

# Original Article

# Trends in Blood Pressure Control among US Adults With Hypertension, 2013–2014 to 2021–2023

Shakia T. Hardy,<sup>1,\*</sup> Byron C. Jaeger,<sup>2</sup> Kathryn Foti,<sup>3</sup> Lama Ghazi,<sup>3,\*</sup> Gregory Wozniak,<sup>4</sup> and Paul Muntner<sup>3,5</sup>

<sup>1</sup>Department of Epidemiology, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, USA;

<sup>2</sup>Division of Public Health Sciences, Department of Biostatistics and Data Science, Wake Forest University School of Medicine, Winston-Salem, North Carolina, USA;

<sup>3</sup>Department of Epidemiology, School of Public Health, University of Alabama at Birmingham, Birmingham, Alabama, USA;

<sup>4</sup>Improving Health Outcomes, American Medical Association, Chicago, Illinois, USA;

<sup>5</sup>Periscope Real World Evidence, Austin, Texas, USA.

\*Corresponding author: Shakia T. Hardy ([sthardy@live.unc.edu](mailto:sthardy@live.unc.edu)).

**BACKGROUND:** Prior studies have reported a decrease in the proportion of US adults with hypertension who had controlled blood pressure (BP).

**METHODS:** We analyzed data from the National Health and Nutrition Examination Survey ( $n = 25,128$ ,  $\geq 18$  years of age) to determine changes in BP control from 2013–2014 to 2021–2023. Hypertension was defined as systolic BP  $\geq 140$  mm Hg, diastolic BP  $\geq 90$  mm Hg, or antihypertensive medication use. BP control was defined as systolic BP  $< 140$  mm Hg and diastolic BP  $< 90$  mm Hg.

**RESULTS:** The age-adjusted prevalence of hypertension (95% CI) was 32.8% (31.2%–34.4%) in 2013–2014 and 32.0% (30.1%–33.9%) in 2021–2023. Among US adults with hypertension, the age-adjusted proportion (95% CI) with controlled BP was 54.1% (49.1%–59.2%), 48.6% (44.5%–52.7%), and 48.3% (45.8%–50.8%) in 2013–2014, 2015–2016, and 2017–2020, respectively, ( $P$ -trend = 0.058), and 51.1% (47.9%–54.3%) in 2021–2023 ( $P$ -value = 0.184 comparing 2021–2023 vs. 2017–2020). The proportion (95% CI) of US adults taking antihypertensive medication with controlled BP was 72.0% (68.5%–75.5%), 66.7% (62.9%–70.5%), and 67.8% (65.3%–70.3%) in 2013–2014, 2015–2016, and 2017–2020, respectively, ( $P$ -trend = 0.085), and 68.3% (64.8%–71.9%) in 2021–2023 ( $P$ -value = 0.654 comparing 2021–2023 vs. 2017–2020). Among non-Hispanic Black adults, BP control increased from 37.4% (95% CI 33.6%–41.1%) to 49.6% (95% CI 42.3%–56.9%) between 2017–2020 and 2021–2023 for those with hypertension ( $P$ -value = 0.005), and from 52.6% (95% CI 47.4%–57.8%) to 62.6% (95% CI 55.6%–69.7%) for those taking antihypertensive medication ( $P$ -value = 0.033). There was no difference in BP control across race/ethnicity groups in 2021–2023.

**CONCLUSIONS:** The decline in BP control from 2013–2014 to 2017–2020 did not continue through 2021–2023. An increase in BP control occurred from 2017–2020 and 2021–2023 among non-Hispanic Black adults.

**Keywords:** antihypertensive medication; blood pressure; hypertension; prevalence; trends.

More cardiovascular disease (CVD) events can be attributed to high blood pressure (BP) than any other modifiable risk factor.<sup>1,2</sup> The proportion of US adults with hypertension that had controlled BP, defined as systolic BP (SBP)  $< 140$  mm Hg and diastolic BP (DBP)  $< 90$  mm Hg, increased from 31.8% in 1999–2000 to 53.8% in 2013–2014.<sup>3</sup> However, this trend was reversed and in 2017–2020, 48.2% of US adults with hypertension had controlled BP.<sup>4</sup> The decline in controlled BP was larger among older adults, women, and non-Hispanic Black adults.<sup>3</sup>

The coronavirus disease 2019 (COVID-19) pandemic resulted in disruptions in healthcare services and limited access to care, including reduced BP screenings to identify hypertension and reduced BP monitoring for medication titration among those with hypertension.<sup>5–8</sup> Data from healthcare systems suggest the proportion of US adults with controlled BP may have declined

during the COVID-19 pandemic.<sup>9–11</sup> However, these studies were conducted among people who received healthcare, and many people may have avoided healthcare visits during the pandemic.<sup>5</sup> Determining if declines in BP control have continued during and after the COVID-19 pandemic among a general population sample of US adults can inform and direct interventions and policies to increase BP control.

