Ethnic Disparities in Cardiovascular Risk Factors and Coronary Disease Prevalence among Individuals with Chronic Kidney Disease: Findings from the Third National Health and Nutrition Examination Survey

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Differences in coronary disease have been reported among ethnic minorities in the US population. Whether these persist in patients with chronic kidney disease is unknown. The prevalence of myocardial infarction (MI) and angina was compared by race and GFR in the Third National Health and Nutrition Examination Survey using the Modification of Diet in Renal Disease Study equation. Age–gender standardized estimates were computed for each GFR category (≥90, 60 to 89, and <60 ml/min per 1.73 m^2), and odds ratios were compared using weighted multivariable logistic regression for each race. The age–gender standardized prevalence of MI was 3.0, 3.1, and 4.9% in white individuals; 2.8, 3.8, and 9.9% in black individuals; and 1.9, 2.9, and 3.8% in Mexican-American individuals in each category: ≥90, 60 to 89, and <60 ml/min, respectively. Compared with the referent (Mexican-American; GFR ≥90 ml/min; odds ratio 1.00), Mexican-American individuals with GFR of 60 to 89 and <60 ml/min had more than four and nine times the odds for MI; black individuals at successively lower GFR levels had 1.6, 6.1, and 16.3 times the odds for MI, whereas white individuals had 1.9, 4.7, and 20.2 times that of the referent, respectively. After adjustment for traditional risk factors, the inverse association of GFR with MI was substantially attenuated in black and white individuals and completely abolished in Mexican-American individuals. The burden of coronary disease is lower in Mexican-American than in white or black individuals with reduced kidney function even accounting for differences in traditional risk factors.

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Cardiovascular (CV) mortality rates are exceedingly high in patients with advanced chronic kidney disease (CKD) compared with the general population, a phenomenon that is due partly to the high prevalence of CV disease as well as the strikingly low use of proven cardiovascular interventions (1–6). Recent data suggest that the risk for CV death is not equal among race groups with reduced kidney function and may represent inherent differences in underlying CV risk as well as differences in access to and use of effective CV interventions (6,7). The identification of true differences in CV risk factor profiles among race groups and the extent to which they might account for differences in underlying coronary disease prevalence may improve our understanding of coronary disease in those with CKD and help unravel racial disparities in CV outcomes.

In the general population, Hispanic individuals experience lower all-cause and CV mortality rates than their non-Hispanic counterparts (8–11). This apparent CV benefit is present despite that Hispanics tend to have more unfavorable CV profiles with higher rates of diabetes, obesity, and insulin resistance compared with whites or black individuals (12–15). Moreover, this "paradoxic advantage" of Hispanic ethnicity over non-Hispanic persists even when consideration is made for several nontraditional CV factors. Although patients with CKD are at increased risk for CV disease overall, it is unclear whether this risk is differentially distributed among racial/ethnic groups. In addition, it is unclear whether the favorable risk that is present for Hispanic individuals in the general population also extends to those with reduced kidney function.

The goals of this study were to (*1*) describe the prevalence of self-reported physician-diagnosed myocardial infarction (MI) and angina by race among individuals with reduced kidney function in the US population, (*2*) compare the prevalence of traditional risk factors and nontraditional risk factors among racial/ethnic categories, and (*3*) determine the extent to which differences in the prevalence of MI across race could be accounted for by differences in traditional and nontraditional risk factor burden. The oversampling of minorities from the Third National Health and Nutrition Examination Survey (NHANES III) allowed us a unique opportunity to evaluate these differences in patients with reduced kidney function in the US population.

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Materials and Methods

Data for this analysis were obtained from NHANES III, a population-based survey that was conducted by the National Center for Health Statistics of the Centers for Disease Control and Prevention (16). The survey was designed to provide accurate information on a representative sample of noninstitutionalized individuals who were living in the United States between 1988 and 1994. Detailed descriptions of the study have been published previously. The NHANES III used a complex stratified multistage sampling design that included oversampling of the very young, elderly, and ethnic minorities, allowing calculation of stable prevalence estimates in these vulnerable groups. Data collection consisted of a standardized questionnaire that was administered during a home interview followed by a detailed physical examination that included collection of blood specimens at a mobile examination center or at the participant's home.

