The Journal of Nutrition. First published ahead of print September 7, 2016 as doi: 10.3945/jn.116.231209.

The Journal of Nutrition
Nutritional Epidemiology

# 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[1–3]

Josiemer Mattei,[4]* Daniela Sotres-Alvarez,[6] Martha L Daviglus,[9] Linda C Gallo,[10] Marc Gellman,[11] Frank B Hu,[4,5] Katherine L Tucker,[12] Walter C Willett,[4,5] Anna Maria Siega-Riz,[7,8] Linda Van Horn,[13] and Robert C Kaplan[14]

Departments of [4]Nutrition and [5]Epidemiology, Harvard T.H. Chan School of Public Health, Boston, MA; [6]Collaborative Studies Coordinating Center, Department of Biostatistics, and Departments of [7]Epidemiology and [8]Nutrition, Gillings School of Global Public Health, University of North Carolina, Chapel Hill, NC; [9]Institute for Minority Health Research, College of Medicine, University of Illinois at Chicago, Chicago, IL; [10]Department of Psychology, San Diego State University, San Diego, CA; [11]Department of Psychology, University of Miami, Miami, FL; [12]Department of Clinical Laboratory and Nutritional Sciences, University of Massachusetts, Lowell, MA; [13]Department of Preventive Medicine, Northwestern University Feinberg School of Medicine, Chicago, IL; and [14]Department of Epidemiology and Population Health, Albert Einstein College of Medicine, Bronx, NY

## Abstract

**Background:** Healthful diet quality has been associated with a lower risk of metabolic syndrome (MetS) in several populations, but reports on Hispanic and Latino cohorts, grouped or by ethnic background, have been limited and inconsistent.

**Objective:** We aimed to examine diet quality by using the 2010 Alternate Healthy Eating Index [(AHEI) range: 0–110, lowest to highest quality] and its cross-sectional association with MetS and its cardiometabolic components across 6 Hispanic and Latino backgrounds.

**Methods:** We studied 12,406 US Hispanics and Latinos, aged 18–74 y and free of diabetes, from the multicenter, population-based Hispanic Community Health Study/Study of Latinos cohort. Food and nutrients were assessed from two 24-h recalls. MetS was defined by using the 2009 harmonized guidelines. Complex survey procedures were used in multivariable-adjusted linear regression models to test the association of the AHEI with continuous markers and in logistic regression models with MetS as an outcome.

**Results:** The prevalence of MetS was 24.2%. Overall, Hispanics and Latinos had low scores for intakes of sugar-sweetened beverages and fruit juices, whole grains, and fruit and favorable scores for *trans* fats and nuts and legumes, according to AHEI criteria. Adjusted mean AHEI and its individual components differed by ethnic background ($P < 0.001$), ranging from 43.0 for Puerto Ricans to 52.6 for Mexicans. Overall, adjusted odds (95% CIs) of having MetS were 22% (9%, 33%) lower for each 10-unit increase in AHEI. This association was modified by ethnic background ($P$-interaction = 0.03), with significantly lower odds observed only for Mexicans (30%; 95% CIs: 13%, 44%) and Central Americans (42%; 95% CIs: 9%, 64%) for each 10-unit increase in AHEI. AHEI was inversely associated with waist circumference, blood pressure, and glucose among Mexicans and Puerto Ricans and with triglycerides among Mexicans only, and positively associated with HDL cholesterol among Puerto Ricans and Central Americans (all $P < 0.05$).

**Conclusions:** Diet quality differed by Hispanic or Latino background. Although healthier diet quality was associated with lower odds of MetS in the overall Hispanic and Latino cohort, the association of AHEI and cardiometabolic factors varied by ethnic background. Nutrition-related research and interventions among ethnically diverse groups should consider individual ethnic backgrounds to optimally address diet quality and cardiometabolic health. This trial was registered at clinicaltrials.gov as NCT02060344. *J Nutr* doi: 10.3945/jn.116.231209.

**Keywords:** metabolic syndrome, diet quality, Hispanics, Latinos, cardiometabolic risk factors, HCHS/SOL, health disparities, race/ethnicity, minority health

## Introduction

A disproportionate burden of type 2 diabetes and cardiovascular disease (CVD)[15], as well as their intermediate biological risk factors, has been noted among US Hispanic and Latino adults. The prevalence of diabetes in this adult population has been estimated to be between 11% (1) and 17% (2), and in 2015, 48% of Hispanic and Latino men and 32% of women had CVD (3).


Manuscript received February 10, 2016. Initial review completed March 28, 2016. Revision accepted August 3, 2016.
doi: 10.3945/jn.116.231209.

Metabolic syndrome (MetS) is a cluster of cardiometabolic risk factors that has been associated with twice the risk of CVD and nearly 5 times the risk of diabetes (4, 5). Consequently, a call to recognize MetS in clinical and public health practice has been put forth by multiple agencies (5).

Current reports show that the profile of cardiometabolic risk factors differs significantly across US Hispanic and Latino backgrounds (6–10). For example, adults aged 18–74 y of South American or Dominican backgrounds tended to have the lowest prevalence of MetS (27% and 31%, respectively), whereas Puerto Rican women had the highest (41%) (10). It has been posited that CVD-prevention strategies and clinical management should focus on addressing the high rates of multiple risk factors presented by Hispanics and Latinos as a group, as well as by individual ethnic background (8, 10).

Following an overall healthy diet is a recognized strategy to prevent cardiometabolic risk. Overall diet can be assessed by using composite evidence-based scores that comprise multiple nutrients and food groups, such as the Alternate Healthy Eating Index (AHEI). There is strong evidence of associations between higher AHEI (which reflects better diet quality, based on current evidence) and lower risk of diabetes, CVD, and MetS (11–15). Some of these studies reported stronger associations with chronic disease risk with the AHEI than with other diet quality scores (12, 13, 15). This is likely because the AHEI includes specific foods and nutrients, such as legumes, sugar-sweetened beverages, and red or processed meats, which have a role in the development of chronic disease but are absent or incorporated within general food groups in other diet scores (15). However, few studies, to our knowledge, have looked at the association between diet quality and cardiometabolic risk factors among Hispanics and Latinos, and the results have been inconsistent. One study found a significantly lower risk of diabetes for Hispanic and Latino women in the highest quintile of AHEI (16), whereas other studies found null associations between diet quality and obesity markers (17) or CVD mortality (18). Analysis by Hispanic or Latino background was not conducted in these studies. Moreover, although some variation in intakes of individual nutrients and foods by Hispanic or Latino background has been reported (19, 20), systematic reports of diet quality by ethnic background are scarce (6).

It remains unknown whether there are ethnic background–specific differences in diet quality and whether these would translate into observed differences in cardiometabolic risk profile. Thus, we aimed to compare diet quality, as measured by the AHEI, and to determine its association with MetS and its cardiometabolic components across 6 Hispanic and Latino backgrounds, with the use of a large, multiethnic US Hispanic and Latino cohort. The hypothesis was that both diet quality and the strength of the association between AHEI and MetS would vary by ethnic background. Ethnicity-specific analyses may help clarify inconsistent results of diet-disease associations that have been reported among aggregated Hispanic and Latino populations. Moreover, recommendations to improve diet quality for chronic disease prevention may need to be tailored specifically to each Hispanic or Latino group.

## Methods

*Study population.* The Hispanic Community Health Study/Study of Latinos (HCHS/SOL) is a community-based prospective cohort study in 16,415 individuals who self-identified as having Hispanic or Latino ethnicity (hereafter referred to by using their country of origin), aged 18–74 y, from randomly selected households in 4 US field centers (Chicago, Illinois; Miami, Florida; Bronx, New York; and San Diego, California) with baseline examinations (2008–2011) and yearly telephone follow-up assessments (21). Baseline data were used for this analysis.

Recruitment involved a stratified 2-stage area probability sample of household addresses in each field center (22). Individuals from identified households were contacted and screened for eligibility (living in the household, aged 18–74 y, ability to attend a clinic visit, and not planning to move within 6 mo). All participants signed an informed consent. The institutional review boards of each field center, coordinating center, reading centers, and the National Heart, Lung, and Blood Institute approved this study. The trial was registered at clinicaltrials.gov as NCT02060344.

*Data collection.* The detailed methodology was described previously (6, 21). Briefly, participants visited one of the centers where all clinical assessments and interviews were conducted by centrally trained personnel, in the participant's preferred language. The interview included questions on demographic and socioeconomic characteristics, lifestyle behaviors, acculturation, and self-reported medical history and medication use. Specifically, participants self-reported the total years of schooling completed and the highest grade or level of education achieved, the household income earned in 1 y, and the years living in the United States for those not born in the United States (equivalent to the age of the participant if born in the United States). Number of years living in the United States was used as a proxy measure of acculturation; other measures probed included being born in the United States, generational level (i.e., first, second, third, or fourth generation, based on place of birth of participant, parents, and grandparents), and language of preference. Physical activity was assessed by using the Global Physical Activity Questionnaire, and self-reported hours of activity and sedentary behavior were converted into metabolic equivalents and categorized as high, moderate, or low levels.

