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Race and Sex Differences in Hypertension Control in CKD: Results From the Kidney Early Evaluation Program (KEEP)

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Abstract

Background—African American men with chronic kidney disease (CKD) progress to end-stage renal disease more rapidly than African American women or whites. Uncontrolled hypertension worsens CKD, and disparities in hypertension control may contribute to disparities in CKD progression.

Study Design—Cross-sectional.

Setting & Participants—10,827 individuals with CKD and self-reported hypertension screened in the Kidney Early Evaluation Program.

Predictors—African American race, sex.

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Outcomes—Hypertension control (blood pressure <130 mm Hg systolic and/or <80 mm Hg diastolic).

Measurements—Self-report, physical examination (blood pressure), laboratory data (serum creatinine, microalbuminuria by urine dipstick). We calculated estimated glomerular filtration rates by using the 4-variable isotope dilution mass spectrometry Modification of Diet in Renal Disease Study equation. We classified CKD as early (stages 1 to 2) or late (stages 3 to 5) based on estimated glomerular filtration rate and microalbuminuria.

Results—In individuals with early CKD, African American women (odds ratio [OR], 1.47; 95% confidence interval [CI], 1.14 to 1.88), white men (OR, 1.85; 95% CI, 1.39 to 2.46), and white women (OR, 1.69; 95% CI, 1.28 to 2.22) had greater odds of hypertension control (blood pressure <130/80 mm Hg) than African American men. In individuals with late CKD, white men (OR, 1.66; 95% CI, 1.10 to 2.52) and white women (OR, 1.67; 95% CI, 1.13 to 2.46) had greater odds of hypertension control than African American men. No differences were seen between African American men and women with late CKD.

Limitations—No information for medication regimens.

Conclusions—African American men with CKD have poorly controlled hypertension compared with African American women and whites, particularly in the early stages of disease. Efforts to aggressively treat hypertension in this population may help narrow the race and sex disparities in progression to end-stage renal disease.

INDEX WORDS

Hypertension; chronic kidney disease; ethnic groups; sex

African Americans have a markedly greater prevalence of end-stage renal disease (ESRD) compared with whites.^{1–3} This disparity is caused in part by accelerated progression from chronic kidney disease (CKD) to ESRD at a rate 5 times higher for African Americans than whites.⁴ Sex is independently associated with accelerated CKD progression. Men with CKD experience more rapid progression of disease than women with CKD in persons who have nondiabetic renal disease.^{5–6} African American men therefore are at particularly high risk of CKD progression. Of 100 prevalent cases of CKD from any cause, 7 incident cases of ESRD will develop in African American men during a 5-year period compared with 4 incident ESRD cases in African American women and 2 incident ESRD cases in white men.⁴

One approach to eliminate these race and sex disparities is the early identification and treatment of risk factors that can slow disease progression in high-risk populations. Poorly controlled hypertension as either a cause or consequence of CKD predisposes to cardiovascular disease complications, as well as more rapid progression to ESRD.^{7,8} In the United States, the incidence of ESRD from hypertensive CKD in African American men is 5 times that in white men and 1.4 times that in African American women.⁹ African Americans with CKD have poorly controlled hypertension compared with whites with CKD,¹⁰ but differences in hypertension control between African American men and other race/sex groups with CKD have not been well described.

Using data from the Kidney Early Evaluation Program (KEEP), a community-based health screening program sponsored by the National Kidney Foundation (NKF), we evaluated the adequacy of hypertension control in African American men, African American women, white men, and white women with self-reported hypertension and CKD.

METHODS

Study Design

We used a cross-sectional study design, classifying KEEP participants with self-reported hypertension into 4 groups by race and sex. KEEP was designed to identify individuals at high risk of CKD, rather than assess differences in the prevalence of specific risk factors, and the hypothesis for this analysis of race-sex differences in hypertension control was developed after the completion of data collection.