The goal of the current study was to determine if the decline in BP control from 2013–2014 to 2017–2020 has continued through 2021–2023 in a population sample of US adults. A secondary goal was to examine changes in BP control within subgroups and to determine demographic and healthcare factors associated with BP control. To achieve these goals, we analyzed data from the US National Health and Nutrition Examination Survey (NHANES).

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## METHODS

NHANES is conducted in 2-year cycles by the National Center for Health Statistics of the Centers for Disease Control and Prevention. In each cycle, NHANES enrolled a sample of the civilian, non-institutionalized US population. For the current analysis, we included data from four NHANES periods, 2013–2014, 2015–2016, 2017–2020, and 2021–2023. We chose 2013–2014 as the earliest period as a prior analysis found BP control among US adults with hypertension started to decline at this time.<sup>3</sup> The examination response rates in 2013–2014, 2015–2016, 2017–2020, and 2021–2023 were 68.5%, 58.7%, 46.9%, and 25.6%, respectively.<sup>12</sup> The protocols for each NHANES cycle were approved by the National Center for Health Statistics of the Centers for Disease Control and Prevention Institutional Review Board. Written informed consent was obtained from each participant.

### Data collection

Data for NHANES were collected through interviews and physical examinations. Age, gender, race, ethnicity, education received, total annual family income, having a routine place to receive healthcare, and type of health insurance were self-reported. Using self-reported family income and US Department of Health and Human Services poverty guidelines, the ratio of family income to poverty was calculated and divided into 4 approximately equal groupings <1, 1 to <2, 2 to <4, and ≥4.

### BP measurement

In NHANES 2013–2014 and 2015–2016, a trained physician measured BP using a mercury sphygmomanometer. In 2017–2020 and 2021–2023, a health technician measured BP using a validated oscillometric device (Omron HEM-907XL). There were 4,417 NHANES 2017–2018 participants who had SBP and DBP measured with both devices.<sup>13</sup> We added 1.5 mm Hg to the oscillometric-measured SBP and subtracted 1.3 mm Hg from the oscillometric-measured DBP for participants in the 2017–2020 and 2021–2023 cycles, to calibrate the oscillometric device values to the mercury device values.<sup>4</sup> The average of up to three measurements from a single visit was used to define SBP and DBP.

### Definitions of hypertension, awareness, treatment, and BP control

We defined hypertension as SBP ≥140 mm Hg and/or DBP ≥90 mm Hg and/or self-reported antihypertensive medication use.<sup>14</sup> Among participants with hypertension, those answering “yes” to the question “Have you ever been told by a doctor or other healthcare professional that you had hypertension, also called high blood pressure?” were categorized as being aware of having hypertension. Antihypertensive medication use was self-reported. BP control was defined as SBP <140 mm Hg and DBP <90 mm Hg.<sup>14</sup>

### Statistical analysis

We restricted the analyses to NHANES participants who were ≥18 years of age and completed both the NHANES interview and examination ( $n = 26,961$ ). We excluded participants who were pregnant ( $n = 263$ ), missing SBP and DBP data ( $n = 1,535$ ), and missing data on antihypertensive medication use ( $n = 35$ ). After these exclusions were applied, we included 25,128 participants in the analyses (Supplementary Figure S1).

We estimated the distribution of participant characteristics including age (18–44, 45–64, 65–74, and ≥75 years), gender, and race and ethnicity (Hispanic, non-Hispanic Asian, non-Hispanic Black, non-Hispanic White, and other including more than one

race), education, family income-to-poverty ratio, having a routine place to receive healthcare and type of health insurance, the age-adjusted mean SBP and DBP, and the age-adjusted distribution of BP categories (SBP/DBP <120/80, 120–129/<80, 130–139/80–89, and ≥140/90 mm Hg) for US adults in each period (2013–2014, 2015–2016, 2017–2020, and 2021–2023).

Next, we estimated the age-adjusted prevalence of hypertension and the proportion of US adults with hypertension who were aware they had hypertension. Among those who were aware they had hypertension, we calculated the age-adjusted proportion who reported taking antihypertensive medication. The age-adjusted proportion with BP control was estimated for those with hypertension and among those taking antihypertensive medication. In addition to calculating the age-adjusted proportion of US adults with hypertension, aware, treated, and with controlled BP for the overall population, we calculated these statistics in subgroups defined by participant characteristics. The presence of linear trends for the age-adjusted prevalence of hypertension, awareness, treatment, and BP control from 2013–2014 through 2021–2023 was assessed using logistic regression with adjustment for age categories and modeling the mid-point of each time period.<sup>15</sup> In addition, we assessed the linear trend from 2013–2014 to 2017–2020 and the change from 2017–2020 to 2021–2023 using logistic regression with adjustment for age categories.

