e., higher cognitive function scores with increasing AHEI-2010 quintiles; P-trend ≤ 0.050). AHEI-2010 was not significantly associated with verbal fluency or processing speed in the fully-adjusted Model 2, and there was no evidence of a linear trend. When treating AHEI-2010 as a continuous measure, each 10-unit increase in AHEI-2010 was associated with higher verbal learning (B: 0.31; 95% CI: 0.02, 0.61) and verbal memory (B: 0.17; 95% CI: 0.02, 0.31) (**Supplemental Table 2**).

Interaction effects

There was no evidence of interaction by sex or by type 2 diabetes in any of the associations of AHEI-2010 (treated as quintiles) and any cognitive metric in the fully adjusted Model 2 (all P-interaction > 0.05). Therefore, stratified analyses by sex or by diabetes status were not conducted. There was evidence of interaction by Hispanic/Latino background only in the association between AHEI-2010 (treated as quintiles) and verbal memory in the fully adjusted Model 2 (P-interaction = 0.013). Hence, we conducted additional stratified analysis between AHEI-2010 quintiles and verbal memory by Hispanic/Latino background adjusting for all covariates except Hispanic/Latino background (**Supplemental Table 3**). The highest AHEI-2010 quintile (versus lowest) was associated with higher verbal memory among Mexicans (B: 1.5; 95% CI: 0.7, 2.3; P-trend < 0.001) and Puerto Ricans (B: 1.5; 95% CI: 0.4, 2.6; P-trend < 0.010) but not among Dominicans, Central Americans, Cubans, or South Americans. Significant findings were replicated among Puerto Ricans but not among Mexicans when treating AHEI-2010 as continuous.

Associations between components of AHEI-2010 score and cognitive function

Secondary analyses tested the associations of each AHEI-2010 component with the statistically significant cognitive function outcomes (Table 3), adjusting for all covariates included in Model 2 as well as the other dietary components. Compared to those at the lowest quintile, those with the highest intake of vegetables had significantly higher global cognition (β: 0.35; 95% CI: 0.03, 0.66), verbal learning (B: 0.72; 95% CI: 0.10, 1.34), and memory (B: 0.44; 95% CI: 0.11, 0.76) scores with evidence of a linear trend (P-trend ≤ 0.05). Those with the highest intake of whole fruits had a significantly higher global cognition score (β: 0.39; 95% CI: 0.10, 0.69) with evidence of a linear trend (P-trend < 0.001). Those at the highest alcohol consumption quintile, representing low-to-moderate intake, had higher global cognition (0.52; 95% CI: 0.22, 0. 83), verbal learning (B: 1.13; 95% CI: 0.49, 1.76), and memory (B: 0.53; 95% CI: 0.21, 0.85) scores with evidence of a linear trend (P-trend ≤ 0.010). No associations were observed of the highest quintile of the other dietary components (i.e., whole grains, sugar-sweetened beverages and fruit juice, nuts and legumes, red/processed meats, *trans* fat, ω-3 fatty acids, PUFA, and sodium) with any of cognitive function variables.

Discussion

In a large sample of middle-aged and older US Hispanics/Latinos of diverse backgrounds, we found that healthier diet quality was associated with higher global cognition, verbal learning, and verbal memory independent of sociodemographic characteristics, daily total energy intake, type 2 diabetes, current smoking, and depressive symptoms which are known contributors to cognitive decline and Alzheimer disease and related dementias. The association of diet quality and memory was stronger among those of Mexican and Puerto Rican backgrounds. Furthermore, our results suggest that cognitive benefits may be gained mostly from adhering to recommended intake of vegetables and low-to-moderate alcohol consumption, and to a lesser extent, whole fruits.

Results of our study contribute to the literature in several ways. First, our study used a more comprehensive approach to assess cognitive function than previous research that relied upon cognitive screening tools (such as Mini-Mental State Examination) and/or telephone adaptations. Second, our study moves beyond cohorts of US older non-Hispanic whites of higher income and education (15–17) to suggest that AHEI-2010 is associated with global cognition, verbal learning, and verbal

TABLE 1 Characteristics of the overall target population and according to AHEI-2010 quintiles: among middle-aged and older Hispanics/Latinos, HCHS/SOL: 2008–2011[1]

