National Trends in Racial and Ethnic Disparities in Antihypertensive Medication Use and Blood Pressure Control Among Adults With Hypertension, 2011–2018

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ABSTRACT: Poor hypertension awareness and underuse of guideline-recommended medications are critical factors contributing to poor hypertension control. Using data from 8095 hypertensive people aged ≥18 years from the National Health and Nutrition Examination Survey (2011–2018), we examined recent trends in racial and ethnic differences in awareness and antihypertensive medication use, and their association with racial and ethnic differences in hypertension control. Between 2011 and 2018, age-adjusted hypertension awareness declined for Black, Hispanic, and White individuals, but the 3 outcomes increased or did not change for Asian individuals. Compared with White individuals, Black individuals had a similar awareness (odds ratio, 1.20 [0.96–1.45]) and overall treatment rates (1.04 [0.84–1.25]), and received more intensive antihypertensive medication if treated (1.41 [1.27–1.56]), but had a lower control rate (0.72 [0.61–0.83]). Asian and Hispanic individuals had significantly lower awareness rates (0.69 [0.52–0.85] and 0.74 [0.59–0.89]), overall treatment rates (0.72 [0.57–0.88] and 0.69 [0.55–0.82]), received less intensive medication if treated (0.60 [0.50–0.72] and 0.86 [0.75–0.96]), and had lower control rates (0.66 [0.54–0.79] and 0.69 [0.57–0.81]). The racial and ethnic differences in awareness, treatment, and control persisted over the study period and were consistent across age, sex, and income strata. Lower awareness and treatment were significantly associated with lower control in Asian and Hispanic individuals (\(P<0.01\) for all) but not in Black individuals. These findings highlight the need for interventions to improve awareness and treatment among Asian and Hispanic individuals, and more investigation into the downstream factors that may contribute to the poor hypertension control among Black individuals. (Hypertension. 2022;79:207–217. DOI: 10.1161/HYPERTENSIONAHA.121.18381.)

Supplemental Material

Key Words: cardiovascular disease ◼ guideline ◼ ethnic groups ◼ health equity ◼ hypertension

Progress in hypertension control in the United States (US) has been slow over the past decade. Despite ongoing efforts to improve hypertension control, the national blood pressure (BP) control rate (BP<140/90 mm Hg) among those with hypertension declined from 54% in 2013 to 2014 to 44% in 2017 to 2018.\(^1\) The decline in BP control is more pronounced in Black and Hispanic communities.\(^1,2\) Identifying factors impeding BP control is necessary to inform future strategies to address race and ethnicity equity in cardiovascular diseases.

Lack of awareness and underuse of guideline-recommended medications are among the critical factors contributing to poor BP control.\(^3\) Studies show that Black individuals were more aware of their hypertension and were more likely to be on treatment compared with
Novelty and Significance

What Is New?
• We quantified racial and ethnic differences in the intensity of antihypertensive treatment.
• We systematically evaluated how much progress the United States has made in eliminating disparities in awareness and treatment of hypertension and whether these differences in awareness and treatment sufficiently explain the difference in hypertension control.

What Is Relevant?
• Despite receiving more antihypertensive medications, Black people had a significantly lower hypertension control rate compared with White people.
• The poorer hypertension control among Asian and Hispanic people is associated with their lower hypertension awareness and treatment compared with White people.

Nonstandard Abbreviations and Acronyms

| Abbreviation | Description |
|--------------|-------------|
| ACC/AHA      | American College of Cardiology/American Heart Association |
| ACE          | angiotensin-converting enzyme |
| ARBs         | angiotensin II receptor blockers |
| BP           | blood pressure |
| DBP          | diastolic blood pressure |
| NHANES       | National Health and Nutrition Examination Survey |
| OR           | odds ratio |
| REGARDS      | Reasons for Geographic and Racial Differences in Stroke |
| SBP          | systolic blood pressure |
| US           | United States |

their White counterparts, while Hispanic individuals were more likely to be untreated or undertreated for hypertension. These studies, however, did not quantify racial and ethnic differences in the intensity of antihypertensive treatment (number and type of medication), which may play an important role in hypertension control. Additionally, they did not perform analysis specific to the Asian-American population, a group that is increasing in size and has high hypertension prevalence. Finally, they did not systematically evaluate how much progress the US has made in eliminating disparities in awareness and treatment of hypertension in recent years and whether these differences in awareness and treatment sufficiently explain the difference in hypertension control.

Accordingly, we leveraged data from the National Health and Nutrition Examination Survey (NHANES) to evaluate racial and ethnic disparities in hypertension awareness, intensity of treatment, and control from 2011 to 2018. Due to the influence of income on health and health care access in the US, we also evaluated how racial and ethnic differences varied by income. Finally, we assessed whether racial and ethnic differences in awareness and treatment were associated with differences in hypertension control. By better understanding the racial and ethnic differences in hypertension management in the US we sought to identify targets for public health interventions.

