Association of Diet Quality Indices with Longitudinal Changes in Kidney Function in U.S. Hispanics/Latinos: Findings from the Hispanic Community Health Study/Study of Latinos (HCHS/SOL)

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Abstract

Background Recent studies suggest an association between diet quality and incident CKD. However, Hispanics/Latinos were under-represented in these studies. We examined the relationship of diet quality with change in kidney function in the Hispanic Community Health Study/Study of Latinos (HCHS/SOL).

Methods Individuals who participated in HCHS/SOL visits 1 (2008–2011) and 2 (2014–2017) were analyzed (n=9921). We used Alternate Healthy Eating Index 2010 (AHEI-2010), Dietary Approaches to Stop Hypertension (DASH), and Mediterranean Diet (MeDS) scores as measures of dietary quality. Scores were calculated from two 24-hour dietary recalls administered at visit 1 and categorized into quartiles of each dietary score (higher quartiles correspond to a healthier diet). Kidney function was assessed at both visits using eGFR and urine albumin-creatinine ratio (UACR). Annualized change was computed as the difference in eGFR or UACR between visits divided by follow-up time in years. Weighted linear-regression models were used to examine the association between quartiles of each dietary quality index and annualized change in eGFR and UACR, adjusted for potential confounders.

Results At visit 1, the mean (SD) age of participants was 41 (0.28) years, and 56% were female. The baseline mean eGFR was 107.1 ml/min per 1.73 m^2, and baseline median UACR was 6.1 mg/g. On average, eGFR declined by 0.65 ml/min per 1.73 m^2 per year, and UACR increased by 0.79 mg/g per year over a 6-year period. Lower AHEI-2010 quartiles were associated with eGFR decline in a dose-response manner (P trend=0.02). Higher AHEI-2010 quartiles showed a trend toward lower annualized change in UACR, but the result did not reach significance. Neither MeDS nor DASH scores were associated with eGFR decline or change in UACR.

Conclusions Unhealthy diet, assessed at baseline by AHEI-2010, was associated with kidney-function decline over 6 years. Improving the quality of foods and nutrients according to the AHEI-2010 may help maintain kidney function in the Hispanic/Latino community.

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Introduction

CKD is emerging as a major public-health problem with an increasing burden worldwide. In the United States, CKD affects 15% of the population (1). Although the prevalence of CKD has stabilized in the United States over the last decade, it continues to increase among Mexican Americans (2). CKD is associated with high risk of morbidity and mortality (3–6), lower quality of life (7–9), and high medical costs (1). In addition, CKD disproportionately burdens minority populations (1,10–12). According to the United States Renal Data System, the rate of incident ESKD among Hispanics in the United States is 50% greater than in non-Hispanics (1). Furthermore, Hispanics in the United States have higher rates of progression of CKD compared with non-Hispanic Whites (11,12). The increasing burden of CKD among Hispanics/Latinos calls for prevention strategies geared toward this population.

Healthy dietary patterns have been found to have protective associations with risk of incident CKD. Data

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from the Atherosclerosis Risk in Communities (ARIC) study showed that healthy dietary patterns assessed by the Alternate Healthy Eating Index 2010 (AHEI-2010), Dietary Approaches to Stop Hypertension (DASH), and Mediterranean Diet score (MeDS) were independently associated with a lower risk for developing CKD (13,14).

Although there is growing evidence that healthier dietary patterns are associated with lower risk of CKD, it remains unclear whether the association is consistent across ethnic groups. Hispanics/Latinos were under-represented in studies that have assessed the association between diet quality and risk for developing CKD. It is important to recognize that the Hispanic/Latino community is a heterogeneous group with diverse cultural, ethnic, and linguistic backgrounds, which can influence food choices (15). For example, it has been reported that Mexican Americans have a higher intake of legumes and eggs as their main protein source than non-Hispanic White and Black Americans after adjusting for income and education (16). As such, the diet-disease relationship may vary in terms of ethnicity and culture. Therefore, evaluating the role of dietary patterns in relation to change in kidney function in a large population of Hispanics/Latinos warrants further investigation.

The goal of this study was to examine the relationship between diet quality and change in kidney function in the Hispanic Community Health Study/Study of Latinos (HCHS/SOL). Several indices that assess the healthiness of dietary patterns have been developed. To compare this study with prior diet-kidney disease research, we explored three commonly used diet-quality indices: the AHEI-2010 (17,18), DASH (19), and MeDS (20).

Materials and Methods

Study Population

HCHS/SOL is a population-based, longitudinal study in the United States that enrolled adults between 2008 and 2011. The methods used to recruit, follow up, and collect data have been described previously (21,22). Participants were self-identified Hispanic/Latino individuals aged 18–74 years, randomly selected from households in the Bronx, New York; San Diego, California; Chicago, Illinois;