Waist circumference was measured at the horizontal line just above the uppermost lateral border of the right ilium by using an anthropometric tape. Blood pressure was measured in triplicate with an automatic sphygmomanometer after a quiet rest, and was averaged. 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 serum TGs, serum HDL cholesterol, and plasma glucose (Roche Diagnostics). All field center procedures and laboratory protocols are published online (23).

*Dietary assessment and exposure definition.* Methods for dietary data collection have been published (19, 24). Briefly, two 24-h recalls were administered, 1 in-person at the baseline visit and 1 via telephone or in-person within 5–90 d, usually after the baseline visit. More than 88% of the second recalls were unannounced and were scheduled by field center staff with the goal of distributing them throughout all days of the week. The rest of the second recalls were scheduled at the participant's

[1] Supported by a Mentored Career Development Award to Promote Faculty Diversity in Biomedical Research (K01-HL120951) from the NIH, National Heart, Lung, and Blood Institute (NHLBI). The Hispanic Community Health Study/Study of Hispanics/Latinos/Latinos was carried out as a collaborative study supported by contracts from the NHLBI to the University of North Carolina (N01-HC65233), University of Miami (N01-HC65234), Albert Einstein College of Medicine (N01-HC65235), Northwestern University (N01-HC65236), and San Diego State University (N01-HC65237). The following institutes/centers/offices contribute to the Hispanic Community Health Study/Study of Latinos through a transfer of funds to the NHLBI: National Center on Minority Health and Health Disparities, the National Institute of Deafness and Other Communications Disorders, the National Institute of Dental and Craniofacial Research, the National Institute of Diabetes and Digestive and Kidney Diseases, the National Institute of Neurological Disorders and Stroke, and the Office of Dietary Supplements.
[2] Author disclosures: J Mattei, D Sotres-Alvarez, ML Daviglus, LC Gallo, M Gellman, FB Hu, KL Tucker, WC Willett, AM Siega-Riz, L Van Horn, and RC Kaplan, no conflicts of interest.

[3] Supplemental Tables 1–3 are available from the ''Online Supporting Material'' link in the online posting of the article and from the same link in the online table of contents at http://jn.nutrition.org.

*To whom correspondence should be addressed. E-mail: jmattei@hsph.harvard.edu.

[15] Abbreviations used: AHEI, Alternate Healthy Eating Index; CVD, cardiovascular disease, HCHS/SOL, Hispanic Community Health Study/Study of Latinos; MetS, metabolic syndrome.

convenience. Recalls with energy intakes below the sequence sex-specific first percentile or >99th percentile, or that were unreliable according to the interviewer, were excluded. Participants estimated portion sizes with the use of food models (in-person) and a food-amount booklet (for telephone interviews). Foods and nutrients were analyzed by using the multiple-pass methods of the Nutrition Data System for Research software version 11 from the Nutrition Coordinating Center at University of Minnesota, which includes Hispanic and Latino foods. Although underreporting of energy and protein intakes and overreporting of protein density have been shown in an ancillary study of this cohort (24), this is a common occurrence across nutritional studies that does not diminish the value of self-reported dietary data (25).

The 2010 AHEI comprised 11 dietary components with evidence of association with chronic diseases (11, 15). Four steps were followed to calculate the index. First, each component was created by adding the corresponding Nutrition Data System for Research food subgroups at the dietary recall level. The components, cutoffs, and portion sizes used to define the AHEI are described in **Supplemental Table 1**. Second, predicted usual-intake amounts for each AHEI component were estimated by using the National Cancer Institute method (26), which accounts for within- and between-person variance components and corrects for the high intraindividual variation intrinsic to 24-h recalls. Third, each component was scored from 0 to 10 as continuous (prorated intermediate values) from minimal to maximal observance of the recommended amount of each item. Last, individual component scores were summed. Possible scores for the AHEI range from 0 to 110 (unhealthiest to healthiest).

*MetS definition.* A dichotomous variable for MetS (yes or no) was defined following the harmonized guidelines from the 2009 Joint Scientific Statement (5). MetS was assigned to participants who met ≥3 of the following criteria: abdominal obesity by using thresholds corresponding to US populations for consistency and comparability (>102 cm in men, >88 cm in women), elevated blood pressure (>130/85 mm Hg) or the use of antihypertension medications, high TGs [≥1.28 mmol/L (150 mg/dL)], low HDL cholesterol [<1.03 mmol/L (40 mg/dL) in men, <1.28 mmol/L (50 mg/dL) in women], and impaired fasting glucose [≥5.8 mmol/L (100 mg/dL)] or the use of antidiabetic medications. Analyses were repeated by using the International Diabetes Federation definition of MetS, which defines abdominal obesity by using lower thresholds (≥94 cm in men, ≥80 cm in women), as recommended for populations of European and sub-Sahara African heritages, plus 2 other components equivalent to the additional 4 markers included in the harmonized definition (27).

*Statistical analysis.* We excluded participants with diabetes based on self-report or laboratory values (2) ($n$ = 3,383), who reported multiple or other Hispanic or Latino ethnic backgrounds ($n$ = 436), or those with missing data on diabetes status ($n$ = 23), AHEI ($n$ = 145), or ethnic background ($n$ = 22). Thus, 12,406 participants were included in this analysis. Participants with diabetes were excluded because MetS is a strong risk factor for diabetes (4, 5). In addition, those with diagnosed diabetes or prediabetes tend to have healthier dietary habits (28, 29), which may lead to reverse causation in cross-sectional analysis. Participants with multiple or other backgrounds were excluded to avoid heterogeneity in diet and MetS, on the basis of our hypothesis that these would differ by specific ethnic background.

Differences in characteristics by ethnic background and by tertile of AHEI were performed by using survey regression for continuous variables and chi-square tests for categorical variables. Age-adjusted means (prevalence estimate) were estimated by using the weighted average age of the sample (39 y). The $P$-trend by tertile of AHEI was determined by assigning the median of each category to a participant in the respective tertile, then entering the resulting continuous variable into the model. Differences in nutrient and food-group composition by ethnic background were tested by using survey regression, adjusted for age, sex, household income, marital status, educational attainment, years living in the United States, physical activity, smoking status, center, and energy intake, with Tukey's adjustment for multiple comparisons. Age-adjusted probability density distribution of AHEI by ethnic background and center (to discern the influence of location singly and across backgrounds) was obtained by using the SAS SGPLOT procedure (SAS Institute).

Survey linear regression analysis was used to determine associations between each 10-unit increase in AHEI as a continuous exposure and each component of MetS as a continuous outcome. Standardized β-coefficients were calculated for each model by dividing the original parameter estimate by the ratio of the sample SD of the dependent variable to the sample SD of the independent variable. Standardized coefficients were used to compare the magnitude of associations for exposures of different units. Values of TGs were log-transformed to attain normal distribution. Model covariates were selected a priori on the basis of previous reports and potential for confounding and included those described above as well as health insurance status, antihypertensive medication for blood pressure, and lipid-lowering medication for TGs and HDL cholesterol. Associations between each 10-unit increase in AHEI with MetS as a dichotomous outcome were tested with survey logistic regression models fitted to estimate ORs and 95% CIs, controlling for the same covariates except for medications. The interaction term between AHEI and ethnic background was tested in regression models. All analyses accounted for clustering and stratification and were weighted to adjust for sampling probability of selection and nonresponse with the use of complex survey procedures in SAS software version 9.4 (SAS Institute). A significance level of $P < 0.05$ was used.

## Results

Sociodemographic and health characteristics of HCHS/SOL individuals by ethnic background are shown in **Table 1** and by tertile of AHEI in **Supplemental Table 2**. Mexicans comprised the majority of the sample and had higher incomes and physical activity level but lower educational attainment than other groups. Puerto Ricans were more likely to be single, smoke, have health insurance, have been living in the mainland United States for longer (as expected, given their US citizenship), and have higher waist circumference and lower HDL cholesterol. Few Dominicans were current smokers, and they had significantly lower TGs and fasting glucose and higher HDL cholesterol than did the other Hispanic and Latino groups. Nearly 1 in 4 individuals met the criteria for MetS, but the prevalence differed significantly by ethnic group, ranging from 17% in Dominicans to nearly 30% in Cubans.