Characteristics	All	Quintiles of AHEI-2010[2]					
		Q1 (0.00–42.24)	Q2 (42.25–46.49)	Q3 (46.50–50.61)	Q4 (50.62–55.59)	Q5 (55.60–110.00)	
n	8461	1055	1487	1700	1953	2266	*P*[3]
Age, y	56.0 ± 0.1	52.9 ± 0.3	55.3 ± 0.3	56.5 ± 0.3	56.3 ± 0.4	57.4 ± 0.3	<0.001
Sex, %							
Female	56.0	66.6	56.1	55.6	60.3	45.8	<0.001
Male	44.0	33.4	43.9	44.4	39.7	54.2	
Hispanic/Latino background, %							
Central American	6.7	2.1	5.8	9.4	9.8	10.3	<0.001
Cuban	27.0	45.3	48.2	32.4	15.9	3.8	
Dominican	8.4	1.1	3.5	10.6	13.4	10.3	
Mexican	32.3	2.5	5.6	20.5	43.0	73.7	
Puerto Rican	17.4	41.9	27.6	17.4	9.4	1.4	
South American	5.8	5.1	7.3	7.0	5.9	3.9	
Other/more than one	2.3	2.1	2.0	2.6	2.6	2.2	
Education, %							
<High school	37.5	29.9	31.3	36.8	40.9	45.1	<0.001
High school	22.0	28.5	28.0	19.8	19.7	17.3	
>High school	40.5	41.7	40.7	43.4	39.4	37.6	
Annual household income, %							
<$20,000	44.5	49.8	47.0	49.2	39.4	39.6	<0.001
$20,000–$50,000	35.1	33.2	32.5	32.8	38.0	38.0	
>$50,000	11.6	7.7	8.7	9.9	13.1	16.4	
Not reported	8.8	9.2	11.8	8.1	9.5	6.0	
Language preference, %							
Spanish	86.0	75.0	85.3	86.3	89.8	89.5	<0.001
English	14.0	25.0	14.7	13.7	10.2	10.5	
Depressive symptoms[4]	7.4 ± 0.1	9.4 ± 0.3	7.8 ± 0.2	7.5 ± 0.3	7.0 ± 0.2	6.0 ± 0.2	<0.001
Energy intake, kcal/d	1853 ± 11	1923 ± 21	1924 ± 19	1841 ± 23	1759 ± 18	1851 ± 14	<0.001
Diabetes, %	26.1	23.2	23.2	24.7	26.1	31.7	<0.001
Current smoking, %	20.1	32.6	29.0	20.9	12.9	11.0	<0.001
Cognitive function							
Global cognition[5]	0.2 ± 0.1	0.1 ± 0.1	0.0 ± 0.1	0.1 ± 0.1	0.4 ± 0.1	0.3 ± 0.1	0.057
Verbal learning	22.7 ± 0.1	22.2 ± 0.2	22.4 ± 0.2	22.5 ± 0.2	23.2 ± 0.2	23.0 ± 0.2	0.004
Verbal memory	8.2 ± 0.1	7.9 ± 0.1	8.0 ± 0.1	8.2 ± 0.1	8.5 ± 0.1	8.4 ± 0.1	<0.001
Verbal fluency	18.6 ± 0.2	17.9 ± 0.3	17.9 ± 0.2	18.7 ± 0.3	19.0 ± 0.3	19.1 ± 0.3	0.004
Processing speed	34.4 ± 0.3	36.9 ± 0.6	34.6 ± 0.5	33.8 ± 0.5	34.3 ± 0.6	33.5 ± 0.6	<0.001

[1]Values are percentages (%) or means ± SEs. All reported results are weighted except number of observations which are unweighted. AHEI-2010, Alternate Healthy Eating Index; HCHS/SOL, Hispanic Community Health Study/Study of Latinos (HCHS/SOL); Q, quintile.
[2]Q1: represents the unhealthiest diet quality. Q5: represents the healthiest diet quality. Values in parentheses indicate the range of the AHEI-2010 score for each quintile.
[3]*P*-values refer to differences across quintiles and were calculated using chi-square tests for categorical variables and F-tests for continuous variables.
[4]Depressive symptoms score was assessed using the 10-item Center for Epidemiologic Studies Depression Scale.
[5]Cognitive function was calculated by summing the *z* scores [i.e., (individual value − mean value)/SD] for performance across the 4 cognitive tests (i.e., verbal learning, verbal memory, verbal fluency, and processing speed).

memory among middle-aged and older Hispanics/Latinos of relatively lower income and education. Finally, our results, if replicated longitudinally, suggest there may be utility of an overall healthier diet (based on the recommendations of the AHEI-2010 food and nutrient components) as a tool to promote better cognitive health outcomes in Hispanics/Latinos, which may provide additional incentive for dietary change in this population. Towards this end, our study addresses previous calls (10) for more research to build a body of evidence among racial/ethnic minorities that could inform the development of targeted dietary guidelines to promote cognitive health.

Previous studies have reported conflicting findings on the AHEI-2010 and cognition associations. Our findings on the associations of an overall healthier diet quality with higher global cognition, verbal learning, and memory are consistent with previous studies in middle-aged and older Chinese adults (19) and Puerto Rican adults without type 2 diabetes (20). These findings are also supported by extensive literature on the positive association of other similar and well-known diet quality scores with better verbal learning and memory performance (36, 9–11). Likewise, higher cumulative AHEI-2010 score was linked to larger hippocampal volumes (a key brain structure involved in learning and memory) among middle-aged and older British adults (37). In contrast, our results on the association of healthiest diet quality with global cognition, verbal learning, and memory are inconsistent with previous studies (15–18) that had reported null associations among older US non-Hispanic whites, potentially because of, in part, differences in the income and education of the study populations. For example, a study among Canadian adults reported that a dietary patter similar to the AHEI-2010 was associated with cognitive function among

TABLE 2 Associations of quintiles of AHEI-2010 with cognitive function: middle-aged and older Hispanics/Latinos, HCHS/SOL: 2008–2011 ($n = 8461$)[1]