METHODS

Study Design and Population
All data and materials have been made publicly available at the NHANES website and can be accessed at https://wwwn.cdc.gov/nchs/nhanes/default.aspx. We included data from 23,825 adults, aged ≥18 years, included in the NHANES for the years 2011 to 2018. The NHANES is a series of cross-sectional, weighted, multistage sampled surveys that provide nationally representative estimates on the noninstitutionalized US population. Since 1999, the NHANES has been conducted in 2-year cycles. All survey participants received in-home interviews; among these individuals, a random subsample also received standardized physical examinations conducted in mobile examination centers and laboratory tests using blood and urine specimens collected during the physical examination. The average time between interview and examination was 2 weeks. For the current analysis, we used data from 4 cycles conducted from 2011 to 2012 through 2017 to 2018 to focus on recent trends. During our study period, the mean participant response rate was 65.3% for interviews and 62.3% for physical examinations. We categorized individuals into 4 mutually exclusive subgroups based on their self-reported race and ethnicity information: non-Hispanic Asian, non-Hispanic Black, Hispanic, and non-Hispanic White individuals. For simplicity, we hereafter refer to the study groups as Asian, Black, Hispanic, and White individuals. We excluded individuals who identified as Alaskan Native or American Indian or other race (n=876) due to small numbers. We also excluded pregnant women (n=179, Figure S1).
Measurements of Hypertension Awareness, Antihypertensive Medication Use, and BP
During the home interviews, participants were asked if they had ever been told by a doctor or other health professional that they had hypertension or high BP. Those who answered yes were then asked if they were currently taking prescribed medicine for hypertension. Those who answered yes were then further asked to show the interviewer the medication containers of all the products used in the past 30 days. For each medication reported, the interviewer entered the product’s complete name from the container into a computer. If no container was available, the interviewer asked the participant to verbally report the name of the medication.

During the standardized physical examinations, participants' BP levels were measured by trained clinicians using a mercury sphygmomanometer and an appropriately sized BP cuff. Three consecutive BP measurements were obtained after participants rested quietly in a seated position for 5 minutes. If a BP measurement was interrupted or incomplete, a fourth attempt was made. Mean systolic BP (SBP) and diastolic BP (DBP) were calculated for each individual per the NHANES reporting guidelines. 17

Definitions of Hypertension, Awareness, Treatment, and Control
Consistent with studies by Muntner et al1 and with the Eighth Joint National Committee (JNC 8) hypertension guidelines available during the time of this study, 18 hypertension was defined as a mean SBP level of 140 mm Hg or higher, a mean DBP level of 90 mm Hg or higher, or an affirmative response to “are you now taking prescribed medicine to lower your blood pressure?” Among those with hypertension, awareness was defined by an affirmative response to the question: “Have you ever been told by a doctor or other health care professional that you had hypertension, also called high BP?” Among those with hypertension, individuals who had the name of antihypertensive medication documented (either individuals showed the interviewer the medication containers or verbally reported the name of the medication, as described above) were categorized as taking antihypertensive medications. BP control was defined as a mean SBP level lower than 140 mm Hg and a mean DBP level lower than 90 mm Hg.

In the sensitivity analyses, we used thresholds from the 2017 American College of Cardiology/American Heart Association (ACC/AHA) BP guideline to define hypertension and BP control. Hypertension was defined as a mean SBP level of 130 mm Hg or higher, a mean DBP level of 80 mm Hg or higher, or self-reported antihypertensive medication use. BP control was defined as a mean SBP level lower than 130 mm Hg and a mean DBP level lower than 80 mm Hg.

Class and Number of Antihypertensive Medications
Antihypertensive medications were categorized into the following classes: (1) ACE (angiotensin-converting enzyme) inhibitors, (2) ARBs (angiotensin II receptor blockers), (3) calcium channel blockers, (4) β-blockers, (5) thiazide and thiazide-like diuretics, and (6) others (eg, other diuretics, direct vasodilators, renin inhibitors, α1-blockers, and other centrally acting drugs, see list of medications in Table S1). When a person reported taking only one class of antihypertensive agents, it was classified as monotherapy. When a person reported taking more than one class of antihypertensive agents, it was classified as combination therapy.