Sample

Our analysis was restricted to adult (20 yr or older), nonpregnant participants (n = 18,595) who reported their race and ethnicity as non-Hispanic white, non-Hispanic black, or Mexican-American (n = 17,885). Respondents who did not participate in the examination component (n = 1752) or had missing serum creatinine measurements (n = 1123) were excluded. The final sample used in this study contained 15,010 participants who represented 152,443,703 adults in the US population.

Measurements

The NHANES III provided data that were collected from face-to-face interviews, physical examinations, and laboratory results. The following self-reported variables were extracted from the interview portion: age; gender; race/ethnicity; family history of premature (<50 yr) MI; tobacco use; physical inactivity; and self-report of a previous physician diagnosis of MI, hypertension, and diabetes. In addition, a diagnosis of angina was ascertained from questions based on the World Health Organization (WHO) Rose Angina questionnaire (17). These measures have been used widely to study the prevalence and the natural history of ischemic heart disease, to predict morbidity and mortality in diverse populations, and to make population comparisons (18–20).

Data that were collected from the physical examination included height, weight, waist circumference, and the average of at least three BP readings. Body mass index was classified according to World Health Organization guidelines. Abdominal obesity, defined as a waist circumference (cm) >102 cm in men and >88 cm in women, served as an additional index of overweight.

White blood cells (WBC) count, C-reactive protein (CRP), serum cholesterol, and serum creatinine values were obtained from the laboratory results data file. The predictive impact of CRP on MI occurrence and its prognostic role in assessing global CV risk has been demonstrated in the general population, and recent studies have validated its contribution in patients with CKD (21–24). Similarly, emerging data have identified strong associations of elevated WBC count with increased CV risk in the general population, although data in CKD populations are limited (25–27).

GFR was estimated from the abbreviated Modification of Diet in Renal Disease (MDRD) Study formula (28,29) as follows: Estimated GFR = $186.3 \times (\text{serum creatinine mg/dl})^{-1.154} \times \text{age}^{-0.203} \times$ (0.742 if female) $\times$ (1.21 if black). Serum creatinine measurements were recalibrated to the Cleveland Clinic to ensure validity of the results (28,29).

Analytical Methods

Participants were categorized into one of three GFR groups: ≥90, 60 to 89, and <60 ml/min per 1.73 m^2 (30). Although a more finely specified categorization would have been desirable, the current classification ensured adequate power for comparisons among race groups and is consistent with previous studies (31). GFR estimates that were >200 ml/min were deemed physiologically implausible, and these patients were assigned a maximal GFR value of 200 for these analyses. The prevalence of MI, angina, CV risk factors, and inflammatory factors were calculated for the entire cohort and for each GFR category across race groups. To account for age and gender differences in the demographic distribution among racial groups, the prevalence was adjusted to a standardized population. The US population during the NHANES III study (1988 to 1994) with mean age 44 yr, 45% male, 76% white, 11% non-Hispanic black, 5% Mexican American, and 8% other race or ethnicity served as the reference standard.

Separate univariate and multivariable logistic regression models were developed to explore the associations of GFR with MI for each race group with GFR ≥90 ml/min as the referent category. Model building was based on an *a priori* decision to include covariates that previously were determined to be associated with MI. All traditional factors and many additional markers of representative measures of inflammation were considered. Ultimately, three models were constructed for each race group: An unadjusted model, a model that adjusted for all traditional risk factors, and finally a model that adjusted for traditional factors and inflammatory markers combined. In addition, a second series of analyses explored the conjoint associations of GFR and race in a single logistic model. For these, Mexican Americans with a GFR ≥90 ml/min served as the referent category, and all other GFR categories within each racial/ethnic group were compared with this referent. All multivariable models were restricted to participants with valid values for all variables, resulting in a final sample size of 14,043 participants. Analyses were conducted using SAS-callable SUDAAN statistical software (Research Triangle Institute, Research Triangle Park, NC) with the appropriate sampling weights and survey design variables.

