

# Trends in Blood Pressure Control Among US Adults With Hypertension, 1999-2000 to 2017-2018

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**IMPORTANCE** Controlling blood pressure (BP) reduces the risk for cardiovascular disease.

**OBJECTIVE** To determine whether BP control among US adults with hypertension changed from 1999-2000 through 2017-2018.

**DESIGN, SETTING, AND PARTICIPANTS** Serial cross-sectional analysis of National Health and Nutrition Examination Survey data, weighted to be representative of US adults, between 1999-2000 and 2017-2018 (10 cycles), including 18 262 US adults aged 18 years or older with hypertension defined as systolic BP level of 140 mm Hg or higher, diastolic BP level of 90 mm Hg or higher, or use of antihypertensive medication. The date of final data collection was 2018.

**EXPOSURES** Calendar year.

**MAIN OUTCOMES AND MEASURES** Mean BP was computed using 3 measurements. The primary outcome of BP control was defined as systolic BP level lower than 140 mm Hg and diastolic BP level lower than 90 mm Hg.

**RESULTS** Among the 51 761 participants included in this analysis, the mean (SD) age was 48 (19) years and 25 939 (50.1%) were women; 43.2% were non-Hispanic White adults; 21.6%, non-Hispanic Black adults; 5.3%, non-Hispanic Asian adults; and 26.1%, Hispanic adults. Among the 18 262 adults with hypertension, the age-adjusted estimated proportion with controlled BP increased from 31.8% (95% CI, 26.9%-36.7%) in 1999-2000 to 48.5% (95% CI, 45.5%-51.5%) in 2007-2008 ( $P < .001$  for trend), remained stable and was 53.8% (95% CI, 48.7%-59.0%) in 2013-2014 ( $P = .14$  for trend), and then declined to 43.7% (95% CI, 40.2%-47.2%) in 2017-2018 ( $P = .003$  for trend). Compared with adults who were aged 18 years to 44 years, it was estimated that controlled BP was more likely among those aged 45 years to 64 years (49.7% vs 36.7%; multivariable-adjusted prevalence ratio, 1.18 [95% CI, 1.02-1.37]) and less likely among those aged 75 years or older (37.3% vs 36.7%; multivariable-adjusted prevalence ratio, 0.81 [95% CI, 0.65-0.97]). It was estimated that controlled BP was less likely among non-Hispanic Black adults vs non-Hispanic White adults (41.5% vs 48.2%, respectively; multivariable-adjusted prevalence ratio, 0.88; 95% CI, 0.81-0.96). Controlled BP was more likely among those with private insurance (48.2%), Medicare (53.4%), or government health insurance other than Medicare or Medicaid (43.2%) vs among those without health insurance (24.2%) (multivariable-adjusted prevalence ratio, 1.40 [95% CI, 1.08-1.80], 1.47 [95% CI, 1.15-1.89], and 1.36 [95% CI, 1.04-1.76], respectively). Controlled BP was more likely among those with vs those without a usual health care facility (48.4% vs 26.5%, respectively; multivariable-adjusted prevalence ratio, 1.48 [95% CI, 1.13-1.94]) and among those who had vs those who had not had a health care visit in the past year (49.1% vs 8.0%; multivariable-adjusted prevalence ratio, 5.23 [95% CI, 2.88-9.49]).

**CONCLUSIONS AND RELEVANCE** In a series of cross-sectional surveys weighted to be representative of the adult US population, the prevalence of controlled BP increased between 1999-2000 and 2007-2008, did not significantly change from 2007-2008 through 2013-2014, and then decreased after 2013-2014.

JAMA. 2020;324(12):1190-1200. doi:10.1001/jama.2020.14545  
Published online September 9, 2020.

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**H**ypertension is a major risk factor for cardiovascular disease and more cardiovascular disease events in the US have been attributed to hypertension than any other modifiable risk factor.<sup>1-3</sup> Antihypertensive medication use and controlling blood pressure (BP) levels reduce the risk for cardiovascular disease and all-cause mortality among adults with hypertension.<sup>4,5</sup> Previous studies have reported that the proportion of US adults with hypertension who were aware they had it and were taking antihypertensive medication increased between 1988-1994 and 2009-2010.<sup>6,7</sup> The proportion of US adults with controlled BP (defined as systolic BP [SBP] <140 mm Hg and diastolic BP [DBP] <90 mm Hg) also increased during this period. However, the National Center for Health Statistics reported that the proportion of US adults with hypertension who had controlled BP did not increase between 2009-2010 and 2015-2016 and may have decreased between 2013-2014 and 2015-2016.<sup>8</sup> In addition, racial/ethnic differences in BP control have been reported among US adults, with a lower proportion of non-Hispanic Black adults having controlled BP compared with non-Hispanic White adults.<sup>9,10</sup>

The purpose of the current analysis was to determine whether the increase in BP control that occurred among US adults from 1999-2000 through 2009-2010 continued through 2017-2018. A secondary objective was to identify subgroups of individuals whose BP management could be improved. Therefore, demographic, socioeconomic, and health care-related factors associated with BP control among US adults in 2015-2018 were determined. Changes in hypertension awareness and use of antihypertensive medication among US adults from 1999-2000 through 2017-2018 were examined as secondary outcomes. To accomplish these goals, data from 10 cycles of the US National Health and Nutrition Examination Survey (NHANES) were analyzed.

## Methods

NHANES was designed to assess the health and nutritional status of the US population and is conducted by the National Center for Health Statistics within the US Centers for Disease Control and Prevention.<sup>11</sup> Since 1999-2000, the survey has been conducted in 2-year cycles. For the current analysis, 10 cycles conducted from 1999-2000 through 2017-2018 were used. Each cycle is independent with different participants recruited and with protocols approved by the institutional review board of the National Center for Health Statistics, Centers for Disease Control and Prevention. Written informed consent was obtained from each participant. The institutional review board of the University of Alabama at Birmingham considered the analysis of anonymous data to be exempt research.

### Data Collection

Data were collected during an in-home interview and a study visit conducted at a mobile examination center. Of relevance to the current analysis, age, sex, race/ethnicity, education, household income, type of health insurance, and

## Key Points

**Question** Has blood pressure control changed among adults with hypertension over the past 20 years in the US?

**Findings** In this serial cross-sectional study that included 18 262 US adults aged 18 years or older with hypertension, with data weighted to be representative of the US population, the age-adjusted estimated proportion with controlled blood pressure increased from 31.8% in 1999-2000 to 48.5% in 2007-2008, remained stable through 2013-2014 (53.8%), and then declined to 43.7% in 2017-2018.

**Meaning** The prevalence of controlled blood pressure in the US may have decreased from 2013-2014 to 2017-2018.

health care use were assessed using standardized questionnaires. Race/ethnicity was included in the current analysis because BP control has been reported to be lower for non-Hispanic Black adults compared with non-Hispanic White adults.<sup>9,10</sup> Race/ethnicity was self-reported by study participants using questions with fixed category responses. Health care use included questions about having a usual facility to receive health care and whether the participant had a health care visit in the previous year.