Setting and Participants

From August 2000 through December 2004, a total of 45 NKF affiliates organized free KEEP screening programs to identify cases of CKD in individuals at risk. NKF affiliates advertised with local media to draw participants and carried out the screenings at churches, health centers, and other community venues. KEEP screenings were conducted across the country, but the majority were in the southeast and mid-Atlantic regions. Eligible participants were at least 18 years old with self-reported diabetes or hypertension or a family history of diabetes, hypertension, or kidney disease.^{11,12} The Institutional Review Board at the Hennepin County Medical Center approved the KEEP program, including the research protocol, process of obtaining informed consent, and data management procedures. Some NKF affiliates targeted recruitment efforts in areas with large African American populations because of their known high prevalence of diabetes and hypertension. As of December 2004, a total of 37,155 participants were enrolled in KEEP. Our study population (n = 10,827) was limited to African American or white individuals with self-reported hypertension and CKD.

Variables of Interest

Study outcomes were rates of adequate hypertension control, including overall (blood pressure <130/80 mm Hg), systolic (<130 mm Hg), and diastolic (<80 mm Hg) control. Our predictor variables were race and sex. We measured several potential confounders, including age, education, self-reported diabetes, insurance status, tobacco use, body mass index, and family history of CKD.

Measurement

All participants provided informed consent before data collection. Data were collected by means of questionnaire for demographic characteristics and medical history. However, information for medication status was not obtained during KEEP health assessments; therefore, we were unable to distinguish between treated and untreated hypertension in this analysis.

Systolic and diastolic blood pressures were measured, along with height and weight to calculate body mass index. Blood specimens were collected and processed for determination of creatinine level, along with other laboratory tests. Urinary dipstick was used to assess the presence of microalbuminuria, defined as albumin excretion greater than 0.002 g/dL (>0.02 g/L). We calculated estimated glomerular filtration rate using the 4-variable isotope dilution mass spectrometry Modification of Diet in Renal Disease (MDRD) Study equation ($186.3 \times [\text{serum creatinine (mg/dL)}^{-1.154}] \times [\text{age (years)}^{-0.203}]$); calculated values were multiplied by 0.742 for women and by 1.21 for African Americans.¹³ This MDRD Study equation was adequately validated in African Americans with hypertensive CKD.¹⁴ Using the CKD staging system from the Kidney Disease Outcomes Quality Initiative guidelines, we categorized estimated glomerular filtration rates based on the following cutoff values: 90 mL/min/1.73 m² or greater (≥ 1.50 mL/s/1.73 m²) in the presence of microalbuminuria (stage 1), 60 to 89 mL/min/1.73 m² (1.00 to 1.48 mL/s/1.73 m²) in the presence of microalbuminuria (stage 2), 30 to 59 mL/min/1.73 m² (0.50 to 0.98 mL/s/1.73 m²; stage 3), 15 to 29 mL/min/1.73 m² (0.25 to 0.48 mL/

s/1.73 m²; stage 4), and less than 15 mL/min/1.73 m² (<0.25 mL/s/1.73 m²; stage 5).¹⁵ We classified participants at stage 1 or stage 2 as early-stage CKD, and those at stage 3 or greater, with late-stage CKD.

Statistical Methods

All analyses were executed using the SAS statistical package (release 8.2; SAS Institute Inc, Cary, NC). Participants with missing values for race, sex, body mass index, insurance status, self-reported diabetes, systolic blood pressure, or diastolic blood pressure were excluded from the analytic sample (n = 2,571). Because we did not adjust for smoking status and family history of CKD in the multivariate analysis, we included participants who were missing values for those 2 variables within the analytic sample. We conducted descriptive analyses to examine clinical and demographic characteristics of our 4 comparison groups of interest: African American men, African American women, white men, and white women. We evaluated percentages with adequate hypertension control among the 4 groups, as well as median and interquartile ranges of systolic and diastolic blood pressure values.

In multivariate logistic regression models controlling for age, self-reported diabetes, education, and insurance, we examined the odds of adequate systolic blood pressure control (<130 mm Hg), diastolic blood pressure control (<80 mm Hg), and overall hypertension control (blood pressure <130/80 mm Hg) in participants with early-stage CKD and late-stage CKD. We conducted separate sensitivity analyses limited to participants not currently smoking and limited to those without self-reported diabetes. Because results from these sensitivity analyses did not differ substantially from the main analysis, we report only results from the original models.

