Original Article

Racial and Ethnic Differences in Antihypertensive Medication Use and Blood Pressure Control Among US Adults With Hypertension

The National Health and Nutrition Examination Survey, 2003 to 2012

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Background—A key to reduce and eradicate racial disparities in hypertension outcomes is to understand their causes. We aimed at evaluating racial differences in antihypertensive drug utilization patterns and blood pressure control by insurance status, age, sex, and presence of comorbidities.

Methods and Results—A total of 8796 hypertensive individuals ≥18 years of age were identified from the National Health and Nutrition Examination Survey (2003–2012) in a repeated cross-sectional study. During the study period, all 3 racial groups (whites, blacks, and Hispanics) experienced substantial increase in hypertension treatment and control. The overall treatment rates were 73.9% (95% confidence interval [CI], 71.6%–76.2%), 70.8% (95% CI, 68.6%–73.0%), and 60.7% (95% CI, 57.0%–64.3%) and hypertension control rates were 42.9% (95% CI, 40.5%–45.2%), 36.9% (95% CI, 34.7%–39.2%), and 31.2% (95% CI, 28.6%–33.9%) for whites, blacks, and Hispanics, respectively. When stratified by insurance status, blacks (odds ratio, 0.74 [95% CI, 0.64–0.86] for insured and 0.59 [95% CI, 0.36–0.94] for uninsured) and Hispanics (odds ratio, 0.74 [95% CI, 0.60–0.91] for insured and 0.58 [95% CI, 0.36–0.94] for uninsured) persistently had lower rates of hypertension control compared with whites. Racial disparities also persisted in subgroups stratified by age (≥60 and <60 years of age) and presence of comorbidities but worsened among patients <60 years of age.

Conclusions—Black and Hispanic patients had poorer hypertension control compared with whites, and these differences were more pronounced in younger and uninsured patients. Although black patients received more intensive antihypertensive therapy, Hispanics were undertreated. Future studies should further explore all aspects of these disparities to improve cardiovascular outcomes. (***Circ Cardiovasc Qual Outcomes*. 2017;10:e003166. DOI: 10.1161/CIRCOUTCOMES.116.003166.)**

Key Words: blood pressure ■ cardiovascular diseases ■ drug therapy ■ hypertension ■ treatment outcome

Hypertension is a highly prevalent risk factor and a major contributor to a myriad of cardiovascular diseases. It is difficult to overestimate the overall impact of effective hypertension control on the cardiovascular disease burden in the population. Because of consistent efforts to increase the awareness and treatment of hypertension in the United States during the past several decades, the overall control of hypertension seems to be improving.[1,2] Despite this effort, several studies have raised the concern of racial and ethnic inequalities in terms of hypertension treatment and control.[3–6] Although suboptimal insurance coverage and poor access to health care are most widely accepted determinants of health disparities, the causes of racial inequalities are complex and require systematic studies to bridge the gap in achieving universal high-quality clinical outcomes. We sought to examine the racial differences in hypertension treatment and control, describe antihypertensive drug utilization patterns, and explore potential causes of racial disparities in these measures.

Methods

The National Health and Nutrition Examination Survey (NHANES) was conducted by the US Centers for Disease Control and Prevention National Center for Health Statistics. NHANES volunteers were selected using stratified, multistage probability sampling of the noninstitutionalized US population.[7] Since 1999, NHANES has been implemented as a continuous, cross-sectional annual survey, and data are publicly released in 2-year circles. Survey participants receive detailed in-person home interviews, followed by standardized physical examinations conducted in mobile examination centers, and laboratory tests using blood and urine specimens provided by participants during the physical examination. The overall participant response rate ranged from 72.6% to 80.5% for interviews and from 69.5% to 77.4%

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WHAT IS KNOWN

- Hypertension treatment and control have been improving during the past several decades, but some high-risk groups (including racial minorities) may still have suboptimal blood pressure control.

WHAT THE STUDY ADDS

- The current repeated cross-sectional study was based on National Health and Nutrition Examination Survey from 2003 to 2012 and was aimed at evaluating racial differences in antihypertensive drug utilization patterns and blood pressure control.
- Black and Hispanic patients seemed to have poorer hypertension control compared with non-Hispanic whites, and these differences were more pronounced in younger and uninsured patients.
- Suboptimal insurance coverage and poor access to health care are most widely accepted determinants of health disparities, but the causes of racial inequalities are complex and can be broadly categorized as patient related and healthcare related.
- Further efforts should focus on understanding the reasons for racial inequalities in hypertension control and mounting a broader effort in addressing these reasons.

for examination at mobile examination centers for each survey cycle from 2003 to 2012. The surveys were reviewed and approved by the National Center for Health Statistics Institutional Review Board, and documented consent was obtained from participants.

Participants included adults ≥18 years of age in NHANES 2003 to 2012.

Hypertension was defined if 1 or more of the following conditions were met: (1) systolic blood pressure (BP)≥140 mm Hg; (2) diastolic BP ≥90 mm Hg; and an affirmative response to "Are you currently taking medication to lower your blood pressure?" A small proportion (<1%) of such participants were excluded from the analysis because of lack of valid BP measurements or pregnancy.

Race/ethnicity was self-reported and separated into non-Hispanic white (white), non-Hispanic black (black), and Hispanic ethnicity of any race.