Results

Prevalence of MI and Angina by Level of GFR

Of the 15,010 NHANES III participants included in the final weighted analysis, the mean age was 44.7 yr (±0.5), 76% were white, 10.9% were black, and 5.1% were Mexican-American. The overall prevalence of MI was 3.6% in black individuals, 3.5% in white individuals, and 2.5% in Mexican-American individuals. The age–gender standardized prevalence of MI increased with declining GFR for each racial/ethnic category, with the greatest increases occurring for those with GFR <60 ml/min per 1.73 m^2 as shown in Figure 1. Within GFR categories, prevalence was greatest for black and white individuals and lowest for Mexican-American individuals. These differences were most marked among groups with GFR <60 ml/min, in which black individuals (9.9%) had twice the prevalence of MI than white individuals (4.9%) and almost three times that of Mexican-American individuals (3.8%).

In contrast to MI, the prevalence of angina did not increase in a graded manner with declining GFR (Figure 2). Among individuals with a GFR <60 ml/min, the prevalence of angina was greatest in black (22.3%) and white (26.5%) individual and almost five-fold higher than in Mexican-American individuals (4.8%).

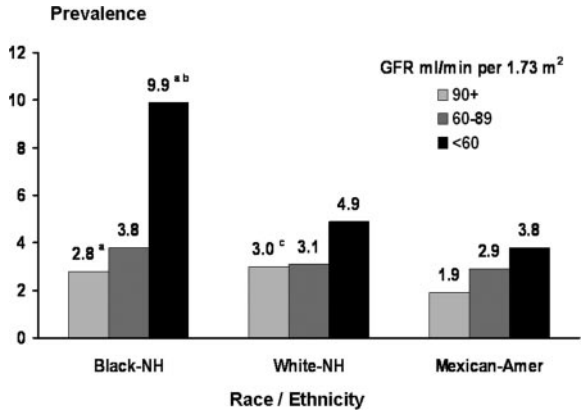

Figure 1. Age–gender standardized population prevalence of physician-diagnosed myocardial infarction by race-ethnic group and GFR in the US population. GFR (ml/min per 1.73 m^2) was measured by the Modification of Diet in Renal Disease Study (MDRD) equation. Amer, American. [a]$P < 0.05$ for black *versus* Mexican-American within the GFR >90 and <60 ml/min categories; [b]$P < 0.05$ for black *versus* white within the GFR <60 ml/min category; [c]$P < 0.05$ for white *versus* Mexican-American within the GFR >90 ml/min category.

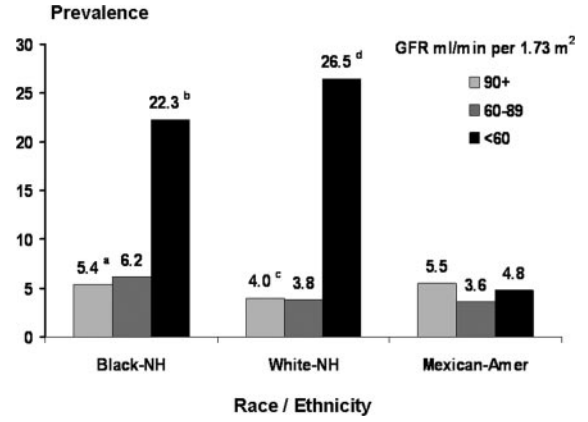

Figure 2. Age–gender standardized population prevalence of angina from the rose questionnaire by race/ethnic group and GFR in the US population. [a]$P < 0.05$ for black *versus* white within the GFR >90 ml/min category; [b]$P < 0.05$ for black *versus* Mexican-American within the GFR <60 ml/min category; [c]$P < 0.05$ for white *versus* Mexican-American within the GFR >90 ml/min category; [d]$P < 0.05$ for white *versus* Mexican-American within the GFR <60 ml/min category.