Other Sociodemographic, Behavioral, and Clinical Variables
We included other variables in the analysis, including age (in years), sex (male and female), education level (less than high school, high school diploma, some college, Bachelor’s degree, or higher), family income (based on the percent of family income relative to the federal poverty limit from the Census Bureau: high/middle income [≥200%) and low income (<200%)], insurance status (insured and uninsured), marital status (married and unmarried), employment status (working, not in the labor force, unemployed), smoking status (current, former, and never smoker), alcohol intake (never, former, light drinker, moderate drinker, and heavy drinker), physical activity (inactive, insufficient, and recommended), obesity defined as body mass index ≥30 kg/m2, diabetes defined as previous physician diagnosis or HbA1c ≥6.5% or currently on antidiabetic medication, self-reported history of hyperlipidemia, myocardial infarction or stroke, cancer, and kidney disease. Consistent with previous studies, 19,20 physical activity was categorized into inactive (no participation or fewer than 10 minutes of moderate or vigorous physical activity per week), insufficient (between 10 and 149 minutes per week of moderate physical activity or between 10 and 74 minutes per week of vigorous physical activity), and recommended (150 minutes or more of moderate physical activity or 75 minutes or more of vigorous physical activity per week) based on established physical activity guidelines. 21,22

Detailed definitions of the covariates are reported in Table S2. Information on all sociodemographic variables was available for all years and responses coded as unknown or not ascertained were analyzed under a separate category of unknown.

Statistical Analysis
All analyses used methods appropriate for structured survey data, incorporating strata and weights to produce nationally representative estimates. All person weights were pooled and divided by the number of cycles studied, following the NHANES guidance. 14

We first described sociodemographic and clinical characteristics among hypertensive adults by race and ethnicity. Among all hypertensive individuals, we estimated the age-adjusted annual rates of awareness, overall treatment, and BP control by racial and ethnic subgroups using multivariable linear regression models. A separate model was estimated for each racial and ethnic subgroup and each outcome, including standardized age and an indicator for each survey year as independent variables. The coefficients for each year then represented the age-adjusted annual rates for the designated outcome. 23 Using a similar approach, we estimated the age-adjusted annual rate for the number and class of antihypertensive medication use by racial and ethnic subgroup among treated hypertensive individuals. The trend for each outcome was estimated by a weighted linear regression, using the reciprocal of the annual rate's SE as weights.

We estimated the odds ratios (ORs) for each outcome comparing each racial and ethnic group relative to its White
counterpart using multivariable logistic regression models. We developed 2 models: a minimally adjusted model adjusting for age (categorized as 18–39, 40–59, 60–79, and 80+ years) and sex, and a fully adjusted model additionally adjusting for individuals’ sociodemographic, behavior, and clinical characteristics. These characteristics included family income, insurance status, smoking status, diabetes, kidney disease, and cardiovascular disease (myocardial infarction or stroke), all of which have been shown to be relevant in previous studies to hypertension treatment and control. We reported the OR of both minimally adjusted and fully adjusted models.

Finally, we assessed how racial and ethnic differences in BP control changed after accounting for differences in hypertension awareness and treatment using a propensity score weighting method. Specifically, we applied gradient boosting models to estimate the propensity scores for predicting race and ethnicity. The covariates used in the propensity score estimation included age, sex, education level, marital status, family income, insurance status, employment status, smoking status, physical activity, body mass index, and comorbidities (diabetes, hyperlipidemia, myocardial infarction, stroke, kidney disease, and cancer). The Kolmogorov-Smirnov statistic and the corresponding P values were used to assess covariate balance after propensity score weighting. We then developed 2 weighted regression models to estimate the racial and ethnic differences in hypertension awareness and antihypertension treatment. Survey weights were incorporated in both the process of the propensity scores estimation and the racial and ethnic difference estimation.

We considered 2-sided P<0.05 to be statistically significant. All analyses were performed using R 4.0. This study received an exemption for review from the Institutional Review Board at Yale University because the NHANES data are publically available and de-identified. The study was reported following the Strengthening the Reporting of Observational Studies in Epidemiology reporting guidelines.26

RESULTS

A total of 22,770 adults (5659 in 2011–2012, 5874 in 2013–2014, 5721 in 2015–2016, and 5516 in 2017–2018) were included in the NHANES 2011 to 2018, of whom 8095 (1935 in 2011–2012, 2009 in 2013–2014, 1996 in 2015–2016, and 2155 in 2017–2018) had hypertension and were in the final analysis (Figure S1). Among individuals with hypertension, the mean age was 60.3 (SD, 13.8) years, 51.5% (95% CI, 50.0–53.0) were women, 46% (3.7–5.5) were Asian, 15.0% (12.4–17.7) were Black, 10.9% (8.8–13.0) were Hispanic, and 69.5% (65.7–73.2) were White. Asian and White individuals were older, had a higher income level, were more likely to be physically active, and were more likely to have health insurance compared with Black and Hispanic individuals (Table). Among all 4 racial and ethnic groups with hypertension, Asian individuals had the highest prevalence of obesity and diabetes and the lowest percentages of current smokers and moderate/heavy drinkers.