Using data from the most recent cycle, NHANES 2021–2023, Poisson regression with robust variance estimates was used to estimate prevalence ratios for hypertension awareness and treatment among those with hypertension. Prevalence ratios were also estimated for BP control among those with hypertension and among those taking antihypertensive medication. Prevalence ratios were estimated for participant characteristics, with an initial model adjusting for age group, gender, and race/ethnicity and a second model adjusting for all of the variables simultaneously. As a *post hoc* analysis, we used Poisson regression models to examine characteristics explaining changes in BP control between 2017–2020 and 2021–2023 among non-Hispanic Black adults. We estimated the percent reduction in the increase in BP control after adjustment for all participant characteristics simultaneously vs. age and gender adjustment.

In secondary analyses, we defined hypertension and BP control according to the 2017 American College of Cardiology/American Heart Association (ACC/AHA) BP guideline.<sup>16</sup> In these analyses, hypertension was defined as SBP ≥130 mm Hg and/or DBP ≥80 mm Hg and/or self-reported antihypertensive medication use, and BP control was defined as SBP <130 mm Hg and DBP <80 mm Hg.

Age adjustment was performed using direct standardization. The age distribution of the standard population was set to all US adults in 2013–2023 when estimating the prevalence of hypertension (18–44 years: 45.5%, 45–64 years: 34.3%, 65–74 years: 12.4% and ≥75 years: 7.7%) and US adults with hypertension for the analyses of hypertension awareness and treatment and BP control (18–44 years: 13.8%, 45–64 years: 44.5%, 65–74 years: 24.4% and ≥75 years: 17.3%). All estimates were weighted using the NHANES examination sample weights. Data analysis was conducted using R-4.2.3 (R Foundation for Statistical Computing, Vienna, Austria). NHANES data are available on the Centers for Disease Control and Prevention website.

## RESULTS

Participant characteristics for US adults in each period are provided in Table 1. The age-adjusted mean SBP increased from 2013–2014 to 2017–2020, while DBP increased from 2013–2014 to

**Table 1.** Demographic characteristics of US adults in 2013–2014, 2015–2016, 2017–2020, and 2021–2023

Characteristic	Calendar period			
	2013–2014 (n = 5,633)	2015–2016 (n = 5,484)	2017–2020 (n = 7,934)	2021–2023 (n = 6,077)
Age group, y				
18–44	47.2 (44.9, 49.6)	44.7 (41.5, 48.0)	44.6 (41.6, 47.6)	45.6 (42.6, 48.6)
45–64	34.8 (32.8, 36.8)	35.0 (32.8, 37.3)	35.0 (33.3, 36.6)	32.5 (30.2, 35.0)
65–74	11.0 (10.0, 12.0)	12.3 (10.9, 14.0)	12.9 (11.0, 15.0)	13.5 (12.5, 14.7)
≥75	7.04 (5.79, 8.54)	7.90 (6.31, 9.85)	7.59 (6.58, 8.75)	8.35 (7.05, 9.87)
Sex				
Men	48.9 (47.5, 50.3)	48.9 (47.6, 50.2)	49.3 (47.4, 51.2)	49.3 (47.9, 50.7)
Women	51.1 (49.7, 52.5)	51.1 (49.8, 52.4)	50.7 (48.8, 52.6)	50.7 (49.3, 52.1)
Race-ethnicity				
Non-Hispanic White	65.7 (58.7, 72.1)	64.0 (55.3, 71.8)	63.9 (59.0, 68.6)	60.3 (56.0, 64.3)
Non-Hispanic Black	11.3 (8.30, 15.2)	11.3 (7.45, 16.9)	11.2 (8.63, 14.4)	10.7 (8.17, 13.9)
Non-Hispanic Asian	5.29 (4.10, 6.80)	5.63 (3.56, 8.79)	5.49 (4.01, 7.48)	6.18 (4.13, 9.14)
Hispanic	14.9 (10.7, 20.5)	15.4 (10.6, 21.9)	15.3 (12.5, 18.5)	16.7 (11.8, 23.2)
Other including more than one race	2.74 (1.88, 3.97)	3.64 (2.94, 4.49)	4.15 (3.46, 4.98)	6.15 (5.18, 7.29)
Education				
Less than high school	15.0 (12.0, 18.6)	14.2 (10.9, 18.3)	10.2 (9.16, 11.3)	10.1 (8.25, 12.4)
High school graduate <sup>a</sup>	54.3 (51.7, 57.0)	53.6 (49.0, 58.0)	58.0 (54.1, 61.8)	55.7 (50.5, 60.7)
College graduate	30.7 (26.6, 35.0)	32.2 (26.1, 38.9)	31.8 (27.8, 36.2)	34.2 (28.2, 40.8)
Income-to-poverty ratio				
<1	15.9 (12.5, 19.8)	14.4 (11.8, 17.5)	12.7 (10.9, 14.8)	13.9 (11.3, 17.0)
1 to <2	21.4 (18.9, 24.3)	20.5 (17.9, 23.3)	18.9 (17.1, 20.9)	19.4 (16.5, 22.7)
2 to <4	28.5 (26.0, 31.2)	28.2 (24.7, 32.1)	28.3 (26.0, 30.8)	30.0 (27.5, 32.7)
4+	34.2 (29.0, 39.7)	36.9 (30.7, 43.6)	40.0 (36.5, 43.6)	36.7 (31.3, 42.5)
Routine place to go for healthcare				
No	16.3 (14.7, 17.9)	17.1 (15.4, 18.9)	16.3 (14.3, 18.6)	13.8 (11.8, 16.0)
Yes	83.7 (82.1, 85.3)	82.9 (81.1, 84.6)	83.7 (81.4, 85.7)	86.2 (84.0, 88.2)
Health insurance <sup>b</sup>				
None	18.1 (15.8, 20.8)	13.7 (11.1, 16.7)	13.0 (10.7, 15.7)	9.37 (7.53, 11.6)
Private	52.6 (49.0, 56.3)	51.2 (46.6, 55.8)	49.0 (46.1, 51.8)	46.9 (43.1, 50.6)
Medicare	17.5 (16.4, 18.7)	21.0 (18.5, 23.7)	22.4 (19.9, 25.1)	24.8 (22.7, 27.1)
Medicaid	6.08 (4.87, 7.57)	5.42 (3.87, 7.54)	7.86 (6.65, 9.27)	8.80 (7.26, 10.6)
Other government insurance	5.65 (4.64, 6.87)	8.68 (7.47, 10.1)	7.78 (6.54, 9.23)	10.1 (8.41, 12.2)