The age-adjusted probability density plots of AHEI showed differences in the distribution of AHEI by ethnic background, with the curve positioned to the right for Mexicans (higher AHEI) and to the left for Puerto Ricans (lower AHEI) (**Figure 1**A). Only 4.3% of Puerto Ricans and 6.1% of Cubans were within the top AHEI tertile (of the entire population), compared with 46.6% of Mexicans (**Supplemental Table 3**). The distribution of AHEI score for San Diego shifted to the right, indicative of higher dietary quality, compared with the Bronx and Miami (Figure 1B). When contrasting the 2 largest ethnicities in cities with ≥5% of the population represented by that ethnicity, the AHEI distribution remained higher for Mexicans and lower for Puerto Ricans regardless of location, although 17.4% of Mexicans in the Bronx compared with 59.3% in Chicago were within the top AHEI tertile (Figure 1C, Supplemental Table 3).

Means for AHEI and its components across ethnic backgrounds are shown in **Figure 2**. Specific mean values for scores and intakes are presented in **Table 2**. Mean ± SE AHEI differed significantly by background ($P < 0.0001$ for all pairwise comparisons), and ranged from 43.0 ± 0.2 in Puerto Ricans, 45.0 ± 0.3 in Cubans, 47.0 ± 0.3 in South Americans, 49.0 ± 0.2 in Central Americans, 51.0 ± 0.2 in Dominicans, and 52.6 ± 0.2 in Mexicans. Overall, most ethnicities had unhealthy intakes of sugar-sweetened beverages and fruit juices, whole grains, and whole fruit and favorable intakes of *trans* fats and nuts and legumes. Individual food and nutrient components of the AHEI varied

**TABLE 1** Sociodemographic characteristics and cardiometabolic components of Hispanic and Latino adults without diabetes by ethnic background: HCHS/SOL 2008–2011[1]

| | Mexicans | Puerto Ricans | Cubans | Dominicans | Central Americans | South Americans | All |
|---|---|---|---|---|---|---|---|
| Participants, *n* (%) | 5067 (40.8) | 1944 (15.7) | 1892 (15.3) | 1175 (9.5) | 1402 (11.3) | 926 (7.5) | 12,406 |
| Age, y | 36.6 (35.9, 37.3) | 40.3 (39.2, 41.3) | 43.8 (42.8, 44.8) | 36.7 (35.5, 37.9) | 37.5 (36.6, 38.3) | 40.7 (39.3, 42.1) | 39.0 (38.5, 39.5) |
| Females, % | 53.3 | 48.0 | 47.1 | 61.0 | 51.1 | 54.1 | 48.2 |
| Educational attainment | | | | | | | |
| No high school or GED | 33.6 | 34.2 | 19.5 | 33.6 | 36.0 | 20.6 | 30.3 |
| High school or GED | 31.3 | 28.5 | 31.1 | 25.0 | 27.4 | 26.8 | 29.6 |
| Above high school or GED | 35.0 | 37.3 | 49.4 | 41.4 | 36.6 | 52.6 | 40.1 |
| Annual income, % | | | | | | | |
| ≤$20,000 | 36.2 | 43.3 | 44.0 | 46.1 | 47.3 | 39.2 | 41.0 |
| $20,001–$40,000 | 34.8 | 26.1 | 26.6 | 30.7 | 29.1 | 35.4 | 30.9 |
| >$40,000 | 23.8 | 21.9 | 13.3 | 12.7 | 11.9 | 17.7 | 18.9 |
| Not reported | 5.2 | 8.7 | 16.1 | 10.5 | 11.6 | 7.7 | 9.2 |
| Current smoker, % | 18.1 | 34.7 | 27.4 | 11.3 | 15.6 | 12.6 | 21.5 |
| Physical activity level,[2] % | | | | | | | |
| High | 16.7 | 15.7 | 9.1 | 13.6 | 15.3 | 12.5 | 14.3 |
| Moderate | 47.4 | 47.1 | 39.9 | 47.2 | 45.5 | 48.1 | 45.7 |
| Low | 35.6 | 36.7 | 50.5 | 38.1 | 38.5 | 39.0 | 39.5 |
| Marital status, % | | | | | | | |
| Single | 30.5 | 50.4 | 28.0 | 49.5 | 41.2 | 31.8 | 36.1 |
| Married or with partner | 58.2 | 32.8 | 52.0 | 36.4 | 45.9 | 49.4 | 49.1 |
| Separated, divorced, or widowed | 11.3 | 16.8 | 19.8 | 14.1 | 12.5 | 18.7 | 14.7 |
| Health insurance, % | 41.0 | 74.9 | 38.1 | 65.1 | 28.9 | 38.1 | 47.2 |
| Center, % | | | | | | | |
| Bronx | 8.8 | 71.7 | 1.7 | 94.5 | 19.5 | 23.6 | 28.1 |
| Chicago | 25.7 | 20.9 | 0.7 | 0.9 | 14.6 | 21.0 | 16.1 |
| Miami | 1.3 | 4.5 | 97.1 | 4.4 | 62.4 | 51.0 | 29.4 |
| San Diego | 64.2 | 2.8 | 0.5 | 0.2 | 3.6 | 4.4 | 26.4 |
| Years living in mainland United States | 19.9 (19.3, 20.6) | 31.9 (30.9, 32.9) | 11.5 (10.4, 12.5) | 18.0 (17.0, 18.9) | 14.7 (13.8, 15.6) | 13.0 (12.1, 13.9) | 19.1 (18.5, 19.8) |
| Waist circumference, cm | 96.8 (96.2, 97.5) | 97.7 (96.5, 98.8) | 95.0 (94.1, 95.8) | 95.0 (93.3, 96.6) | 94.1 (93.2, 95.0) | 92.4 (91.2, 93.5) | 95.9 (95.5, 96.4) |
| Systolic blood pressure, mm Hg | 117 (116, 117) | 119 (118, 120) | 120 (119, 121) | 121 (119, 122) | 120 (119, 121) | 116 (115, 117) | 118 (118, 119) |
| Diastolic blood pressure, mm Hg | 69.8 (69.3, 70.3) | 72.8 (72.2, 73.5) | 73.7 (73.0, 74.3) | 73.9 (73.2, 74.7) | 72.8 (72.0, 73.7) | 69.5 (68.6, 70.4) | 71.7 (71.4, 72.1) |
| Serum TGs, mg/dL | 130 (126, 134) | 122 (115, 130) | 129 (123, 135) | 102 (97, 106) | 140 (134, 146) | 125 (119, 131) | 126 (124, 129) |
| Serum HDL cholesterol, mg/dL | 49.0 (48.4, 49.5) | 47.8 (46.7, 48.8) | 47.8 (47.1, 48.5) | 51.1 (50.1, 52.1) | 48.8 (47.8, 49.7) | 49.7 (48.7, 50.8) | 48.8 (48.4, 49.1) |
| Fasting plasma glucose, mg/dL | 93.7 (93.3, 94.0) | 93.2 (92.5, 94.0) | 93.9 (93.4, 94.4) | 91.9 (91.2, 92.5) | 93.9 (93.4, 94.4) | 93.5 (92.8, 94.3) | 93.5 (93.2, 93.7) |
| Metabolic syndrome[3] | 22.7 | 26.9 | 29.6 | 17.3 | 23.7 | 20.3 | 24.2 |

[1] Values are age-adjusted means (39 y) (95% CIs), except for age, unless otherwise indicated. All analyses were weighted to adjust for sampling probability of selection and nonresponse. To convert TGs to mmol/L, multiply values by 0.0113. To convert HDL cholesterol to mmol/L, multiply values by 0.0259. To convert fasting blood glucose to mmol/L, multiply values by 0.0555. All variables differed significantly by ethnic background (overall $P < 0.001$). GED, General Educational Development; HCHS/SOL, Hispanic Community Health Study/Study on Latinos.

[2] Physical activity was assessed by using the Global Physical Activity Questionnaire. Self-reported hours of activity at work, travel, and leisure, as well as sedentary behavior, were converted into metabolic equivalents and categorized as high, moderate, or low levels, on the basis of number of days spent doing physical activity at each designated intensity level.

[3] Metabolic syndrome was defined by using the harmonized guidelines from the 2009 Joint Scientific Statement, including use of medication (5). The use of medications relevant to the definition of metabolic syndrome was minimal for participants in this analysis because it excluded those with diabetes (use of diabetes medication was 0.2% and of hypertension medication was 7.4%).

significantly by ethnic background. Among those excluded from the main analysis, participants with multiple or other ethnicities had a mean ± SE AHEI of 49.4 ± 0.34 and participants with diabetes had a significantly higher mean AHEI than did those without diabetes (48.9 ± 0.2 compared with 48.4 ± 0.3; $P = 0.005$) after adjusting for sociodemographic and lifestyle behavioral factors (data not shown).

The *P*-interaction between AHEI and Hispanic or Latino background was significant ($P = 0.03$), suggesting variation in the association of diet and MetS across ethnic backgrounds; thus, stratified analyses were conducted. Each increase of 10 units in AHEI was associated with 22% lower odds (95% CI: 9%, 33%; $P = 0.001$) of having MetS for all Hispanics and Latinos (**Table 3**), after covariate adjustment. The strength of the association varied by ethnic background and remained significant for Mexicans and Central Americans but not for those of the other backgrounds. Results that used the International Diabetes Federation definition of MetS were similar (data not shown). When we analyzed the association between AHEI and MetS for participants with diabetes, we observed nonsignificant ($P = 0.18$) odds of having MetS (OR: 0.83; 95% CI: 0.63, 1.09; data not shown).