Mean systolic and diastolic BP were determined per NHANES reporting guidelines. Up to 3 BP readings were obtained and used to calculate a mean systolic BP and a mean diastolic BP for each individual. A detailed description of the procedures for BP measurement in NHANES has been published elsewhere.[8]

Hypertension control was defined first based on the Joint National Committee (JNC) 7 standards: systolic BP <140 mm Hg and diastolic BP <90 mm Hg for patients without chronic kidney disease and diabetes mellitus (DM) and systolic BP <130 mm Hg and diastolic BP <80 mm Hg for patients with either comorbidity.[9] Alternatively, BP control thresholds recommended by the JNC 8 guidelines were explored. This analysis relies on retrospective application of JNC 8 recommendations aimed at contrasting the measures of hypertension control based on old (JNC 7) and proposed (JNC 8) definitions. JNC 8 eased the BP goals for older patients (≥60 years of age) without chronic kidney disease and DM to <150 mm Hg systolic BP and <90 mm Hg diastolic BP, whereas for all other patients ≥18 years of age, the goals were set at <140/90 mm Hg.[10]

Antihypertensive medications were categorized into the following classes: (1) diuretics, (2) β-blockers, (3) calcium channel blockers (CCBs), (4) angiotensin II receptor blockers, (5) angiotensin-converting enzyme inhibitors, and (6) others (eg, direct vasodilators, renin inhibitors, α_1-blockers, and other centrally acting drugs). Monotherapy was defined when a person only reported taking 1 antihypertensive agent. Combination therapy (polytherapy) was defined when a person reported taking >1 antihypertensive agents, including fixed-dose combination agents and combinations of different diuretics. Antihypertensive treatment rates (overall and class-specific) were defined as the percentages of hypertensive individuals who reported using respective class of antihypertensive agents during the study period. Likewise, prevalence of controlled hypertension was defined as the proportion of hypertensive individuals whose BP measured was below the thresholds for controlled hypertension per JNC recommendations.

DM was defined if 1 or more of the following conditions were met: (1) a positive response to 1 or more of the following questions, "Have you ever been told by a doctor that you have diabetes?", "Are you now taking insulin?", and "Are you now taking diabetic pills to lower your blood sugar?"; (2) antidiabetic medication(s) reported or brought to examination by the interviewee; (3) fasting glucose ≥7 mmol/L; and (4) glycosylated hemoglobin ≥6.5%.[11,12]

Chronic kidney disease was defined as either an estimated glomerular filtration rate <60 mL/min/1.73 m^2 or a urinary albumin concentration of >200 mg/g urinary creatinine, where glomerular filtration rate was estimated using the Modification of Diet in Renal Disease equation.[2] Serum creatinine values from NHANES 2005 to 2006 data were recalibrated according to the recommended standards.[13]

Participants' age, sex, health insurance status, presence of a routine place for health care, poverty income ratio, and history of physician-diagnosed cardiovascular disease (such as stroke, congestive heart failure, angina pectoris, myocardial infarction, or coronary artery disease) were obtained by questionnaire.

Statistical Methods

We used descriptive statistics to identify the following patient characteristics: (1) sociodemographic, clinical, and healthcare utilization characteristics; (2) antihypertensive prescribing rates; and (3) hypertension control. Linear trends in the prescribing pattern and control of hypertension were assessed with regression models with a 2-year period treated as a continuous variable. We conducted logistic regressions to model the probability of antihypertensive treatment and BP control among treated and reported odds ratios (ORs) of each racial/ethnic group relative to whites. This analysis was conducted in all study subjects and in subgroups by insurance, age, sex, and comorbidity status. We reported ORs in 2 ways: unadjusted and fully adjusted. In the fully adjusted model, we adjusted for 3 categories of patient-level variables: patient demographics, insurance status and whether patient had a routine place for healthcare, and clinical characteristics. Demographics included age bins (18–39, 40–59, ≥60 years of age), sex, and poverty-to-income ratio (<100%, 200% to 299%, 300% to 499%, and ≥500%). Clinical characteristics included physician-diagnosed DM, chronic kidney disease, and cardiovascular disease. These variables were shown to be relevant in previous studies[1,2,14] to hypertension treatment and control, and they were all significantly associated with race (2-sided $P<0.01$) from χ^2 tests. Pairwise interactions between race and each of the other independent variables were tested for significance.

Appropriate sample weights were used to account for differential probabilities of selection and the complex multistage sample survey design.[7] Taylor linearization was used for variance estimation, and domain analysis was used for subpopulation analysis because selection of subpopulations may be unrelated to sample design. The analyses were performed only for subgroups with sample sizes large enough to produce reliable estimates according to the National Center for Health Statistics standards (sample size ≥30 and relative SE <0.30).[7] Examination of the hypertensive patient sample in our study indicated that the distributions of age were similar across survey years (P=0.74). Hence, we present estimates of antihypertensive-prescribing rates and hypertension control among US adults with hypertension without age standardization.

Results

Baseline Characteristics

Baseline patient characteristics are presented in Table 1. Among the groups, whites were older, had a higher income level, and were more likely to have health insurance. These differences were more pronounced compared with Hispanic patients. Also, whites carried lower rates of obesity and DM and were less likely to be active smokers. Although they had high rates of chronic kidney disease and cardiovascular disease, it is possible that comorbidities were underdiagnosed because of suboptimal access to healthcare, especially in the Hispanic group. Among the 3 groups, the rates of hypertension control based on JNC 7 recommendations were highest among whites (42.9%; 95% CI, 40.5%–45.2%), followed by blacks (36.9%; 95% CI, 34.7%–39.2%), and lowest among Hispanics (31.2%; 95% CI, 28.6%–33.9%); these differences were similar when JNC 8 standards were applied.