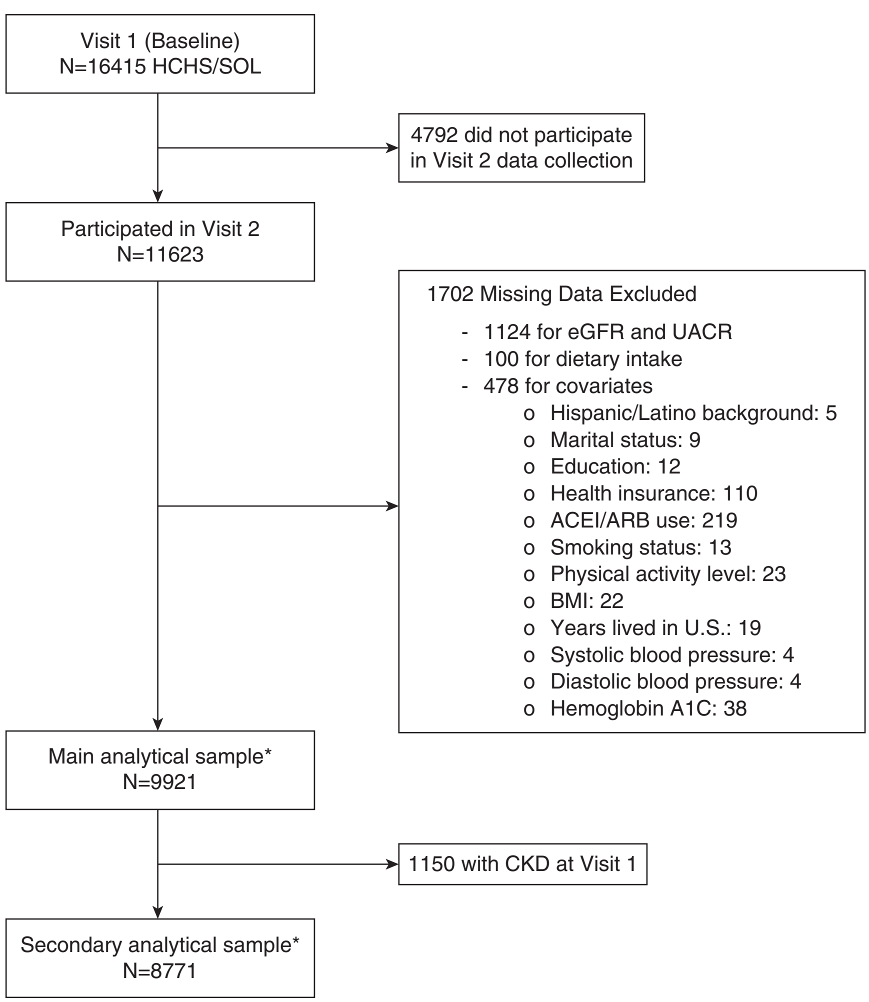

Figure 1. | The main and secondary analytical samples were created based on inclusion and exclusion criteria, resulting in 9921 and 8771 individuals, respectively. *Analytic sample weighted for participation at visit 2. ACEI/ARB, angiotensin-converting enzyme inhibitor/angiotensin receptor blocker; BMI, body mass index; HCHS/SOL, Hispanic Community Health Study/Study of Latinos; UACR, urinary albumin-creatinine ratio.

and Miami, Florida. A stratified, two-stage sampling method was used to select households. The study oversampled individuals aged 45–74 years. Each participating institutional review board approved the study, and written informed consent was obtained from all participants.

At baseline, between 2008 and 2011 (visit 1), a total of 16,415 individuals were enrolled in HCHS/SOL. Between 2014 and 2017, participants were invited to a second clinic visit. A total of 11,623 participants completed this follow-up visit (visit 2). Of these 11,623 individuals, we excluded those with missing information on kidney-function measures (urinary albumin-creatinine ratio [UACR], serum creatinine, cystatin C) (n=1124), incomplete diet data (n=100), or missing data on covariates (n=478) (Figure 1). This yielded 9921 individuals for our main analytic sample. We further excluded 1150 individuals with CKD at baseline to obtain our secondary analytic sample of 8771 individuals. Compared with the excluded individuals, our study samples at baseline were comparable in acculturation (place of birth, language spoken at home, and years of residence in the United States) and eGFR, but were more likely to be older, female, and have diabetes, hypertension, and cardiovascular disease (CVD). Both analytic samples were weighted to account for the complex survey design and nonresponse.

Assessment of Diet Quality

Dietary intake was measured at visit 1 using one or two 24-hour dietary recalls, approximately one 1 month apart, and administered using the Nutrition Data System for Research software developed by the University of Minnesota. The dietary information gathered included types of food intake, frequency of consumption, and serving sizes. Detailed information about dietary data collection were previously reported (23,24). The following diet-quality assessment indices were used: (*1*) AHEI-2010, which is a measure of diet quality on the basis of foods and nutrients predictive of chronic disease risk (17,18); (*2*) DASH (19), which reflects adherence to the DASH diet; and (*3*) MeDS, which reflects adherence to a Mediterranean dietary style (20).

The AHEI-2010, DASH, and MeDS scores were calculated from self-reported dietary intake of vegetables and fruits, grains, sugar-sweetened beverages and fruit juices, nuts and legumes, red/processed meat, fish, trans fat, long-chain fats, polyunsaturated fats, dairy, sodium, and alcohol, and scored on the basis of serving cutoffs (17–20). A healthy dietary pattern recommends a high consumption of certain foods/nutrients and a moderate consumption of others. The AHEI-2010 score was derived from 11 food components, each scored from zero (worst) to ten (best) (17,18). The AHEI-2010 score was the sum of the 11 individual component scores and ranged from zero to 110 points, with higher points indicating better diet quality (17,18). The DASH score was constructed by focusing on pattern of consumption of eight food components (19). Each food component was scored from zero to ten using predefined cut points, and scoring was consistent with previous DASH studies in HCHS/SOL (25,26). Individual food component scores were then added to generate an overall DASH score ranging from zero to 80, with higher points indicating better diet quality. The MeDS was calculated from nine food components (20). For each component, participants were assigned a score of zero if they consumed below the sex-specific median level of a healthy consumption of the component in the study population, or one if otherwise (20). Thus, MeDS ranged from zero to nine, with higher scores reflecting greater observance of a Mediterranean diet style.

Measurements of Kidney Function and Damage

eGFR

At visits 1 and 2, blood specimens were collected from participants. GFR, a measure of kidney function, was estimated at each study visit using the, Chronic Kidney Disease Epidemiology Collaboration Creatinine–Cystatin C Equation (27). Of the study participants, 38% did not report their race; therefore, race was not used in the calculation of eGFR. Serum creatinine was measured on a Roche Modular P Chemistry Analyzer (Roche Diagnostics, Indianapolis, IN) using a creatinase enzymatic method, and serum cystatin C was measured using a turbidimetric method on the Roche Modular P Chemistry Analyzer (Gentian AS, Moss, Norway).

UACR

Urinary assays were performed on spot collections at visits 1 and 2. Urinary creatinine was measured on a Roche Modular P Chemistry Analyzer using a creatinase enzymatic method, and urinary albumin was measured using an immunoturbidimetric method on the ProSpec nephelometric analyzer (D-35041; Dade Behring GMBH, Marburg, Germany). UACR approximates urinary albumin excretion rate, which is a measure of kidney damage (28,29).

Incident CKD

Incident CKD was defined as an eGFR of $<$60 ml/min per 1.73 m^2 and eGFR decline of $\geq$1 ml/min per year, or UACR $\geq$30 mg/g at visit 2. As a sensitivity analysis, we also defined incident CKD as an eGFR of $<$60 ml/min per 1.73 m^2 or a UACR of $\geq$30 mg/g at visit 2.

Covariates

At HCHS/SOL visit 1, sociodemographic data including age, sex, Hispanic/Latino background (Central American, Cuban, Dominican, Mexican, Puerto Rican, and South American), level of educational attainment, marital status, and health-insurance coverage were self-reported. Additional self-reported information assessed at visit 1 included the number of years lived in the United States, household income, smoking status, CVD (self-reported coronary heart disease, stroke, peripheral artery disease, or heart failure), and medication use. Information on acculturation, representing place of birth, language spoken at home, and years of residence in the United States, was included in HCHS/SOL. Acculturation was scored from zero to five, with five being the highest acculturation, as described previously (30). BP, height, and weight were ascertained on physical examination. Height and weight were used to calculate body mass index as weight (in kilograms) divided by height (in meters) squared. Hypertension was defined as systolic BP of $\geq$140 mm Hg, diastolic BP of $\geq$90 mm Hg, or use of antihypertensive medications. Venous blood specimens were also collected at visit 1 and analyzed to measure blood glucose, hemoglobin A1C, cholesterol, and triglycerides.