### Measurement of BP and Antihypertensive Medication Use

An identical protocol was used to measure SBP and DBP levels between 1999 and 2018. Blood pressure levels were measured by trained clinicians using a mercury sphygmomanometer and an appropriately sized BP cuff. Readings were obtained after 5 minutes of seated rest. Three BP measurements were obtained at 30-second intervals. The mean of all available measurements was used to define the SBP and DBP levels. Quality control included quarterly recertification of clinicians with retraining if needed and annual retraining of all clinicians. Hypertension was defined as SBP level of 140 mm Hg or higher, DBP level of 90 mm Hg or higher, or self-reported use of antihypertensive medication.<sup>12</sup>

### Outcomes

The primary outcome of BP control was defined as SBP level lower than 140 mm Hg and DBP level lower than 90 mm Hg. The secondary outcomes were hypertension awareness and use of antihypertensive medication. 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 participants who were aware they had hypertension, those who answered yes to the question "Are you now taking prescribed medication for high BP?" were categorized as taking antihypertensive medication.

### Statistical Analysis

The age-adjusted prevalence of hypertension and the demographic, socioeconomic, and health care-related characteristics of adults with hypertension were calculated separately using data from each of the ten 2-year cycles from 1999-2000 through 2017-2018. For each 2-year cycle, the age-adjusted mean

SBP and DBP levels and the age-adjusted distribution of BP among adults with hypertension were calculated (SBP <120 mm Hg and DBP of 80 mm Hg; SBP of 120-129 mm Hg and DBP <80 mm Hg; SBP of 130-139 mm Hg and DBP of 80-89 mm Hg; SBP of 140-159 mm Hg and DBP of 90-99 mm Hg; and SBP  $\geq$ 160 mm Hg and DBP of 100 mm Hg).

The age-adjusted proportion of adults with controlled BP was calculated for all adults with hypertension and for adults with hypertension who were taking antihypertensive medication. These proportions were estimated for the overall population and within a priori-selected categories of age group (18-44 years, 45-64 years, 65-74 years, and  $\geq$ 75 years), sex, race/ethnicity, education, household income, type of health insurance (none, private, Medicare, Medicaid, and other government health insurance), and health care use (had a usual care facility and a health care visit in the past year). Age adjustment was performed using direct standardization with the standard being all adults with hypertension across the entire period (1999-2018); the age categories used for standardization were 18 to 44 years (15.5%), 45 to 64 years (45.4%), 65 to 74 years (21.5%), and 75 years or older (17.7%).

Joinpoint statistical software (Joinpoint Regression Program version 4.8.0.1 [April 2020], Statistical Methodology and Applications Branch, Surveillance Research Program, National Cancer Institute) was used to identify changes in trends for the age-adjusted estimated proportion of the population with controlled BP among all adults with hypertension and separately among those taking antihypertensive medication.<sup>13</sup> Logistic regression was used to assess the statistical significance of trends.

Using data pooled from the 2015-2016 and 2017-2018 cycles, factors associated with BP control were determined among all adults with hypertension and separately among adults with hypertension taking antihypertensive medication. The 2015-2016 and 2017-2018 data were pooled to provide more stable estimates. Poisson regression with robust variance estimates was used to estimate the prevalence ratios associated with a priori-selected variables of age group, sex, race/ethnicity, education, household income, type of health insurance, having a usual facility to receive health care, and having a health care visit in past year. Prevalence ratios were estimated using models that included age group, sex, and race/ethnicity and each other variable one at a time, and using models that included all of the variables simultaneously.

Missing data were multiply imputed using a multilevel approach designed for survey data.<sup>14,15</sup> A Gibbs sampling procedure was used to generate 10 imputed data sets after a burn-in of 500 iterations and 100 updates to ensure stochastic independence between imputed data sets. Factors associated with BP control also were assessed in regression models using a complete case approach.

In a sensitivity analysis, the age-adjusted proportion of adults with hypertension and with controlled BP was calculated using thresholds in the 2017 American College of Cardiology/American Heart Association (ACC/AHA) BP guideline to define hypertension and BP control.<sup>16</sup> Hypertension was defined as SBP level of 130 mm Hg or higher, DBP level of

80 mm Hg or higher, or antihypertensive medication use. Blood pressure control was defined as SBP level lower than 130 mm Hg and DBP level lower than 80 mm Hg, except for low-risk adults aged 65 years or older for whom BP control was defined as SBP level lower than 130 mm Hg.<sup>10</sup>

For the secondary outcomes, the age-adjusted proportion of adults with hypertension that was aware of their condition and that was taking antihypertensive medication among those who were aware was calculated for each 2-year cycle. Trends for the age-adjusted estimated proportion of adults with hypertension awareness and who were taking antihypertensive medication were determined using Joinpoint software and logistic regression as described above for the primary outcome. Factors associated with hypertension awareness and antihypertensive medication use were determined using Poisson regression models with robust variance estimates as described above.

Sampling weights, estimated as the inverse probability of being selected for the survey, were used in all calculations to obtain US nationally representative estimates. The data analyses were conducted using Stata version 14 (StataCorp) and R version 3.6.3 (R Foundation for Statistical Computing). Statistical significance was defined by a 2-sided *P* value <.05. Because of the potential for type I error due to multiple comparisons, the findings for the analyses of the secondary end points should be interpreted as exploratory.

## Results

The analyses were restricted to adults aged 18 years or older who completed a study interview and examination (*n* = 56 367). Participants who were pregnant (*n* = 1588) and those who did not have at least 1 SBP and DBP measurement (*n* = 2772) or were missing information on antihypertensive medication use (*n* = 246) were excluded. After these exclusions, a total of 51 761 participants, including 18 262 with hypertension, were included in the analysis (eFigure 1 in the [Supplement](#)). The response rate across cycles declined from 76% in 1999-2000 to 49% in 2017-2018.

Of the 51 761 participants included in this analysis, the mean (SD) age was 48 years (19 years) and 25 939 (50.1%) were women; 43.2% were non-Hispanic White adults; 21.6%, non-Hispanic Black adults; 5.3%, non-Hispanic Asian adults; and 26.1%, Hispanic adults. The estimated age-adjusted prevalence of hypertension (weighted to the US population) was 30.0% in 1999-2000 and 32.0% in 2017-2018 (eFigure 2 in the [Supplement](#)). Characteristics of adults with hypertension from 1999-2000 through 2017-2018 appear in [Table 1](#). No participants were missing data on age, race/ethnicity, or sex. There were missing data for household income (9.6% of participants), education (1.8%), type of health insurance (1.2%), having a usual facility to receive health care (1.2%), and having a health care visit in the past year (0.1%). The age-adjusted estimated mean SBP level was 144 mm Hg and the mean DBP level was 77 mm Hg in 1999-2000 and 139 mm Hg and 77 mm Hg, respectively, in 2017-2018 ([Table 2](#)).