Temporal Trends

The percentage of hypertensive adults who reported taking an antihypertensive drug increased from 65.6% in 2003 to 2004 to 77.3% in 2010 to 2012 (P_{trend}<0.001), and this was consistent in all 3 groups (whites: 66.9% to 78.8%; P_{trend}<0.001; blacks: 63.0% to 76.0%; P_{trend}<0.001; and Hispanics: 57.1% to 68.3%; P_{trend}<0.01) as shown in Table 2. Most notably, significant increases in utilization were observed for diuretics among whites (diuretics: 30.4% to

Table 1. Sociodemographic and Clinical Characteristics Among Hypertensive Adults, by Race/Ethnicity—National Health and Nutrition Examination Survey, 2003 to 2012

Characteristics	All Patients (n=8796), % (95% CI)	White (n=4509), % (95% CI)	Black (n=2475), % (95% CI)	Hispanic (n=1812), % (95% CI)	*P* Value
Female sex	51.6 (50.3–52.9)	50.9 (49.3–52.4)	56.9 (54.7–59.2)	48.6 (46.2–50.9)	<0.001
Age, y					
18–39	9.1 (8.1–10.0)	7.5 (6.3–8.6)	13.8 (11.9–15.7)	15.0 (12.2–17.9)	<0.001
40–59	39.9 (38.2–41.6)	37.5 (35.5–39.5)	49.4 (47.0–51.9)	44.5 (40.9–48.0)	
≥60	51.0 (49.1–53.0)	55.1 (52.8–57.3)	36.8 (34.1–39.5)	40.5 (37.1–43.9)	
Poverty-to-income ratio					
<100%	17.1 (15.7–18.4)	13.0 (11.3–14.6)	27.8 (24.9–30.6)	35.3 (31.2–39.3)	<0.001
100%–299%	37.8 (35.7–39.9)	36.2 (33.6–38.9)	42.4 (40.0–44.8)	43.3 (40.0–46.6)	
300%–499%	22.9 (21.0–24.8)	25.1 (22.8–27.3)	17.0 (15.0–19.1)	13.7 (10.4–17.1)	
≥500%	22.2 (20.3–24.2)	25.7 (23.0–28.4)	12.8 (10.7–14.9)	7.7 (5.5–9.9)	
Covered by health insurance	88.9 (87.9–90.0)	92.1 (90.9–93.3)	83.7 (81.7–85.7)	69.7 (66.2–73.2)	<0.001
Had a routine place for health care	93.2 (92.4–94.0)	94.3 (93.4–95.2)	93.4 (92.3–94.5)	82.7 (79.9–85.5)	<0.001
Smoking status					
Nonsmoker	49.2 (47.8–50.6)	47.4 (45.6–49.1)	53.7 (50.9–56.4)	57.8 (54.7–60.8)	
Past smoker	31.3 (30.0–32.6)	34.5 (33.1–35.9)	19.9 (17.9–21.8)	22.9 (20.4–25.4)	
Current smoker	19.5 (18.2–20.8)	18.1 (16.6–19.7)	26.4 (23.7–29.2)	19.3 (17.1–21.5)	<0.001
BMI, kg/m^2					
<25	20.7 (19.5–21.8)	21.9 (20.4–23.4)	17.7 (15.9–19.5)	14.7 (12.4–17.1)	
25–<30	32.6 (31.3–34.0)	33.5 (31.8–35.2)	27.2 (25.4–29.0)	33.4 (30.6–36.3)	
≥30	46.8 (45.2–48.4)	44.6 (42.6–46.5)	55.1 (52.7–57.5)	51.9 (48.4–55.3)	<0.001
SBP, mean (95% CI), mm Hg	136.9 (136.2–137.6)	136.1 (135.3–136.9)	139.0 (137.9–140.2)	140.4 (139.1–141.7)	<0.001
DBP mean (95% CI), mm Hg	73.6 (72.9–74.3)	72.7 (72.0–73.5)	76.5 (75.4–77.7)	75.9 (74.6–77.2)	<0.001
Blood pressure control					
Controlled (JNC 7)	41.0 (39.0–42.9)	42.9 (40.5–45.2)	36.9 (34.7–39.2)	31.2 (28.6–33.9)	<0.001
Controlled (JNC 8)	53.8 (52.0–55.6)	56.3 (54.3–58.2)	47.3 (45.0–49.6)	43.2 (40.0–46.3)	<0.001
Comorbidities					
Diabetes	24.2 (23.0–25.3)	21.6 (20.2–22.9)	30.7 (28.3–33.1)	36.3 (32.8–39.8)	<0.001
Chronic kidney disease	19.9 (18.6–21.2)	20.9 (19.4–22.4)	16.1 (14.4–17.8)	17.2 (14.9–19.6)	<0.001
Cardiovascular disease	18.9 (17.7–20.2)	19.4 (17.9–20.9)	18.7 (16.9–20.6)	15.0 (12.9–17.1)	<0.01
Without comorbidity	55.3 (53.6–57.0)	55.9 (53.9–57.8)	54.6 (51.9–57.4)	51.2 (47.6–54.7)	0.047

BMI indicates body mass index; CI, confidence interval; DBP, diastolic blood pressure; JNC, Joint National Committee; and SBP, systolic blood pressure.