Diabetes mellitus was defined according to the American Diabetes Association as follows: fasting time >8 hours and fasting blood glucose of ≥126 mg/dl, fasting time <8 hours and fasting glucose of ≥200 mg/dl, a post–oral glucose tolerance test glucose of ≥200 mg/dl, hemoglobin A1C of ≥6.5%, or use of antihyperglycemic medications. These covariates were considered potential confounders because they were previously reported to be associated with dietary patterns and/or kidney-function decline (31–34).

Statistical Analyses

Associations of baseline dietary scores with change in kidney function were examined using the whole sample (n=9921). Among those without CKD at baseline (n=8771), we assessed the associations of dietary scores with incident CKD. We calculated Pearson correlations across the three dietary scores. To be consistent with the published literature, the study population was divided into quartiles according to their dietary scores (13,14). Baseline population characteristics across quartiles of dietary scores were reported using weighted proportions and means. Annual rate of change in kidney function was computed as the difference in eGFR or UACR between visits 1 and 2 divided by follow-up time in years. Weighted linear-regression models were used to examine the association between quartiles of each dietary score and annual rate of change in eGFR and UACR adjusted for potential confounders, with the highest quartile (higher quality diet) as the referent category. Covariates included in the adjusted models were sociodemographic characteristics (age, sex, educational attainment, marital status, Hispanic/Latino background, years lived in the United States, household income, and health insurance coverage), clinical characteristics (body mass index, diabetes, hemoglobin A1C, hypertension, systolic BP, diastolic BP, total cholesterol, triglycerides, baseline kidney-function measures), health behaviors (cigarette smoking and physical activity), renoprotective medication use (angiotensin-converting enzyme inhibitor/angiotensin receptor blocker), and study site. A dose-response relationship was evaluated by testing for trend across quartiles of dietary patterns. We further explored associations with individual AHEI-2010 components. Individual dietary component scores (range from zero to ten) that comprised the overall AHEI-2010 score were analyzed as continuous variables and mutually adjusted for each other and other covariates. Logistic-regression models were used to examine the association between quartiles of each dietary score and incident CKD, while adjusting for covariates and follow-up time between visits 1 and 2. As sensitivity analyses, we analyzed dietary scores as continuous variables to investigate their association with annualized change in kidney function. We also repeated the analyses by restricting the analytic sample to individuals with an eGFR of ≥90 ml/min per 1.73 m^2 at baseline. All statistical analyses accounted for the HCHS/SOL complex design and were weighted to adjust for sampling probability and nonresponse. Analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC).

Results

The demographic profile of the study population shows that 38% of Hispanics/Latinos were of Mexican origin, 21% were Cuban, 16% were Puerto Rican, 9% were Dominican, 8% were Central American, 5% were South American, and the remaining (4%) came from diverse countries of origin. Mexicans were largely concentrated in San Diego (63%) and Chicago (27%); Cubans in Miami (97%); Puerto Ricans in Bronx (71%) and Chicago (21%); Dominicans in Bronx (94%); Central Americans in Miami (62%) and Bronx (20%); and South Americans in Miami (51%), Chicago (22%), and Bronx (22%).

Overall, the study population had a mean age of 41 years and 56% was female at visit 1. Two fifths (43%) of participants reported an annual household income <$20,000, 32% attained less than a high-school education, and nearly half (49%) reported not having health-insurance coverage. Chronic conditions were prevalent at visit 1, with 24% reporting CVD, 24% having hypertension, and 16% having diabetes. At visit 1, the mean eGFR was 107.1 ml/min per 1.73 m^2, and the median UACR was 6.1 mg/g. Overall, the diet quality of Hispanics/Latinos at baseline was low to average, with a mean AHEI-2010 of 47.5 (the highest 25% of scores ranged from 55 to 77 on a scale of 0–110), a mean DASH of 36.0 (the highest 25% of scores ranged from 45 to 76 on a scale of 0–80), and a mean MeDS of 4.7 (the highest 25% of scores ranged from seven to nine on a scale of 0–9). The distribution of dietary scores was similar across income levels (Table 1). The correlation between dietary scores was strong to moderate: 0.64 for AHEI-2010 and MeDS, 0.50 for AHEI-2010 and DASH, and 0.42 for DASH and MeDS. The study population characteristics, stratified by quartiles of dietary scores, are presented in Table 1. Cubans and Puerto Ricans were predominant in the lowest quartiles of dietary scores. An analysis of individual AHEI-2010 components showed that Cubans and Puerto Ricans, on average, scored two or less on whole fruit, whole grain, sweetened beverages, and fruit juice. In addition, Cubans scored on average less than two on red/processed meat, whereas Puerto Ricans scored on average less than three on vegetables. Both Cubans and Puerto Ricans scored about three, on average, on long-chain fats. Together, these findings indicate that Cubans and Puerto Ricans have higher intakes of sugar-sweetened drinks, fruit juice, and red and processed meat; and lower intakes of vegetables, whole fruit, whole grain, and long-chain fats. Being older, Mexican, or married/living with a partner, or having diabetes, high total cholesterol, or high triglycerides were all more common among those in the highest quartiles compared with the lowest quartiles of AHEI-2010, DASH, and MeDS scores. Individuals in the highest quartile of AHEI-2010 score were more likely to have hypertension and CVD compared with the lowest, whereas there were no such distinctions with MeDS and DASH scores. Those with the highest AHEI-2010 score tended to be men, whereas those with the highest DASH score tended to be women, but sex distribution was similar between the lowest and highest quartiles of MeDS. The mean UACR was significantly higher in the highest quartile of AHEI-2010 than the lowest quartile, and was similar in the first and fourth quartiles of MeDS and DASH scores.

Annualized Change in eGFR

Over a median follow-up period of 6 years (range, 3.4–9.6 years), on average, eGFR declined by 0.65 ml/min per 1.73 m^2 per year. Figure 2 shows the annualized change in eGFR across quartiles of AHEI-2010, DASH, and MeDS adjusted for covariates in Table 1. The adjusted decline for

Table 1. Baseline characteristics by lowest versus highest quartiles of dietary scores, HCHS/SOL (2008–2011) (*n*=9921)