Quintiles of AHEI-2010	n	Cognitive function: Global cognition[2] β (95% CI)	Verbal learning B (95% CI)	Verbal memory B (95% CI)	Verbal fluency B (95% CI)	Processing speed B (95% CI)
Model 1[3]						
Q1 (0.00–42.24)[4]	1055	0.00 (Ref)	0.00 (Ref)	0.00 (Ref)	0.00 (Ref)	0.00 (Ref)
Q2 (42.25–46.49)	1487	0.37 (0.15, 0.60)	0.92 (0.45, 1.39)	0.53 (0.27, 0.80)	0.36 (−0.38, 1.11)	− 0.29 (−1.42, 0.84)
Q3 (46.50–50.61)	1700	0.69 (0.44, 0.95)	1.31 (0.82, 1.81)	0.82 (0.54, 1.09)	1.38 (0.50, 2.26)	− 0.59 (−1.28, 1.08)
Q4 (50.62–55.59)	1953	1.10 (0.84, 1.37)	2.04 (1.50, 2.58)	1.20 (0.92, 1.47)	1.97 (1.12, 2.81)	0.86 (−0.35, 2.06)
Q5 (55.60–110.00)	2266	1.32 (1.05, 1.59)	2.38 (1.34, 2.92)	1.40 (1.11, 1.69)	2.33 (1.57, 3.10)	1.34 (0.09, 2.59)
P-trend[5]		<0.001	<0.001	<0.001	<0.001	0.010
Model 2[6]						
Q1 (0.00–42.24)	1055	0.00 (Ref)	0.00 (Ref)	0.00 (Ref)	0.00 (Ref)	0.00 (Ref)
Q2 (42.25–46.49)	1487	0.28 (0.04, 0.52)	0.60 (0.11, 1.09)	0.33 (0.03, 0.59)	0.23 (−0.52, 0.98)	0.39 (−0.64, 1.41)
Q3 (46.50–50.61)	1700	0.38 (0.08, 0.68)	0.62 (0.05, 1.19)	0.40 (0.04, 0.67)	0.75 (−0.27, 1.77)	0.40 (−0.89, 1.69)
Q4 (50.62–55.59)	1953	0.48 (0.17, 0.80)	0.92 (0.22, 1.62)	0.52 (0.12, 0.80)	0.66 (−0.32, 1.64)	0.65 (−0.62, 1.92)
Q5 (55.60–110.00)	2266	0.32 (−0.01, 0.65)	0.88 (0.18, 1.58)	0.46 (0.01, 0.72)	0.23 (−0.80, 1.26)	− 0.32 (−1.79, 1.16)
P-trend		0.042	0.020	0.007	0.486	0.836

[1] All reported results are weighted except number of observations which are unweighted. Bs are unstandardized regression cofficients. AHEI-2010, Alternate Healthy Eating Index; HCHS/SOL, Hispanic Community Health Study/Study of Latinos (HCHS/SOL); Q, quintile.
[2] Global cognition score was calculated by summing the z scores [i.e., (individual value – mean value)/SD] for performance across the 4 cognitive tests (i.e., verbal learning, memory, verbal fluency, and processing speed).
[3] Model 1: age, sex, education, and log of daily energy intake.
[4] Q1: represents the unhealthiest diet quality; Q5: represents the healthiest diet quality. Values in parentheses indicate the range of the AHEI-2010 score for each quintile.
[5] *P*-trend represents difference across the AHEI-2010 quintiles.
[6] Model 2: Model 1 + Hispanic/Latino background, annual household income, language preference, type 2 diabetes, current smoking, and depressive symptoms.

adults of lower socioeconomic position but not among those of higher socioeconomic position (38).

Our finding on interaction by Hispanic/Latino background contributes to the growing literature on the complex associations of diet quality with CVD-RFs among US Hispanics/Latinos of diverse backgrounds (31, 39). Our stratified analysis suggests that the association of AHEI-2010 with verbal memory was largely driven by US Hispanics/Latinos of Mexicans and Puerto Rican backgrounds (with most robust findings observed among Puerto Ricans). Among Puerto Ricans, vegetables, whole grains, and alcohol (treated as continuous variables) were each associated with higher verbal memory scores, regardless of all covariates and other dietary components. No associations were observed of specific dietary components and verbal memory among Mexicans, suggesting that the overall dietary pattern is driving the association, not particular components (data not shown). This is an important finding because a study using data from the HCHS/SOL showed significant differences in verbal memory scores across Hispanic/Latino backgrounds (24), which were not fully explained by important correlates such as education, income, and sex, but may be related to background distinctions in the burden of CVD-RFs (40). Our study suggests that diet quality may be an additional explanation for some of the more specific differences in verbal memory between Hispanic/Latino backgrounds. However, our findings stratified by Hispanic/Latino background should be interpreted with caution given the relatively smaller sample size in some of the cells. While a previous study reported an association between AHEI-2010 and 2-y changes in memory only among Puerto Rican adults without type 2 diabetes (but not those with type 2 diabetes) (20), we did not find evidence of effect modification by type 2 diabetes, possibly because of differences in the Hispanic/Latino background composition between studies.

Mechanisms by which an overall healthy diet may lead to better cognitive function are beyond the scope of the current cross-sectional study; however, several direct mechanisms have been proposed in the literature (7, 8). Findings from our secondary analyses on the independent associations of recommended intake of vegetables with higher global cognition, verbal learning, and verbal memory scores, as well as recommended intake of whole fruits with higher global cognition, provide further support for the potential role of vitamins and nutrients secondary to higher diet quality on cognitive function. Bioactive compounds such as antioxidants found in vegetables and fruits including carotenoids, vitamin C, and vitamin E are considered important for the protection against oxidative stress (41, 42), which, in turn, has been shown to play a role in the early pathophysiology of cognitive decline (43) and dementia (44). In addition, epidemiologic evidence (45) has shown that light-to-moderate alcohol consumption has protective effects for CVD-RFs (46) and cognitive function (47) through multiple mechanisms including reduction in inflammatory response (46, 47), impairments in cells that lead to buildup of plaque in arteries (45), and changes in arterial-vascular function (48).