Table 1. Characteristics of Adults With Hypertension From 1999-2000 to 2017-2018

Characteristic	Adults with hypertension <sup>a</sup>									
	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	2015-2016	2017-2018
No. of adults	1518	1605	1623	1495	2090	2099	1837	1933	1968	2094
Age group, y										
18-44	20.2	16.7	16.3	16.0	16.6	13.6	14.9	15.0	14.2	13.1
45-64	40.3	44.9	46.2	45.8	46.1	45.6	47.4	45.2	44.1	46.8
65-74	22.1	20.2	20.8	21.1	18.7	22.4	19.6	23.0	23.9	22.0
≥75	17.4	18.3	16.7	17.1	18.7	18.4	18.1	16.7	17.8	18.1
Sex										
Female	52.6	55.2	51.0	51.5	52.4	51.3	51.8	50.8	51.6	49.5
Male	47.4	44.8	49.0	48.5	47.6	48.7	48.2	49.2	48.4	50.5
Race/ethnicity										
Non-Hispanic White	72.1	74.2	74.8	75.2	73.2	71.3	69.5	69.5	66.5	64.2
Non-Hispanic Black	12.5	14.0	13.3	14.1	14.2	14.4	15.2	14.4	14.2	14.3
Non-Hispanic Asian <sup>b</sup>							3.7	4.2	4.3	5.4
Hispanic	11.3	8.2	7.3	6.1	8.8	8.9	9.3	9.8	11.1	11.5
Education										
<High school	30.6	24.8	22.8	21.2	24.3	22.6	20.8	17.6	16.7	12.4
High school graduate and some college	53.4	53.3	59.6	56.4	54.7	55.8	52.7	58.3	57.7	62.3
College graduate	16.0	21.9	17.6	22.5	21.1	21.6	26.5	24.1	25.6	25.3
Household income, \$										
<20 000	29.5	24.6	21.2	19.1	20.1	18.3	19.3	17.8	18.4	14.7
20 000-44 999	33.5	31.4	33.5	31.1	30.6	30.8	28.4	29.5	25.0	26.3
45 000-74 999	18.7	22.3	26.0	25.4	20.2	22.8	20.1	21.0	23.4	18.9
≥75 000	18.3	21.7	19.3	24.4	29.1	28.2	32.2	31.7	33.1	40.0
Type of health insurance										
Private	66.2	64.5	60.3	63.6	63.6	63.9	59.1	60.3	58.5	57.5
Medicare	19.1	21.2	23.2	17.6	15.9	16.6	17.7	18.5	21.2	19.4
None	9.9	8.3	11.1	10.1	12.1	11.6	10.7	10.5	7.9	8.9
Medicaid	3.0	3.8	2.1	2.6	3.7	3.4	5.0	5.3	5.3	8.1
Other government	1.9	2.2	3.4	6.2	4.7	4.5	7.6	5.4	7.1	6.2
Had usual health care facility	92.8	94.2	93.6	92.7	93.5	94.2	93.5	94.1	92.2	90.8
Had health care visit in past year	91.2	89.0	93.9	91.8	92.7	94.0	91.3	93.8	92.0	93.2

<sup>a</sup> Data were self-reported and expressed as percentages unless otherwise indicated.<sup>b</sup> Characteristic description first used in 2011-2012.

**Table 2. Age-Adjusted Mean Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) and Distribution of BP Among Adults With Hypertension From 1999-2000 to 2017-2018<sup>a</sup>**

	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	2015-2016	2017-2018
No. of adults	1518	1605	1623	1495	2090	2099	1837	1933	1968	2094
Mean level (95% CI), mm Hg										
SBP	144 (142-146)	143 (141-144)	141 (139-142)	139 (137-140)	136 (135-137)	134 (133-136)	136 (134-138)	135 (133-137)	138 (136-139)	139 (137-140)
DBP	78 (76-79)	77 (76-78)	75 (74-77)	75 (74-76)	74 (73-75)	73 (71-74)	74 (73-76)	73 (72-74)	73 (72-74)	77 (76-79)
SBP/DBP category, % (95% CI) <sup>b</sup>										
<120/<80 mm Hg	9.2 (7.4-10.9)	12.5 (10.0-15.0)	13.1 (11.2-14.9)	14.9 (12.8-17.0)	18.2 (15.8-20.6)	21.4 (19.4-23.4)	18.4 (14.7-22.1)	20.2 (16.8-23.6)	17.2 (13.5-20.9)	15.8 (12.9-18.6)
120-129/<80 mm Hg	6.5 (5.3-7.6)	7.1 (5.7-8.5)	9.6 (8.0-11.3)	10.7 (8.5-12.8)	12.3 (10.0-14.5)	12.5 (10.9-14.0)	15.8 (13.8-17.8)	14.6 (12.5-16.7)	14.3 (11.6-16.9)	11.3 (9.4-13.2)
130-139/80-89 mm Hg	16.2 (12.4-19.9)	15.3 (13.0-17.5)	17.1 (14.6-19.7)	18.3 (14.8-21.8)	18.0 (15.5-20.6)	19.2 (17.3-21.0)	17.7 (16.4-18.9)	19.1 (15.3-22.8)	16.9 (14.0-19.7)	16.7 (15.0-18.3)
140-159/90-99 mm Hg	48.2 (44.3-52.1)	44.8 (41.8-47.7)	42.4 (38.2-46.6)	41.5 (38.8-44.2)	39.3 (36.3-42.4)	36.7 (33.3-40.0)	35.7 (31.7-39.7)	35.1 (31.0-39.2)	40.1 (36.8-43.4)	41.7 (38.6-44.8)
≥160/100 mm Hg	20.0 (16.5-23.6)	20.4 (17.2-23.5)	17.8 (15.4-20.2)	14.6 (12.4-16.9)	12.2 (10.7-13.7)	10.3 (8.7-12.0)	12.4 (9.6-15.2)	11.1 (9.3-12.9)	11.5 (9.9-13.2)	14.6 (11.7-17.5)

<sup>a</sup> Age adjustment was performed using direct standardization with the standard being adults with hypertension across the entire period from 1999-2018; the age categories used for standardization were 18 to 44 years (15.5%), 45 to 64 years (45.4%), 65 to 74 years (21.5%), and 75 years or older (17.7%).

<sup>b</sup> Adults with SBP and DBP levels that crossed over into another category were assigned the higher SBP/DBP category.

**Primary Outcome**

Among all adults with hypertension, the age-adjusted estimated proportion with controlled BP increased from 31.8% (95% CI, 26.9%-36.7%) in 1999-2000 to 48.5% (95% CI, 45.5%-51.5%) in 2007-2008, remained stable and was 53.8% (95% CI, 48.7%-59.0%) in 2013-2014, and then declined to 43.7% (95% CI, 40.2%-47.2%) in 2017-2018 (Table 3 and part A in the Figure). Among adults taking antihypertensive medication, the age-adjusted estimated proportion with controlled BP increased from 53.4% (95% CI, 49.0%-57.9%) in 1999-2000 to 68.3% (95% CI, 65.9%-70.8%) in 2007-2008, remained stable and was 72.2% (95% CI, 68.6%-75.8%) in 2013-2014, and then declined to 64.8% (95% CI, 61.3%-68.3%) in 2017-2018 (part B in the Figure). The estimated proportions of adults with controlled BP by the categories of age group, sex, race/ethnicity, education, household income, type of health insurance, and health care use among those with hypertension, overall, and restricted to those taking antihypertensive medication appear in Table 3 and eTable 1 in the Supplement.