Overall, a higher AHEI was significantly associated with all cardiometabolic risk factors except for systolic blood pressure (Table 3). The AHEI was inversely associated with waist circumference, blood pressure, and glucose for Mexicans and Puerto Ricans and with TGs for Mexicans, and was positively associated with HDL cholesterol for Puerto Ricans and Central Americans. Standardized measures showed that associations

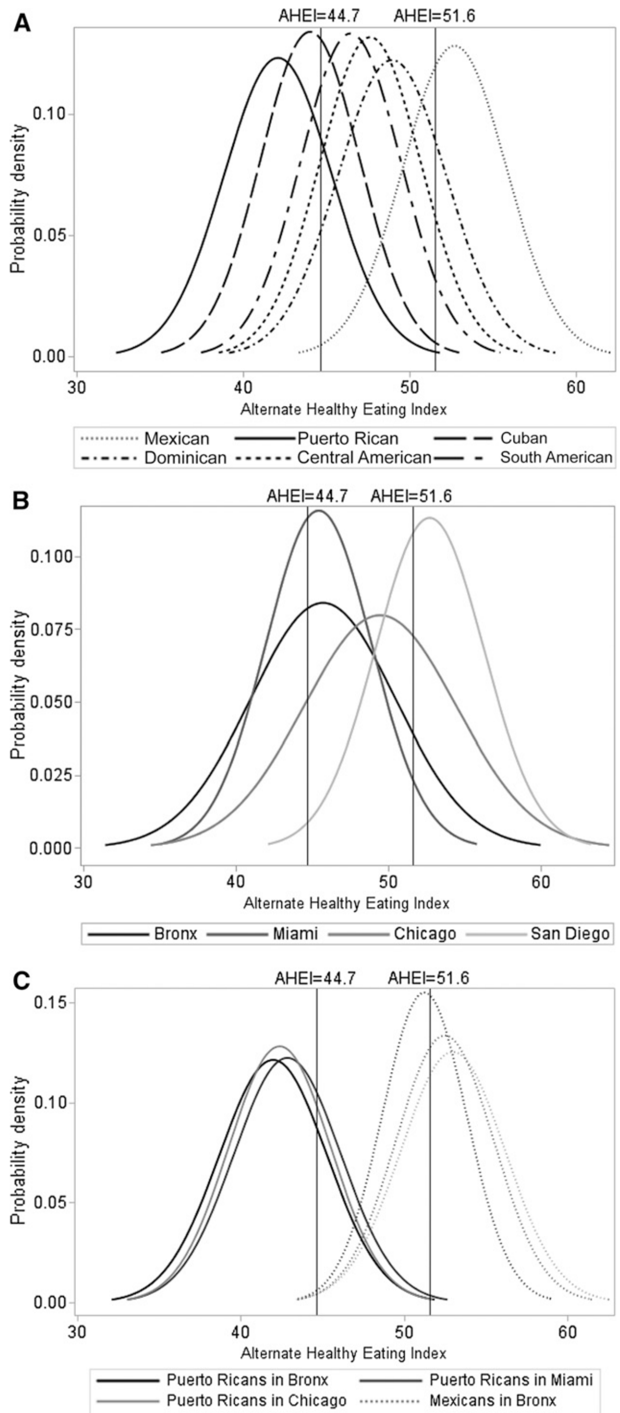


**FIGURE 1** Age-adjusted probability density distributions of AHEI by Hispanic or Latino background and center in HCHS/SOL individuals without diabetes. Values are age-adjusted probability densities of AHEI. Vertical lines represent tertile values of AHEI in the overall sample. (A) AHEI by Hispanic or Latino background (sample sizes per background: Mexican = 5067, Puerto Rican = 1944, Cuban = 1892, Dominican = 1175, Central American = 1402, and South American = 926). (B) AHEI by HCHS/SOL center (sample sizes per center: Bronx = 2928, Miami = 3226, Chicago = 3113, and San Diego = 3,139). (C) AHEI for Mexicans (dashed lines) and Puerto Ricans (solid lines) by HCHS/SOL center with ≥5% of those of that ethnic background living in that location (sample sizes per background by center: Puerto Ricans in Bronx = 1289, Puerto Ricans in Miami = 63, Puerto Ricans in Chicago = 567, Mexicans in Bronx = 175, Mexicans in Chicago = 1836, and Mexicans in San Diego = 3021). AHEI, Alternate Healthy Eating Index; HCHS/SOL, Hispanic Community Health Study/Study on Latinos.

between AHEI and waist circumference were stronger for Puerto Ricans and with HDL cholesterol for Puerto Ricans and Central Americans.

## Discussion

We found that HCHS/SOL participants with varied US Hispanic and Latino ethnic backgrounds differed in the quality of their diets and the strength of association between diet quality and MetS. Overall, each additional 10-unit increase in AHEI (equivalent to 1 maximally scored component) was associated with 22% lower odds of MetS. This estimates the potential magnitude of benefit that could be obtained by modest improvements in diet quality according to AHEI criteria. The association between AHEI and MetS remained significant for Mexicans and Central Americans but not for other backgrounds, when examined separately. This suggests that the dietary components included in the AHEI may be particularly beneficial for MetS prevention for Mexicans and Central Americans. The results agree with previous observations of significant associations between diet quality constructs and MetS in Mexicans (30) and Guatemalans (31). A study conducted in Cubans showed an association between higher AHEI and reduced 10-y predicted coronary heart disease risk, but only in participants with diabetes (32); we excluded those with diabetes in our study. Among individual cardiometabolic risk factors, waist circumference for Puerto Ricans and HDL cholesterol for Puerto Ricans and Central Americans were more influenced by diet.

A healthy diet is generally effective in preventing cardiometabolic conditions, so our results should not be interpreted as diet being irrelevant for some Hispanic or Latino groups. Possible explanations for the lack of associations in some groups could be smaller sample sizes, misreporting of diet in some groups (24, 33), incomplete capture of specific traditional foods, or genetic variations between ethnic backgrounds (34, 35) that may translate into gene-diet interactions with differential phenotypes. It is possible that other interactive or mediating factors are operating. For example, we previously showed that the odds of MetS were 31% lower for every 10-unit increase in diet quality in men but not in women from a Puerto Rican middle-aged cohort (36), which is similar in magnitude to the nonsignificant results for Puerto Ricans in our study. The nonsignificant results for Puerto Ricans were unexpected given the multiple cardiometabolic components strongly associated with AHEI in this group, but effect modification by sex or age could be operating. Finally, the use of a lower abdominal obesity criterion proposed by the International Diabetes Federation did not alter the results observed with higher thresholds recommended for US populations. There is no consensus on the most applicable thresholds for waist circumference for Hispanics and Latinos, which are likely influenced by their mixed racial/ethnic genetic profile. Nonetheless, although different cutoffs may slightly alter prevalence estimates of abdominal obesity or MetS, associations with cardiometabolic correlates tend to be unaffected (10).

Little information has been reported on differences in overall diet quality across Hispanic and Latino background groups. Most previous studies in the Hispanic and Latino population have either reported on just one ethnicity or grouped them all together. However, grouped reports should be interpreted with caution. For example, NHANES studies that combined Hispanic and Latino ethnicities concluded that the diet quality of all Hispanics and Latinos is better than that of non-Hispanic whites (37, 38).