There are several limitations to this study. The cross-sectional design does not allow for an examination of causality or directionality of the observed associations. For example, it may be that those with higher socioeconomic status and overall healthier lifestyles, which are associated with better cognitive function, also have better diet quality (38). Future research should further examine socioeconomic gradients and the clustering of healthier lifestyles in these associations. Thus, prospective work is needed in Hispanics/Latinos to assess the utility of adhering to the AHEI-2010 on cognitive function over time to validate our current associations. Second, dietary intake was self-reported, and underreporting of energy and protein intakes and over reporting of protein density was demonstrated in an ancillary study to the HCHS/SOL cohort

TABLE 3 Associations of quintiles of AHEI-2010 components with cognitive function: middle-aged and older Hispanics/Latinos, HCHS/SOL: 2008–2011 ($n = 8461$)[1]

		Cognitive function		
Components	n[3]	Global cognition[2] β (95% CI)	Verbal learning B (95% CI)	Verbal memory B (95% CI)
Vegetables (without potatoes)				
Q1 (0.00–2.73)[4]	1461	0.00 (Ref)	0.00 (Ref)	0.00 (Ref)
Q2 (2.74–3.49)	1604	− 0.04 (−0.31, 0.24)	0.04 (−0.46, 0.54)	0.24 (−0.06, 0.54)
Q3 (3.50–4.18)	1655	0.06 (−0.22, 0.35)	0.19 (−0.35, 0.73)	0.29 (−0.03, 0.56)
Q4 (4.19–5.01)	1772	0.13 (−0.18, 0.45)	0.30 (−0.33, 0.93)	0.34 (−0.01, 0.66)
Q5 (5.02–10.00)	1969	0.35 (0.03, 0.66)	0.72 (0.10, 1.34)	0.44 (0.11, 0.76)
P-trend[5]		0.023	0.023	0.011
Whole fruit (without fruit juice)				
Q1 (0.00–1.28)	1084	0.00 (Ref)	0.00 (Ref)	0.00 (Ref)
Q2 (1.29–1.97)	1558	0.08 (−0.20, 0.36)	0.04 (−0.52, 0.60)	0.07 (−0.23, 0.37)
Q3 (1.98–2.89)	1754	0.34 (−0.03, 0.70)	0.39 (−0.26, 1.04)	0.19 (−0.16, 0.55)
Q4 (2.90–4.16)	1879	0.38 (0.10, 0.65)	0.56 (−0.03, 1.15)	0.31 (0.00, 0.61)
Q5 (4.17–10.00)	2186	0.39 (0.10, 0.69)	0.57 (−0.06, 1.20)	0.20 (−0.11, 0.52)
P-trend		<0.001	0.019	0.064
Whole grains				
Q1 (0.00–0.77)	1661	0.00 (Ref)	0.00 (Ref)	0.00 (Ref)
Q2 (0.78–1.78)	1634	0.08 (−0.17, 0.33)	0.07 (−0.42, 0.55)	0.04 (−0.21, 0.28)
Q3 (1.79–3.37)	1716	0.04 (−0.21, 0.30)	0.13 (−0.51, 0.72)	0.20 (−0.05, 0.45)
Q4 (3.38–5.31)	1784	− 0.03 (−0.37, 0.30)	− 0.15 (−1.00, 0.57)	0.13 (−0.23, 0.50)
Q5 (5.32–10.00)	1666	− 0.46 (−0.91, −0.01)	− 0.56 (−1.72, 0.36)	0.09 (−0.37, 0.54)
P-trend	1661	0.064	0.250	0.637
Sugar-sweetened beverage and fruit juice				
Q1 (0.00)	5071	0.00 (Ref)	0.00 (Ref)	0.00 (Ref)
Q2 (0.01–0.99)	491	0.28 (−0.10, 0.66)	0.44 (−0.28, 1.17)	0.25 (−0.10, 0.60)
Q3 (1.00–3.00)	891	0.09 (−0.16, 0.34)	0.10 (−0.40, 0.60)	0.03 (−0.25, 0.32)
Q4 (3.01–4.76)	745	0.19 (−0.10, 0.48)	− 0.05 (−0.82, 0.72)	0.04 (−0.25, 0.33)
Q5 (4.77–10.00)	1263	0.00 (−0.06, 0.51)	− 0.02 (−0.51, 0.47)	0.09 (−0.17, 0.35)
P-trend		0.379	0.522	0.928
Nuts and legumes				
Q1 (0.00–3.74)	1303	0.00 (Ref)	0.00 (Ref)	0.00 (Ref)
Q2 (3.75–5.00)	1682	− 0.31 (−0.61, −0.01)	− 0.53 (−1.01, −0.04)	− 0.02 (−0.28, 0.25)
Q3 (5.01–6.85)	1715	− 0.12 (−0.40, 0.15)	0.14 (−0.37, 0.64)	0.19 (−0.08, 0.46)
Q4 (6.86–8.93)	1847	− 0.20 (−0.48, 0.08)	0.02 (−0.55, 0.59)	0.27 (−0.01, 0.55)
Q5 (8.94–10.00)	1914	− 0.38 (−0.69, −0.08)	− 0.09 (−0.76, 0.59)	0.10 (−0.21, 0.42)
P-trend		0.057	0.646	0.193
Red and processed meats				
Q1 (0.00–1.36)	1193	0.00 (Ref)	0.00 (Ref)	0.00 (Ref)
Q2 (1.37–3.27)	1523	− 0.07 (−0.34, 0.20)	0.01 (−0.61, 0.64)	− 0.04 (−0.29, 0.22)
Q3 (3.28–4.60)	1661	− 0.05 (−0.39, 0.29)	− 0.06 (−0.84, 0.72)	− 0.16 (−0.49, 0.18)
Q4 (4.61–5.83)	1911	− 0.04 (−0.40, 0.33)	− 0.13 (−0.97, 0.70)	− 0.01 (−0.36, 0.35)
Q5 (5.84–10.00)	2173	0.10 (−0.29, 0.50)	0.25 (−0.63, 1.13)	0.10 (−0.30, 0.50)
P-trend		0.602	0.729	0.634
Trans fat				
Q1 (0.00–7.47)	1212	0.00 (Ref)	0.00 (Ref)	0.00 (Ref)
Q2 (7.48–7.92)	1498	− 0.01 (−0.30, 0.27)	0.24 (−0.41, 0.88)	0.21 (−0.08, 0.51)
Q3 (7.93–8.28)	1710	− 0.10 (−0.31, 0.22)	0.24 (−0.47, 0.89)	0.15 (−0.16, 0.47)
Q4 (8.29–8.66)	1904	− 0.20 (−0.38, 0.12)	− 0.06 (−0.75, 0.63)	0.08 (−0.25, 0.47)
Q5 (8.67–10.00)	2137	− 0.52 (−0.68, −0.18)	− 0.46 (−1.18, 0.27)	− 0.02 (−0.37, 0.33)
P-trend		0.004	0.154	0.695
ω-3 fatty acids				
Q1 (0.00–2.28)	1726	0.00 (Ref)	0.00 (Ref)	0.00 (Ref)
Q2 (2.29–2.85)	1729	0.08 (−0.18, 0.34)	0.26 (−0.22, 0.4)	− 0.05 (−0.29, 0.19)
Q3 (2.86–3.45)	1658	0.09 (−0.14, 0.32)	− 0.12 (−0.58, 0.34)	− 0.14 (−0.38, 0.10)
Q4 (3.46–4.30)	1643	0.07 (−0.22, 0.35)	− 0.10 (−0.67, 0.48)	− 0.17 (−0.45, 0.11)
Q5 (4.31–10.00)	1705	0.14 (−0.21, 0.50)	0.16 (−0.48, 0.80)	− 0.23 (−0.51, 0.05)
P-trend		0.498	0.962	0.090