Trends in Racial and Ethnic Differences in Hypertension Awareness

From 2011 to 2012 through 2017 to 2018, the age-adjusted hypertension awareness rate declined from 84.0% (79.5–86.2) to 77.5% (74.0–80.5) in the overall population. This decline was consistent for Black individuals (86.4% [83.9 to 88.9] in 2011–2012 versus 82.6% [78.5 to 86.7] in 2017–2018), Hispanic individuals (82.2% [78.1 to 86.2] in 2011–2012 versus 73.6% [68.5 to 78.7] in 2017–2018), and White individuals (82.9% [78.2 to 87.6] in 2011–2012 versus 77.4% [72.4 to 82.3] in 2017–2018). However, hypertension awareness rate did not change for Asian individuals (72.6% [67.1–78.1] in 2011–2012 versus 78.0% [70.4–85.7] in 2017–2018), although their initial awareness rates were significantly lower than other groups (Figure 1).

Compared with White individuals, Black individuals did not have a significantly different awareness rate (OR 1.2 [0.96–1.45]), whereas Asian and Hispanic individuals had significantly lower rates (0.69 [0.52–0.85] and 0.74 [0.59–0.89], respectively; Figure 4). Between 2011 to 2012 and 2017 to 2018, the racial and ethnic differences between White individuals and other groups did not change significantly (P>0.05 for all, Figure 1).

When stratified by age, sex, and income, the Asian-White and Hispanic-White differences in hypertension awareness persisted across all strata (Figure S2). The sensitivity analyses based on BP cutoffs in the 2017 ACC/AHA guideline provided consistent results (Figures S3 through S6).

Trends in Racial and Ethnic Differences in Antihypertensive Medication Use

From 2011 to 2012 through 2017 to 2018, the age-adjusted treatment rate among hypertensive individuals declined from 77.3% (73.4–81.1) to 71.4% (69.0–73.8) in the overall population. This decline was consistent for Black individuals (79.2% [75.5 to 82.9] in 2011–2012 versus 74.7% [70.5 to 79.0] in 2017–2018), Hispanic individuals (71.7% [65.0 to 78.4] in 2011–2012 versus 67.6% [62.5 to 72.7] in 2017–2018) and White individuals (78.3% [72.9 to 83.8] in 2011–2012 versus 71.5% [67.5 to 75.0] in 2017–2018). However, the treatment rate among Asian individuals improved significantly from 67.5% [61.9–73.1] in 2011–2012 to 74.5% [70.2–78.8] in 2017–2018 (Figure 1).

Among patients who received antihypertensive medication, the utilization of ACE inhibitors, thiazide, and thiazide-like diuretics declined during the study period (Figure 2). However, there was an increasing trend in utilization for ARBs, and no significant changes for β-blockers, calcium channel blockers, and other antihypertensive medications. Across all the drug classes, ACE inhibitors were the most commonly used.
## Table. General Characteristics of Hypertensive Adults by Race and Ethnicity in 2011 to 2018