Racial Differences in the Prevalence of Traditional Risk Factors by GFR levels

The pattern of association of traditional and nontraditional risk factors with race/ethnicity for each GFR category is shown in Table 1. In general, the prevalence of risk factors increased with declining GFR for each race group, although significant differences were present among groups. Among participants with GFR <60 ml/min, the prevalence of diabetes and hypertension was greater in Mexican-American and black individuals compared with white individuals. Moreover, mean systolic BP and pulse pressure were significantly greater in ethnic minorities with GFR <60 ml/min compared with white individuals. Indeed, when we classified individuals according to the stage of hypertension, white individuals with CKD had the highest percentage of patients with normal BP (73.7% in white individuals *versus* 45% in black individuals and 51% in Mexican-American individuals), whereas black and Mexican-American individuals had the highest percentages of individuals with either stage I or II hypertension.

The prevalence of tobacco use (current or former smokers) was greater in those with GFR <60 ml/min compared with those with normal kidney function for all race categories. Within race groups, prevalence was greatest in white individuals (73.1%) and lowest in Mexican-American individuals (50%) for those with GFR <60 ml/min.

The prevalence of obesity increased with declining GFR for white (19.7 *versus* 22.4 *versus* 52.6%) and Mexican-American individuals (29.1 *versus* 29.4 *versus* 37.1%) but not for black individuals. Obesity prevalence was highest among white individuals (52.6%) and lowest among black individuals (28.6%) with GFR <60 ml/min. The findings were similar when obesity was defined in terms of waist circumference. Physical inactivity also increased with declining GFR for all race categories in the US population. Prevalence of physical inactivity was consistently highest among Mexican-American individuals and lowest among white individuals in each GFR category.

The pattern of cholesterol and its subfractions also is demonstrated in Table 1. Mean serum total cholesterol levels increased with declining kidney function and were highest for white (223 ± 5.2 mg/dl) and black (224 ± 7.2 mg/dl) individuals and lowest for Mexican-American individuals (213 ± 7.8 mg/dl). Much of this was attributed to a rise in non-HDL cholesterol, for which mean levels were highest in white individuals and lowest in Mexican-American individuals with CKD. In contrast, HDL levels were lowest in white individuals (44.3 ± 1.1 mg/dl) and highest in black individuals (54.4 ± 2.7 mg/dl) with CKD.

Racial Differences in the Prevalence of Inflammatory Markers by GFR Level

Overall, 20.8% of individuals had detectable CRP levels, and an additional 7.6% had levels that are considered clinically elevated (≥10.0 mg/L). The prevalence of clinically elevated CRP levels was highest in black individuals (12.2%) and lowest in white individuals (7.0%). In general, the prevalence of detectable and clinically elevated CRP increased with declining kidney function. The prevalence of clinically elevated CRP was highest in black individuals at each level of GFR and lowest for Mexican-American individuals with a GFR <60 ml/min. Mean values of WBC count followed a similar trend, increasing with declining GFR for all race groups. However, in contrast to CRP levels, mean WBC levels were highest for Mexican-American individuals and lowest for black individuals with CKD.

Multivariate Models of MI

Results from the logistic regression analyses are illustrated in Table 2. In univariate analysis, white individuals with reduced kidney function experienced higher odds of MI (odds ratio

Table 1. Age–gender standardized prevalence of traditional and nontraditional risk factors for coronary artery disease by race and level of GFR[a]