(*Continued*)

TABLE 3 (*Continued*)

Components	n[3]	Cognitive function Global cognition[2] β (95% CI)	Verbal learning B (95% CI)	Verbal memory B (95% CI)
PUFA				
Q1 (0.00–4.93)	2174	0.00 (Ref)	0.00 (Ref)	0.00 (Ref)
Q2 (4.94–5.44)	1919	0.04 (−0.19, 0.28)	− 0.02 (−0.49, 0.46)	− 0.06 (−0.28, 0.16)
Q3 (5.45–5.92)	1689	0.07 (−0.15, 0.28)	− 0.12 (−0.56, 0.32)	− 0.01 (−0.23, 0.21)
Q4 (5.93–6.52)	1503	0.21 (−0.04, 0.47)	0.16 (−0.33, 0.66)	0.04 (−0.21, 0.29)
Q5 (6.53–10.00)	1176	− 0.02 (−0.30, 0.26)	− 0.19 (−0.73, 0.35)	− 0.03 (−0.28, 0.22)
P-trend		0.682	0.754	0.906
Sodium				
Q1 (0.00–3.99)	1261	0.00 (Ref)	0.00 (Ref)	0.00 (Ref)
Q2 (4.00–5.78)	1541	0.19 (−0.05, 0.44)	0.37 (−0.15, 0.90)	0.12 (−0.09, 0.34)
Q3 (5.79–7.13)	1667	0.13 (−0.16, 0.41)	0.20 (−0.41, 0.80)	0.13 (−0.14, 0.40)
Q4 (7.14–8.86)	1858	0.12 (−0.19, 0.43)	0.31 (−0.39, 1.01)	− 0.09 (−0.41, 0.23)
Q5 (8.87–10.00)	2134	− 0.03 (−0.41, 0.36)	0.20 (−0.61, 1.01)	− 0.06 (−0.42, 0.30)
P-trend		0.782	0.739	0.461
Alcohol				
Q1 (0.00–3.26)	1949	0.00 (Ref)	0.00 (Ref)	0.00 (Ref)
Q2 (3.27–3.72)	1849	− 0.19 (−0.43, 0.05)	− 0.11 (−0.58, 0.35)	0.16 (−0.09, 0.38)
Q3 (3.73–4.50)	1535	0.35 (0.06, 0.63)	0.68 (0.12, 1.24)	0.29 (0.00, 0.57)
Q4 (4.51–6.41)	1559	0.35 (0.05, 0.65)	0.80 (0.14, 1.47)	0.40 (0.00, 0.74)
Q5 (6.42–10.00)	1569	0.52 (0.22, 0.83)	1.13 (0.49, 1.76)	0.53 (0.21, 0.85)
P-trend		<0.001	<0.001	0.002

[1] All reported results are weighted except number of observations which are unweighted. Bs are unstandardized regression cofficients. Models adjusted for age, sex, education, log of daily energy intake, Hispanic/Latino background, annual household income, language preference, type 2 diabetes, current smoking, depressive symptoms, and other AHEI-2010 components. AHEI-2010, Alternate Healthy Eating Index; HCHS/SOL, Hispanic Community Health Study/Study of Latinos (HCHS/SOL); Q, quintile.
[2] Global cognition score was calculated by summing the *z* scores [i.e., (individual value − mean value)/SD] for performance across the 4 cognitive tests (i.e., verbal learning, memory, verbal fluency, and processing speed).
[3] Column indicates sample size of quintiles, which were created based on the distribution of each AHEI-2010 component.
[4] Q1: represents the unhealthiest diet quality; Q5: represents the healthiest diet quality. Values in parentheses indicate the range of the AHEI-2010 component score for each quintile.
[5] *P*-trend represents difference across the AHEI-2010 quintiles.