| % (95% CI) | Asian (n = 803) | Black (n = 2452) | Hispanic (n = 1700) | White (n = 3140) |
|------------|----------------|-----------------|---------------------|-----------------|
| **Total**  | 4.6% [3.7–5.5] | 15% [12.4–17.7] | 10.9% [8.8–13.2] | 69.5% [65.7–73.2] |
| **Age, y** |               |                 |                     |                 |
| 18–39      | 9.9% [7.2–12.6] | 12.8% [10.8–14.8] | 13.3% [10.5–16.1] | 7% [5.7–8.3] |
| 40–59      | 36.2% [32.8–39.6] | 45.5% [42.7–48.3] | 44.2% [40.7–47.8] | 33.9% [31.9–35.8] |
| 60–79      | 46.3% [42–50.6] | 36% [33.7–38.3] | 37% [34.1–40.8] | 46% [43.8–48.2] |
| 80+        | 7.6% [5.3–10] | 5.7% [4.6–6.8] | 5% [3.8–6.2] | 13.1% [11.8–14.5] |
| **Sex**    |               |                 |                     |                 |
| Women      | 50.4% [47.4–53.3] | 56.7% [54.7–58.7] | 51.1% [48.1–54.2] | 50.6% [48.6–52.6] |
| Men        | 49.6% [46.7–52.6] | 43.3% [41.3–45.3] | 48.9% [45.8–51.9] | 49.4% [47.4–51.4] |
| **Education level** |               |                 |                     |                 |
| More than high school | 59.9% [54.8–65.1] | 49.6% [46.4–52.8] | 34.7% [30.6–38.7] | 62.6% [59.5–65.6] |
| High school | 17.1% [13.8–20.3] | 27.6% [25.9–23.9] | 21% [18.4–23.5] | 26.3% [23.8–28.7] |
| Less than high school | 23% [18.5–27.5] | 22.8% [20.1–25.6] | 44.4% [40–48.7] | 11.2% [9.1–13.2] |
| **Family income** |               |                 |                     |                 |
| High/middle income | 65.4% [58.8–72.1] | 25.6% [23.1–28.1] | 15.2% [13–17.4] | 28.8% [15.6–19.2] |
| Low income | 18.7% [15.8–21.5] | 20.4% [18.2–22.6] | 21% [18.4–23.5] | 33.4% [32.4–37.2] |
| **Insurance status** |               |                 |                     |                 |
| Uninsured | 9.5% [7.3–11.8] | 13.7% [11.6–15.8] | 20.4% [17.6–23.2] | 6.5% [5–7.9] |
| Insured    | 90.5% [88.2–92.7] | 86.3% [84.2–88.4] | 79.6% [76.8–82.4] | 93.5% [92.3–95] |
| **Marital status** |               |                 |                     |                 |
| Married/living with partner | 74.2% [70.3–78.1] | 44.1% [41.6–48.6] | 62.3% [59–65.6] | 65.1% [62.9–67.3] |
| Unmarried  | 25.8% [21.9–29.7] | 55.9% [53.4–58.4] | 37.7% [34.4–41] | 34.9% [32.7–37.1] |
| **Employment status** |               |                 |                     |                 |
| Not in labor force | 47.3% [42.4–52.2] | 47.1% [46.4–49.6] | 46.4% [42.4–50.3] | 53.3% [51–55.6] |
| Unemployed | 21% [0.8–3.4] | 4.2% [3.4–5] | 3.9% [2.8–4.9] | 21% [1.2–3] |
| With a job/working | 50.6% [45.7–55.4] | 48.7% [46.2–51.2] | 49.8% [46–53.5] | 44.6% [42.3–46.9] |
| **Smoking status** |               |                 |                     |                 |
| Current smoker | 8.9% [6.4–11.4] | 25.6% [23.1–28.1] | 15.2% [13–17.4] | 17.4% [15.6–19.2] |
| Former smoker | 18.7% [15.8–21.5] | 20.4% [18.2–22.6] | 27.6% [24.8–30.4] | 34.8% [32.4–37.2] |
| Never smoker | 72.4% [68.8–76] | 54% [51.5–56.5] | 57.2% [54.1–60.3] | 47.8% [45.4–50.2] |
| **Physical activity** |               |                 |                     |                 |
| Recommended | 31.2% [26.9–35.4] | 25.9% [23.8–28.1] | 22.1% [19.5–24.8] | 29.5% [27.4–31.7] |
| Inactive | 51.4% [47.4–55.3] | 58.9% [56.2–61.6] | 63% [59.6–66.3] | 55% [52.4–57.6] |
| Insufficient | 17.5% [14.3–20.6] | 15.2% [13.8–16.8] | 14.9% [12.5–17.3] | 15% [14.1–16.9] |
| **Alcohol intake** |               |                 |                     |                 |
| Never | 34.3% [29.7–38.9] | 14.7% [13.1–16.2] | 18.9% [16.4–21.4] | 9.6% [8–11.2] |
| Former | 18% [14.3–21.7] | 20.4% [18.2–22.6] | 21.5% [18.8–24.3] | 21.9% [20.2–23.6] |
| Light drinker | 39.1% [34.2–43.9] | 44.2% [41.6–48.8] | 41.8% [38.9–44.7] | 46.5% [43.8–49.3] |
| Moderate drinker | 6.2% [3.6–8.7] | 9.8% [8.6–10.9] | 12.8% [10.9–14.7] | 13.3% [11.8–14.9] |
| Heavy drinker | 2.4% [1.3–3.7] | 5.6% [4.4–6.8] | 4.9% [3.3–6.5] | 8.6% [7.2–10] |
| **BMI, kg/m²** |               |                 |                     |                 |
| <25 | 40.5% [36.8–44.2] | 427 [16.8–19.8] | 180 [79–112] | 175% [15.8–19.1] |
| 25–<30 | 19.1% [16.6–21.7] | 129 [58.1–60.3] | 572 [54–60.4] | 50.4% [47.9–52.9] |
| ≥30 | 40.4% [36.3–44.4] | 26 [23.6–27] | 48 [30.5–36] | 32 [30.1–34.2] |
| **Comorbidities** |               |                 |                     |                 |
| Diabetes | 34.2% [30.3–38.2] | 31.2% [29–33.3] | 50.1% [37.9–37.1] | 24.4% [22.8–26] |
| Hyperlipidemia | 49.2% [45.4–53.0] | 48.1% [45.7–50.5] | 50.1% [47.2–53.1] | 56.3% [53.8–58.9] |

(Continued)
antihypertensive medication class accounting for >40% of all prescriptions.