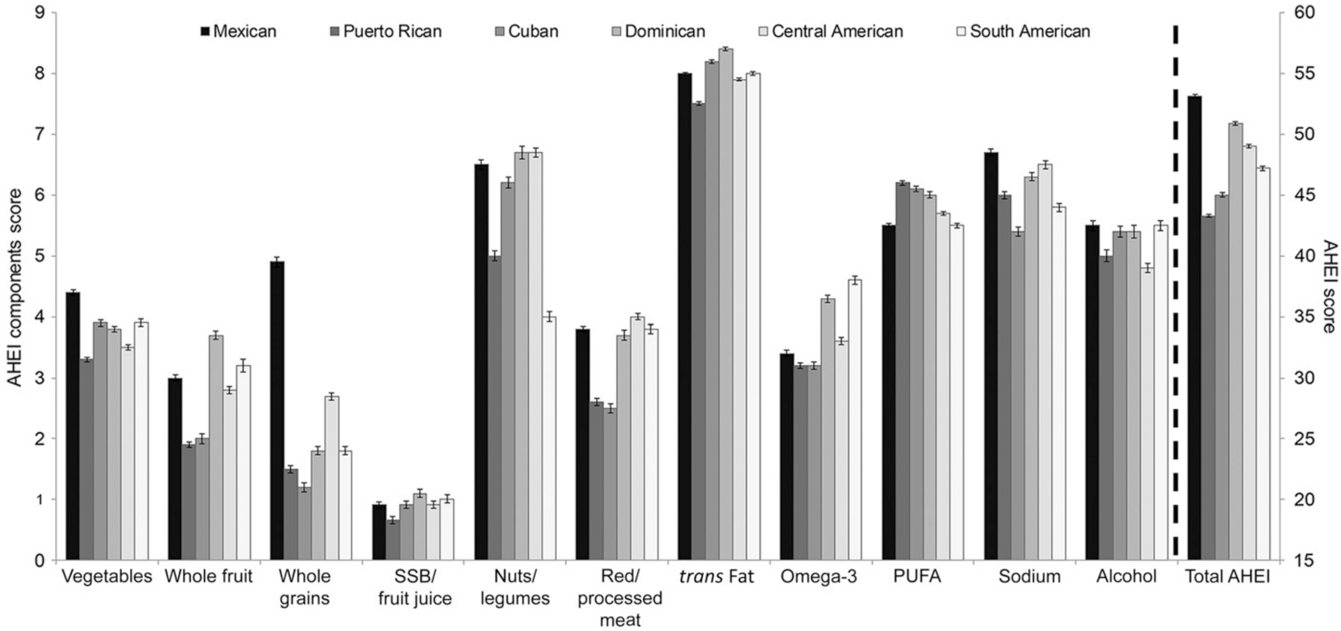


**FIGURE 2** Mean AHEI and its components by Hispanic and Latino background in HCHS/SOL individuals without diabetes. Values are means ± SEs for the score of the overall AHEI and its individual components, adjusted for age, sex, household income, marital status, educational attainment, years living in the United States, physical activity, smoking status, and center. In addition, nutrient and food group scores and intakes were adjusted for energy intake. The AHEI score has a possible range of 0–110 points; each individual score ranges from 0 to 10 points. The AHEI differed significantly by Hispanic or Latino background ($P < 0.001$). Sample sizes per background: all = 12,406, Mexicans = 5067, Puerto Ricans = 1944, Cubans = 1892, Dominicans = 1175, Central Americans = 1402, and South Americans = 926. AHEI, Alternate Healthy Eating Index; HCHS/SOL, Hispanic Community Health Study/Study on Latinos; SSB, sugar-sweetened beverages.

Such grouped-based conclusions may pertain to the predominant background of the study population and not represent the estimates and needs of distinct Hispanic and Latino ethnic backgrounds with poorer dietary intakes. Indeed, the NHANES Hispanic and Latino sample is predominantly composed of Mexican Americans (39), who tend to have a higher diet quality than other Hispanic and Latino groups, on the basis of the current results and on another NHANES study that reported on Mexican Americans exclusively (40). Moreover, grouped reports from different source populations of Hispanics or Latinos may yield disparate observations. For example, the Multi-Ethnic Study of Atherosclerosis showed that, overall, Hispanics and Latinos had the lowest AHEI among other major races/ethnicities (18, 41), contrary to the findings mentioned above. Recruitment locations and sociodemographic characteristics varied between the aforementioned cohorts. Among other studies conducted for individual Hispanic or Latino backgrounds, one study reported a mean AHEI of 34 in Cubans, 10 points lower than in our sample (32). Puerto Ricans have been shown to have poor diet quality with the use of another index derived from evidence-based dietary recommendations (36), similar to our findings.

Reports on individual foods and nutrients suggest differences across US Hispanic and Latino ethnic backgrounds (19, 20); thus, variations in diet quality components were to be expected. Our results not only reflect shared traditional diet components for all Hispanics and Latinos (e.g., legumes are a typical food and "nuts and legumes" were rated fairly high) but also suggest the need for ethnicity-specific dietary advice. Evidence-based practices for successful, sustainable dietary interventions to reduce the risk of CVD and related conditions among Hispanics and Latinos focus mainly on the delivery strategies (e.g., use of bicultural staff, appropriate settings, and social support) but also recommend that the foods must be familiar and culturally appropriate to the group (42, 43). Our study can help strengthen these strategies by suggesting types of foods and nutrients to be targeted for specific ethnic groups, for a deeper cultural tailoring. Although we should reinforce overall healthy eating habits for all Hispanics and Latinos (e.g., reducing sugar-sweetened beverages and increasing whole grains and fruit), additional emphasis could be placed on increasing intakes of nuts and legumes and PUFAs among South Americans, reducing sodium among Cubans, and increasing vegetable intake among Puerto Ricans, for example. Taken together, our results support a call from the American Heart Association (9) to avoid generalizations on diet or cardiometabolic health for Hispanics and Latinos as a whole, or as compared with other races and ethnicities, on the basis of a singular background.

Our results also suggest that the geographical locations of the field sites of this study have a role on diet quality. However, Mexican diet quality remained generally higher, whereas Puerto Rican diet quality remained poor in the 3 locations analyzed. Although differences across sites are likely driven by the ethnic majority of the site, other recognized factors such as socioeconomic status, acculturation, regional differences in food markets, and the built environment should be explored further.

We excluded participants with diabetes from the analysis because of the strong association of MetS with diabetes and a potential healthier diet for those with the disease. Indeed, we observed that HCHS/SOL participants with diabetes had slightly higher AHEI scores than those without diabetes, suggesting that individuals with the condition may be following a healthier diet as part of diabetes management. Other studies found similar results (28, 29), especially if the dietary advice was given by a health care provider (44, 45). HCHS/SOL participants aware of their diabetes status have been shown to have reduced carbohydrate and sugar intake and increased monounsaturated fat intake (46). Still, dietary intakes among Hispanics and Latinos