(49); however, this is a consistent finding across studies using self-reported dietary intake measures, which does not diminish the value of dietary recalls (50). It must also be kept in mind when interpreting our findings that those with worse cognitive function may not be able to adequately recall food intake, as such, results involving verbal learning and memory should be interpreted with caution. Nevertheless, we attempted to address this bias with use of 24-h recalls (as opposed to weekly or monthly recalls), employing validated "probing" techniques (i.e., food models and booklets, multiple-pass interviewing techniques, and follow-up questions) (51), and by excluding dietary recalls deemed unreliable when participants could not remember their food intake. Moreover, the majority of our relatively young cohort has been shown (24) to have high performance in the brief Six-Item Screener (52) for cognitive impairment. Despite these limitations, our study has several strengths. For example, we addressed the limitations of previous research (15–17) as well as calls for additional studies (10) by focusing on a growing but understudied segment of the population at high risk for Alzheimer disease and related dementias. Further, the HCHS/SOL's hybrid design, which uses probability sampling within pre-selected diverse regions, extends the generalizability of our results. Finally, given that the HCHS/SOL is a comprehensive study, we were able to examine the role of important lifestyle and clinical CVD-RFs and depressive symptoms which are associated with lower cognitive function. To shed further light on the implications of our findings, future research should elucidate whether higher performance in these cognitive tests is associated with better health-related quality of life of Hispanics/Latinos in our cohort.

Among middle-aged and older Hispanics/Latinos, we showed that an overall healthy diet such as that recommended by the AHEI-2010 was associated with higher global cognition, verbal learning, and verbal memory scores, after adjustments for well-known risk factors for poor cognitive function. Overall, our findings suggest the need for additional prospective longitudinal research on the potential role of diet quality as a strategy for promoting cognitive health among middle-aged and older Hispanics/Latinos of diverse backgrounds. Although the magnitude of effects observed in our study were relatively small, given the expected growth of the Hispanic/Latino population (2) and their higher risk of dementias (1), even modest positive effects in cognitive function related to greater adherence to an overall dietary pattern could have valuable public health implications (5, 53). In the context of the growing Hispanic/Latino aging population, the development of targeted public health initiatives focused on promoting cognitive health are particularly relevant and timely.

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interpretation, and critical revisions of the manuscript; RAD-A: analyzed data; YM-R, AMS-R, DSA, HMG, LCG, and MLD: contributed to the study concept and design and to the revision of the manuscript; and all authors: read and approved the final manuscript.