Table 2. Prevalence of Antihypertensive Medication Use Among Hypertensive Adults Over Time by Race/Ethnicity—National Health and Nutrition Examination Survey, 2003 to 2012

	2003–2004, % (95% CI)	2005–2006, % (95% CI)	2007–2008, % (95% CI)	2009–2010, % (95% CI)	2011–2012, % (95% CI)	P_{trend} (Adjusted)
All patients	n=1606	n=1475	n=2057	n=2017	n=1641	
Diuretics	30.5 (27.2–33.8)	33.6 (29.0–38.1)	34.6 (30.3–38.9)	35.5 (33.1–38.0)	36.8 (33.1–40.4)	<0.01
Thiazide diuretics	22.9 (20.6–25.3)	26.0 (21.9–30.1)	26.9 (23.2–30.6)	27.4 (24.9–29.8)	29.6 (25.8–33.5)	<0.01
Calcium channel blockers	19.9 (17.1–22.7)	21.0 (17.4–24.7)	19.2 (16.7–21.8)	20.0 (17.4–22.7)	19.7 (16.4–23.0)	0.447
Angiotensin-converting enzyme inhibitors	29.3 (25.2–33.5)	29.1 (25.6–32.5)	28.7 (25.3–32.2)	33.0 (30.7–35.3)	33.3 (30.0–36.6)	0.04
β-Blockers	24.6 (21.8–27.4)	30.2 (25.9–34.4)	26.8 (24.4–29.2)	32.3 (28.6–36.0)	28.7 (23.7–33.7)	0.07
Angiotensin receptor blockers	13.0 (10.8–15.3)	14.9 (12.3–17.4)	20.4 (17.9–23.0)	20.2 (17.4–23.0)	17.1 (14.2–20.1)	<0.01
Any antihypertensive drug use	65.6 (61.2–70.0)	69.0 (63.8–74.3)	72.2 (70.2–74.2)	76.3 (72.9–79.6)	77.3 (72.9–81.7)	<0.001
White	n=899	n=819	n=1055	n=1045	n=691	
Diuretics	30.4 (26.7–34.2)	33.9 (28.4–39.3)	35.1 (30.5–39.7)	35.2 (32.0–38.4)	37.2 (32.1–42.3)	0.04
Thiazide diuretics	22.6 (20.1–25.2)	26.3 (21.2–31.3)	27.1 (22.9–31.3)	26.8 (23.8–30.0)	29.8 (24.4–35.3)	0.03
Calcium channel blockers	18.5 (15.4–21.6)	20.1 (15.8–24.4)	17.9 (15.1–20.8)	18.5 (15.4–21.7)	17.3 (13.9–20.7)	0.308
Angiotensin-converting enzyme inhibitors	30.3 (25.3–35.3)	30.3 (26.0–34.6)	28.6 (24.3–32.9)	33.6 (30.6–36.5)	34.2 (30.0–38.7)	0.125
β-Blockers	26.3 (22.4–30.1)	32.9 (28.2–37.6)	28.4 (25.3–31.5)	34.2 (30.0–38.5)	31.1 (24.8–37.4)	0.168
Angiotensin receptor blockers	13.9 (11.7–16.1)	14.9 (12.0–17.8)	21.6 (18.2–25.0)	20.8 (17.8–23.7)	17.0 (13.2–20.9)	0.04
Any antihypertensive drug use	66.9 (62.4–71.5)	71.0 (64.2–77.9)	74.2 (72.0–76.4)	77.9 (73.7–82.1)	78.8 (73.2–84.4)	<0.001
Black	n=362	n=447	n=531	n=484	n=651	
Diuretics	36.0 (29.7–42.3)	40.0 (33.8–46.1)	39.0 (33.5–44.6)	42.3 (38.5–46.1)	43.1 (39.3–46.9)	<0.01
Thiazide diuretics	27.4 (22.5–32.4)	30.8 (25.7–35.9)	31.1 (27.3–34.9)	33.9 (29.2–38.6)	34.7 (30.4–39.1)	<0.001
Calcium channel blockers	27.1 (21.0–33.2)	31.5 (26.8–36.2)	27.5 (22.5–32.5)	27.8 (22.7–32.9)	30.5 (27.0–34.0)	0.581
Angiotensin-converting enzyme inhibitors	26.9 (23.5–30.3)	26.2 (21.3–31.2)	31.1 (25.2–37.1)	29.3 (24.9–33.6)	28.5 (22.8–34.2)	0.740
β-Blockers	15.8 (10.4–21.2)	22.5 (18.0–27.0)	21.4 (17.5–25.3)	26.9 (21.1–32.7)	21.8 (18.4–25.1)	0.02
Angiotensin receptor blockers	9.4 (5.8–13.1)	18.4 (14.7–22.0)	16.7 (13.3–20.1)	19.2 (13.2–25.3)	18.1 (14.0–22.3)	<0.01
Any antihypertensive drug use	63.0 (56.6–69.3)	69.7 (64.6–74.8)	69.1 (64.5–73.6)	74.0 (70.1–77.9)	76.0 (71.3–80.7)	<0.001
Hispanic	n=345	n=209	n=471	n=`488	n=299	
Diuretics	21.3 (15.2–27.3)	14.5 (8.1–20.9)	23.0 (18.7–27.2)	26.9 (23.1–30.7)	22.7 (16.3–29.1)	0.427
Thiazide diuretics	18.1 (12.1–24.1)	10.7 (5.4–16.0)	18.5 (14.5–22.5)	21.2 (16.4–26.0)	19.8 (13.0–26.5)	0.279
Calcium channel blockers	21.3 (8.4–34.3)	8.1 (4.2–12.0)	16.5 (13.2–19.8)	19.5 (13.3–25.7)	19.8 (14.3–25.2)	0.862
Angiotensin-converting enzyme inhibitors	24.0 (16.9–31.0)	20.7 (12.8–28.6)	26.1 (22.5–29.7)	34.7 (28.7–40.6)	33.5 (26.9–40.2)	0.01
β-Blockers	23.7 (16.2–31.3)	14.4 (8.6–20.1)	22.7 (19.7–25.6)	25.5 (21.4–29.7)	22.0 (17.6–26.3)	0.860
Angiotensin receptor blockers	10.9 (6.5–15.4)	6.0 (1.8–10.2)	16.6 (9.7–23.5)	17.5 (13.8–21.2)	16.4 (11.2–21.7)	<0.01
Any antihypertensive drug use	57.1 (47.1–67.2)	42.5 (33.0–52.1)	60.4 (56.9–63.9)	66.9 (61.4–72.4)	68.3 (60.5–76.1)	<0.01