Compared with White individuals, Black individuals did not have a significantly different overall treatment rate (OR 1.04 [0.84–1.24]). However, when treated, they were significantly more likely to receive combination therapy (OR 1.45 [1.22–1.68]) and single-pill combination drugs (OR 1.36 [1.10–1.61]; Figures 2 through 4). The utilization pattern for Black individuals who received treatment compared with White individuals was notable for significantly higher odds of receiving thiazide and thiazide-like diuretics (OR 1.29 [1.09–1.50]) and calcium channel blockers (OR 2.56 [2.24–2.89]) and lower odds of receiving β-blockers (OR 0.86 [0.74–0.98]) and ACE inhibitors (OR 0.74 [0.62–0.87]). Unlike Black individuals, Asian and Hispanic individuals were significantly less likely to receive any antihypertensive therapy compared with White individuals (OR 0.72 [0.57–0.88] and 0.68 [0.55–0.81], respectively). Among those treated, Asian and Hispanic individuals received significantly fewer medications (OR for combination therapy, 0.60 [0.50–0.72] and 0.86 [0.75–0.96], respectively). Across all racial and ethnic subgroups, Asian individuals had the highest odds of receiving ARBs but the lowest odds of receiving ACE inhibitor and thiazide and thiazide-like diuretics. Between 2011 to 2012 and 2017 to 2018, the Asian-White differences in overall treatment rate significantly decreased due to the improvement in treatment rate among Asian individuals (P=0.05). The Hispanic-White differences in overall treatment rate also significantly decreased (P=0.03), but it was due to a larger decrease in treatment rate among Hispanic individuals. The treatment differences between Black and White individuals did not significantly change in this period.

When stratified by age, sex, and income, the racial and ethnic differences in hypertension treatment persisted across all strata. Asian and Hispanic individuals were less likely to receive any antihypertensive therapy and combination therapy compared with White individuals, whereas Black individuals had a similar overall treatment rate but were more likely to receive combination therapy (Figure S2). The sensitivity analyses based on BP cutoffs in the 2017 ACC/AHA guideline provided consistent results (Figures S3 through S6).

### Trends in Racial and Ethnic Differences in BP Control

From 2011 to 2012 through 2017 to 2018, the age-adjusted BP control rate among hypertensive individuals declined from 51.9% (47.1–56.7) to 43.1% (39.7–46.5) in

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**Figure 1.** Racial and ethnic differences in awareness, treatment, and blood pressure control rate among all hypertensive adults, 2011–2018.
the overall population. This decline was consistent in Black, Hispanic, and White individuals and was most obvious from 2013 to 2014. Specifically, the control rate declined from 49.8% (44.6–55.1) in 2013 to 2014 to 38.8% (33.8–43.8) in 2017 to 2018 among Black individuals, from 49.1% (43.6–54.7) to 37.8% (32.0–43.6) among Hispanic individuals, and from 57.5% (50.2–64.9) to 45.5% (40.6–50.4) among White individuals. If the control rates had not declined from 2013 to 2014, it was estimated that 986,111 more Black individuals, 1,084,653 more Hispanic individuals, and 6,240,265 more White individuals in the US would have had their BP controlled in 2017 to 2018. Unlike other groups, the control rate among Asian individuals improved from 2015 to 2016 (38.3% [29.6–47.0] in 2015–2016 versus 44.1% [38.9–49.3] in 2017–2018; Figure 1).

Despite being similarly aware of hypertension and receiving more intensive therapy, Black individuals were less likely to achieve BP control (OR 0.72 [0.61–0.83])

Figure 2. Racial and ethnic differences in type of antihypertensive medications among treated hypertensive adults, 2011–2018. ACE indicates angiotensin-converting enzyme; ARB, angiotensin II receptor blockers; and CCB, calcium channel blocker.

Figure 3. Racial and ethnic differences in number of antihypertensive medications among treated hypertensive adults, 2011–2018.
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compared with White individuals (Figure 4). The difference in BP control rates between White and Black individuals increased from 4.0 percentage points in 2011 to 2012 (53.8% versus 49.8%) to 6.7 percentage points in 2017 to 2018 (45.5% versus 38.8%), although the change was not statistically significant. Asian and Hispanic individuals were also less likely to attain the BP control goals compared with White individuals (0.66 [0.54–0.79] and 0.69 [0.56–0.81]). The difference in BP control rates between White and Asian individuals decreased from 8.1 percentage points in 2011 to 2012 (53.8% versus 45.7%) to 1.4 percentage points in 2017 to 2018 (45.5% versus 44.1%). But the difference in BP control rates between White and Hispanic individuals did not change significantly, with a difference of 7.2 (53.8% versus 46.6%) percentage points in 2011 to 2012 and 7.7 percentage points (45.5% versus 37.8%) in 2017 to 2018.