Sample Characteristic	GFR < 60			GFR 60 to 89			GFR 90 to 200		
	White	Black	Mexican American	White	Black	Mexican American	White	Black	Mexican American
No. of participants	715	185	92	2656	785	702	3279	3182	3414
Traditional risk factors									
Diabetes (by history; %)	11.9	20.0	22.4	4.2	8.1	7.1	4.1	7.2	9.1
Hypertension (ever told; %)	43.1	75.9	56.8	24.4	35.7	21.8	21.3	29.2	20.6
Systolic BP (mmHg)	124	145	140	123	128	125	121	126	123
Diastolic BP (mmHg)	78	86	77	75	78	75	74	76	74
Pulse pressure (mmHg)	47	59	63	47	50	50	48	50	49
Family history of premature MI (%)	8.8	21.9	0.5	18.4	15.4	11.8	20.0	11.4	11.5
Tobacco use (%)									
current smoker	22.1	38.0	8.1	21.8	30.0	19.4	32.8	35.1	22.1
former smokers	51.0	20.9	41.7	28.5	17.0	24.5	26.8	18.1	21.9
never smokers	26.9	41.1	50.2	49.7	52.9	56.1	40.5	46.9	56.0
Body mass index (%)									
normal (<25)	29.4	42.5	39.1	43.2	27.1	31.3	48.5	39.4	32.3
overweight (25 to 29)	17.9	28.9	23.8	34.4	36.3	39.3	31.8	31.9	38.7
obese (≥30)	52.6	28.6	37.1	22.4	36.6	29.4	19.7	28.7	29.1
Abdominal obesity	70.4	40.6	58.7	37.5	51.7	44.0	35.0	41.1	45.3
Physically inactive (%)	31.7	35.1	55.1	9.2	20.8	24.2	13.2	21.8	27.9
Total cholesterol (mg/dl)	223	224	213	207	206	210	203	201	202
HDL cholesterol (mg/dl)	44.3	54.4	47.2	50.4	53.5	50.1	51.1	55.2	48.7
Total cholesterol/HDL ratio	5.5	4.5	5.4	4.5	4.2	4.5	4.4	3.9	4.5
Inflammatory factors									
C-reactive protein (mg/dl)									
below detection (<3 mg/L; %)	59.8	43.8	58.4	74.1	62.0	68.1	73.6	61.7	65.0
detectable level (3 to 9 mg/L; %)	25.9	39.5	30.0	19.6	26.6	25.9	19.6	25.8	26.7
clinically elevated (≥10 mg/L; %)	14.3	16.7	11.5	6.4	11.4	5.9	6.8	12.5	8.3
white blood cell count	7.9	6.8[v]	8.0	7.1	6.6	7.7	7.3	6.5	7.5

[a]Prevalence and mean are age–gender standardized to the early 1990s US population. National Health and Nutrition Examination Survey participants age ≥20. GFR (ml/min per 1.73 m^2) estimated from the Modification of Diet in Renal Disease (MDRD) Study Formula. Pulse pressure = difference in systolic BP and diastolic BP. Abdominal obesity defined as waist circumference >102 cm in men and >88 cm in women.

[OR] 2.44 and 10.42 for GFR 60 to 89 and <60 ml/min per 1.73 m^2, respectively) compared with those with normal kidney function (GFR >90 ml/min per 1.73 m^2; referent OR 1.00). The univariate associations for black (OR 1.00, 3.91, and 10.50, respectively) and Mexican-American individuals (OR 1.00, 4.16, and 9.74, respectively) were similar in magnitude to those of white individuals.

With adjustment for traditional CV risk factors, the magnitude of the association of GFR with MI was greatly diminished in each respective racial/ethnic category. Among white individuals, the estimates were 1.00 (referent), 1.06, and 2.05 for the GFR ranges of >90, 60 to 89, and <60 ml/min. The patterns of association were similar in black (1.00, 1.47, and 1.64, respectively) and Mexican-American (1.00, 1.63, and 1.67 respectively) individuals. Overall, the discrimination index of the models was excellent, ranging from 82.1% in white individuals to 86.8% in black individuals. Furthermore, in the fully adjusted model, in which we included additional covariates that represented CRP and WBC count, the associations of GFR with MI in each group were virtually unchanged and the c-statistic showed no further improvement.