CI indicates confidence interval.

37.2%; P_{trend}=0.04) and blacks (diuretics: 36.0% to 43.1%; P_{trend}<0.01), β-blockers among blacks (15.8%–21.8%; P_{trend}=0.02), and angiotensin receptor blockers (10.9% to 6.4%, P_{trend}<0.01) and angiotensin-converting enzyme inhibitors (24.0% to 33.5%; P_{trend}=0.01) among Hispanics. No significant changes in the prescription pattern were observed for CCBs.

Prescription Patterns

Overall, diuretics (predominantly thiazide diuretics) were the most commonly utilized antihypertensive drug class accounting for more than one third of all prescriptions throughout the study period (Table 3). At the same time, they were preferentially used in combination therapy compared with other classes. Hispanic patients (60.7%; 95% CI, 57.0%–64.3%)

Table 3. Overall Prevalence of Antihypertensive Medication Use Among Hypertensive Adults by Race/Ethnicity—National Health and Nutrition Examination Survey, 2003 to 2012

Drug Classes and Therapy	All Patients (n=8796), % (95% CI)	White (n=4509), % 95% CI	Black (n=2475), % (95% CI)	Hispanic (n=1812), % (95% CI)	$P_{difference}$ (Adjusted)
Diuretics					
Overall	34.3 (32.6–35.9)	34.4 (32.4–36.4)	40.3 (38.0–42.6)	22.3 (19.8–24.8)	<0.001
Monotherapy	3.3 (2.7–3.8)	3.0 (2.4–3.7)	5.1 (4.0–6.1)	2.1 (1.1–3.1)	<0.001
Polytherapy	31.0 (29.4–32.6)	31.4 (29.4–33.3)	35.3 (32.9–37.6)	20.2 (17.8–22.5)	<0.001
Thiazide diuretics					
Overall	26.7 (25.2–28.2)	26.6 (24.7–28.5)	31.8 (29.8–33.9)	18.2 (15.7–20.7)	<0.001
Monotherapy	2.7 (2.2–3.2)	2.5 (1.9–3.1)	4.3 (3.3–5.3)	1.9 (0.9–2.8)	<0.001
Polytherapy	24.0 (22.5–25.4)	24.1 (22.3–25.9)	27.5 (25.4–29.6)	16.4 (14.0–18.7)	<0.001
β-Blockers					
Overall	28.6 (26.9–30.3)	30.6 (28.5–32.8)	21.9 (19.7–24.0)	22.1 (19.9–24.3)	<0.001
Monotherapy	6.4 (5.6–7.3)	7.2 (6.2–8.2)	3.0 (2.3–3.8)	5.4 (4.2–6.7)	<0.001
Polytherapy	22.1 (20.7–23.6)	23.4 (21.6–25.2)	18.8 (16.8–20.9)	16.7 (14.3–19.1)	<0.001
Calcium channel blockers					
Overall	20.0 (18.6–21.3)	18.5 (16.9–20.0)	29.0 (26.8–31.1)	17.6 (14.3–20.9)	<0.001
Monotherapy	3.1 (2.6–3.7)	2.7 (2.0–3.4)	5.0 (3.9–6.0)	3.6 (2.6–4.6)	<0.001
Polytherapy	16.9 (15.6–18.1)	15.8 (14.4–17.1)	24.0 (22.0–26.0)	14.0 (11.1–16.8)	<0.001
Angiotensin-converting enzyme inhibitors					
Overall	30.8 (29.2–32.3)	31.4 (29.5–33.4)	28.5 (26.2–30.8)	28.7 (25.6–31.8)	<0.001
Monotherapy	9.5 (8.5–10.4)	10.1 (8.9–11.3)	5.4 (4.4–6.4)	11.1 (9.6–12.5)	<0.001
Polytherapy	21.3 (20.1–22.5)	21.3 (19.8–22.9)	23.1 (21.0–25.2)	17.6 (15.0–20.3)	<0.001
Angiotensin receptor blockers					
Overall	17.3 (16.1–18.5)	17.7 (16.3–19.2)	16.7 (14.7–18.6)	14.3 (11.7–16.8)	<0.001
Monotherapy	3.8 (3.2–4.4)	3.9 (3.1–4.7)	3.1 (2.3–4.0)	3.7 (2.5–5.0)	0.02
Polytherapy	13.5 (12.5–14.5)	13.8 (12.5–15.0)	13.5 (11.8–15.3)	10.5 (8.7–12.3)	<0.001
Any antihypertensive					
Overall	72.3 (70.5–74.1)	73.9 (71.6–76.2)	70.8 (68.6–73.0)	60.7 (57.0–64.3)	<0.001
Monotherapy	27.1 (25.8–28.5)	28.1 (26.5–29.7)	22.5 (20.5–24.4)	26.5 (24.2–28.8)	<0.001
Polytherapy overall	45.2 (43.4–47.0)	45.8 (43.6–48.0)	48.3 (45.8–50.8)	34.1 (30.6–37.6)	<0.001
Single-pill combination	17.2 (15.9–18.4)	17.0 (15.5–18.5)	20.5 (18.4–22.6)	12.9 (10.9–14.9)	<0.001
Multipill combination	28.0 (26.3–29.7)	28.8 (26.8–30.8)	27.8 (25.6–30.0)	21.2 (18.5–23.9)	<0.001
Average no. of pills*	1.79 (1.75–1.83)	1.78 (1.73–1.82)	1.91 (1.84–1.97)	1.69 (1.61–1.77)	<0.001