When stratified by age, sex, and income, Asian, Black, and Hispanic individuals were less likely to achieve BP control compared with White individuals across all strata, and these racial and ethnic differences were more prominent in younger (<60 years of age), female, and low-income individuals (Figure S1). The sensitivity analyses based on BP cutoffs in the 2017 ACC/AHA guideline provided lower control rates and persistent racial and ethnic disparities (Figures S3 through S6).

**Figure 4. Odds ratios of racial and ethnic differences in hypertension awareness, treatment and control rates.**

In model 1, we adjusted for participants' age (categorized as 18–39, 40–59, 60–79, and 80+ years) and sex. In model 2, we additionally adjusted for participants' family income, education, insurance status, smoking status, diabetes, history of kidney disease, and cardiovascular disease (myocardial infarction [MI] or stroke). ACE indicates angiotensin-converting enzyme; ARB, angiotensin II receptor blockers.

**Racial and Ethnic Differences in BP Control and Association With Awareness and Treatment**

Figure S7 showed that balance was achieved after propensity score weighting. The weighted Asian-White and Hispanic-White differences in BP control were −5.2% (−12.5 to 2.1) and −8.5% (−15.0 to −2.0), respectively. They attenuated to −4.0% (−9.7 to 1.67) and 3.5% (−8.5 to 1.5) after additionally adjusting for hypertension awareness and treatment (P < 0.01 for both). However, the weighted Black-White difference in BP control rate was −6.6% (−11.2 to −1.9), and it was significantly magnified after additionally adjusting for hypertension awareness and treatment (−9.3 [−13.1 to −5.5]).
DISCUSSION

In this nationally representative serial cross-sectional study, hypertension awareness, treatment, and control rates in the US were found to have plateaued or worsened from 2011 to 2018. Asian, Black, and Hispanic individuals had poorer hypertension control than did White individuals. Compared with White individuals, Black individuals had similar rates of awareness and treatment, and among those treated, they received a greater number of medications. Asian and Hispanic individuals had lower rates of awareness and treatment than White individuals, and among those treated, they received fewer medications. Racial and ethnic differences in awareness and treatment may partially explain the difference in hypertension control for Asian and Hispanic individuals but not for Black individuals. These findings highlight the need for interventions to improve awareness and treatment among Asian and Hispanic individuals, and more investigation into the downstream factors that may contribute to the poor hypertension control among Black individuals.

Our study expands what is known about hypertension awareness and treatment in several ways. We showed that the previously described stagnant or decreasing hypertension awareness, treatment, and control occurred in each of the racial and ethnic groups analyzed (except for Asians), with persistent racial and ethnic disparities. Such a lack of progress in hypertension control overall as well as reducing racial and ethnic disparities in hypertension management occurred during a period in which the total and per capita health care costs increased substantially. Studies have reported similar race and ethnic disparities, but we analyzed yearly trends and racial and ethnic disparities in the intensity of antihypertensive treatment. Black individuals had higher rates of treatment and received more medications than White individuals, whereas Asian and Hispanic individuals had lower rates of treatment and among those treated, they received fewer medications. These racial and ethnic disparities did not significantly change from 2011 to 2018.

To the best of our knowledge, this is the first study to analyze recent national trends in hypertension awareness, treatment, and control among the Asian-American population and to compare these outcomes with those of other racial and ethnic subgroups. Previous studies on the Asian population covered a shorter time period and did not assess disparities with other racial and ethnic groups. During the study period, we found Asian individuals had significantly lower hypertension awareness, treatment, and control rates compared with White individuals, but all 3 metrics had improvements from 2015 to 2016. Notably, the Asian subgroup was the only racial and ethnic subgroup that had improvement; all other subgroups had worsening hypertension awareness, treatment, and control from 2015 to 2016. This finding signals the importance of investigating why the Asian population had improvement in hypertension management despite the slow progress nationally and identifying factors that could be applicable to other racial and ethnic groups.

This study has important public health implications. First, despite receiving more antihypertensive medications, Black people had a significantly lower BP control rate compared with White people. There may be other responsible factors, including behavior, environmental, social, and structural distinctions that disproportionately impair BP control among Black people. For example, Black people are more likely to have unhealthy dietary habits, sedentary lifestyle, poor sleep quality, and stress compared with White people. They were also more likely to lack access to parks and healthy foods, and to suffer from neighborhood noise. Additionally, as literature shows, systemic racism is a fundamental cause of health inequalities, impacting quality of care and the resources and opportunities available to support a healthy life. Therefore, efforts to increase hypertension awareness and treatment rates alone are insufficient to improve BP control among Black people. Public health strategies to improve hypertension control should be tailored to the needs of individuals and communities—this may include delivering care through trusted community resources, expanding the focus of BP interventions to include stress reduction and improved sleep quality, and working with policy officials to expand access to care and health resources. In addition, the poorer hypertension control among Asian and Hispanic individuals is associated with their lower hypertension awareness and treatment compared with White individuals. Strategies to increase awareness and guideline-recommended antihypertensive medications are critical to improving hypertension control among Asian and Hispanic communities. Such strategies may include patient and provider education, home BP monitoring, behavioral counseling, and increase access to preventive care. These strategies can address misconceptions about hypertension, improve adherence to drug therapy, encourage lifestyle modifications, and improve access to care.