RESULTS

The analytic sample consisted of 8,256 participants with self-reported hypertension and CKD (Table 1). African American men and women were younger than white men and women and more likely to have early CKD. Participants excluded from analysis because of missing data had fewer years of education and were less likely to have health insurance than included participants.

Table 2 lists blood pressure values for individuals by race, sex, and stages of CKD. Overall, few KEEP participants had adequate hypertension control, with African Americans more likely to be in poor control. Table 3 lists adjusted odds ratios (ORs) for the association between hypertension control and race and sex in early CKD. After adjustment for age, self-reported diabetes, education, insurance, and body mass index, African American women (OR, 1.47; 95% confidence interval [CI], 1.14 to 1.88), white men (OR, 1.85; 95% CI, 1.39 to 2.46), and white women (OR, 1.69; 95% CI, 1.28 to 2.22) with early CKD had greater odds of adequate hypertension control than African American men. Table 4 lists results of a parallel analysis in participants with late CKD. Both white men and white women with late CKD had greater odds of being in adequate diastolic blood pressure and overall hypertension control compared with African American men. In addition, white women (OR, 1.47; 95% CI, 1.06 to 2.05) with late CKD had greater odds of adequate systolic blood pressure control compared with African American men, whereas no statistical differences were seen for white men or African American women compared with African American men.

DISCUSSION

We observed differences in hypertension control by race and sex within the KEEP sample, particularly in patients with early CKD. These differences correspond to disparities in the risk of progression from CKD to ESRD. African American men are at the greatest risk of CKD

progression and have higher blood pressure values than other race/sex groups. Because adequate hypertension control may be the single most important intervention available at this time to slow the progression of renal disease,¹⁶ our findings emphasize the particular need to screen for, diagnose, and aggressively treat hypertension in African American men with CKD.

There are several potential explanations for the increased blood pressure values we observed in African American men with CKD. First, differences in blood pressure between African American men and women with CKD may be in part biological because both human and animal studies indicated that sex hormones have a role in vascular reactivity. Estrogens may upregulate production of such vasorelaxant substances as nitric oxide, react directly on vascular smooth muscle cells, and dampen the cardiovascular stress response to adrenergic stimuli.^{17–19} Conversely, testosterone was shown to increase secretion of such vasoconstrictors as endothelin and stimulates the renin-angiotensin-aldosterone system, leading to inadequate sodium excretion in the setting of increased arterial blood pressure.^{18,19} Genetic variability related to the renin-angiotensin-aldosterone system and/or the α -adrenergic receptor also was linked in population-based studies to sex differences in blood pressure in both African Americans²⁰ and whites.²¹

However, a primary biological explanation for sex differences in hypertension control would suggest persistently increased blood pressures for both African American and white men relative to women. Although this was true in the past,¹⁷ recent data showed a different pattern and suggested a second potential explanation for our findings; specifically, that the race/sex disparity we observed is caused largely by differences in treatment rates. Analyses of the 1999–2000 National Health and Nutrition Examination Survey (NHANES) indicate that a sex disparity in hypertension control persists for African Americans, but white men now have equivalent or better hypertension control than white women because of increasing treatment rates over time.^{22,23} Our findings therefore support the need for additional analyses, including studies with data for the frequency and intensity of antihypertensive therapy, to determine the cause of poor hypertension control in African American men with early- and late-stage CKD.

A third potential explanation for our findings of poor hypertension control for African American men with CKD is variations in access to and use of health care in individuals receiving antihypertensive treatment. In African Americans with hypertension, some data indicate that men are less likely to have health insurance, more likely to receive care in a public clinic, and less likely to have regular physician visits than women regardless of socioeconomic status.²⁴ The lack of insurance in the NHANES III cohort was associated with lower rates of blood pressure control in treated patients with hypertension, but had no effect on blood pressure control in untreated persons with hypertension.²⁵ The majority of African Americans who participated in KEEP had adequate access to health care because more than 80% had health insurance and more than 85% had a regular physician.²⁶ However, men were less likely than women to have either insurance or an identified physician, suggesting that sex-based differences in access could contribute to suboptimal medication regimens and poor hypertension control in men.