The conjoint associations of race and GFR with likelihood of MI are demonstrated in Figures 3 and 4, respectively. In univariate analysis, Mexican-American individuals with a GFR of 60 to 89 and <60/ml per min had more than four times and nine times the odds of MI, respectively, compared with the referent category (Mexican-American individuals with GFR >90 ml/min, OR 1.00). For black individuals, the likelihood of MI at each GFR category were 1.6, 6.1, and 16 times higher than the referent, whereas for white individuals, the corresponding odds were 1.9, 4.7, and 20 times higher, respectively. With adjustment for traditional risk factors and inflammatory markers, the magnitude and strength of these associations were substantially reduced in white and black individuals and were completely abolished in Mexican-American individuals (Figure 4).

Table 2. Multivariate adjusted OR for myocardial infarction by level of GFR for each racial/ethnic category[a]

Model[b]	White (n = 6,252)		Black (n = 3,942)		Mexican-American (n = 3,849)	
	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
Unadjusted GFR (ml/min)						
90 to 200	1.00 (reference)		1.00 (reference)		1.00 (reference)	
60 to 89	2.44 (1.85 to 3.23)	<0.0001	3.91 (2.68 to 5.72)	<0.0001	4.16 (2.20 to 7.84)	<0.0001
<60	10.42 (7.55 to 14.38)	<0.0001	10.50 (6.03 to 18.28)	<0.0001	9.74 (4.56 to 20.78)	<0.0001
c-statistic	65.6%		69.6%		64.5%	
Traditional GFR (ml/min)						
90 to 200	1.00 (reference)		1.00 (reference)		1.00 (reference)	
60 to 89	1.06 (0.80 to 1.41)	NS	1.47 (1.01 to 2.12)	<0.05	1.63 (0.93 to 2.85)	NS
<60	2.05 (1.48 to 2.86)	<0.0001	1.64 (0.82 to 3.26)	NS	1.67 (1.02 to 2.73)	<0.05
c-statistic	82.1%		86.8%		84.7%	
Full model GFR (ml/min)						
90 to 200	1.00 (reference)		1.00 (reference)		1.00 (reference)	
60 to 89	1.07 (0.80 to 1.44)	NS	1.60 (0.82 to 3.12)	<0.05	1.68 (0.97 to 2.90)	NS
<60	1.97 (1.42 to 2.72)	<0.0001	1.45 (1.01 to 2.08)	NS	1.39 (0.80 to 2.40)	NS
c-statistic	82.4%		86.8%		85.6%	

[a]The unadjusted model assessed the relationship of GFR with coronary artery disease in each racial/ethnic category. The traditional model adjusted for age, gender, diabetes, hypertension, family history of premature myocardial infarction, smoking status, obesity, physical inactivity during leisure time, and total cholesterol/HDL cholesterol ratio. Full model contains both traditional and nontraditional risk factors where the nontraditional factors are represented by C-reactive protein and white blood cell count. CI, confidence interval; OR, odds ratio.

[b]Three parallel models were built for each racial/ethnic group.

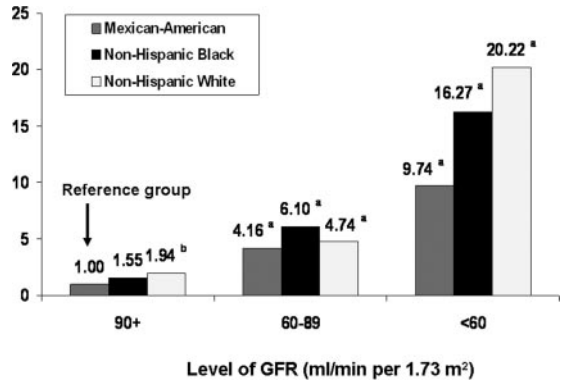

Figure 3. Unadjusted likelihood (odds ratios [OR]) of myocardial infarction (MI) by racial/ethnic group and GFR category in the US population. This model compares the joint associations of each racial/ethnic category and GFR category with the odds of MI. The referent group, with which all other groups are compared, is Mexican-American individuals with GFR >90 ml/min per 1.73 m^2. [a]$P < 0.001$ *versus* the referent; [b]$P < 0.05$ *versus* the referent.