**TABLE 2** Mean AHEI and its components in HCHS/SOL individuals without diabetes, by ethnic background: 2008–2011[1]

| | Mexicans ($n$ = 5067) | Puerto Ricans ($n$ = 1944) | Cubans ($n$ = 1892) | Dominicans ($n$ = 1175) | Central Americans ($n$ = 1402) | South Americans ($n$ = 926) |
|---|---|---|---|---|---|---|
| Energy intake, kcal/d | 2003 ± 17.2$^{e}$ | 2077 ± 18.1$^{d,e,f}$ | 2029 ± 18.9 $^{e}$ | 1956 ± 20.3$^{b,e}$ | 1870 ± 17.3$^{a,b,c,d,f}$ | 1973 ± 18.9$^{b,e}$ |
| Total AHEI score | 52.6 ± 0.2 | 43.0 ± 0.2 | 45.0 ± 0.3 | 51.0 ± 0.2 | 49.0 ± 0.2 | 47.0 ± 0.3 |
| Vegetables (without potatoes) | | | | | | |
| Score | 4.4 ± 0.04$^{b,c,d,e,f}$ | 3.3 ± 0.04$^{a,c,d,f}$ | 3.9 ± 0.05$^{a,b,e}$ | 3.8 ± 0.05$^{a,b,e}$ | 3.5 ± 0.05$^{a,c,d,f}$ | 3.9 ± 0.06$^{a,b,e}$ |
| Servings/d[2] | 2.2 ± 0.02$^{b,c,d,e,f}$ | 1.6 ± 0.02$^{a,c,d,f}$ | 1.9 ± 0.03$^{a,b,e}$ | 1.9 ± 0.03$^{a,b,e}$ | 1.7 ± 0.02$^{a,c,d,f}$ | 1.9 ± 0.03$^{a,b,e}$ |
| Whole fruit (without fruit juice) | | | | | | |
| Score | 3.0 ± 0.05$^{b,c,d}$ | 1.9 ± 0.05$^{a,d,e,f}$ | 2.0 ± 0.08$^{a,d,e,f}$ | 3.7 ± 0.07$^{a,b,c,e,f}$ | 2.8 ± 0.06$^{b,c,d,f}$ | 3.2 ± 0.10$^{b,c,d,e}$ |
| Servings/d[2] | 1.2 ± 0.02$^{b,c,d}$ | 0.75 ± 0.02$^{a,d,e,f}$ | 0.79 ± 0.03$^{a,d,e,f}$ | 1.5 ± 0.03$^{a,b,c,e,f}$ | 1.1 ± 0.03$^{b,c,d,f}$ | 1.3 ± 0.04$^{b,c,d,e}$ |
| Whole grains | | | | | | |
| Score | 4.9 ± 0.08$^{b,c,d,e,f}$ | 1.5 ± 0.06$^{a,c,d,e}$ | 1.2 ± 0.08$^{a,b,d,e,f}$ | 1.8 ± 0.07$^{a,b,c,e}$ | 2.7 ± 0.06$^{a,b,c,d,f}$ | 1.8 ± 0.07$^{a,c,e}$ |
| Servings/d[2] | 2.7 ± 0.04$^{b,c,d,e,f}$ | 0.84 ± 0.04$^{a,c,d,e}$ | 0.65 ± 0.05$^{a,b,d,e,f}$ | 1.0 ± 0.04$^{a,b,c,e}$ | 1.5 ± 0.04$^{a,b,c,d,f}$ | 0.98 ± 0.04$^{a,c,e}$ |
| Sugar-sweetened beverages, fruit juices | | | | | | |
| Score | 0.91 ± 0.05$^{b}$ | 0.66 ± 0.06$^{a,c,d,e,f}$ | 0.91 ± 0.06$^{b}$ | 1.1 ± 0.07$^{b}$ | 0.91 ± 0.06$^{b}$ | 1.01 ± 0.07$^{b}$ |
| Servings/d[2] | 1.8 ± 0.04$^{b,c,d}$ | 2.0 ± 0.04$^{a,c,d}$ | 1.5 ± 0.05$^{a,b,e,f}$ | 1.5 ± 0.05$^{a,b,e,f}$ | 1.8 ± 0.04$^{c,d}$ | 1.8 ± 0.08$^{c,d}$ |
| Nuts and legumes | | | | | | |
| Score | 6.5 ± 0.08$^{b,f}$ | 5.0 ± 0.08$^{a,c,d,e,f}$ | 6.2 ± 0.09$^{b,d,e,f}$ | 6.7 ± 0.10$^{b,c,f}$ | 6.7 ± 0.08$^{b,c,f}$ | 4.0 ± 0.08$^{a,b,c,d,e}$ |
| Servings/d[2] | 0.70 ± 0.01$^{b,f}$ | 0.51 ± 0.01$^{a,c,d,e,f}$ | 0.68 ± 0.01$^{b,f}$ | 0.71 ± 0.01$^{b,f}$ | 0.74 ± 0.01$^{b,c,f}$ | 0.39 ± 0.01$^{a,b,c,d,e}$ |
| Red or processed meat | | | | | | |
| Score | 3.8 ± 0.05$^{b,c}$ | 2.6 ± 0.06$^{a,d,e,f}$ | 2.5 ± 0.07$^{a,d,e,f}$ | 3.7 ± 0.08$^{b,c,e}$ | 4.0 ± 0.05$^{b,c,d}$ | 3.8 ± 0.07$^{b,c}$ |
| Servings/d[2] | 0.93 ± 0.01$^{b,c,d}$ | 1.2 ± 0.01$^{a,c,d,e,f}$ | 1.2 ± 0.01$^{a,b,d,e,f}$ | 0.98 ± 0.01$^{a,b,c,e}$ | 0.91 ± 0.01$^{b,c,d}$ | 0.94 ± 0.01$^{b,c}$ |
| *trans* Fat | | | | | | |
| Score | 8.0 ± 0.02$^{b,c,d,e}$ | 7.5 ± 0.03$^{a,c,d,e,f}$ | 8.2 ± 0.03$^{a,b,d,e,f}$ | 8.4 ± 0.03$^{a,b,c,e,f}$ | 7.9 ± 0.02$^{a,b,c,d}$ | 8.0 ± 0.03$^{b,c,d}$ |
| % of energy | 1.2 ± 0.01$^{b,c,d,e}$ | 1.4 ± 0.01$^{a,c,d,e,f}$ | 1.1 ± 0.01$^{a,b,d,e,f}$ | 1.1 ± 0.01$^{a,b,c,e,f}$ | 1.2 ± 0.01$^{a,b,c,d}$ | 1.2 ± 0.01$^{b,c,d}$ |
| Omega-3 FAs | | | | | | |
| Score | 3.4 ± 0.05$^{b,d,f}$ | 3.2 ± 0.05$^{a,d,e,f}$ | 3.2 ± 0.06$^{d,e,f}$ | 4.3 ± 0.06$^{a,b,c,e,f}$ | 3.6 ± 0.06$^{b,c,d,f}$ | 4.6 ± 0.08$^{a,b,c,d,e}$ |
| mg/d | 84.5 ± 1.3$^{b,d,f}$ | 80.0 ± 1.2$^{a,d,e,f}$ | 79.5 ± 1.4$^{d,e,f}$ | 107 ± 1.6$^{a,b,c,e,f}$ | 89.0 ± 1.4$^{b,c,d,f}$ | 116 ± 1.9$^{a,b,c,d,e}$ |
| PUFAs | | | | | | |
| Score | 5.5 ± 0.03$^{b,c,d,e}$ | 6.2 ± 0.04$^{a,d,e,f}$ | 6.1 ± 0.04$^{a,e,f}$ | 6.0 ± 0.05$^{a,b,e,f}$ | 5.7 ± 0.03$^{a,b,c,d,f}$ | 5.5 ± 0.04$^{b,c,d,e}$ |
| % of energy | 6.4 ± 0.03$^{b,c,d,e}$ | 6.9 ± 0.03$^{a,d,e,f}$ | 6.9 ± 0.04$^{a,e,f}$ | 6.8 ± 0.04$^{a,b,e,f}$ | 6.6 ± 0.03$^{a,b,c,d,f}$ | 6.4 ± 0.03$^{b,c,d,e}$ |
| Sodium | | | | | | |
| Score | 6.7 ± 0.06$^{b,c,d,f}$ | 6.0 ± 0.06$^{a,c,d,e}$ | 5.4 ± 0.08$^{a,b,d,e,f}$ | 6.3 ± 0.07$^{a,b,c,e,f}$ | 6.5 ± 0.07$^{b,c,d,f}$ | 5.8 ± 0.07$^{a,c,d,e}$ |
| g/d | 3.11 ± 0.02$^{b,c,d,f}$ | 3.31 ± 0.02$^{a,c,e}$ | 3.49 ± 0.02$^{a,b,d,e,f}$ | 3.26 ± 0.02$^{a,c,e,f}$ | 3.16 ± 0.02$^{b,c,d,f}$ | 3.35 ± 0.02$^{a,c,d,e}$ |
| Alcohol | | | | | | |
| Score | 5.5 ± 0.08$^{b,e}$ | 5.0 ± 0.10$^{a,f}$ | 5.4 ± 0.09$^{e}$ | 5.4 ± 0.11$^{e}$ | 4.8 ± 0.08$^{a,c,d,f}$ | 5.5 ± 0.08$^{b,e}$ |
| Drinks/d[2] | 0.35 ± 0.02$^{b}$ | 0.26 ± 0.02$^{a,d,f}$ | 0.34 ± 0.02 | 0.38 ± 0.02$^{b,e}$ | 0.30 ± 0.02$^{d,f}$ | 0.36 ± 0.02$^{b,e}$ |

[1] Values are means ± SEs for the score of the overall AHEI and its individual components, with respective means ± SEs of intakes below each food group or nutrient score. Survey linear regressions were adjusted for age, sex, household income, marital status, educational attainment, years living in the United States, physical activity, smoking status, and center. In addition, nutrient and food group scores and intakes were adjusted for energy intake. AHEI score represents a range of 0–110 points; each individual score ranges from 0 to 10 points. AHEI was significantly different by background, $P < 0.0001$. Labeled means in a row with a common superscript letter differ by backgrounds ($P < 0.05$), after adjustment for Tukey's multiple pairwise comparisons: [a]Mexican, [b]Puerto Rican, [c]Cuban, [d]Dominican, [e]Central American, [f]South American. AHEI, Alternate Healthy Eating Index; HCHS/SOL, Hispanic Community Health Study/Study of Latinos.

[2] Serving size equivalents are as follows: 0.5 cup of vegetables or whole fruit or legumes = 100 g; 0.5 cup of whole grains = 31 g; 8 ounces of sugar-sweetened beverages or fruit juice = 250 mL; 1 ounce of red or processed meat = ~28 g; 1 standard drink (wine, beer, or liquor) = 14 g ethanol.

with diabetes remain poor (46). Given the critical role of diet on glycemic control, clinicians caring for Hispanics and Latinos should emphasize healthy dietary habits as part of diabetes management. Finally, we observed null results for the analysis of the association between AHEI and MetS for those with diabetes, suggestive of reverse causation.

A limitation of this study is that its cross-sectional nature cannot establish directionality between diet quality and cardiometabolic profile, although it is unlikely that diagnosis of MetS conditions would lead to worse diet quality. Acquiring longitudinal clinical and dietary data in this population is essential to confirm the observed associations. The study collected only two 24-h recalls, and measurement error (24) may underestimate the observed diet quality estimates and associations (25). We used only 1 measure of diet quality, which was originally developed from evidence gained from predominantly non-Hispanic white cohorts. It is possible that other components of the traditional Hispanic and Latino diet and important for their health are not represented in the AHEI or that the predefined AHEI cutoffs and weights for each component are less applicable to Hispanics and Latinos. Thus, adapting or contrasting various indexes and component weights by ethnic background may help to determine which ones have stronger associations with cardiometabolic diseases.