Baseline Characteristics	AHEI-2010[a]		DASH[b]		MeDS[c]	
	Q1: 28–43	Q4: 55–77	Q1: 1–29	Q4: 45–76	Q1: 0–3	Q4: 7–9
N	2481	2481	2480	2481	1993	2076
Age (yr)	35.80 (0.35)[d]	49.15 (0.60)[d]	39.61 (0.42)[d]	43.67 (0.60)[d]	38.30 (0.49)[d]	45.74 (0.57)[d]
Female sex, %	60[d]	40[d]	48[d]	62[d]	52	54
Hispanic/Latino background, %						
Central American	8[d]	5[d]	8[d]	7[d]	5[d]	8[d]
Cuban	32[d]	4[d]	25[d]	13[d]	22[d]	8[d]
Dominican	5[d]	10[d]	5[d]	13[d]	9[d]	4[d]
Mexican	12[d]	74[d]	29[d]	51[d]	12[d]	70[d]
Puerto Rican	32[d]	2[d]	23[d]	9[d]	44[d]	0.91[d]
South American	6[d]	3[d]	5	4	2[d]	7[d]
More than one/other heritage	4	3	5	3	6[d]	2[d]
Less than high school diploma, %	27[d]	40[d]	28[d]	37[d]	30[d]	41[d]
Marital status, %						
Single	48[d]	16[d]	40[d]	27[d]	48[d]	18[d]
Married or living with a partner	38[d]	67[d]	46[d]	55[d]	38[d]	65[d]
Separated/divorced/widow(er)	14	17	14	18	15	17
Household income ≤$20,000, %	46[d]	38[d]	46	46	43	40
Having health insurance, %	54	52	50	51	65[d]	43[d]
Acculturation score	2.14 (0.08)[d]	1.78 (0.05)[d]	2.12 (0.07)[d]	1.67 (0.05)[d]	2.54 (0.08)[d]	1.58 (0.05)[d]
Years lived in the United States	19.50 (0.57)[d]	22.80 (0.54)[d]	21.22 (0.56)	19.53 (0.49)	23.78 (0.62)[d]	19.67 (0.55)[d]
Current smokers, %	27[d]	13[d]	28[d]	12[d]	29[d]	13[d]
Low physical activity level, %	44	41	44	42	43	41
Body mass index (kg/m^2)	29.42 (0.19)	29.23 (0.17)	29.58 (0.19)	29.42 (0.18)	29.86 (0.23)	29.45 (0.16)
Medical conditions, %						
Diabetes	9[d]	25[d]	12[d]	19[d]	11[d]	20[d]
Hypertension	16[d]	29[d]	21	24	21	23
CVD	19[d]	29[d]	21	25	23	24
ACEI/ARB use, %	6[d]	12[d]	8	10	7	9
Hemoglobin A1C (%)	5.56 (0.02)[d]	6.03 (0.04)[d]	5.66 (0.03)[d]	5.84 (0.04)[d]	5.63 (0.03)[d]	5.92 (0.05)[d]
Systolic BP (mm Hg)	116.51 (0.40)[d]	122.83 (0.49)[d]	119.61 (0.42)	119.71 (0.53)	119.37 (0.51)	120.28 (0.55)
Diastolic BP (mm Hg)	71.79 (0.30)	71.91 (0.35)	72.43 (0.34)	71.30 (0.33)	73.01 (0.35)[d]	71.26 (0.32)[d]
Total cholesterol (mg/dl)	186.44 (1.16)[d]	202.34 (1.44)[d]	192.36 (1.13)	196.17 (1.41)	190.69 (1.36)[d]	201.54 (1.48)[d]
Triglycerides (mg/dl)	123.14 (3.19)[d]	146.74 (3.01)[d]	131.45 (3.96)	134.70 (2.77)	127.70 (4.24)[d]	144.58 (3.06)[d]
eGFR (ml/min per 1.73 m^2)	109.87 (0.50)[d]	102.45 (0.75)[d]	107.50 (0.57)	106.26 (0.67)	106.95 (0.65)	105.76 (0.75)
UACR (mg/g)	17.47 (1.44)[d]	30.39 (4.99)[d]	18.67 (1.73)	28.29 (3.85)	20.58 (2.62)	30.07 (4.70)
		Mean dietary scores by income level, mean (SEM)				
	n (%)	AHEI-2010	DASH	MeDS		
Income levels						
Income ≤$20,000	4334 (43)	47.10 (0.20)	36.02 (0.25)	4.69 (0.05)		
Income $20,001–$40,000	3146 (30)	48.20 (0.23)	36.49 (0.25)	4.87 (0.05)		
Income $40,001–$75,000	1239 (13)	48.45 (0.33)	35.26 (0.41)	4.61 (0.07)		
Income >$75,000	410 (5)	49.77 (0.54)	34.99 (0.67)	4.72 (0.13)		
Missing	792 (9)	44.95 (0.38)	35.72 (0.46)	4.35 (0.09)		
All	9921 (100)	47.55 (0.17)	35.99 (0.16)	4.71 (0.03)		

All data shown as weighted percentage or mean (SEM). AHEI-2010, DASH, and MeDS scores were categorized into quartiles (Q1, Q2, Q3, and Q4). Q1 is the lowest quartile (unhealthiest diet) and Q4 is the highest quartile (healthiest diet). HCHS/SOL, Hispanic Community Health Study/Study of Latinos; AHEI-2010, Alternate Healthy Eating Index 2010; DASH, Dietary Approaches to Stop Hypertension; MeDS, Mediterranean Diet score; CVD, cardiovascular disease; ACEI/ARB, angiotensin-converting enzyme inhibitor/angiotensin receptor blocker; UACR, urinary albumin-creatinine ratio.

[a]AHEI-2010 is based on intake of 11 of the following food components: vegetable and fruit, whole grains, sugar-sweetened beverages and fruit juices, nuts and legumes, red/processed meat, trans fat, long-chain fats, polyunsaturated fats, sodium, and alcohol. Each component score ranges from zero to ten, and overall AHEI-2010 score ranges from zero (worst) to 110 (best).

[b]DASH is based on the intake of eight food components: grains, vegetables, fruit, dairy, and nuts/seeds/legumes, red/processed meat, fats/oils, and sweets. Each component score ranges from zero to ten, and overall DASH score ranges from zero (worst) to 80 (best).

[c]MeDS is derived from nine food components: fruits, vegetables, grains, nuts/legumes, meat, fish, dairy, alcohol, and monounsaturated-saturated fat ratio. Each food component is assigned zero or one depending on if an individual meets sex-specific median level of a healthy consumption. Overall MeDS score ranges from zero (worst) to nine (best).

[d]Denotes significant differences by first and fourth quartiles.

the lowest versus highest quartiles of AHEI-2010, DASH, and MeDS was 0.98 versus 0.71, 0.88 versus 0.79, and 0.87 versus 0.87 ml/min per 1.73 m^2 per year, respectively. Table 2 compares adjusted annualized change in eGFR across quartiles of the three dietary patterns. Lower AHEI-2010 quartiles were associated with greater decline in eGFR in a dose-response manner (P trend=0.02). In contrast, quartiles of DASH and MeDS were not statistically different with regard to annualized change in eGFR.