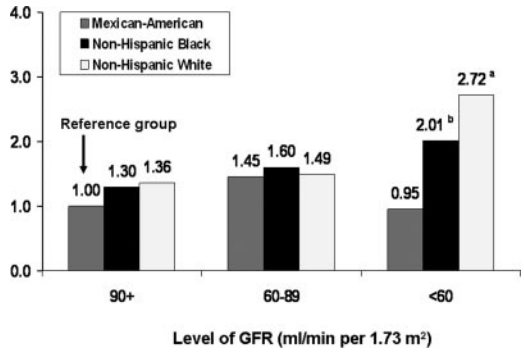

Figure 4. Multivariable-adjusted likelihood (OR) of MI by racial/ethnic group and GFR category in the US population. This model compares the joint associations of each racial/ethnic category and GFR category with the odds of MI adjusting for traditional risk factors and inflammatory markers. The referent group, with which all other groups are compared, is Mexican-American individuals with GFR >90 ml/min per 1.73 m^2. [a]$P < 0.001$ *versus* the referent; [b]$P = 0.06$ *versus* the referent.

Discussion

This study highlights substantial differences in the prevalence of coronary disease among race groups with reduced kidney function in the adult US population. As GFR declined, the prevalence of MI increased disproportionately among white, black, and Mexican-American individuals. Within GFR category, overall MI prevalence was significantly lower in Mexican-American compared with black or white individuals, and these differences were most pronounced among those with GFR <60 ml/min per 1.73 m^2, currently classified as having CKD. Moreover, the finding of lower prevalence of MI in Mexican-American individuals despite having an excess of several traditional risk factors was consistent with what literature has labeled the "Hispanic paradox" (32). Finally, our study found that a large percentage of coronary disease in black and white individuals with reduced kidney function was accounted for by traditional risk factors, and an even larger percentage

that was found in Mexican-American individuals was explained by these same risk factors. These observations suggest that whereas declining kidney function is accompanied by increasing prevalence of coronary disease and associated risk factors in all race groups, Mexican-American individuals seem to be protected despite their unfavorable CV profiles.

Recent studies have demonstrated a graded association of reduced kidney function with increased CV risk, suggesting that loss of renal function in itself may independently predict CV outcomes (33–36). Many of these studies have focused on the magnitude of risk in diverse populations and its prognostic importance. An unanswered question, however, is whether CV risk profiles among individuals with reduced GFR differ by race and whether such differences contribute to clinically important differences in CV disease prevalence. In this analysis of NHANES data, we demonstrated that although a reduction in GFR was associated with increased coronary prevalence, significant race differences were found. We speculated that these differences might be accounted for by differential increases either in traditional risk factors or in inflammatory factors. Surprising, the prevalence of several Framingham risk factors was higher in Mexican-American individuals or at least equal to those in black or in white individuals, especially among those with CKD. Diabetes and physical inactivity were far more prevalent in Hispanic individuals with CKD. Moreover, hypertension as defined by history or by BP measurements and obesity as defined by elevated body mass index or increased waist circumference were higher or equal to those of other race groups. These observations are consistent with the theory that Mexican-American individuals, despite having adverse CV risk profiles, especially with regard to the distribution of traditional risk factors, have "paradoxically" better CV outcomes (8–10,37).