Our study has several strengths. First, the HCHS/SOL is the largest cohort of individuals of Hispanic and Latino origin in the United States, and the study design and probability sampling in urban areas with large ethnically diverse Hispanic and Latino populations provide adequate representation. We expect that results could be generalized to similar Hispanic and Latino communities,

**TABLE 3** Associations between each 10-unit increase in AHEI and metabolic syndrome, and its cardiometabolic risk factors, among Hispanic and Latino adults without diabetes by ethnic background: HCHS/SOL 2008–2011[1]

| | Mexicans (*n* = 5067) | Puerto Ricans (*n* = 1944) | Cubans (*n* = 1892) | Dominicans (*n* = 1175) | Central Americans (*n* = 1402) | South Americans (*n* = 926) | All (*n* = 12,406) |
|---|---|---|---|---|---|---|---|
| OR (95% CI) for metabolic syndrome[2] | 0.70 (0.56, 0.87) | 0.77 (0.51, 1.14) | 1.07 (0.79, 1.46) | 0.66 (0.43, 1.01) | 0.58 (0.36, 0.91) | 1.18 (0.72, 1.93) | 0.78 (0.67, 0.91) |
| *P* | 0.002 | 0.19 | 0.67 | 0.05 | 0.018 | 0.51 | 0.001 |
| Waist circumference,[2] cm | −1.79 ± 0.52 | −3.76 ± 1.23 | 0.83 ± 0.98 | −1.20 ± 1.20 | −1.00 ± 1.04 | −1.11 ± 1.01 | −1.59 ± 0.40 |
| Standardized β | −0.087 | −0.134 | 0.031 | −0.051 | −0.044 | −0.058 | −0.083 |
| *P* | < 0.001 | 0.002 | 0.40 | 0.32 | 0.34 | 0.27 | <0.0001 |
| Systolic blood pressure,[3] mm Hg | −1.58 ± 0.54 | −0.87 ± 1.4 | −0.10 ± 1.0 | −1.21 ± 1.1 | −0.96 ± 1.0 | −1.63 ± 1.0 | −0.88 ± 0.46 |
| Standardized β | −0.069 | 0.029 | −0.003 | −0.046 | −0.034 | −0.069 | −0.039 |
| *P* | 0.004 | 0.52 | 0.92 | 0.29 | 0.33 | 0.12 | 0.06 |
| Diastolic blood pressure,[3] mm Hg | −1.47 ± 0.43 | −1.89 ± 0.73 | 0.58 ± 0.70 | 0.02 ± 0.81 | −1.29 ± 0.84 | −1.78 ± 0.75 | −0.88 ± 0.28 |
| Standardized β | −0.093 | −0.094 | 0.028 | 0.001 | −0.066 | −0.111 | −0.059 |
| *P* | < 0.001 | 0.01 | 0.41 | 0.98 | 0.12 | 0.02 | 0.002 |
| Log serum TGs,[4] mg/dL | −0.05 ± 0.02 | −0.05 ± 0.04 | 0.01 ± 0.04 | −0.06 ± 0.04 | −0.03 ± 0.04 | 0.02 ± 0.04 | −0.04 ± 0.01 |
| Standardized β | −0.065 | −0.049 | 0.009 | −0.075 | −0.032 | 0.020 | −0.046 |
| *P* | 0.008 | 0.25 | 0.80 | 0.07 | 0.43 | 0.68 | 0.01 |
| Serum HDL cholesterol,[4] mg/dL | 1.00 ± 0.59 | 2.95 ± 1.1 | 1.44 ± 1.0 | 1.57 ± 1.1 | 3.71 ± 1.0 | 0.58 ± 0.94 | 1.35 ± 0.39 |
| Standardized β | 0.052 | 0.123 | 0.058 | 0.078 | 0.160 | 0.029 | 0.076 |
| *P* | 0.09 | 0.007 | 0.13 | 0.15 | < 0.001 | 0.54 | 0.001 |
| Fasting plasma glucose, mg/dL | −1.07 ± 0.27 | −1.25 ± 0.60 | 0.18 ± 0.45 | −0.33 ± 0.55 | −0.01 ± 0.54 | 0.93 ± 0.79 | −0.63 ± 0.20 |
| Standardized β | −0.089 | −0.075 | 0.011 | −0.025 | −0.001 | 0.076 | −0.055 |
| *P* | < 0.001 | 0.04 | 0.69 | 0.55 | 0.99 | 0.23 | 0.002 |

[1] Values are β-coefficients ± SEs (unless otherwise indicated), standardized β-coefficients, and *P* values for individual cardiometabolic components. To convert TGs to mmol/L, multiply values by 0.0113. To convert HDL cholesterol to mmol/L, multiply values by 0.0259. To convert fasting blood glucose to mmol/L, multiply values by 0.0555. AHEI, Alternate Healthy Eating Index; HCHS/SOL, Hispanic Community Health Study/Study on Latinos.
[2] Adjusted for age, sex, household income, marital status, educational attainment, years living in the United States, health insurance, physical activity, smoking status, energy intake, and center. Metabolic syndrome was defined by using the harmonized guidelines from the 2009 Joint Scientific Statement, including use of medication (5).
[3] Blood pressure was additionally adjusted for use of antihypertensive medication.
[4] Serum TGs and HDL cholesterol were additionally adjusted for use of lipid-lowering medication (fibric and nicotinic acids).

but larger multiethnic studies across the United States should be conducted to support this. Dietary assessment with 24-h recalls has been deemed useful in providing details about foods consumed, as well as culturally neutral data that can be compared across cultural and population groups (25). In addition, the use of an index that reflects the whole diet quality may convey stronger associations with disease outcomes than individual food or nutrient components (47). We adjusted for several factors that may influence the studied associations, including a proxy measure of acculturation (i.e., years of living in the United States).

In conclusion, although healthier diet quality may protect all Hispanics and Latinos against MetS, the strength of association of AHEI and cardiometabolic factors varied by ethnic background. The diverging results may explain why some studies that group all Hispanics and Latinos when analyzing associations between diet and disease outcomes can have null or inconsistent results. Our study adds evidence that can help shift the current paradigm of conducting observational and clinical studies on diet and lifestyles and disease in Hispanics and Latinos together toward ethnicity-specific analysis. A similar approach may be used for other multiethnic populations who tend to be grouped or to geographic regions with diverse dietary habits. Successful dietary interventions for disease prevention are those that incorporate culturally appropriate diet quality components (48). Our study contributes to the understanding of ethnic differences in diet and health and may therefore inform clinical and public health strategies for each ethnicity to help improve diet quality and to prevent eventual chronic conditions for the growing population of US Hispanics and Latinos.

**Acknowledgments**

JM researched the literature, developed the study concept and design, analyzed and interpreted the data, and organized and wrote the manuscript; DS-A assisted with statistical analysis, provided data verification and interpretation, and critically revised and edited the manuscript; FBH, KLT, WCW, and RCK contributed to the study design and concept, data interpretation, and careful revision of the manuscript; and MLD, LCG, MG, AMS-R, and LVH contributed to the interpretation of data and critically reviewed and edited the manuscript. All authors read and approved the final manuscript.

## References

1. Geiss LS, Wang J, Cheng YJ, Thompson TJ, Barker L, Li Y, Albright AL, Gregg EW. Prevalence and incidence trends for diagnosed diabetes among adults aged 20 to 79 years, United States, 1980–2012. JAMA 2014;312:1218–26.
2. Schneiderman N, Llabre M, Cowie CC, Barnhart J, Carnethon M, Gallo LC, Giachello AL, Heiss G, Kaplan RC, LaVange LM, et al. Prevalence of diabetes among Hispanics/Latinos from diverse backgrounds: the Hispanic Community Health Study/Study of Latinos (HCHS/SOL). Diabetes Care 2014;37:2233–9.
3. Statistical Fact Sheet. 2015 Update: Hispanics/Latinos & Cardiovascular Diseases. American Heart Association. [Internet]; 2015. [cited 2015 Dec 21]. Available from: http://www.heart.org/idc/groups/heart-public/@wcm/@sop/@smd/documents/downloadable/ucm_472912.pdf.
4. Lorenzo C, Williams K, Hunt KJ, Haffner SM. The National Cholesterol Education Program–Adult Treatment Panel III, International Diabetes Federation, and World Health Organization definitions of the metabolic syndrome as predictors of incident cardiovascular disease and diabetes. Diabetes Care 2007;30:8–13.