Compared with adults who were aged 18 to 44 years in the overall population with hypertension in 2015-2018, it was estimated that controlled BP was more likely among their counterparts aged 45 to 64 years (49.7% vs 36.7%; multivariable-adjusted prevalence ratio, 1.18 [95% CI, 1.02-1.37]) and less likely among those 75 years or older (37.3% vs 36.7%; multivariable-adjusted prevalence ratio, 0.81 [95% CI, 0.65-0.97]; Table 4). It was estimated that controlled BP was less likely among non-Hispanic Black adults vs non-Hispanic White adults (41.5% vs 48.2%, respectively; multivariable-adjusted prevalence ratio, 0.88 [95% CI, 0.81-0.96]) and more likely among those with private insurance (48.2%), Medicare (53.4%), or government health insurance other than Medicare or Medicaid (43.2%) vs no health insurance (24.2%) (multivariable-adjusted prevalence ratio, 1.40 [95% CI, 1.08-1.80], 1.47 [95% CI, 1.15-1.89], and 1.36 [95% CI, 1.04-1.76], respectively). Controlled BP was more likely among those with vs without a usual health care facility (48.4% vs 26.5%, respectively; multivariable-adjusted prevalence ratio, 1.48 [95% CI, 1.13-1.94]) and those who had vs those who had not had a health care visit in the past year (49.1% vs 8.0%; multivariable-adjusted prevalence ratio, 5.23 [95% CI, 2.88-9.49]).

Among adults taking antihypertensive medication, it was estimated that controlled BP was less likely among those aged 65 to 74 years (64.3%) and aged 75 years or older (47.3%) vs those aged 18 to 44 years (71.9%) (multivariable-adjusted prevalence ratio, 0.84 [95% CI, 0.74-0.95] and 0.63 [95% CI, 0.55-0.73], respectively). Controlled BP among adults taking antihypertensive medication was less likely in non-Hispanic Black adults (55.6%) and non-Hispanic Asian adults (60.0%) vs non-Hispanic White adults (69.3%) (multivariable-adjusted prevalence ratio, 0.82 [95% CI, 0.77-0.88] and 0.87 [95% CI, 0.77-0.98], respectively). Controlled BP was more likely among those with Medicaid vs no health insurance (61.7% vs 44.4%, respectively; multivariable-adjusted prevalence ratio, 1.35 [95% CI, 1.03-1.78]). The results were similar in an analysis using a complete case approach (eTable 2 in the Supplement).

Table 3. Percentage of Adults With Controlled Blood Pressure Among the Overall Population With Hypertension From 1999-2000 to 2017-2018

Characteristic	Adults with controlled blood pressure, % (95% CI) <sup>a</sup>										
	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	2015-2016	2017-2018	
No. of adults	1518	1605	1623	1495	2090	2099	1837	1933	1968	2094	
Overall <sup>b</sup>	31.8 (26.9-36.7)	34.9 (31.9-37.8)	39.8 (35.5-44.1)	43.8 (41.0-46.7)	48.5 (45.5-51.5)	53.0 (49.7-56.3)	51.9 (47.4-56.4)	53.8 (48.7-59.0)	48.4 (44.3-52.4)	43.7 (40.2-47.2)	
Age group, y											
18-44	26.4 (17.1-35.8)	29.9 (23.3-36.5)	42.8 (31.7-54.0)	29.1 (22.7-35.6)	45.4 (36.8-54.1)	35.5 (26.9-44.2)	42.2 (31.6-52.9)	44.6 (38.3-50.8)	40.0 (33.9-46.0)	33.4 (24.5-42.2)	
45-64	40.0 (34.1-45.8)	38.8 (34.1-43.5)	39.5 (33.3-45.7)	48.3 (43.9-52.7)	49.6 (44.7-54.5)	57.1 (52.6-61.7)	56.2 (49.6-62.8)	57.0 (49.8-64.2)	53.7 (48.1-59.2)	46.2 (42.4-50.0)	
65-74	31.0 (24.9-37.1)	33.8 (28.4-39.3)	46.9 (41.8-51.9)	48.6 (43.6-53.7)	52.9 (48.1-57.8)	59.2 (54.7-63.7)	57.8 (51.2-64.5)	59.2 (54.7-63.6)	51.5 (44.5-58.5)	51.9 (44.9-58.8)	
≥75	16.4 (11.8-20.9)	30.5 (24.6-36.5)	29.5 (24.4-34.6)	39.5 (33.1-45.9)	43.0 (38.2-47.8)	50.3 (44.1-56.4)	42.0 (33.4-50.5)	47.4 (38.7-56.1)	38.2 (31.7-44.8)	36.5 (30.3-42.7)	
Sex <sup>b</sup>											
Female	30.9 (25.7-36.1)	36.9 (32.6-41.3)	38.2 (33.7-42.8)	46.7 (44.0-49.5)	51.1 (48.2-54.0)	57.2 (53.1-61.3)	55.3 (49.3-61.3)	57.5 (52.4-62.6)	53.2 (48.2-58.2)	43.9 (39.8-48.0)	
Male	34.0 (26.5-41.5)	34.7 (30.7-38.6)	42.6 (36.2-49.0)	43.9 (40.0-47.8)	46.6 (42.3-50.9)	50.0 (46.5-53.5)	49.6 (45.4-53.7)	51.6 (45.0-58.2)	45.5 (40.7-50.4)	44.6 (40.0-49.4)	
Race/ethnicity <sup>b,c</sup>											
Non-Hispanic White	35.2 (30.0-40.4)	35.7 (32.2-39.1)	41.6 (36.4-46.8)	44.9 (42.0-47.7)	51.1 (47.9-54.2)	55.8 (52.0-59.7)	54.0 (48.1-60.0)	57.3 (49.6-64.9)	51.3 (45.5-57.1)	45.2 (39.6-50.8)	
Non-Hispanic Black	30.2 (23.9-36.5)	32.8 (30.3-35.3)	37.4 (32.5-42.3)	43.1 (38.8-47.4)	45.2 (40.8-49.5)	48.0 (42.5-53.5)	49.0 (43.6-54.4)	46.3 (40.8-51.8)	44.9 (41.0-48.7)	38.5 (33.6-43.4)	
Non-Hispanic Asian <sup>d</sup>	23.3 (13.3-33.4)	32.6 (25.5-39.7)	33.4 (21.2-45.6)	32.0 (22.9-41.1)	41.6 (35.8-47.4)	40.2 (37.6-42.9)	45.9 (39.7-52.1)	47.0 (41.1-53.0)	44.4 (38.3-50.4)	36.8 (30.7-42.8)	
Hispanic	27.4 (21.1-33.8)	33.1 (27.0-39.2)	37.1 (32.2-42.0)	34.7 (30.2-39.3)	43.1 (36.0-50.3)	50.3 (46.6-54.1)	50.0 (41.6-54.1)	55.0 (47.0-63.1)	44.7 (36.5-52.8)	34.9 (29.3-40.5)	
Education <sup>b</sup>											
<High school	32.2 (25.7-38.8)	37.0 (32.2-41.9)	38.9 (34.0-43.8)	43.9 (40.2-47.6)	48.4 (45.5-51.3)	52.0 (48.6-55.4)	51.9 (47.7-56.0)	54.2 (48.6-59.8)	49.1 (43.5-54.8)	43.8 (39.1-48.5)	
High school graduate and some college	39.6 (27.8-51.5)	31.6 (27.5-35.6)	45.4 (36.6-54.2)	50.2 (43.9-56.6)	54.0 (48.1-59.9)	58.3 (50.1-66.6)	53.6 (45.0-62.2)	51.4 (43.9-58.8)	48.6 (41.5-55.7)	47.1 (41.8-52.5)	
College graduate	31.5 (25.2-37.8)	33.7 (28.6-38.9)	37.7 (30.8-44.7)	38.2 (31.9-44.6)	47.9 (41.2-54.6)	50.6 (45.9-55.4)	52.7 (46.1-59.2)	53.2 (46.1-59.2)	44.3 (40.5-48.0)	33.9 (24.5-43.3)	
Household income, \$ <sup>b</sup>											
<20 000	33.1 (24.7-41.4)	38.3 (31.9-44.8)	38.1 (32.6-43.5)	41.8 (37.5-46.1)	47.3 (40.3-54.2)	50.5 (46.1-54.9)	52.5 (45.8-59.2)	53.0 (47.5-58.5)	50.5 (43.9-57.1)	39.7 (33.8-45.6)	
20 000-44 999	32.2 (22.4-42.0)	32.0 (26.7-37.3)	39.0 (29.2-48.9)	42.8 (37.3-48.3)	47.6 (42.2-53.0)	57.8 (51.6-63.9)	53.6 (46.8-60.4)	53.4 (46.5-60.2)	49.2 (39.1-59.4)	49.0 (40.9-57.0)	
45 000-74 999	34.4 (23.5-45.4)	35.1 (30.5-39.6)	44.8 (38.7-50.9)	51.1 (44.0-58.0)	50.0 (45.5-54.4)	56.5 (50.0-63.1)	50.6 (43.7-57.5)	55.2 (47.8-62.5)	51.8 (43.3-60.3)	48.9 (43.1-54.7)	
≥75 000	35.0 (30.0-40.1)	38.2 (32.9-43.6)	44.2 (38.2-50.1)	45.8 (41.8-49.8)	50.0 (46.9-53.1)	55.9 (51.8-60.1)	52.6 (47.4-57.7)	56.8 (50.4-63.1)	50.2 (44.7-55.6)	46.5 (42.4-50.7)	
Type of health insurance <sup>b</sup>											
Private	39.0 (29.6-48.3)	32.2 (25.0-39.5)	48.2 (41.7-54.6)	52.4 (40.5-64.3)	59.4 (52.6-66.2)	50.7 (42.8-58.5)	60.2 (50.9-69.4)	62.1 (56.4-67.8)	60.3 (48.6-71.9)	46.8 (36.8-56.7)	
Medicare	13.7 (8.9-18.5)	17.4 (8.1-26.6)	16.8 (11.0-22.5)	33.4 (19.0-47.8)	35.5 (25.9-45.0)	31.9 (23.8-40.0)	43.3 (30.4-56.2)	34.5 (23.8-45.2)	27.9 (18.3-37.5)	22.2 (14.8-29.6)	
None	24.5 (12.4-36.6)	33.1 (22.2-44.1)	35.7 (19.9-51.6)	42.9 (28.2-57.6)	63.9 (51.6-76.2)	57.4 (44.8-69.9)	59.3 (47.5-71.0)	51.6 (36.1-67.2)	46.6 (35.4-57.7)	39.6 (28.2-51.0)	
Medicaid	20.1 (7.0-33.2)	41.7 (24.1-59.3)	51.1 (39.4-62.9)	51.0 (42.9-59.2)	67.9 (54.7-81.2)	61.0 (50.9-71.1)	49.2 (36.0-62.4)	42.7 (33.7-51.6)	43.9 (32.4-55.3)	42.4 (33.3-51.6)	
Other government											