Numbers in the table are estimated percentages (95% confidence interval) of the US adult population.

<sup>a</sup>High school graduates include participants who reported graduating high school with or without some college education.

<sup>b</sup>Participants with Medicare and other types of insurance were categorized as Medicare. Those without Medicare but private insurance were considered to have private insurance, regardless of whether they had Medicaid or other government insurance.

2021–2023 ([Supplementary Table S1](#)). The age-adjusted proportion of US adults with SBP/DBP ≥140/90 mm Hg increased from 14.5% in 2013–2014 to 17.3% in 2017–2020 and then decreased to 15.8% in 2021–2023.

## Hypertension prevalence

There was no evidence of a change in the age-adjusted prevalence of hypertension from 2013–2014 (32.8%) to 2021–2023 (32.0%) ([Table 2](#), [Supplementary Figure S2](#)). Among US adults aged ≥75 years, the prevalence of hypertension was lower in 2021–2023 (68.8%) compared with 2017–2020 (74.5%).

## Hypertension awareness and treatment

The age-adjusted proportion of US adults who were aware they had hypertension decreased from 84.9% in 2013–2014 to 79.2% in 2017–2020, and 81.6% of US adults were aware they had hypertension in 2021–2023 ([Supplementary Table S2](#) and [Figure S3](#)). Between 2017–2020 and 2021–2023, hypertension awareness decreased among adults aged 18–44 years of age. From 2013–2014 to 2021–2023, the age-adjusted proportion of adults aware of their hypertension who were taking antihypertensive medication increased from 88.9% to 91.6% ([Supplementary Table S3](#)). Between 2017–2020 and 2021–2023, the use of antihypertensive medication increased among non-Hispanic Black adults, those with less than a high school education, those

with no routine place to receive healthcare, and those without health insurance.

In 2021–2023, after multivariable adjustment, hypertension awareness was more likely among adults aged 45–64, 65–74, and ≥75 years vs. those aged 18–44 years, with a high school vs. less than high school education, with vs. without a routine place to receive healthcare, and with Medicaid vs. no insurance ([Supplementary Table S4](#)). Among those aware of their hypertension, adults aged 45–64, 65–74, and ≥75 years vs. those aged 18–44 years, those with vs. without a routine place to receive healthcare, and those with Medicaid vs. no insurance were more likely to be taking antihypertensive medication after multivariable adjustment.

## BP control

The age-adjusted proportion of adults with hypertension who had controlled BP decreased from 54.1% in 2013–2014 to 48.6% in 2017–2020 and was 51.1% in 2021–2023 ([Figure 1](#)). Among adults taking antihypertensive medication, the age-adjusted proportion who had controlled BP decreased from 72.0% in 2013–2014 to 67.8% in 2017–2020 and was 68.3% in 2021–2023.

BP control decreased from 2013–2014 to 2017–2020, then increased between 2017–2020 and 2021–2023 among US adults with hypertension aged ≥75 years, women, who were non-Hispanic Black or Hispanic adults, with less than high