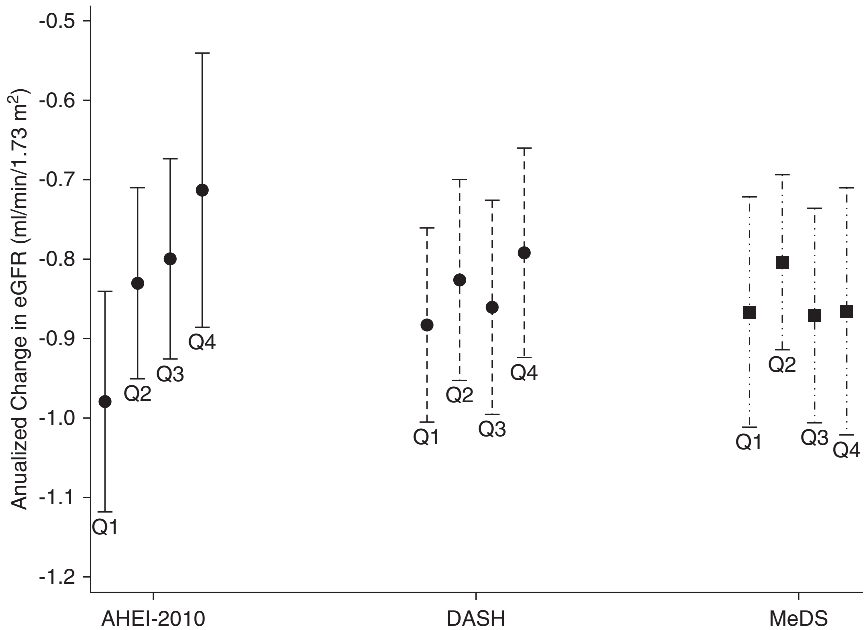

Figure 2. | Dose-response relationship between AHEI-2010 quartiles and eGFR decline. No association of DASH and MeDS with eGFR decline (n=9921). Model adjusted for age, sex, educational attainment, marital status, Hispanic/Latino background, acculturation score, income, health-insurance coverage, smoking status, physical activity level, body mass index, history of hypertension, diabetes, lipids (cholesterol and triglycerides), glycated hemoglobin, systolic BP, diastolic BP, angiotensin-converting enzyme inhibitor/angiotensin receptor blocker, baseline kidney-function measures, and study site. Alternate Healthy Eating Index 2010 (AHEI-2010) is based on 11 food components and score ranges from zero (worst) to 110 (best). Dietary Approaches to Stop Hypertension (DASH) is based on eight food components and score ranges from zero (worst) to 80 (best). Mediterranean Diet Score (MeDS) is based on nine food components and score ranges from zero (worst) to nine (best). AHEI-2010, DASH, and MeDS scores were categorized into quartiles (Q1, Q2, Q3, and Q4). Q1 is the lowest quartile (unhealthiest diet) and Q4 is the highest quartile (healthiest diet).

Annualized Change in UACR

On average, UACR increased at the rate of 0.79 mg/g (95% CI, 0.18 to 1.40) per year over a 6-year period. Figure 3 shows the annualized change in UACR across quartiles of AHEI-2010, DASH, and MeDS adjusted for covariates in Table 1. The adjusted change in UACR for the lowest versus highest quartiles of AHEI-2010, DASH, and MeDS was 1.41 versus −0.9, 1.36 versus 0.39, and 0.55 versus 0.18 mg/g per

Table 2. Differences in annualized change in eGFR and urinary albumin-creatinine ratio across quartiles of AHEI-2010, DASH, and MeDS scores (n=9921)

Dietary Quality Scores	Quartiles	Difference in Annualized Change in eGFR		Difference in Annualized Change in UACR	
		β (95% CI)	P Trend	β (95% CI)	P Trend
AHEI-2010	Q1: <44	−0.27 (−0.47 to −0.06)	0.02	1.47 (−2.13 to 5.07)	0.41
	Q2: 44–48	−0.12 (−0.30 to 0.06)		0.81 (−1.47 to 3.08)	
	Q3: 49–54	−0.09 (−0.24 to 0.06)		0.50 (−1.48 to 2.48)	
	Q4: >54	0.00 (Ref.)		0.00 (Ref.)	
DASH	Q1: <30	−0.10 (−0.24 to 0.05)	0.31	0.96 (−0.85 to 2.77)	0.40
	Q2: 30–36	−0.04 (−0.18 to 0.10)		−0.11 (−1.57 to 1.34)	
	Q3: 37–43	−0.07 (−0.23 to 0.08)		0.21 (−1.30 to 1.71)	
	Q4: >43	0.00 (Ref.)		0.00 (Ref.)	
MeDS	Q1: 0–3	−0.009 (−0.193 to 0.176)	0.82	0.32 (−3.07 to 3.71)	0.83
	Q2: 4–5	0.06 (−0.09 to 0.20)		0.75 (−1.41 to 2.92)	
	Q3: 6	−0.005 (−0.164 to 0.153)		0.59 (−1.25 to 2.42)	
	Q4: 7–9	0.00 (Ref.)		0.00 (Ref.)	

Model adjusted for age, sex, educational attainment, marital status, Hispanic/Latino background, acculturation score, income, health-insurance coverage, smoking status, physical activity level, body mass index, history of hypertension, diabetes, lipids (cholesterol and triglycerides), glycated hemoglobin, systolic BP, diastolic BP, angiotensin-converting enzyme inhibitor/angiotensin receptor blocker, baseline kidney-function measures, and study site. AHEI-2010, DASH, and MeDS scores were categorized into quartiles (Q1, Q2, Q3, and Q4). Q1 is the lowest quartile (unhealthiest diet) and Q4 is the highest quartile (healthiest diet). AHEI-2010: median, 47.0, range: 28.2–77.2; DASH: median, 35.7, range:1.7–75.9; MeDS: median, 4.2, range: 0.9. AHEI-2010, Alternate Healthy Eating Index 2010; DASH, Dietary Approaches to Stop Hypertension; MeDS, Mediterranean Diet score; UACR, urinary albumin-creatinine ratio; Ref., referent.

year, respectively. The result showed a favorable trend toward lower annualized change in UACR with a healthier AHEI-2010 dietary pattern, although this was not statistically significant. There was no clear pattern in annualized change in UACR across quartiles of MeDS and DASH. Quartiles of AHEI-2010, MeDS, and DASH were not statistically different with respect to annualized change in UACR (Table 2).

Incident CKD

Out of the 8771 individuals without CKD at visit 1, 481 (6%) developed incident CKD at visit 2. None of the three diet-quality indices were associated with incident CKD (Table 3).

Individual AHEI-2010 Component Scores and Change in Kidney Function

Table 4 shows the association of individual AHEI-2010 components with annualized change in eGFR and UACR. No significant association between individual AHEI-2010 components and eGFR decline was identified. Of the AHEI-2010 components, higher consumption of whole fruit was associated with a significant decrease in annualized change in UACR.