5. Alberti KG, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, Fruchart JC, James WP, Loria CM, Smith SC Jr. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. Circulation 2009;120:1640–5.
6. Daviglus ML, Talavera GA, Aviles-Santa ML, Allison M, Cai J, Criqui MH, Gellman M, Giachello AL, Gouskova N, Kaplan RC, et al. Prevalence of major cardiovascular risk factors and cardiovascular diseases among Hispanic/Latino individuals of diverse backgrounds in the United States. JAMA 2012;308:1775–84.
7. Derby CA, Wildman RP, McGinn AP, Green RR, Polotsky AJ, Ram KT, Barnhart J, Weiss G, Santoro N. Cardiovascular risk factor variation within a Hispanic cohort: SWAN, the Study of Women's Health Across the Nation. Ethn Dis 2010;20:396–402.
8. Daviglus ML, Pirzada A, Talavera GA. Cardiovascular disease risk factors in the Hispanic/Latino population: lessons from the Hispanic Community Health Study/Study of Latinos (HCHS/SOL). Prog Cardiovasc Dis 2014;57:230–6.
9. Rodriguez CJ, Allison M, Daviglus ML, Isasi CR, Keller C, Leira EC, Palaniappan L, Pina IL, Ramirez SM, Rodriguez B, et al. Status of cardiovascular disease and stroke in Hispanics/Latinos in the United States: a science advisory from the American Heart Association. Circulation 2014;130:593–625.
10. Heiss G, Snyder ML, Teng Y, Schneiderman N, Llabre MM, Cowie C, Carnethon M, Kaplan R, Giachello A, Gallo L, et al. Prevalence of metabolic syndrome among Hispanics/Latinos of diverse background: the Hispanic Community Health Study/Study of Latinos. Diabetes Care 2014;37:2391–9.
11. 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.
12. Fung TT, McCullough M, van Dam RM, Hu FB. A prospective study of overall diet quality and risk of type 2 diabetes in women. Diabetes Care 2007;30:1753–7.
13. Belin RJ, Greenland P, Allison M, Martin L, Shikany JM, Larson J, Tinker L, Howard BV, Lloyd-Jones D, Van Horn L. Diet quality and the risk of cardiovascular disease: the Women's Health Initiative (WHI). Am J Clin Nutr 2011;94:49–57.
14. Akbaraly TN, Singh-Manoux A, Tabak AG, Jokela M, Virtanen M, Ferrie JE, Marmot MG, Shipley MJ, Kivimaki M. Overall diet history and reversibility of the metabolic syndrome over 5 years: the Whitehall II prospective cohort study. Diabetes Care 2010;33:2339–41.
15. 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.
16. Qiao Y, Tinker L, Olendzki BC, Hebert JR, Balasubramanian R, Rosal MC, Hingle M, Song Y, Schneider KL, Liu S, et al. Racial/ethnic disparities in association between dietary quality and incident diabetes in postmenopausal women in the United States: the Women's Health Initiative 1993–2005. Ethn Health 2014;19:328–47.
17. Gao SK, Beresford SA, Frank LL, Schreiner PJ, Burke GL, Fitzpatrick AL. Modifications to the Healthy Eating Index and its ability to predict obesity: the Multi-Ethnic Study of Atherosclerosis. Am J Clin Nutr 2008;88:64–9.
18. Harmon BE, Boushey CJ, Shvetsov YB, Ettienne R, Reedy J, Wilkens LR, Le Marchand L, Henderson BE, Kolonel LN. Associations of key diet-quality indexes with mortality in the Multiethnic Cohort: the Dietary Patterns Methods Project. Am J Clin Nutr 2015;101:587–97.
19. 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.
20. Gans KM, Burkholder GJ, Upegui DI, Risica PM, Lasater TM, Fortunet R. Comparison of baseline fat-related eating behaviors of Puerto Rican, Dominican, Colombian, and Guatemalan participants who joined a cholesterol education project. J Nutr Educ Behav 2002;34:202–10.
21. Sorlie PD, Aviles-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, Aviles-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 and forms of the Hispanic Community Health Study/Study of Latinos [Internet]. c2008 [updated 2016; cited 2016 May 13]. Available from: http://www2.cscc.unc.edu/hchs/manuals-forms.
24. 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.
25. 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.
26. 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.
27. Alberti KG, Zimmet P, Shaw J. Metabolic syndrome—a new world-wide definition. A consensus statement from the International Diabetes Federation. Diabet Med 2006;23:469–80.
28. Ulrichsen SP, Mor A, Svensson E, Larsen FB, Thomsen RW. Lifestyle factors associated with type 2 diabetes and use of different glucose-lowering drugs: cross-sectional study. PLoS One 2014;9:e111849.
29. Geiss LS, James C, Gregg EW, Albright A, Williamson DF, Cowie CC. Diabetes risk reduction behaviors among U.S. adults with prediabetes. Am J Prev Med 2010;38:403–9.
30. Ramírez-Vargas E, Arnaud-Vinas Mdel R, Delisle H. Prevalence of the metabolic syndrome and associated lifestyles in adult males from Oaxaca, Mexico. Salud Publica Mex 2007;49:94–102.
31. Gregory CO, McCullough ML, Ramirez-Zea M, Stein AD. Diet scores and cardio-metabolic risk factors among Guatemalan young adults. Br J Nutr 2009;101:1805–11.
32. Huffman FG, Zarini GG, McNamara E, Nagarajan A. The Healthy Eating Index and the Alternate Healthy Eating Index as predictors of 10-year CHD risk in Cuban Americans with and without type 2 diabetes. Public Health Nutr 2011;14:2006–14.
33. Banna JC, Fialkowski MK, Townsend MS. Misreporting of dietary intake affects estimated nutrient intakes in low-income Spanish-speaking women. J Acad Nutr Diet 2015;115:1124–33.
34. Shtir CJ, Marjoram P, Azen S, Conti DV, Le Marchand L, Haiman CA, Varma R. Variation in genetic admixture and population structure among Latinos: the Los Angeles Latino Eye Study (LALES). BMC Genet 2009;10:71.
35. Choudhry S, Coyle NE, Tang H, Salari K, Lind D, Clark SL, Tsai HJ, Naqvi M, Phong A, Ung N, et al. Population stratification confounds genetic association studies among Latinos. Hum Genet 2006;118:652–64.
36. Mattei J, Bhupathiraju S, Tucker KL. Higher adherence to a diet score based on American Heart Association recommendations is associated with lower odds of allostatic load and metabolic syndrome in Puerto Rican adults. J Nutr 2013;143:1753–9.
37. Rehm CD, Monsivais P, Drewnowski A. The quality and monetary value of diets consumed by adults in the United States. Am J Clin Nutr 2011;94:1333–9.
38. Hiza HA, Casavale KO, Guenther PM, Davis CA. Diet quality of Americans differs by age, sex, race/ethnicity, income, and education level. J Acad Nutr Diet 2013;113:297–306.
39. CDC. National Health and Nutrition Examination Survey: note on 2007–2010 Sampling Methodology [Internet]; 2011 [updated 2015; cited 2015 Dec 21]. Available from: http://www.cdc.gov/nchs/nhanes/nhanes2007–2008/sampling_0708.htm/.
40. Wang DD, Leung CW, Li Y, Ding EL, Chiuve SE, Hu FB, Willett WC. Trends in dietary quality among adults in the United States, 1999 through 2010. JAMA Intern Med 2014;174:1587–95.
41. Moore LV, Diez Roux AV, Nettleton JA, Jacobs DR, Franco M. Fast-food consumption, diet quality, and neighborhood exposure to fast food: the multi-ethnic study of atherosclerosis. Am J Epidemiol 2009;170:29–36.

42. Perez LG, Arredondo EM, Elder JP, Barquera S, Nagle B, Holub CK. Evidence-based obesity treatment interventions for Latino adults in the U.S.: a systematic review. Am J Prev Med 2013;44:550–60.
43. Mier N, Ory MG, Medina AA. Anatomy of culturally sensitive interventions promoting nutrition and exercise in Hispanics: a critical examination of existing literature. Health Promot Pract 2010;11:541–54.
44. Yang K, Lee YS, Chasens ER. Outcomes of health care providers' recommendations for healthy lifestyle among U.S. adults with prediabetes. Metab Syndr Relat Disord 2011;9:231–7.
45. Dorsey R, Songer T. Lifestyle behaviors and physician advice for change among overweight and obese adults with prediabetes and diabetes in the United States, 2006. Prev Chronic Dis 2011;8:A132.
46. Wang X, Jung M, Mossavar-Rahmani Y, Sotres-Alvarez D, Espinoza Giacinto RA, Pirzada A, Reina SA, Casagrande SS, Wang T, Aviles-Santa ML, et al. Macronutrient intake, diagnosis status, and glycemic control among US Hispanics/Latinos with diabetes. J Clin Endocrinol Metab 2016;101:1856–64.
47. Wirt A, Collins CE. Diet quality—what is it and does it matter? Public Health Nutr 2009;12:2473–92.
48. Kreuter MW, Lukwago SN, Bucholtz RD, Clark EM, Sanders-Thompson V. Achieving cultural appropriateness in health promotion programs: targeted and tailored approaches. Health Educ Behav 2003;30:133–46.