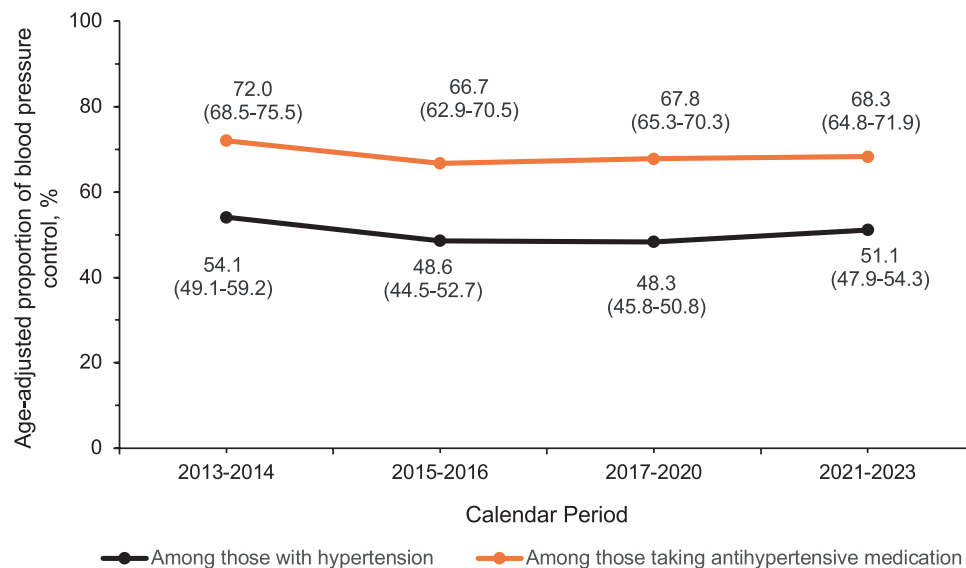
**Table 2.** Age-specific and age-adjusted prevalence of hypertension among US adults in 2013–2014, 2015–2016, 2017–2020, and 2021–2023, overall and in subgroups

Characteristic	Calendar period				P values for change over time		
	2013–2014	2015–2016	2017–2020	2021–2023	2013–2014 through 2021–2023	2013–2014 through 2017–2020	2021–2023 vs. 2017–2020
Overall	32.8 (31.2, 34.4)	31.8 (29.7, 33.9)	33.1 (31.4, 34.9)	32.0 (30.1, 33.9)	0.778	0.665	0.392
Age group, y							
18–44	10.1 (8.69, 11.4)	10.2 (8.09, 12.3)	9.75 (8.28, 11.2)	9.34 (7.80, 10.9)	0.440	0.753	0.707
45–64	41.2 (38.2, 44.1)	40.4 (36.9, 43.9)	43.6 (40.3, 47.0)	43.0 (39.8, 46.2)	0.245	0.254	0.798
65–74	66.4 (62.9, 69.9)	62.3 (55.6, 68.9)	64.1 (59.9, 68.3)	61.8 (58.0, 65.6)	0.248	0.519	0.426
≥75	75.0 (70.7, 79.4)	72.2 (67.3, 77.1)	74.5 (70.9, 78.2)	68.8 (64.6, 73.0)	0.077	0.946	0.051
Sex							
Men	33.7 (31.8, 35.6)	32.5 (29.7, 35.4)	34.4 (32.1, 36.6)	32.9 (30.4, 35.4)	0.936	0.570	0.439
Women	31.8 (29.5, 34.0)	30.8 (28.7, 32.9)	31.8 (30.0, 33.7)	30.9 (29.2, 32.6)	0.642	0.897	0.437
Race-ethnicity							
Non-Hispanic White	31.6 (29.7, 33.5)	30.3 (27.4, 33.2)	30.9 (28.5, 33.4)	29.7 (27.5, 31.8)	0.261	0.705	0.406
Non-Hispanic Black	44.8 (42.3, 47.3)	44.0 (40.6, 47.4)	46.9 (44.6, 49.3)	46.9 (43.9, 49.9)	0.171	0.219	0.953
Non-Hispanic Asian	29.9 (26.7, 33.1)	28.6 (25.3, 31.8)	33.9 (31.2, 36.6)	31.7 (27.0, 36.3)	0.367	0.060	0.504
Hispanic	29.3 (26.1, 32.6)	31.0 (28.1, 33.9)	33.6 (30.2, 36.9)	32.4 (28.8, 36.0)	0.409	0.221	0.734
Other including more than one race	35.6 (28.1, 43.1)	36.6 (29.9, 43.3)	36.5 (30.9, 42.0)	32.7 (27.9, 37.5)	0.488	0.721	0.368
Education							
Less than high school	36.2 (32.9, 39.5)	36.9 (33.7, 40.2)	38.9 (35.9, 42.0)	35.9 (32.9, 38.9)	0.951	0.247	0.152
High school graduate <sup>a</sup>	36.4 (34.3, 38.5)	34.2 (32.1, 36.4)	36.8 (35.0, 38.6)	34.6 (33.1, 36.0)	0.432	0.604	0.058
College graduate	26.0 (23.7, 28.3)	26.4 (24.1, 28.8)	25.5 (22.8, 28.1)	27.2 (23.8, 30.6)	0.644	0.718	0.428
Income-to-poverty ratio							
<1	36.0 (34.2, 37.8)	37.1 (33.5, 40.7)	37.7 (35.3, 40.1)	37.6 (34.5, 40.8)	0.321	0.299	0.904
1 to <2	36.2 (32.9, 39.4)	35.2 (32.0, 38.3)	35.4 (33.0, 37.8)	34.8 (32.9, 36.6)	0.508	0.709	0.676
2 to <4	33.0 (30.1, 35.9)	33.5 (31.1, 35.9)	34.3 (30.2, 38.3)	33.8 (31.5, 36.0)	0.769	0.611	0.738
4+	29.7 (27.6, 31.9)	28.1 (24.6, 31.5)	30.3 (27.1, 33.6)	28.0 (25.0, 30.9)	0.747	0.653	0.335
Routine place to go for healthcare							
No	22.3 (17.6, 27.0)	24.1 (18.7, 29.4)	25.5 (21.0, 29.9)	22.9 (18.6, 27.2)	0.325	0.036	0.352
Yes	34.2 (32.5, 35.9)	33.0 (30.8, 35.2)	34.1 (32.1, 36.0)	33.0 (31.1, 34.9)	0.578	0.974	0.442
Health insurance <sup>b</sup>							
None	27.3 (21.3, 33.3)	30.4 (27.4, 33.4)	35.4 (31.7, 39.0)	29.4 (24.7, 34.1)	0.821	0.262	0.189
Private	30.9 (28.3, 33.4)	31.7 (28.1, 35.3)	32.9 (30.1, 35.7)	30.8 (26.7, 35.0)	0.581	0.978	0.655
Medicare	49.5 (39.3, 59.7)	45.2 (35.5, 54.9)	43.6 (37.8, 49.4)	36.6 (30.1, 43.0)	0.055	0.361	0.139
Medicaid	39.3 (35.1, 43.5)	41.4 (36.5, 46.2)	40.4 (34.6, 46.2)	31.8 (25.9, 37.8)	0.270	0.132	0.026
Other government insurance	33.2 (27.8, 38.7)	33.2 (28.6, 37.8)	35.6 (28.9, 42.2)	35.8 (29.2, 42.3)	0.993	0.608	0.583