The NKF issued practice guidelines emphasizing that interventions to improve hypertension control and slow the progression of kidney disease must begin during early CKD, specifically stages 1 and 2, which are characterized by microalbuminuria, but maintained glomerular filtration rate.²⁷ Within our sample, African Americans were more likely than whites to have stage 1 or 2 CKD versus stage 3 CKD, consistent with published NHANES III data.²⁸ African Americans with CKD were also younger than whites. This earlier-onset hypertension may present an increased risk of decreases in renal function starting at a younger age. Our findings indicate missed opportunities to prevent ESRD in a relatively young and high-risk population. Aggressive hypertension treatment of all persons with early CKD, delivered mainly by primary

care providers, may decrease both the race and sex disparities in progression from CKD to ESRD.

We observed race and sex disparities in both systolic and diastolic blood pressure values, but the magnitude of differences was greater for diastolic blood pressures. The preponderance of evidence suggests that systolic blood pressure, rather than diastolic blood pressure, is the primary determinant of CKD progression.^{8,29} However, data from the MDRD trial indicate that controlling mean arterial pressure, which is primarily determined by diastolic blood pressure, slows CKD progression in persons without diabetes.³⁰ The MDRD intervention group achieved a mean arterial pressure of 5.1 mm Hg less than in the control group, with a corresponding hazard ratio of 0.68 for the development of ESRD at 6 years of follow-up. Current guidelines for hypertension control in patients with CKD recommend systolic blood pressure less than 130 mm Hg along with diastolic blood pressure less than 80 mm Hg to prevent progression of renal disease and associated cardiovascular complications.³¹

Our study has several limitations. We did not have access to medical records or information for antihypertensive medication regimens and classified participants as hypertensive based on self-report. We used 2 blood pressure measurements on a single day to evaluate hypertension control. The predictive value of this approach should not vary by participant race or sex and therefore should not introduce directional bias into our analyses. We did not have information about quantity of microalbuminuria and are unable to comment on the relationship between severity of microalbuminuria and poor hypertension control. Also, KEEP was a targeted screening of individuals at risk of CKD and therefore is not representative of the general population of the United States. Persons who participate in such screening programs tend to be those who are more concerned about their health. In addition, KEEP enrolled large numbers of participants in the southeastern United States, a region with low rates of hypertension control for both African Americans and whites.³²

In conclusion, we found that in hypertensive patients in a community-based screening of patients at risk of CKD, blood pressure values varied by both race and sex, with African American men at greatest risk of inadequate hypertension control compared with whites, followed by African American women at intermediate risk. These race and sex disparities in hypertension control correspond to those at risk of rapid progression from CKD to ESRD and suggest the importance of improved hypertension control in early CKD for African American men in particular. However, these results require confirmation in population-based cohorts with more complete data for medication and health care use.

Acknowledgments

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Table 1

Demographics, Clinical Characteristics, and CKD Stage of KEEP Participants With Self-Reported Hypertension by Race and Sex

	African American Men (n = 1,162)	African American Women (n = 3,008)	White Men (n = 1,461)	White Women (n = 2,625)	KEEP Participants With Missing Values (n = 2,571)
Demographics					
Age (y)	56.2 ± 13.1	57.7 ± 13.4	63.5 ± 13.7	63.8 ± 13.9	58.3 ± 16.3
≤45 (%)	21.1	17.8	11.3	10.9	19.6
46–60 (%)	39.8	39.6	26.1	26.6	34.8
≥61 (%)	39.2	42.7	62.6	62.6	45.7
Education (y)					
<12 (%)	19.4	17.9	15.1	15.3	28.4
12 (%)	27.4	26.8	27.6	34.3	25.6
>12 (%)	53.3	55.3	57.3	50.5	40.7
Health insurance (%)	82.7	85.6	90.3	92.4	62.1
Clinical characteristics					
Self-reported diabetes (%)	33.7	33.2	39.2	36.1	40.1
Body mass index (kg/m ²)	31.0 ± 6.2	33.5 ± 7.4	30.5 ± 5.8	31.4 ± 7.3	31.2 ± 6.9
Current tobacco use (%) [*]	18.4	10.7	10.7	8.2	12.6
Family history of CKD (%) [*]	19.3	27.0	15.4	20.7	23.5
Blood pressure <130/80 mm Hg (%)	10.9	13.5	17.9	17.8	19.3
CKD stage					
1 (%)	31.2	32.0	15.1	11.1	25.7
2 (%)	47.1	41.2	41.8	32.3	39.7
3 (%)	19.2	25.3	39.6	53.8	31.7
4 (%)	1.9	1.0	3.1	2.7	2.3
5 (%)	0.6	0.5	0.5	0.1	0.6

Note: Values expressed as mean ± SD or percent.