(continued)

Table 3. Percentage of Adults With Controlled Blood Pressure Among the Overall Population With Hypertension From 1999-2000 to 2017-2018 (continued)

Characteristic	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	2015-2016	2017-2018
Adults with controlled blood pressure, % (95% CI) <sup>a</sup>										
Had usual health care facility <sup>b</sup>										
No	6.5 (0-14.2)	7.3 (0.6-13.9)	13.4 (0-28.0)	14.0 (4.5-23.4)	12.4 (3.4-21.5)	18.9 (7.2-30.5)	13.4 (7.4-19.4)	17.6 (6.3-28.9)	37.0 (23.9-50.1)	18.2 (11.3-25.0)
Yes	33.6 (28.4-38.8)	36.6 (33.6-39.7)	41.8 (37.2-46.3)	46.1 (43.2-49.1)	51.0 (47.9-54.0)	55.4 (51.9-58.9)	54.6 (49.8-59.4)	56.2 (50.7-61.7)	50.5 (46.5-54.5)	46.5 (42.7-50.2)
Had health care visit in past year <sup>b</sup>										
No	6.2 (2.1-10.3)	3.0 (0-6.4)	7.0 (0-15.7)	6.1 (0.2-11.9)	7.8 (1.7-13.8)	14.1 (7.0-21.2)	15.1 (7.6-22.6)	10.1 (3.5-16.8)	6.9 (0.6-13.2)	7.5 (1.4-13.5)
Yes	34.3 (29.2-39.4)	38.9 (35.8-42.0)	42.0 (37.6-46.3)	47.2 (44.4-50.1)	51.7 (48.6-54.8)	55.8 (52.4-59.2)	55.6 (51.4-59.9)	56.6 (51.2-61.9)	52.1 (48.0-56.1)	46.5 (43.0-50.0)

<sup>a</sup> Defined as systolic blood pressure level below 140 mm Hg and diastolic blood pressure level below 90 mm Hg.

<sup>b</sup> Age adjustment was performed using direct standardization with the standard being adults with hypertension across the entire period from 1999-2018; the age categories used for standardization were 18 to 44 years (15.5%), 45 to 64 years (45.4%), 65 to 74 years (21.5%) and 75 years or older (17.7%).

<sup>c</sup> Due to a small sample size, adults of race/ethnicity other than those listed are not reported separately.

<sup>d</sup> Characteristic description first used in 2011-2012.

### Secondary Outcomes

Among adults with hypertension, the age-adjusted estimated proportion who reported that they were aware they had hypertension increased from 69.9% (95% CI, 65.9%-73.8%) in 1999-2000 to 84.7% (95% CI, 82.3%-87.1%) in 2013-2014 and then declined to 77.0% (95% CI, 73.5%-80.6%) in 2017-2018 (eTable 3 and panel A in eFigure 3 in the Supplement). Among adults that reported being aware they had hypertension, the age-adjusted estimated proportion who reported taking antihypertensive medication increased from 85.0% (95% CI, 81.0%-89.1%) in 1999-2000 to 92.7% (95% CI, 91.0%-94.4%) in 2009-2010 and declined to 88.2% (95% CI, 85.5%-90.9%) in 2017-2018 (eTable 4 and panel B in eFigure 3 in the Supplement).