Sensitivity Analyses

When we reanalyzed the data by restricting the analytic sample to individuals with an eGFR of ≥90 ml/min per 1.73 m^2 at baseline, the results are consistent with those reported above (Table 5). When analyzed as continuous variables, the results of all three dietary scores corroborated those of quartiles of dietary scores. Specifically, we found that, for every 10-unit decrease in AHEI-2010, eGFR decreased by 0.1 ml/min per 1.73 m^2 per year and UACR increased by 0.74 mg/g per year (Supplemental Table 1). The other two diet-quality indices were not associated with either outcome.

Discussion

In this large study of US Hispanics/Latinos, we observed that lower adherence to dietary recommendations, as measured by the AHEI-2010, was associated with a greater decline in eGFR in a dose-response manner over a 6-year period. We found no association between adherence to the AHEI-2010 dietary pattern and annualized change in UACR. DASH and MeDS dietary patterns were not associated with annualized change in UACR and eGFR decline. Although AHEI-2010, DASH, and MeDS overlap (*e.g.*, regarding fruit, vegetables, grains), they differ on the number of food components included and the scoring criteria. Each food component was scored from zero to ten in the AHEI-2010 (11 foods were included), zero or one in the Mediterranean diet (nine foods were considered), and from one to ten in DASH (eight foods were considered). In addition, AHEI-2010 is the only diet-quality index to recommend

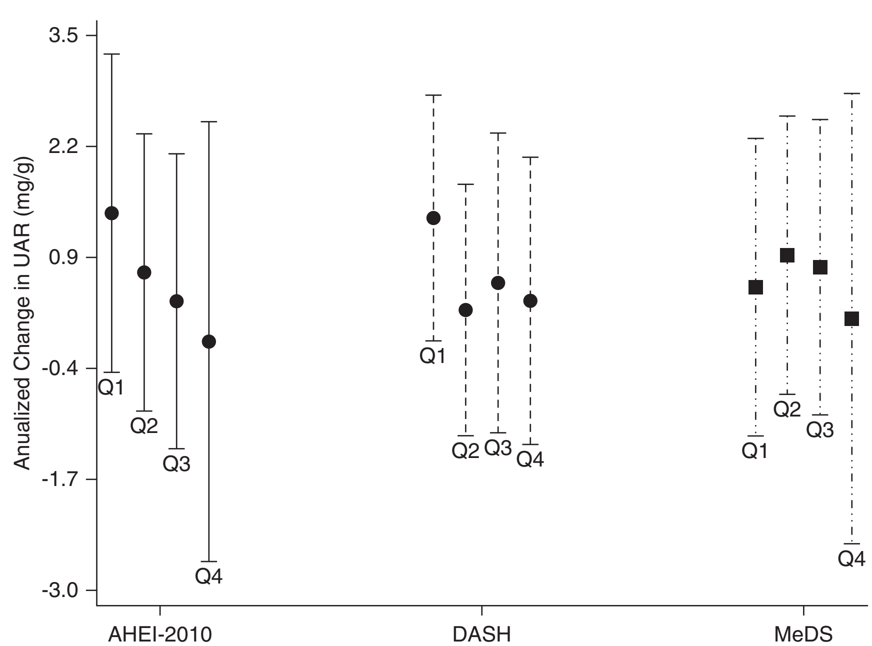

Figure 3. | Favorable trend toward lower UACR with a healthier AHEI-2010 dietary pattern, but not statistically significant. No association of MeDS and DASH with UACR (n=9921). Model adjusted for age, sex, educational attainment, marital status, Hispanic/Latino background, acculturation score, income, health-insurance coverage, smoking status, physical activity level, body mass index, history of hypertension, diabetes, lipids (cholesterol and triglycerides), glycated hemoglobin, systolic BP, diastolic BP, angiotensin-converting enzyme inhibitor/angiotensin receptor blocker, baseline kidney-function measures, and study site. AHEI-2010 is based on 11 food components and score ranges from zero (worst) to 110 (best). DASH is based on eight food components and score ranges from zero (worst) to 80 (best). MeDS is based on nine food components and score ranges from zero (worst) to nine (best). AHEI-2010, DASH, and MeDS scores were categorized into quartiles (Q1, Q2, Q3, and Q4). Q1 is the lowest quartile (unhealthiest diet) and Q4 is the highest quartile (healthiest diet). UAR, urinary albumin-to-creatinine ratio.

Table 3. CKD incidence proportion and odds ratios (95% CIs) of the associations between AHEI-2010, DASH, and MeDS scores (*n*=8771)

Dietary Quality Scores	Quartiles	CKD Incident Proportion, *n* (%)[a]	ORs (95% CI)[a]	CKD Incident Proportion, *n* (%)[b]	ORs (95% CI)[b]
AHEI-2010	Q1: <44	106 (4.75)	0.82 (0.46 to 1.46)	141 (5.07)	0.76 (0.47 to 1.22)
	Q2: 44–48	124 (5.63)	1.08 (0.66 to 1.77)	163 (6.71)	0.94 (0.62 to 1.44)
	Q3: 49–54	132 (5.97)	1.08 (0.72 to 1.63)	174 (7.49)	1.02 (0.72 to 1.44)
	Q4: >54	119 (5.61)	1.00 (Ref.)	179 (8.14)	1.00 (Ref.)
DASH	Q1: <30	128 (5.73)	0.88 (0.56 to 1.39)	172 (6.79)	0.85 (0.58 to 1.25)
	Q2: 30–36	119 (5.42)	0.83 (0.51 to 1.35)	158 (5.88)	0.78 (0.50 to 1.20)
	Q3: 37–43	115 (5.23)	0.75 (0.48 to 1.17)	164 (5.80)	0.76 (0.51 to 1.13)
	Q4: >43	119 (5.55)	1.00 (Ref.)	163 (8.03)	1.00 (Ref.)
MeDS	Q1: 0–3	99 (5.56)	1.05 (0.56 to 1.96)	145 (6.80)	1.07 (0.61 to 1.87)
	Q2: 4–5	193 (5.79)	1.15 (0.71 to 1.88)	256 (6.21)	1.11 (0.71 to 1.72)
	Q3: 6	104 (5.59)	1.23 (0.75 to 2.03)	140 (6.99)	1.18 (0.76 to 1.83)
	Q4: 7–9	85 (4.72)	1.00 (Ref.)	116 (6.54)	1.00 (Ref.)

Model adjusted for age, sex, educational attainment, marital status, Hispanic/Latino background, acculturation score, income, health-insurance coverage, smoking status, physical activity level, body mass index, history of hypertension, diabetes, lipids (cholesterol and triglycerides), glycated hemoglobin, systolic BP, diastolic BP, angiotensin-converting enzyme inhibitor/angiotensin receptor blocker, baseline kidney-function measures, study site, and follow-up time between visits 1 and 2. AHEI-2010, DASH, and MeDS scores were categorized into quartiles (Q1, Q2, Q3, and Q4). Q1 is the lowest quartile (unhealthiest diet) and Q4 is the highest quartile (healthiest diet). AHEI-2010, Alternate Healthy Eating Index 2010; DASH, Dietary Approaches to Stop Hypertension; MeDS, Mediterranean Diet score; OR, odds ratio; Ref., referent.