*Among treated patients n=3435 for whites; n=1819 for blacks; n=1210 for Hispanics. CI indicates confidence interval.

had the lowest utilization rate of antihypertensive medications compared both with whites (73.9%; 95% CI, 71.6%–76.2%) and blacks (70.8%; 95% CI, 68.6%–73.0%). This difference was most pronounced for combination therapy (whites: 45.8%; 95% CI, 43.6%–48.0%; blacks: 48.3%; 95% CI, 45.8%–50.8%; and Hispanics: 34.1%; 95% CI, 30.6%–37.6%). Black patients were most likely to receive combination therapy and they also had the highest average number of antihypertensive medications (whites: 1.78; 95% CI, 1.73–1.82; blacks: 1.91; 95% CI, 1.84–1.97; Hispanics: 1.69; 95% CI, 1.61–1.77).

Hypertension Control

During the 10-year study period from 2003 to 2012, the overall hypertension control based on JNC 7 criteria increased from 33.0% in 2003 to 2004 to 44.9% in 2011 to 2012 (P_{trend}<0.001). All 3 groups experienced substantial improvement in hypertension control (whites: from 34.6% to 47.2%; P_{trend}<0.001; blacks: from 30.2% to 39.2%; P_{trend}<0.001; and Hispanics: from 22.3%– 36.9%; P_{trend} <0.01). Further analysis based on JNC 8 treatment goals and analysis restricted to treated hypertensive patients only (data not shown) showed a similar trend in hypertension control improvement (Figure).

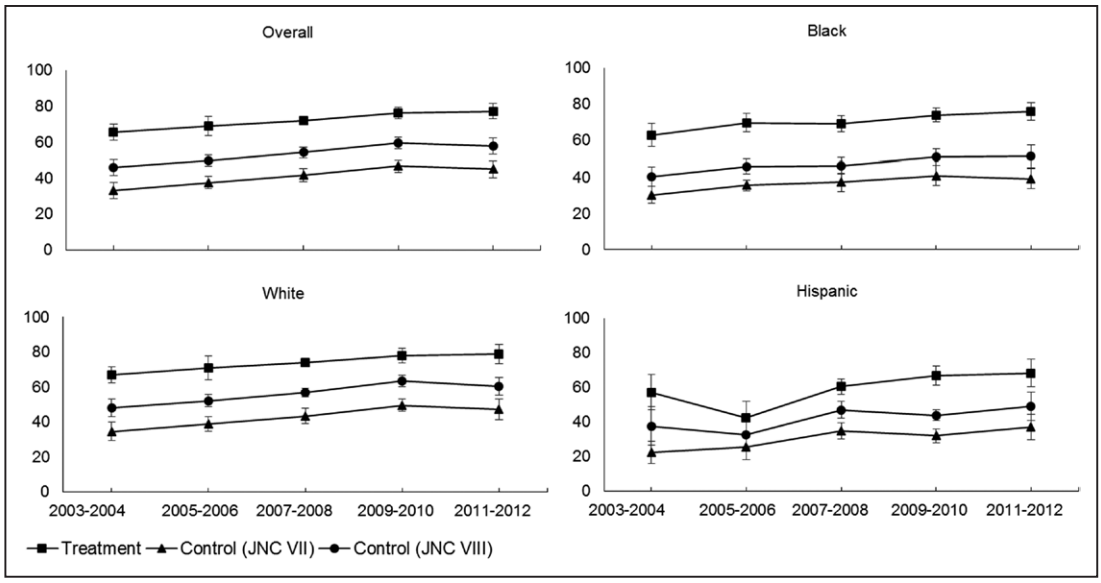

Figure. Antihypertensive treatment rates (treatment) and prevalence of hypertension control (control) by race/ethnicity for hypertensive adults. Definitions of treatment and control (Joint National Committee [JNC] 7 and JNC 8 standards) were discussed in the Methods section. Data are presented as weighted means and 95% confidence intervals. For all curves, $P<0.01$ for change over time between 2003-2004 and 2010-2012.