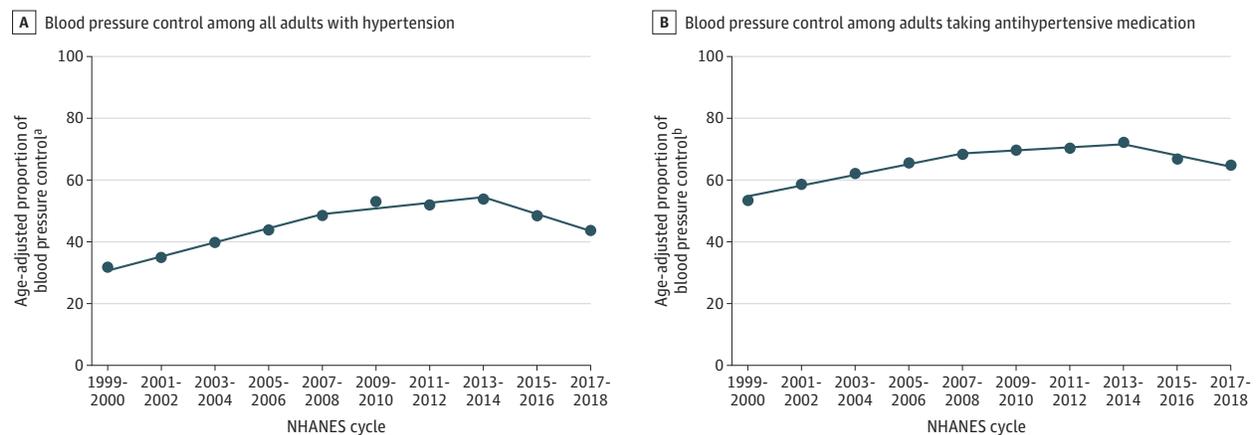
After multivariable adjustment, it was estimated that hypertension awareness was more likely in those who were aged 45 to 64 years (79.3%), 65 to 74 years (85.4%), and 75 years or older (82.1%) vs those aged 18 to 44 years (67.3%) (multivariable-adjusted prevalence ratio, 1.12 [95% CI, 1.03-1.22], 1.16 [95% CI, 1.05-1.27], and 1.10 [95% CI, 1.01-1.19], respectively; left panel in eTable 5 in the Supplement). Hypertension awareness was more likely among those with vs those without a usual health care facility (81.2% vs 59.5%, respectively; multivariable-adjusted prevalence ratio, 1.17 [95% CI, 1.04-1.31]) and among those who had vs those who had not had a health care visit in the past year (82.2% vs 43.3%; multivariable-adjusted prevalence ratio, 1.90 [95% CI, 1.56-2.31]). Hypertension awareness was less likely among college graduates vs adults with less than a high school education (75.3% vs 79.4%, respectively; multivariable-adjusted prevalence ratio, 0.91 [95% CI, 0.85-0.97]).

It was estimated that among adults who reported being aware they had hypertension, the self-reported use of antihypertensive medication was more likely among those aged 45 to 64 years (87.7%), 65 to 74 years (94.1%), and 75 years or older (96.0%) vs those aged 18 to 44 years (75.8%) (multivariable-adjusted prevalence ratio, 1.10 [95% CI, 1.02-1.18], 1.13 [95% CI, 1.06-1.22], and 1.15 [95% CI, 1.07-1.24], respectively; eTable 5 in the Supplement). Antihypertensive medication use was more likely among those having private insurance (90.6%) or Medicare (93.5%) vs those without insurance (75.2%) (multivariable-adjusted prevalence ratio, 1.12 [95% CI, 1.02-1.22] and 1.13 [95% CI, 1.03-1.23], respectively). Antihypertensive medication use was more likely among those with vs those without a usual health care facility (90.9% vs 66.2%, respectively; multivariable-adjusted prevalence ratio, 1.33 [95% CI, 1.16-1.54]) and among those who had vs those who had not had a health care visit in the past year (90.8% vs 45.6%; multivariable-adjusted prevalence ratio, 2.13 [95% CI, 1.59-2.85]; right panel in eTable 5 in the Supplement). It was estimated that men were less likely than women to report taking antihypertensive medication (86.4% vs 91.8%, respectively; multivariable-adjusted prevalence ratio, 0.96 [95% CI, 0.93-1.00]). The factors associated with hypertension awareness and antihypertensive medication use in a complete case analysis appear in eTable 6 in the Supplement.

### Sensitivity Analysis Using 2017 ACC/AHA BP Guideline

Using the 2017 ACC/AHA BP guideline definition, the age-adjusted estimated prevalence of hypertension was 48.6%

Figure. Age-Adjusted Estimated Proportion of Adults With Hypertension and Controlled Blood Pressure



NHANES indicates National Health and Nutrition Examination Survey. The data markers represent the age-adjusted estimated proportion (the numbers and 95% CIs appear in Table 3 and eTable 1 in the Supplement). Hypertension was defined as systolic blood pressure (SBP) level of 140 mm Hg or higher, diastolic blood pressure (DBP) level of 90 mm Hg or higher, and antihypertensive medication use. Controlled blood pressure was defined as SBP level lower than 140 mm Hg and DBP level lower than 90 mm Hg. Treatment was defined by self-reported antihypertensive medication use. Among all adults with hypertension, blood pressure control from 1999-2000 through 2007-2008 yielded  $P < .001$  for trend; from 2007-2008 through 2013-2014,  $P = .14$  for trend; and from 2013-2014 through 2017-2018,  $P = .003$  for trend. Among

adults taking antihypertensive medication, blood pressure control from 1999-2000 through 2007-2008 yielded  $P < .001$  for trend; from 2007-2008 through 2013-2014,  $P = .12$  for trend; and from 2013-2014 through 2017-2018,  $P = .005$  for trend. Age adjustment was performed using direct standardization with the standard being all adults across the entire period (1999-2018); the age categories used for standardization were 18 to 44 years (15.5%), 45 to 64 years (45.4%), 65 to 74 years (21.5%), and 75 years or older (17.7%). The line segments were generated using Joinpoint (National Cancer Institute).

<sup>a</sup> Among all adults with hypertension.

<sup>b</sup> Among adults who self-reported taking antihypertensive medication.

(95% CI, 45.7%-51.5%) in 1999-2000 and 46.5% (95% CI, 44.0%-49.0%) in 2017-2018 (eFigure 4 in the Supplement). Among all adults with hypertension, the age-adjusted estimated proportion with controlled BP increased from 9.7% (95% CI, 8.5%-10.9%) in 1999-2000 to 25.0% (95% CI, 22.5%-27.5%) in 2013-2014 and then decreased to 19.0% (95% CI, 17.0%-20.9%) in 2017-2018 (panel A in eFigure 5 in the Supplement). When restricted to those taking antihypertensive medication, the age-adjusted estimated proportion of adults with controlled BP increased from 27.6% (95% CI, 24.9%-30.3%) in 1999-2000 to 48.5% (95% CI, 45.1%-52.0%) in 2013-2014, and then declined to 38.9% (95% CI, 35.3%-42.5%) in 2017-2018 (panel B in eFigure 5 in the Supplement). Trends in hypertension awareness and antihypertensive medication use from 1999-2000 to 2017-2018 appear in eFigure 6 in the Supplement.