Numbers in the table are estimated percentage (95% confidence interval) with hypertension. Hypertension was defined according to the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure as systolic blood pressure  $\geq 140$  mm Hg, and/or diastolic blood pressure  $\geq 90$  mm Hg and/or self-reported antihypertensive medication use.

<sup>a</sup>High school graduates include participants who reported graduating high school with or without some college education.

<sup>b</sup>Participants with Medicare and other types of insurance were categorized as Medicare. Those without Medicare but private insurance were considered to have private insurance, regardless of whether they had Medicaid or other government insurance.

**Figure 1.** The age-adjusted proportion of US adults with controlled blood pressure among those with hypertension and taking antihypertensive medication.



school education, with a family income-to-poverty ratio 1 to <2, and with Medicare health insurance, (Table 3). Among non-Hispanic Asian adults, BP control increased from 2013–2014 to 2021–2023. Among adults aged 65–74 and ≥75 years, women, and non-Hispanic Black adults taking antihypertensive medication, BP decreased from 2013–2014 to 2017–2020 and then increased from 2017–2020 to 2021–2023 (Table 4). Among those with other government insurance taking antihypertensive medication, BP control increased from 2013–2014 to 2017–2020, with no evidence of a difference from 2017–2020 to 2021–2023. Among those with no routine place of care, BP control increased from 2013–2014 to 2017–2020 and then decreased from 2017–2020 to 2021–2023.

In 2021–2023 and after multivariable adjustment, controlled BP was more likely among those aged 45–64 years vs. those aged 18–44 years, with family income-to-poverty ratio 2 to <4 and ≥4 vs. <1, with vs. without a routine place for healthcare, and with Medicare, Medicaid or other government health insurance vs. no health insurance (Table 5). In 2021–2023 and after multivariable adjustment, controlled BP among adults taking antihypertensive

medication was more likely among those with high school or college education vs. less than high school education and with a family income-to-poverty ratio ≥4 vs. <1. There was no difference in controlled BP by race/ethnicity in 2021–2023.

### Factors explaining the increase in BP control among non-Hispanic Black adults from 2017–2020 to 2021–2023

Education, income-to-poverty ratio, having a routine place to go for healthcare, and health insurance explained 29.7% and 23.8% of the increase in BP control between 2021–2023 and 2017–2020 among non-Hispanic Black adults with hypertension and taking antihypertensive medication, respectively, (Supplementary Table S5).

### Hypertension and BP control are defined using the 2017 ACC/AHA BP Guideline

In 2013–2014, 2015–2016, 2017–2020, and 2021–2023, the age-standardized proportion of US adults with hypertension defined by the 2017 ACC/AHA BP guideline was 45.1%, 46.1%,

**Table 3.** The age-specific and age-adjusted proportion of US adults with hypertension that had controlled blood pressure in 2013–2014, 2015–2016, 2017–2020, and 2021–2023, overall and in subgroups