Abbreviations: CKD, chronic kidney disease; KEEP, Kidney Early Evaluation Program.

^{*} Data missing for a subset of respondents.

Table 2

Blood Pressure Ranges for KEEP Participants With Self-Reported Hypertension and CKD by Race, Sex, and Severity of CKD

	African American Men (n = 910)	African American Women (n = 2,199)	White Men (n = 831)	White Women (n = 1,140)
Early CKD (stages 1 & 2)				
Overall blood pressure (mm Hg)				
<130/80 (%)	10.2	13.2	16.1	14.9
Systolic blood pressure (mm Hg)				
Median	144	142	142	141
25th percentile	132	130	130	130
75th percentile	160	158	156	155
Diastolic blood pressure (mm Hg)				
Median	88	84	82	82
25th percentile	80	78	75	74
75th percentile	96	92	90	90
Late CKD (stages 3–5)	(n = 252)	(n = 809)	(n = 630)	(n = 1,485)
Overall blood pressure (mm Hg)				
<130/80 (%)	13.5	14.3	20.3	19.9
Systolic blood pressure (mm Hg)				
Median	145	142	140	140
25th percentile	130	130	130	128
75th percentile	160	160	155	154
Diastolic blood pressure (mm Hg)				
Median	81	80	78	78
25th percentile	74	71	70	70
75th percentile	90	88	85	83

Abbreviations: CKD, chronic kidney disease; KEEP, Kidney Early Evaluation Program.

Table 3

Odds Ratios of Blood Pressure Control for KEEP Participants With Self-Reported Hypertension and Early CKD (stages 1 to 2)

	African American Men (n = 910)	African American Women (n = 2,199)	White Men (n = 831)	White Women (n = 1,140)
Systolic blood pressure <130 mm Hg	1.0 (reference)	1.44 (1.18–1.76)*	1.63 (1.28–2.07)*	1.49 (1.20–1.87)*
Diastolic blood pressure <80 mm Hg	1.0 (reference)	1.45 (1.21–1.75)*	1.71 (1.38–2.13)*	2.09 (1.71–2.55)*
Overall blood pressure <130/80 mm Hg	1.0 (reference)	1.47 (1.14–1.88)*	1.85 (1.39–2.46)*	1.69 (1.28–2.22)*

Note: Values expressed as odds ratio (95% confidence interval). Adjusted for age, self-reported diabetes mellitus, insurance status, years of education, and body mass index.

Abbreviations: CKD, chronic kidney disease; KEEP, Kidney Early Evaluation Program.

* 95% confidence intervals that do not encompass 1.0.

Table 4

Odds Ratios of Blood Pressure Control for KEEP Participants With Self-Reported Hypertension and Late CKD (stages 3 to 5)

	African American Men (n = 252)	African American Women (n = 809)	White Men (n = 630)	White Women (n = 1,485)
Systolic blood pressure <130 mm Hg	1.0 (reference)	1.17 (0.82–1.66)	1.35 (0.95–1.94)	1.47 (1.06–2.05)*
Diastolic blood pressure <80 mm Hg	1.0 (reference)	1.35 (0.99–1.83)	1.81 (1.32–2.48)*	2.24 (1.68–3.00)*
Overall blood pressure <130/80 mm Hg	1.0 (reference)	1.16 (0.76–1.75)	1.66 (1.10–2.52)*	1.67 (1.13–2.46)*

Note: Values expressed as odds ratio (95% confidence interval). Adjusted for age, self-reported diabetes mellitus, insurance status, years of education, and body mass index.

Abbreviations: CKD, chronic kidney disease; KEEP, Kidney Early Evaluation Program.

* 95% confidence intervals that do not encompass 1.0.