References

1. Vincent GK, Velkoff VA. The next four decades. The older population in the United States: 2010 to 2050 [Internet]. Population Estimates and Projections. US Census Bureau. 2010. [Accessed 2019 Sep 2]. Available from: https://www.census.gov/library/publications/2010/demo/p25-1138.html.
2. Alzheimer's Association. 2017 Alzheimer's Disease Facts and Figures. Alzheimer's Dement 2017;13:325–73.
3. Alkerwi A. Diet quality concept. Nutrition 2014;30:613–8.
4. Beydoun MA, Fanelli-Kuczmarski MT, Shaked D, Dore GA, Beydoun HA, Rostant OS, Evans MK, Zonderman AB. Alternative pathway analyses indicate bidirectional relations between depressive symptoms, diet quality, and central adiposity in a sample of urban US adults. J Nutr 2016;146:1241–9.
5. Gorelick PB, Furie KL, Iadecola C, Smith EE, Waddy SP, Lloyd-Jones DM, Bae H-J, Bauman MA, Dichgans M, Duncan PW, et al. Defining optimal brain health in adults: a Presidential Advisory from the American Heart Association/American Stroke Association. Stroke 2017;48(10):e284–e303.
6. Otaegui-Arrazola A, Amiano P, Elbusto A, Urdaneta E, Martínez-Lage P. Diet, cognition, and Alzheimer's disease: food for thought. Eur J Nutr 2014;53:1–23.
7. Spencer SJ, Korosi A, Layé S, Shukitt-Hale B, Barrientos RM. Food for thought: how nutrition impacts cognition and emotion. NPJ Sci Food 2017;1:7.
8. Gómez-Pinilla F. Brain foods: the effects of nutrients on brain function. Nat Rev Neurosci 2008;9:568–78.
9. Allè B, Samieri C, Féart C, Jutand M-A, Laurin D, Barberger-Gateau P. Dietary patterns: a novel approach to examine the link between nutrition and cognitive function in older individuals. Nutr Res Rev 2012;25:207–22.
10. van de Rest O, Berendsen AA, Haveman-Nies A, de Groot LC. Dietary patterns, cognitive decline, and dementia: a systematic review. Adv Nutr An Int Rev J 2015;6:154–68.
11. Di Marco LY, Marzo A, Muñoz-Ruiz M, Ikram MA, Kivipelto M, Ruefenacht D, Venneri A, Soininen H, Wanke I, Ventikos YA, et al. Modifiable lifestyle factors in dementia: a systematic review of longitudinal observational cohort studies. J Alzheimers Dis 2014;42:119–35.
12. Hardman RJ, Kennedy G, Macpherson H, Scholey AB, Pipingas A. Adherence to a Mediterranean-Style Diet and effects on cognition in adults: a qualitative evaluation and systematic review of longitudinal and prospective trials. Front Nutr 2016;3:22.
13. Chiuve SE, Fung TT, Rimm EB, Hu FB, McCullough ML, Wang M, Stampfer MJ, Willett WC. Alternative dietary indices both strongly predict risk of chronic disease. J Nutr 2012;142:1009–18.
14. Jacobs S, Boushey CJ, Franke AA, Shvetsov YB, Monroe KR, Haiman CA, Kolonel LN, Le Marchand L, Maskarinec G. A priori-defined diet quality indices, biomarkers and risk for type 2 diabetes in five ethnic groups: the Multiethnic Cohort. Br J Nutr 2017;118:312–20.
15. Samieri C, Sun Q, Townsend MK, Chiuve SE, Okereke OI, Willett WC, Stampfer M, Grodstein F. The association between dietary patterns at midlife and health in aging: an observational study. Ann Intern Med 2013;159:584–91.
16. Haring B, Wu C, Mossavar-Rahmani Y, Snetselaar L, Brunner R, Wallace RB, Neuhouser ML, Wassertheil-Smoller S. No association between dietary patterns and risk for cognitive decline in older women with 9-year follow-up: data from the Women's Health Initiative Memory Study. J Acad Nutr Diet 2016;116:921–30 e1.
17. Richard EL, Laughlin GA, Kritz-Silverstein D, Reas ET, Barrett-Connor E, McEvoy LK. Dietary patterns and cognitive function among older community-dwelling adults. Nutrients 2018;10(8):1088.
18. Akbaraly TN, Singh-Manoux A, Dugravot A, Brunner EJ, Kivimäki M, Sabia S. Association of midlife diet with subsequent risk for dementia. JAMA 2019;321:957.
19. Wu J, Song X, Chen GC, Neelakantan N, van Dam RM, Feng L, Yuan JM, Pan A, Koh WP. Dietary pattern in midlife and cognitive impairment in late life: a prospective study in Chinese adults. Am J Clin Nutr 2019;110(4):912–20.
20. Mattei J, Bigornia SJ, Sotos-Prieto M, Scott T, Gao X, Tucker KL. The Mediterranean diet and 2-year change in cognitive function by status of type 2 diabetes and glycemic control. Diabetes Care 2019;42:1372–9.
21. Sorlie PD, Avilés-Santa LM, Wassertheil-Smoller S, Kaplan RC, Daviglus ML, Giachello AL, Schneiderman N, Raij L, Talavera G, Allison M, et al. Design and implementation of the Hispanic Community Health Study/Study of Latinos. Ann Epidemiol 2010;20:629–41.
22. LaVange LM, Kalsbeek WD, Sorlie PD, Avilés-Santa LM, Kaplan RC, Barnhart J, Liu K, Giachello A, Lee DJ, Ryan J, et al. Sample design and cohort selection in the Hispanic Community Health Study/Study of Latinos. Ann Epidemiol 2010;20:642–9.
23. Manuals | Hispanic Community Health Study / Study of Latinos [Internet]. 2018. [Accessed 2019 Sep 2]. Available from: http://sites.cscc.unc.edu/hchs/protocols-and-manuals.
24. González HM, Tarraf W, Gouskova N, Gallo LC, Penedo FJ, Davis SM, Lipton RB, Argüelles W, Choca JP, Catellier DJ, et al. Neurocognitive function among middle-aged and older Hispanic/Latinos: results from the Hispanic Community Health Study/Study of Latinos. Arch Clin Neuropsychol 2015;30:68–77.
25. González HM, Mungas D, Reed BR, Marshall S, Haan MN. A new verbal learning and memory test for English- and Spanish-speaking older people. J Int Neuropsychol Soc 2001;7:544–55.
26. González HM, Mungas D, Haan MN. A verbal learning and memory test for English- and Spanish-speaking older Mexican-American adults. Clin Neuropsychol 2002;16(4):439–51.
27. Lezak MD, Howieson DB, Loring DW, Fischer JS. Neuropsychological assessment. NY; 2004.
28. Benton AL, Hamsher K. Multilingual aphasia examination, 2nd ed. Iowa City; 1989.
29. Wechsler D. WAIS-R manual. San Antonio; 1981.
30. Siega-Riz AM, Sotres-Alvarez D, Ayala GX, Ginsberg M, Himes JH, Liu K, Loria CM, Mossavar-Rahmani Y, Rock CL, Rodriguez B, et al. Food-group and nutrient-density intakes by Hispanic and Latino backgrounds in the Hispanic Community Health Study/Study of Latinos. Am J Clin Nutr 2014;99:1487–98.
31. Mattei J, Sotres-Alvarez D, Daviglus ML, Gallo LC, Gellman M, Hu FB, Tucker KL, Willett WC, Siega-Riz AM, Van Horn L, et al. Diet quality and its association with cardiometabolic risk factors vary by Hispanic and Latino ethnic background in the Hispanic Community Health Study/Study of Latinos. J Nutr 2016;146:2035–44.
32. Tooze JA, Kipnis V, Buckman DW, Carroll RJ, Freedman LS, Guenther PM, Krebs-Smith SM, Subar AF, Dodd KW. A mixed-effects model approach for estimating the distribution of usual intake of nutrients: The NCI method. Stat Med 2010;29:2857–68.
33. McCullough ML, Feskanich D, Stampfer MJ, Giovannucci EL, Rimm EB, Hu FB, Spiegelman D, Hunter DJ, Colditz GA, Willett WC. Diet quality and major chronic disease risk in men and women: moving toward improved dietary guidance. Am J Clin Nutr 2002;76:1261–71.
34. American Diabetes Association. 2. Classification and diagnosis of diabetes. Diabetes Care 2017;40(Suppl 1):S11–S24.
35. Andresen EM, Malmgren JA, Carter WB, Patrick DL. Screening for depression in well older adults: evaluation of a short form of the CES-D (Center for Epidemiologic Studies Depression Scale). Am J Prev Med 1993;10:77–84.
36. Kesse-Guyot E, Andreeva VA, Jeandel C, Ferry M, Hercberg S, Galan P. A healthy dietary pattern at midlife is associated with subsequent cognitive performance. J Nutr 2012;142:909–15.
37. Akbaraly T, Sexton C, Zsoldos E, Mahmood A, Filippini N, Kerleau C, Verdier J-M, Virtanen M, Gabelle A, Ebmeier KP, et al. Association of long-term diet quality with hippocampal volume: longitudinal cohort study. Am J Med 2018;131:1372–81 e4.
38. Parrott MD, Shatenstein B, Ferland G, Payette H, Morais JA, Belleville S, Kergoat M-J, Gaudreau P, Greenwood CE. Relationship between diet quality and cognition depends on socioeconomic position in healthy older adults. J Nutr 2013;143:1767–73.
39. Joyce BT, Wu D, Hou L, Dai Q, Castaneda SF, Gallo LC, Talavera GA, Sotres-Alvarez D, Van Horn L, Beasley JM, et al.