Characteristic	Calendar period				P values for change over time		
	2013–2014	2015–2016	2017–2020	2021–2023	2013–2014 through 2021–2023	2013–2014 through 2017–2020	2021–2023 vs. 2017–2020
Overall	54.1 (49.1, 59.2)	48.6 (44.5, 52.7)	48.3 (45.8, 50.8)	51.1 (47.9, 54.3)	0.544	0.058	0.184
Age group, y							
18–44	44.6 (38.3, 50.8)	40.0 (34.0, 46.0)	40.3 (30.8, 49.8)	36.8 (31.3, 42.3)	0.098	0.490	0.531
45–64	57.0 (49.9, 64.1)	53.7 (48.2, 59.2)	52.0 (47.9, 56.1)	54.7 (49.3, 60.1)	0.668	0.239	0.439
65–74	59.2 (54.7, 63.6)	51.5 (44.5, 58.4)	54.2 (49.4, 59.0)	58.7 (53.6, 63.7)	0.557	0.200	0.215
≥75	47.4 (38.8, 56.0)	38.2 (31.8, 44.7)	36.9 (32.5, 41.2)	42.5 (39.3, 45.7)	0.527	0.041	0.050
Sex							
Men	52.2 (45.7, 58.7)	46.0 (41.2, 50.9)	49.1 (44.9, 53.3)	51.3 (47.2, 55.4)	0.734	0.658	0.618
Women	57.4 (52.4, 62.5)	53.0 (47.9, 58.0)	48.0 (44.8, 51.2)	52.3 (48.9, 55.7)	0.131	0.005	0.084
Race-ethnicity							
Non-Hispanic White	57.6 (50.1, 65.1)	51.4 (45.6, 57.1)	52.2 (48.6, 55.8)	51.8 (47.7, 55.9)	0.317	0.200	0.883
Non-Hispanic Black	46.4 (41.1, 51.7)	45.4 (41.4, 49.3)	37.4 (33.6, 41.1)	49.6 (42.3, 56.9)	0.513	0.008	0.005
Non-Hispanic Asian	40.2 (33.4, 47.0)	38.3 (29.8, 46.9)	45.6 (40.8, 50.4)	53.5 (41.0, 66.0)	0.080	0.169	0.360
Hispanic	47.2 (41.2, 53.2)	44.8 (38.9, 50.6)	41.4 (37.6, 45.2)	48.8 (40.2, 57.3)	0.870	0.015	0.140
Other including more than one race	38.7 (22.0, 55.5)	45.1 (31.9, 58.3)	56.9 (45.7, 68.0)	49.1 (37.4, 60.8)	0.857	0.154	0.260
Education							
Less than high school	55.3 (47.6, 63.0)	44.9 (36.8, 52.9)	39.1 (33.4, 44.8)	45.0 (37.7, 52.3)	0.067	0.001	0.163
High school graduate <sup>a</sup>	54.4 (49.0, 59.8)	49.4 (43.7, 55.0)	48.9 (45.4, 52.4)	51.3 (47.9, 54.6)	0.525	0.121	0.342
College graduate	52.0 (44.6, 59.4)	48.9 (41.9, 55.9)	51.0 (45.3, 56.7)	53.4 (45.5, 61.4)	0.630	0.932	0.721
Income-to-poverty ratio							
<1	50.4 (40.0, 60.8)	49.3 (43.2, 55.4)	38.3 (30.7, 46.0)	43.0 (37.0, 48.9)	0.138	0.104	0.423
1 to <2	54.1 (49.1, 59.1)	47.5 (41.4, 53.7)	43.3 (37.8, 48.7)	50.0 (42.3, 57.7)	0.481	0.003	0.117
2 to <4	55.2 (48.4, 62.0)	50.9 (42.4, 59.3)	48.1 (42.4, 53.8)	49.5 (45.7, 53.4)	0.195	0.108	0.555
4+	55.2 (48.2, 62.1)	50.6 (42.9, 58.2)	54.4 (49.2, 59.6)	54.6 (49.0, 60.2)	0.609	0.948	0.806
Routine place to go for healthcare							
No	17.9 (6.52, 29.3)	38.2 (24.6, 51.9)	23.9 (16.6, 31.3)	23.3 (15.5, 31.1)	0.931	0.449	0.890
Yes	56.4 (51.1, 61.8)	50.6 (46.6, 54.6)	50.6 (47.9, 53.3)	53.1 (50.1, 56.2)	0.552	0.073	0.180
Health insurance <sup>b</sup>							
None	34.4 (23.5, 45.4)	27.9 (18.1, 37.6)	33.4 (24.5, 42.3)	45.2 (32.1, 58.4)	0.246	0.109	0.539
Private	54.8 (47.5, 62.1)	53.0 (43.9, 62.1)	50.1 (44.3, 56.0)	44.4 (38.1, 50.7)	0.241	0.413	0.618
Medicare	62.0 (56.2, 67.8)	58.7 (47.5, 69.9)	53.7 (48.0, 59.5)	59.2 (50.3, 68.0)	0.582	0.022	0.172
Medicaid	—	42.4 (31.6, 53.2)	31.1 (20.1, 42.2)	—	0.788	0.022	0.082
Other government insurance	43.3 (33.9, 52.6)	46.8 (35.0, 58.6)	50.5 (42.0, 58.9)	54.3 (44.6, 64.1)	0.267	0.419	0.858

<sup>a</sup>High school graduates include participants who reported graduating high school with or without some college education.