[a]Incident CKD: eGFR of <60 ml/min per 1.73 m^2 and eGFR decline of ≥1 ml/min per yr or UACR of ≥30 mg/g at visit 2.

[b]Incident CKD: eGFR of <60 ml/min per 1.73 m^2 or UACR of ≥30 mg/g at visit 2.

Table 4. Association between individual component scores of AHEI-2010 and annualized change in eGFR and urinary albumin-creatinine ratio (*n*=9921)

AHEI-2010 Component Scores	Annualized Change in eGFR		Annualized Change in UACR	
	β (95% CI)	*P* Value	β (95% CI)	*P* Value
Vegetables without potatoes	0.03 (−0.02 to 0.08)	0.27	−0.003 (−0.54 to 0.53)	0.98
Whole fruit	0.02 (−0.02 to 0.05)	0.37	−0.51 (−0.88 to -0.15)	0.006
Whole grains	0.01 (−0.03 to 0.05)	0.61	−0.06 (−0.65 to 0.54)	0.85
Sugar-sweetened beverages and fruit juice	−0.01 (−0.04 to 0.02)	0.50	0.08 (−0.29 to 0.45)	0.68
Nuts and legumes	0.02 (−0.01 to 0.04)	0.23	0.08 (−0.19 to 0.35)	0.55
Red/processed meat	0.02 (−0.02 to 0.07)	0.31	−0.37 (−0.89 to 0.14)	0.16
Trans fat	−0.0003 (−0.09 to 0.09)	0.99	0.57 (−0.26 to 1.41)	0.18
Long-chain (n-3) fats (EPA+DHA)	0.01 (−0.04 to 0.07)	0.61	0.29 (−0.33 to 0.90)	0.36
Polyunsaturated fatty acids	−0.04 (−0.10 to 0.02)	0.23	0.31 (−0.19 to 0.81)	0.22
Sodium	0.003 (−0.03 to 0.03)	0.83	−0.14 (−0.47 to 0.20)	0.42
Alcohol	0.01 (−0.02 to 0.04)	0.42	−0.19 (−0.77 to 0.39)	0.51

Model adjusted for age, sex, educational attainment, marital status, Hispanic/Latino background, acculturation score, income, health-insurance coverage, smoking status, physical activity level, body mass index, history of hypertension, diabetes, lipids (cholesterol and triglycerides), glycated hemoglobin, systolic BP, diastolic BP, angiotensin-converting enzyme inhibitor/angiotensin receptor blocker, baseline kidney-function measures, study site, and individual food components. AHEI-2010, Alternate Healthy Eating Index 2010; UACR, urinary albumin-creatinine ratio; EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid.

higher consumption of long-chain fats and polyunsaturated fats, and to specifically discourage consumption of fruit juice, trans fat, and sodium. Our analysis of the individual components of the AHEI-2010 score revealed that consumption of whole fruit was significantly associated with lower annualized change in UACR. The statistically significant effect of whole fruit could occur as a result of multiple testing. The synergistic effect of multiple healthy dietary components that are consumed together is more important than whole fruit as a single driver for the observed association between AHEI-2010 and change in kidney function. Furthermore, the relatively low AHEI-2010 score indicated that, overall, there is a need for improving the quality of foods and nutrients among US Hispanics/Latinos, as assessed by the AHEI-2010. Given the dose-response relationship between the AHEI-2010 and change in kidney function, improving adherence to dietary guidelines could result in a greater renoprotective effect of a healthy AHEI-2010 dietary pattern.

The results of this study are not entirely consistent with earlier studies. Several prospective studies have evaluated AHEI-2010, DASH, and MeDS patterns in relation to renal outcomes (13,14,35). In 2019, Hu *et al.* (13) compared associations of the Healthy Eating Index 2015, AHEI-2010, and MeDS with incident CKD over a median follow-up of 24 years. The study was conducted among US men and women, aged 45–64 years, who participated in the ARIC study. The main result indicates that all three dietary scores

Table 5. Differences in annualized change in eGFR and urinary albumin-creatinine ratio across quartiles of AHEI-2010, DASH, and MeDS scores among individuals with eGFR ≥90 ml/min per 1.73 m^2 (*n*=7505)

Dietary Quality Scores	Quartiles	Difference in Annualized Change in eGFR		Difference in Annualized Change in UACR	
		β (95% CI)	*P* Trend	β (95% CI)	*P* Trend
AHEI-2010	Q1: <44	−0.34 (−0.56 to −0.11)	0.003	1.61 (−2.67 to 5.88)	0.45
	Q2: 44–48	−0.21 (−0.40 to −0.02)		0.45 (−2.20 to 3.09)	
	Q3: 49–54	−0.12 (−0.29 to 0.04)		0.05 (−2.09 to 2.19)	
	Q4: >54	0.00 (Ref.)		0.00 (Ref.)	
DASH	Q1: <30	−0.15 (−0.33 to 0.02)	0.12	0.32 (−1.52 to 2.16)	0.89
	Q2: 30–36	−0.11 (−0.27 to 0.05)		−0.66 (−1.92 to 0.60)	
	Q3: 37–43	−0.12 (−0.29 to 0.04)		0.26 (−1.27 to 1.80)	
	Q4: >43	0.00 (Ref.)		0.00 (Ref.)	
MeDS	Q1: 0–3	0.02 (−0.18 to 0.23)	0.43	1.15 (−2.59 to 4.89)	0.56
	Q2: 4–5	0.08 (−0.07 to 0.24)		0.96 (−1.03 to 2.94)	
	Q3: 6	−0.04 (−0.21 to 0.13)		0.86 (−0.91 to 2.63)	
	Q4: 7–9	0.00 (Ref.)		0.00 (Ref.)	