There are some differences between our findings and the results from other studies that have measured racial and ethnic differences in hypertension awareness, treatment, and control. First, the overall and race-specific hypertension awareness, treatment, and control rates in our study were lower than the estimates by Howard et al, who analyzed data from the REGARDS study (Reasons for Geographic and Racial Differences in Stroke). This could be due to the different study population included in the analysis. The REGARDS study included participants >45 years of age from a national cohort, while we included all participants ≥18 years of age from the NHANES national representative sample. Second, compared with Gu et al who also analyzed the NHANES datasets from 2003 to 2012, our study reports higher
medication use and BP control rates among Black, Hispanic, and White individuals because of the inclusion of more recent data. These findings are consistent with the positive trend seen in hypertension treatment and control from 2003 to 2012, following which treatment and control rates have either stagnated or decreased. Similar to their results, we report that Black individuals are still more likely to receive combination therapy but less likely to have BP control than White individuals, while Hispanic individuals continue to be under-treated and have lesser odds of having BP control than White individuals.

Our study has several limitations. First, the hypertension control targets changed over the study period. We used both the JNC 8 and 2017 ACC/AHA recommendations while understanding that neither of them is universally accepted. Second, the response rates in the NHANES have declined over time. However, we used sampling weights developed by the National Center for Health Statistics to minimize nonresponse bias in our analyses. Third, the data on medication use was self-reported, therefore, they may be subject to recall bias. Finally, this is a cross-sectional study with limitations attributable to the observational study design and residual confounding. The potential reasons for racial differences in hypertension control cannot be addressed by a single observational study, although we tried to assess the association between hypertension awareness, treatment, and control.

In conclusion, hypertension awareness, treatment, and control declined from 2011 to 2018 among adults in the US and this decline was consistent for Black, Hispanic, and White individuals. BP control worsened for Asian, Black, and Hispanic individuals compared with White individuals over the entire study period; this was explained partly by differences in awareness and treatment for Asian and Hispanic individuals but not for Black individuals.

**PERSPECTIVES**

Despite receiving more intensive antihypertensive medications, Black people had a significantly lower hypertension control rate compared with White people. There may be other responsible factors, including behavior, environmental, social, and structural distinctions, that disproportionately impair hypertension control among Black people. Therefore, efforts to increase hypertension awareness and treatment rates alone are insufficient to improve hypertension control among Black people. Public health strategies to improve hypertension control should be tailored to the needs of individuals and communities—this may include delivering care through trusted community resources, expanding the focus of hypertension interventions to include stress reduction and improved sleep quality, and working with policy officials to expand access to care and health resources. The poorer hypertension control among Asian and Hispanic people is associated with their lower hypertension awareness and treatment compared with White people. Strategies to increase awareness and guideline-recommended antihypertensive medications are critical to improving hypertension control among Asian and Hispanic communities. Such strategies may include patient and provider education, home BP monitoring, behavioral counseling, and increased access to preventive care to help address misconceptions about hypertension, nonadherence to drug therapy, and barriers to access to care.

**REFERENCES**

1. Muntner P, Hardy ST, Fine LJ, Jaeger BC, Wozniak G, Levitan EB, Colantonio LD. Trends in blood pressure control among US adults with hypertension, 1999-2000 to 2017-2018. JAMA 2020;324:1190–1200. doi: 10.1001/jama.2020.14545
2. Al Kibria GM. Racial/ethnic disparities in prevalence, treatment, and control of hypertension among US adults following application of the 2017 American College of Cardiology/American Heart Association guideline. Prev Med Rep 2019;14:100850. doi: 10.1016/j.pmedr.2019.100850
3. Carey RM, Muntner P, Bosworth HB, Whelton PK. Prevention and control of hypertension: JACC health promotion series. J Am Coll Cardiol 2018;72:1278–1293. doi: 10.1016/j.jacc.2018.07.008
4. Howard G, Prineas R, Moy C, Cushman M, Kellum M, Temple E, Graham A, Howard V. Racial and geographic differences in awareness, treatment, and control of hypertension: the REasons for Geographic And...