## Discussion

In the current study, the age-adjusted estimated proportion of adults with controlled BP increased from 1999-2000 through 2007-2008 and remained stable from 2007-2008 through 2013-2014. However, the proportion of adults with controlled BP decreased from 2013-2014 through 2017-2018 such that a similar estimated proportion of adults had controlled BP in 2017-2018 as in 2005-2006.

Between 1977 and 2003, the National High BP Education Program of the National Heart, Lung, and Blood Institute coordinated 7 evidence-based guidelines for the screening,

diagnosis, and management of hypertension.<sup>17,18</sup> In December 2013, the panel members appointed to the eighth Joint National Committee (JNC 8) published a report that recommended higher BP goals for some adults compared with the seventh Joint National Committee (JNC 7) guideline.<sup>19</sup> The decrease in BP control that was present among adults in the current study from 2013-2014 through 2017-2018 was predicted by 5 authors of the JNC 8 report, who noted the higher BP goal in JNC 8 vs JNC 7 would result in reduced intensity of antihypertensive medication use.<sup>20</sup>

The ACC/AHA published a BP guideline in November 2017 that recommended adults taking antihypertensive medication achieve a lower BP goal compared with the JNC 7 guideline and the JNC 8 panel member report.<sup>16</sup> A previous study estimated that compared with the JNC 7 guideline, the 2017 ACC/AHA BP guideline increased the proportion of US adults with hypertension by 14%, increased the proportion recommended antihypertensive medication initiation by 2%, and increased the proportion recommended more intensive antihypertensive treatment by 14%.<sup>10</sup> With a higher proportion of adults taking antihypertensive medication and more intensive treatment recommended for those with hypertension, the implementation of the 2017 ACC/AHA BP guideline could result in increasing hypertension awareness, antihypertensive medication use, and BP control.

Although improvements in BP control have occurred since 1999-2000, there were subgroups of adults (including older adults and non-Hispanic Black adults) who were less likely to have controlled BP. These age and racial/ethnic disparities were reported in studies conducted in the 1980s and 1990s.<sup>21,22</sup>

**Table 4. Factors Associated With Controlled Blood Pressure Among Adults in 2015-2018**

Characteristic	All adults with hypertension (n = 4062) <sup>a</sup>			Adults taking antihypertensive medication (n = 2952) <sup>a</sup>		
	Prevalence, % (95% CI) <sup>b</sup>	Prevalence ratio (95% CI)		Prevalence, % (95% CI) <sup>b</sup>	Prevalence ratio (95% CI)	
		Model 1 <sup>c</sup>	Model 2 <sup>d</sup>		Model 1 <sup>c</sup>	Model 2 <sup>d</sup>
<b>Age group, y</b>						
18-44	36.7 (31.1-43.3)	1 [Reference]	1 [Reference]	71.9 (64.6-79.3)	1 [Reference]	1 [Reference]
45-64	49.7 (46.3-53.2)	1.32 (1.14-1.51)	1.18 (1.02-1.37)	71.5 (67.6-75.4)	0.98 (0.88-1.09)	0.96 (0.87-1.07)
65-74	51.7 (46.6-56.8)	1.34 (1.15-1.57)	1.11 (0.92-1.32)	64.3 (58.8-69.9)	0.87 (0.76-0.99)	0.84 (0.74-0.95)
≥75	37.3 (32.7-41.9)	0.96 (0.80-1.15)	0.81 (0.65-0.97)	47.3 (41.7-52.9)	0.64 (0.56-0.73)	0.63 (0.55-0.73)
<b>Sex</b>						
Female	48.5 (45.1-52.0)	1 [Reference]	1 [Reference]	65.6 (62.8-68.4)	1 [Reference]	1 [Reference]
Male	45.0 (41.4-48.6)	0.93 (0.85-1.03)	0.97 (0.88-1.06)	66.7 (63.0-70.5)	1.02 (0.97-1.09)	1.01 (0.95-1.07)
<b>Race/ethnicity</b>						
Non-Hispanic White	48.2 (44.2-52.1)	1 [Reference]	1 [Reference]	69.3 (65.9-72.7)	1 [Reference]	1 [Reference]
Non-Hispanic Black	41.5 (38.3-44.7)	0.85 (0.77-0.94)	0.88 (0.81-0.96)	55.6 (51.7-59.6)	0.80 (0.75-0.86)	0.82 (0.77-0.88)
Non-Hispanic Asian	41.1 (36.6-45.6)	0.86 (0.75-0.99)	0.89 (0.78-1.02)	60.0 (54.2-65.8)	0.88 (0.78-0.99)	0.87 (0.77-0.98)
Hispanic	40.5 (35.8-45.1)	0.83 (0.72-0.96)	0.95 (0.82-1.09)	61.6 (55.6-67.7)	0.89 (0.80-0.98)	0.93 (0.84-1.03)
<b>Education</b>						
<High school	40.5 (35.1-45.8)	1 [Reference]	1 [Reference]	60.7 (54.7-66.7)	1 [Reference]	1 [Reference]
High school graduate and some college	46.2 (42.5-50.0)	1.08 (0.92-1.26)	1.01 (0.85-1.19)	64.4 (60.6-68.1)	1.03 (0.91-1.17)	1.00 (0.88-1.14)
College graduate	48.0 (43.4-52.6)	1.13 (0.97-1.31)	0.99 (0.84-1.18)	72.3 (67.6-77.0)	1.17 (1.06-1.29)	1.10 (0.97-1.24)
<b>Household income, \$</b>						
<20 000	39.4 (34.2-44.5)	1 [Reference]	1 [Reference]	57.3 (50.8-63.8)	1 [Reference]	1 [Reference]
20 000-44 999	45.1 (40.4-49.8)	1.11 (0.93-1.33)	1.11 (0.93-1.32)	63.7 (58.5-68.9)	1.08 (0.94-1.25)	1.07 (0.92-1.23)
45 000-74 999	49.2 (42.3-56.2)	1.22 (1.02-1.46)	1.17 (0.97-1.40)	66.4 (60.2-72.6)	1.12 (0.97-1.29)	1.07 (0.91-1.27)
≥75 000	50.2 (45.1-55.3)	1.18 (1.02-1.37)	1.13 (0.94-1.36)	72.2 (67.3-77.0)	1.20 (1.07-1.33)	1.13 (0.98-1.29)
<b>Type of health insurance</b>						
Private	48.2 (44.8-51.7)	1.83 (1.44-2.32)	1.40 (1.08-1.80)	69.1 (65.6-72.5)	1.40 (1.09-1.80)	1.32 (1.01-1.74)
Medicare	53.4 (45.4-61.4)	1.89 (1.49-2.39)	1.47 (1.15-1.89)	65.4 (58.2-72.7)	1.33 (1.03-1.71)	1.28 (1.00-1.67)
None	24.2 (18.2-30.2)	1 [Reference]	1 [Reference]	44.4 (33.3-55.5)	1 [Reference]	1 [Reference]
Medicaid	41.1 (31.9-50.2)	1.70 (1.24-2.34)	1.34 (0.97-1.86)	61.7 (51.5-71.9)	1.35 (1.03-1.77)	1.35 (1.03-1.78)
Other government	43.2 (34.1-52.3)	1.79 (1.39-2.22)	1.36 (1.04-1.76)	57.3 (46.2-68.3)	1.27 (1.01-1.60)	1.23 (0.96-1.57)
<b>Had usual health care facility</b>						
No	26.5 (18.4-34.7)	1 [Reference]	1 [Reference]	64.6 (51.2-78.1)	1 [Reference]	1 [Reference]
Yes	48.4 (45.6-51.2)	2.25 (1.69-3.00)	1.48 (1.13-1.94)	65.9 (63.4-68.5)	1.04 (0.85-1.27)	0.97 (0.82-1.15)
<b>Had health care visit in past year</b>						
No	8.0 (2.9-13.0)	1 [Reference]	1 [Reference]	48.4 (33.5-63.4)	1 [Reference]	1 [Reference]
Yes	49.1 (46.4-51.9)	6.48 (3.63-11.6)	5.23 (2.88-9.49)	66.1 (63.3-68.8)	1.28 (0.91-1.80)	1.20 (0.84-1.73)