Model adjusted for age, sex, educational attainment, marital status, Hispanic/Latino background, acculturation score, income, health-insurance coverage, smoking status, physical activity level, body mass index, history of hypertension, diabetes, lipids (cholesterol and triglycerides), glycated hemoglobin, systolic BP, diastolic BP, angiotensin-converting enzyme inhibitor/angiotensin receptor blocker, baseline kidney-function measures, and study site. AHEI-2010, DASH, and MeDS scores were categorized into quartiles (Q1, Q2, Q3, and Q4). Q1 is the lowest quartile (unhealthiest diet) and Q4 is the highest quartile (healthiest diet). AHEI-2010, Alternate Healthy Eating Index 2010; DASH, Dietary Approaches to Stop Hypertension; MeDS, Mediterranean Diet score; UACR, urinary albumin-creatinine ratio; Ref., referent.

were associated with lower incident CKD risk, and the strongest association was observed with AHEI-2010. Data from ARIC also showed that the DASH diet was associated with reduced risk for incident CKD (14). Results from a recent meta-analysis of 18 cohort studies, with follow-up time ranging from 2 to 23 years, concluded that diets of the highest quality are associated with reduced risk for incident CKD (35). This study found an association between AHEI-2010 dietary pattern and decline in kidney function, but no association with incident CKD. Moreover, we did not find a significant association between MeDS and DASH scores and change in kidney function. There are potential explanations for the apparent inconsistencies between the results of the earlier studies and this study. First, cultural dietary habits of Hispanics/Latinos may be more reflective of AHEI-2010 dietary patterns than DASH and MeDS food patterns. It has been reported that food choices are influenced by ethnicity and/or culture (15). A dietary analysis, using data from the San Antonio Heart Study, showed that Mexican Americans consumed significantly more carbohydrates and atherogenic foods (on the basis of intake of saturated and polyunsaturated fats and cholesterol) than non-Hispanic Whites (36). However, in this study, we noted a higher consumption of sugar-sweetened drinks and fruit juice and lower intakes of long-chain fats among Cubans and Puerto Ricans. These macro-/micronutrient components are better captured by the AHEI-2010 dietary pattern than DASH or MeDS. For example, carbohydrates, such as sugar-sweetened beverages, are included in the AHEI-2010 score and are absent from MeDS and DASH scores. Second, differences in how diet was assessed to calculate the AHEI-2010, DASH, and MeDS scores could explain the differences across studies. Our study used a 24-hour dietary recall approach to calculate the three dietary scores, whereas a food-frequency questionnaire measurement was the predominant method used across previous studies. Consistent with our findings, a previous study that used 24-hour recall to assess diet quality found no association between the DASH dietary pattern and incident CKD (37). Perhaps the 24-hour dietary recall does not capture an individual's usual dietary intake well, because certain foods may be consumed episodically. Indeed, intraindividual variation over time in dietary intake has been documented in the literature (36,38). However, measuring diet quality on the basis of a food-frequency questionnaire may serve as a better predictor because it is designed to evaluate usual dietary intake (39).

AHEI-2010 has been consistently associated with risk for hypertension and diabetes in the general population (17,40,41). These conditions remain the major risk factors for CKD (42–45), and thus they (or their subclinical precursors, given the age of our population) may potentially mediate the relationship between AHEI-2010 and kidney function. Nevertheless, after adjusting for these potential confounders, the association between AHEI-2010 and eGFR decline remained. The persistent dose-response effect of AHEI-2010 on eGFR decline, after multivariable adjustment, suggests that adherence to AHEI-2010 pattern protects against kidney-function decline through a mechanistic pathway that may not be related to BP or glucose. Hypotheses for the renoprotective effect of healthy dietary patterns have focused on their low content in acid load and their anti-inflammatory actions (46–48). It has been reported that high dietary acid load can cause endothelin-1 production, which, in turn, leads to kidney injury (49). In addition, high dietary acid can activate the renin-angiotensin system through metabolic acidosis, thus resulting in the onset and progression of kidney disease (50). Prior research has documented potential renal benefits of a diet low in dietary acid load (51,52). Healthy dietary patterns are also believed to exert their renoprotective effects through suppression of proinflammatory cytokines, which increase CKD risk (53,54).

Our findings may have implications. Regarding diminishing the kidney-disease burden in this community, our study provides evidence of potential benefits of observing the recommendations of the AHEI-2010 for CKD prevention. Evidence shows that a modest reduction in kidney function is a powerful predictor of death (55). Thus, compliance to the AHEI-2010 may improve survival rates in Hispanics/Latinos. This study may also have methodologic implications relating to CKD research in the Hispanic/Latino populations. This study found that diet quality, assessed by only AHEI-2010, has predictive ability with respect to kidney function. From the perspective of adjustment for diet quality as a confounder in CKD research in Hispanics/Latinos, AHEI-2010 may be a better diet-quality variable.

Strengths of this study include the use of a large sample of Hispanics/Latinos; objectively measured height, weight, diabetes mellitus, and hypertension; and the prospective nature of this study. Although 24-hour dietary recall may not capture usual intake well, it is a valid and reliable diet-measurement method across diverse populations (56). In addition, the HCHS/SOL had high-quality data on covariates, allowing us to simultaneous adjust for confounders and factors known to mediate the relationship between diet quality and change in kidney function. This study has limitations. First, HCHS/SOL collected information on diet only at baseline, and change in kidney function was assessed 6 years later. It remains possible that the baseline dietary information may not reflect the subsequent habitual or usual intake of individuals. Second, the study is subject to diet-measurement error because dietary intake was self-reported, and this may lead to under- or over-reporting. For example, a significant under-reporting of energy and protein intake was noted in a HCHS/SOL biomarker study that compared both self-reported energy and protein intake with biomarkers of doubly labeled water and urinary nitrogen (24). Third, the relatively short follow-up time may not be enough to detect meaningful differences in kidney-function measures across dietary patterns in this young cohort. Fourth, it remains possible that some of the results reported in this study may be due to residual confounding. For example, no data were available on medication adherence, which could potentially confound the relationship between diet quality and kidney function. However, nonadherence to medical therapy is often associated with individual-related factors, such as socioeconomic status and acculturation, which we already adjusted for (57). Notwithstanding these limitations, this study suggests that AHEI-2010 is associated with eGFR decline, whereas MeDS and DASH patterns are not predictors of eGFR decline and change in UACR in Hispanics/Latinos. Future directions of interest include examining how diet-quality tools might predict kidney function in other minority populations. The findings from this study point to a need for culture-specific dietary recommendations geared toward Hispanics/Latinos to reduce the burden of CKD in these populations.

Lower adherence to the AHEI-2010 was independently associated with greater decline in kidney function in a dose-response manner among Hispanics/Latinos. Neither the DASH nor the MeDS performed as predictors of kidney-function decline. On the other hand, the AHEI-2010 did show associations with kidney-function decline, but not CKD. More research is needed to develop culturally sensitive diet indices that can better assess these kidney-related outcomes in Hispanics. In addition, clinical trials are needed that could ultimately guide dietary recommendations for preventing CKD in the Hispanic/Latino community.

Disclosures

C.R. Isasi reports being an elected council member of the International Society for Developmental Origins of Health and Disease, and receiving honoraria from La Caixa Foundation for reviewing grants for their Health Research Programme. J. Mattei reports receiving honoraria from the Robert Wood Johnson Foundation. All remaining authors have nothing to disclose.

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Author Contributions

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Supplemental Material

This article contains supplemental material online at http://kidney360.asnjournals.org/lookup/suppl/doi:10.34067/KID.0004552020/-/DCSupplemental.

Supplemental Table 1. Associations of dietary scores with estimated glomerular filtration rate (eGFR) and urinary albumin-to-creatinine ratio (UACR).

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