DASH diet and prevalent metabolic syndrome in the Hispanic Community Health Study/Study of Latinos. Prev Med Reports 2019;15: 100950.

40. Lamar M, Durazo-Arvizu RA, Sachdeva S, Pirzada A, Perreira KM, Rundek T, Gallo LC, Grober E, DeCarli C, Lipton RB, et al. Cardiovascular disease risk factor burden and cognition: implications of ethnic diversity within the Hispanic Community Health Study/Study of Latinos. PLoS One 2019;14:e0215378.
41. Carty JL, Bevan R, Waller H, Mistry N, Cooke M, Lunec J, Griffiths HR. The effects of vitamin C supplementation on protein oxidation in healthy volunteers. Biochem Biophys Res Commun 2000;273: 729–35.
42. Brennan LA, Morris GM, Wasson GR, Hannigan BM, Barnett YA. The effect of vitamin C or vitamin E supplementation on basal and H2O2-induced DNA damage in human lymphocytes. Br J Nutr 2000;84: 195–202.
43. Hajjar I, Hayek SS, Goldstein FC, Martin G, Jones DP, Quyyumi A. Oxidative stress predicts cognitive decline with aging in healthy adults: an observational study. J Neuroinflammation 2018; 15:17.
44. Huang W-J, Zhang X, Chen W-W. Role of oxidative stress in Alzheimer's disease. Biomed Reports 2016;4:519–22.
45. Peters R, Peters J, Warner J, Beckett N, Bulpitt C. Alcohol, dementia and cognitive decline in the elderly: a systematic review. Age Ageing 2008;37:505–12.
46. Sinforiani E, Zucchella C, Pasotti C, Casoni F, Bini P, Costa A. The effects of alcohol on cognition in the elderly: from protection to neurodegeneration. Funct Neurol 2011;26(2):103–6.
47. Letenneur L. Risk of dementia and alcohol and wine consumption: a review of recent results. Biol Res 2004;37(2):189–93.
48. Cahill PA, Redmond EM. Alcohol and cardiovascular disease–modulation of vascular cell function. Nutrients 2012;4: 297–318.
49. Mossavar-Rahmani Y, Shaw PA, Wong WW, Sotres-Alvarez D, Gellman MD, Van Horn L, Stoutenberg M, Daviglus ML, Wylie-Rosett J, Siega-Riz AM, et al. Applying recovery biomarkers to calibrate self-report measures of energy and protein in the Hispanic Community Health Study/Study of Latinos. Am J Epidemiol 2015;181:996–1007.
50. Subar AF, Freedman LS, Tooze JA, Kirkpatrick SI, Boushey C, Neuhouser ML, Thompson FE, Potischman N, Guenther PM, Tarasuk V, et al. Addressing current criticism regarding the value of self-report dietary data. J Nutr 2015;145:2639–45.
51. Gibson RS, Charrondiere UR, Bell W. Measurement errors in dietary assessment using self-reported 24-hour recalls in low-income countries and strategies for their prevention. Adv Nutr 2017;8:980–91.
52. Callahan C, Unverzagt F, Hui S, Perkins A. Six-item screener to identify cognitive impairment among potential subjects for clinical research. Med Care 2002;40(9):771–81.
53. Gorelick PB. Prevention of cognitive impairment: scientific guidance and windows of opportunity. J Neurochem 2018;144:609–16.