<sup>a</sup> Multiple imputation was performed. The percentage of participants with missing data was 1.8% for education, 9.6% for household income, 1.2% for type of health insurance, 1.2% for having a usual health care facility, and less than 0.1% for having a health care visit in the past year.

<sup>b</sup> Age adjustment was performed for the characteristics (excluding the characteristic of age group) using direct standardization with the standard

being adults with hypertension across the entire period from 1999-2018; the age categories used for standardization were 18 to 44 years (15.5%), 45 to 64 years (45.4%), 65 to 74 years (21.5%) and 75 years or older (17.7%).

<sup>c</sup> Includes adjustment for age groups, sex, and race/ethnicity.

<sup>d</sup> Includes simultaneous adjustment for all characteristics listed.

In 2014, the AHA, the ACC, and the US Centers for Disease Control and Prevention published a scientific advisory focused on approaches to control BP.<sup>23</sup> This advisory recommended health system, clinician, and patient-tailored approaches to control BP. These methods have proven effective in the Kaiser Perma-

nente Northern California health system and may be effective in other settings.<sup>24,25</sup> Identifying strategies to implement these approaches in a wide variety of clinical practice settings may facilitate increases in BP control and reduce racial/ethnic and socioeconomic disparities.<sup>25-27</sup>

In 2015, the US Preventive Services Task Force recommended annual BP screening for adults aged 40 years or older, and among younger adults at high risk for hypertension.<sup>28</sup> Adults younger than 40 years with SBP level lower than 130 mm Hg and DBP level of 85 mm Hg who do not have hypertension risk factors were recommended a BP screening interval of 3 to 5 years. In the current study, a substantial percentage of adults aged 18 to 44 years with hypertension were not aware they had hypertension. Efforts are needed to ensure BP screening occurs for younger adults.

In 2015-2018, younger vs older adults were less likely to be taking antihypertensive medication. Underuse of antihypertensive medication has been reported to be related to low perceived cardiovascular disease risk, lack of access to care, not having a usual source of care, and treatment discontinuation. Although younger adults with hypertension have a lower short-term risk for cardiovascular disease, they have a higher lifetime risk.<sup>29,30</sup> Starting in 2010, the Patient Protection and Affordable Care Act required health insurance coverage for adult dependents aged 18 to 26 years. The proportion of younger adults with hypertension who reported having health insurance, seeing a physician in the past year, having a place to see their clinician when needed, and could afford any prescribed medication increased from 2006-2009 through 2011-2014.<sup>31-33</sup> However, a high proportion of younger adults discontinued use of antihypertensive medication.<sup>34,35</sup> Additional effort is needed to increase the initiation of and adherence to antihypertensive medication among younger adults.

A high prevalence of hypertension among patients hospitalized for coronavirus disease 2019 (COVID-19) has been reported.<sup>36</sup> Black adults have been disproportionately affected by COVID-19 in the US, including higher infection and hos-

pitalization rates.<sup>37,38</sup> In the current study, a significantly lower proportion of non-Hispanic Black adults had controlled BP vs non-Hispanic White adults. It is uncertain if hypertension or uncontrolled BP increase the risk for worse outcomes among adults with COVID-19. In addition to the benefits of BP control in reducing cardiovascular disease risk, future studies should investigate whether achieving BP control in all racial/ethnic groups can reduce disparities in COVID-19 severity.

### Limitations

This study has several limitations. First, each participant completed only a single visit and guidelines recommend obtaining the mean using multiple BP measurements obtained during 2 or more visits.<sup>16,39</sup>

Second, the analysis relied on self-report of hypertension awareness and treatment with antihypertensive medication.

Third, data on diet, medication adherence, adverse effects, insurance reimbursement for medications, and use of home BP monitoring were not available. Therefore, the association of lifestyle factors with BP control was not examined.

Fourth, the response rate for NHANES has declined from 1999-2000 through 2017-2018. The effect of this on the current study's results is unclear.

### Conclusions

In a series of cross-sectional surveys weighted to be representative of the adult US population, the prevalence of controlled BP increased between 1999-2000 and 2007-2008, did not significantly change from 2007-2008 through 2013-2014, and then decreased after 2013-2014.

#### ARTICLE INFORMATION

**Accepted for Publication:** July 21, 2020.

**Published Online:** September 9, 2020.  
doi:10.1001/jama.2020.14545

**Author Contributions:** Drs Muntner and Jaeger had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

**Concept and design:** Muntner, Fine.

**Acquisition, analysis, or interpretation of data:** All authors.

**Drafting of the manuscript:** Muntner, Wozniak.

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**Statistical analysis:** Muntner, Jaeger, Wozniak, Levitan.

**Administrative, technical, or material support:** Muntner.

**Supervision:** Muntner, Colantonio.

**Conflict of Interest Disclosures:** Dr Muntner reported receiving grant funding and consulting fees from Amgen Inc. Dr Levitan reported receiving grant funding from and serving on advisory boards for Amgen Inc; and serving as a consultant to Novartis. Dr Colantonio reported receiving grant funding from Amgen Inc. No other disclosures were reported.

**Funding/Support:** Drs Muntner and Jaeger receive support through grant R01HL144773 from the National Heart, Lung, and Blood Institute and grant 155FRN2390002 from the American Heart Association. Drs Muntner and Hardy receive support through grant R01HL117323 from the National Heart, Lung, and Blood Institute. Dr Muntner receives support through grant R01HL139716 from the National Heart, Lung, and Blood Institute.

**Role of the Funder/Sponsor:** The funders/sponsors had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

**Disclaimer:** The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Heart, Lung, and Blood Institute, the National Institutes of Health, the US government, or the American Medical Association.

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