Racial Difference in Treatment and Control of Hypertension

Table 4 presents the estimated ORs for the differences in the proportions of antihypertensive medications and hypertension control for each racial group relative to whites. Despite being more likely to receive combination therapy, black patients were less likely to achieve hypertension control (adjusted OR, 0.73; 95% CI, 0.63–0.83). This is consistent with a notion that black patients have more aggressive forms of hypertension. As compared with whites, the prescription pattern for black patients was notable for higher odds of receiving diuretics (OR, 1.42; 95% CI, 1.26–1.61) and CCBs (OR, 2.13; 95% CI, 1.86–2.44) and lower odds of receiving β-blockers (OR, 0.66; 95% CI, 0.57–0.78) and angiotensin-converting enzyme inhibitors (OR, 0.86; 95% CI, 0.74–0.99). This pattern reflects the notion that black patients are more responsive to diuretic and CCB therapy and less responsive to agents that affect the renin–angiotensin system.

Similar to black patients, Hispanic patients were less likely to attain the treatment goals in adjusted analysis compared

Table 4. Racial/Ethnic Differences in Hypertension Treatment and Control Among Hypertensive Adults, National Health and Nutrition Examination Survey 2003 to 2012

	Hispanic vs White				Black vs White			
	Unadjusted		Adjusted		Unadjusted		Adjusted	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Diuretics	**0.55**	(0.46–0.65)	**0.65**	(0.55–0.78)	**1.29**	(1.14–1.45)	**1.42**	(1.26–1.61)
Thiazide diuretics	**0.62**	(0.50–0.75)	**0.76**	(0.62–0.94)	**1.29**	(1.14–1.46)	**1.41**	(1.24–1.60)
Calcium channel blockers	0.94	(0.74–1.20)	1.19	(0.93–1.54)	**1.80**	(1.59–2.04)	**2.13**	(1.86–2.44)
Angiotensin-converting enzyme inhibitors	0.88	(0.73–1.05)	0.94	(0.79–1.12)	0.87	(0.75–1.01)	**0.86**	(0.74–0.99)
β-Blockers	**0.64**	(0.54–0.77)	**0.78**	(0.64–0.96)	**0.64**	(0.54–0.74)	**0.66**	(0.57–0.78)
Angiotensin receptor blockers	**0.77**	(0.62–0.97)	0.96	(0.76–1.21)	0.93	(0.78–1.10)	1.01	(0.84–1.22)
Any antihypertensive drug use	**0.54**	(0.44–0.67)	**0.74**	(0.59–0.92)	**0.86**	(0.74–0.99)	0.96	(0.83–1.12)
Monotherapy	0.92	(0.81–1.06)	1.02	(0.88–1.17)	**0.74**	(0.65–0.85)	**0.72**	(0.63–0.83)
Polytherapy	**0.61**	(0.51–0.73)	**0.77**	(0.65–0.92)	1.11	(0.99–1.24)	**1.29**	(1.14–1.47)
Hypertension control (JNC 7)*	**0.68**	(0.59–0.79)	**0.73**	(0.61–0.87)	**0.76**	(0.68–0.86)	**0.73**	(0.63–0.83)
Hypertension control (JNC 8)*	**0.71**	(0.60–0.83)	**0.75**	(0.62–0.90)	**0.70**	(0.62–0.78)	**0.69**	(0.60–0.79)

Bold denotes statistically significant at P value <0.05. *Among treated patients n=6464 (white: 3435, black: 1819, and Hispanic: 1210). CI indicates confidence interval; JNC, Joint National Committee; and OR, odds ratio.

with white patients (OR, 0.73; 95% CI, 0.61–0.87), but unlike black patients, they received less intensive antihypertensive therapy (OR for combination therapy 0.77; 95% CI, 0.65–0.92). They were also least likely to receive any antihypertensive therapy.

Potential Effect Modifiers

We considered the following effect modifiers in exploring the racial differences in hypertension treatment and control: health insurance coverage, age, sex, and comorbidities. Racial disparities in hypertension treatment and control persisted among hypertensive individuals with health insurance coverage, yet they were more prominent among uninsured. For example, compared with whites, the odds of achieving hypertension control per JNC 7 criteria among uninsured Hispanics (OR, 0.58; 95% CI, 0.36–0.94) and blacks (OR, 0.59; 95% CI, 0.36–0.94) were reduced by >40% (Table I in the Data Supplement). Also, uninsured blacks were substantially less likely than whites to receive any antihypertensive treatment (OR 0.64; 95% CI, 0.45–0.91), whereas no significant differences were observed for insured patients.

Racial differences in hypertension control appeared wider among younger (<60 years of age) patients (Table II in the Data Supplement). Both younger black patients (OR, 0.58; 95% CI, 0.47–0.72) and Hispanic patients (OR, 0.62; 95% CI, 0.46–0.83) were ≈40% less likely than whites to achieve hypertension control; these differences were not statistically significant among older patients (Table II in the Data Supplement). The racial differences in antihypertensive medication utilization were evident both in male patients and female patients but were somewhat more prominent in male patients (Table III in the Data Supplement).