The low prevalence of coronary disease among Mexican-American individuals compared with other race groups also may reflect favorable distributions of some traditional risk factors. First, nonsmokers were more common among Mexican-American individuals with CKD than other racial groups. Mean values for total serum cholesterol also were significantly lower in Hispanic individuals. Perhaps even more important, mean values for non-HDL cholesterol, a more accurate measure of atherogenic lipoprotein burden, were lower in the Mexican-American individuals with CKD compared with their counterparts. Finally, CRP, an emerging nontraditional CV risk factor, was lower in Mexican-American individuals than in other race groups in the CKD setting. The combined contributions of these favorable risk profiles may reflect in part a lower disease burden in Mexican-American individuals and protect against future CV events.

In the general population, conflicting opinions exist as to whether Mexican-American individuals are at greater or lesser risk for CV disease compared with other racial groups. On the one hand, data from some cohort studies have demonstrated higher incidence rates of CV events among Hispanic individuals, findings that certainly are consistent with their adverse CV risk profiles (38–41). On the other hand, recent comparisons of CV risk indicators have found lower levels of carotid intima media thickness and lower coronary calcium scores in Mexican-American individuals compared with non-Hispanic white individuals, findings that favor CV protection (42,43). However, unlike the general population, individuals with reduced kidney function have considerably increased CV risk. Whether findings in the general population can be extended to those with reduced kidney function is not entirely clear. Our analysis found lower prevalence of clinical coronary disease among Mexican-American individuals with CKD compared with black or white individuals and is consistent with the theory of CV protection as proposed in the general population. It is unclear, however, whether this observation represents low incident rates of coronary disease as a result of favorable distribution of CV risk factors or even high mortality rates from fatal coronary disease, which also could lead to the same result as suggested in a recent paper by Muntner *et al.* (35).

This study has several limitations. First, the principal outcome was based on self-report, whereby individuals were informed by their physician of the diagnosis with potential for recall and misclassification bias. Racial differences in knowledge of MI could bias the reported prevalence. The requirement that a diagnosis of MI be made by a physician should narrow the variability in knowledge between racial groups, although racial differences in help-seeking patterns and access to care remained. The prevalence of angina showed a significantly higher prevalence in minority groups than in white individual, suggesting that the true prevalence of MI may be biased downward in minority group. Although no validation studies were conducted independently for self-reported disease in the NHANES, previous validation studies in equally large samples have found that self-report captures 60 to 75% of MI (44–46). Furthermore, although this may result in a nondifferential misclassification of MI, it usually underestimates rather than overestimates the true OR.

Second, kidney function was estimated using the MDRD formula, a prediction equation that was developed in individuals with reduced kidney function and consisted only of white and black individuals (29). Although we assumed that Mexican-American individuals are similar to white individuals when estimating GFR using this equation, future studies are required to confirm this. Furthermore, this equation's accuracy is greatest among those with moderate reductions in kidney function and is less precise for predicting GFR at higher levels (47). Third, despite the oversampling of minorities in NHANES III, sufficient numbers were not available to assess prevalence estimates in GFR categories of <30 and <15 ml/min. Finally, the cross-sectional design of the NHANES study limited causal inference. The findings from this cross-sectional analysis, however, provide important information for the design of future longitudinal studies.

Notwithstanding these limitations, this study has several strengths. First, it is the most comprehensive national survey to estimate coronary disease prevalence among race groups with reduced kidney function. Second, the oversampling of minority groups in NHANES III allowed for accurate estimation of disease prevalence for all race groups by GFR. Third, the availability of extensive and complete data on a range of CV risk

factors, both traditional and inflammatory, allowed us to assess their combined associations with coronary disease.

This study highlights significant differences in the prevalence of clinical coronary disease among race groups in the adult US population with reduced kidney function. Although the prevalence increased with declining kidney function in each group, increases were lowest in Mexican-American individuals. It is plausible that favorable distributions of some traditional and novel risk factors accounted for the lower prevalence in Mexican-American individuals compared with other race groups. These results support the continuing Hispanic paradox of CV protection in Hispanic individuals with CKD that is seen in the general population despite adverse CV risk profiles. Future studies should assess whether these findings translate into fewer CV events for Mexican-American individuals using prospectively designed cohorts.

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