The differences in antihypertensive drug utilization and hypertension control persisted across the cohorts categorized by presence of comorbidities: black and Hispanic patients with and without comorbidities were less likely to achieve hypertension control compared with whites, but hispanic patients seemed to be undertreated (Table IV in the Data Supplement).

Discussion

Adequate hypertension control remains a healthcare priority in the United States because of potential large-scale impact on the cardiovascular morbidity and mortality burden. Several studies have reported recent improvements in hypertension awareness, treatment, and control.[1,15,16] Our study confirms positive trends in both antihypertensive therapy utilization and hypertension control in all racial groups during the 10-year study period. At the same time, we observed marked racial differences in these measures. Black and Hispanic patients seemed to have poorer hypertension control (as assessed by both JNC 7 and JNC 8 criteria) compared with whites, and these differences were more pronounced in younger and uninsured patients. Although black patients received more intensive antihypertensive therapy, Hispanics were undertreated. Therefore, further efforts should focus on understanding the reasons for racial inequalities in hypertension control and mounting a broader effort in addressing these reasons.

The reasons for uncontrolled hypertension are complex and can be broadly categorized as patient related and healthcare related.[17,18] Some of the important patient-related reasons include awareness and understanding of the disease,[19] adherence to prescribed antihypertensive therapies and lifestyle changes,[20,21] access to medical care including drug affordability[22,23] and biology of the disease.[24] Healthcare-related reasons include accepted standards and goals in hypertension treatment and control, physician education and familiarity with therapeutic options, antihypertensive regimen complexity, provider–patient interaction, and adequate patient follow-up.[18] The patient-specific factors are largely affected by education level as well as cultural and social environment that determines disease awareness, social support, and patient–physician interaction. Access to health care including affordable medications is also a major factor. In our study, there were significant racial disparities in patient income and health insurance status most pronounced between whites and Hispanics. Hispanic patients were less likely to get any antihypertensive therapy, received less intensive antihypertensive regimen, and were less likely to achieve hypertension control. Racial differences were exaggerated by insurance status and younger age (likely in part because of Medicare ineligibility). Broader efforts to improve access to health care are likely to address social and racial differences in hypertension treatment and control.

In the settings of controlled clinical trials, which decrease confounding and ensure uniform access to health care and pharmacotherapy, Hispanic patients seem to achieve blood pressure control rates similar to white patients. This suggests that biological factors are less likely to explain the differences in blood pressure control between Hispanics and whites observed in our study.[25,26] On the contrary, differences in the biology of the disease should be considered for black patients: it has been suggested that black patients have more aggressive forms of hypertension compared with white patients, and they are more prone to hypertension-related complications.[27–29] Also, black patients differ in responsiveness to various antihypertensive drug classes.[30,31] In our study, black patients received more intensive antihypertensive therapy compared with white patients including higher rates of combination therapy. They also were more likely to receive CCBs and diuretics in favor of angiotensin-converting enzyme inhibitor, which is consistent with the current understanding of responsiveness to antihypertensive drugs. Despite that, black patients were less likely to achieve hypertension control. Aside from innate biological reasons, lifestyle differences also contribute to the observed racial disparities. Black patients are more likely to have obesity, may have lower levels of physical activity, and may have higher caloric intake and lower potassium intake compared with white patients.[32,33] In addition, racial disparities in medication adherence have been described in previous studies. A large study based on Kaiser Permanente's Northern California Diabetes Registry found that Hispanic patients were less likely than white patients to adhere to their cardiovascular medications.[34] English language proficiency was identified as a barrier for good adherence. At the same time, other studies strongly suggested that racial discrepancies in medical adherence do not solely account for the disparities in hypertension control.[35]

While patient-specific factors contribute to the racial discrepancies in hypertension treatment and control, physician-related factors (such as failure to escalate therapy in more severe forms of hypertension) also play a role. Previous studies have suggested some racial differences in patient-centered communications and physician–patient interaction.[34,36,37] Efforts to engage patients in the medical decision making more effectively may improve patient–provider relationship and patient self-management.

Finally, the accepted thresholds for hypertension control are the subject of intense debate.[38,39] Earlier JNC 7 goals were readdressed and somewhat relaxed by JNC 8 committee, but their report has been widely criticized and not uniformly accepted.[40–42] Recently released SPRINT (Systolic Blood Pressure Intervention Trial) results with stricter hypertension control thresholds added another level of complexity.[43] The lack of universally agreed definitions of hypertension control not only affects population studies but also impacts individual physician decision making.[44]

This is a serial cross-sectional study with inherent limitations attributable to the observational study design and residual confounding. All the potential reasons for racial differences in hypertension treatment and control cannot be addressed by a single observational study, although we tried to explore some specific patient-related factors. Finally, data about patient long-term adherence to antihypertensive medications was not directly available. We used both JNC 7 and JVC 8 recommendations with understanding that neither of them is universally and inarguably accepted.

Conclusions

Despite major improvements in hypertension treatment and control during the 10-year study period, the racial differences in these measures persist. Future efforts should focus on systematically exploring and addressing these differences.

Disclosures

None.

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Racial and Ethnic Differences in Antihypertensive Medication Use and Blood Pressure Control Among US Adults With Hypertension: The National Health and Nutrition Examination Survey, 2003 to 2012

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