<sup>b</sup>Participants with Medicare and other types of insurance were categorized as Medicare. Those without Medicare but private insurance were considered to have private insurance, regardless of whether they had Medicaid or other government insurance.

—Indicates that a result was not statistically reliable due to confidence interval width >30, effective sample size <30, or confidence interval width >130% of the corresponding point estimate.

**Table 4.** The age-specific and age-adjusted proportion of US adults with hypertension and taking antihypertensive medication who had controlled blood pressure in 2013–2014, 2015–2016, 2017–2020, and 2021–2023, overall and in subgroups

Characteristic	Calendar period				P-values for change over time		
	2013–2014	2015–2016	2017–2020	2021–2023	2013–2014 through 2021–2023	2013–2014 through 2017–2020	2021–2023 vs. 2017–2020
Overall	72.0 (68.5, 75.5)	66.7 (62.9, 70.5)	67.8 (65.3, 70.3)	68.3 (64.8, 71.9)	0.425	0.085	0.654
Age group, y							
18–44	81.0 (76.1, 85.9)	70.9 (63.3, 78.5)	76.8 (65.6, 88.1)	72.1 (62.7, 81.5)	0.274	0.551	0.538
45–64	75.2 (69.8, 80.7)	74.0 (68.1, 79.9)	73.5 (69.2, 77.9)	71.8 (66.4, 77.3)	0.391	0.643	0.635
65–74	70.6 (66.4, 74.7)	64.4 (56.7, 72.1)	66.5 (61.5, 71.6)	71.3 (67.6, 75.1)	0.357	0.299	0.143
≥75	58.5 (50.5, 66.6)	47.7 (39.3, 56.1)	47.7 (42.9, 52.5)	52.0 (48.3, 55.8)	0.407	0.037	0.169
Sex							
Men	72.7 (67.6, 77.7)	66.7 (61.4, 72.0)	70.2 (66.6, 73.8)	68.4 (63.5, 73.4)	0.568	0.605	0.653
Women	72.1 (67.9, 76.3)	67.5 (63.5, 71.5)	65.8 (62.6, 69.0)	69.3 (66.3, 72.3)	0.493	0.041	0.142
Race-ethnicity							
Non-Hispanic White	75.3 (70.4, 80.2)	70.1 (65.4, 74.9)	71.9 (68.6, 75.2)	69.3 (64.9, 73.7)	0.252	0.226	0.752
Non-Hispanic Black	60.0 (54.3, 65.7)	58.2 (53.0, 63.4)	52.6 (47.4, 57.8)	62.6 (55.6, 69.7)	0.572	0.077	0.052
Non-Hispanic Asian	63.2 (56.8, 69.5)	54.9 (44.8, 64.9)	63.6 (57.5, 69.7)	71.0 (59.3, 82.7)	0.084	0.336	0.341
Hispanic	68.5 (61.4, 75.6)	64.9 (58.9, 70.9)	61.8 (56.7, 66.8)	66.4 (56.4, 76.4)	0.634	0.024	0.558
Other including more than one race	—	67.7 (54.1, 81.3)	77.7 (68.7, 86.7)	70.5 (60.4, 80.6)	0.277	0.069	0.330
Education							
Less than high school	73.5 (67.5, 79.6)	65.0 (56.0, 73.9)	59.3 (54.7, 63.8)	60.7 (51.9, 69.6)	0.021	<0.001	0.539
High school graduate <sup>a</sup>	70.8 (67.3, 74.4)	65.6 (60.6, 70.7)	67.7 (64.2, 71.2)	67.6 (64.1, 71.0)	0.642	0.267	0.781
College graduate	72.9 (65.9, 79.9)	70.1 (63.1, 77.2)	72.9 (67.7, 78.2)	73.7 (67.5, 79.9)	0.724	0.933	0.957
Income-to-poverty ratio							
<1	68.2 (58.9, 77.5)	64.9 (56.2, 73.7)	59.6 (51.1, 68.1)	58.4 (50.5, 66.4)	0.110	0.219	0.815
1 to <2	72.3 (67.1, 77.5)	65.4 (58.3, 72.5)	61.2 (55.5, 66.9)	62.6 (56.2, 69.0)	0.068	0.002	0.367
2 to <4	71.6 (65.5, 77.6)	65.9 (58.6, 73.1)	66.3 (61.0, 71.5)	67.3 (63.3, 71.3)	0.361	0.140	0.492
4+	74.8 (70.6, 79.1)	72.4 (65.2, 79.6)	74.2 (70.6, 77.9)	76.5 (71.7, 81.3)	0.339	0.809	0.518
Routine place to go for healthcare							
No	52.0 (40.7, 63.3)	77.7 (68.0, 87.4)	71.6 (59.9, 83.3)	52.6 (38.6, 66.6)	0.388	0.021	0.017
Yes	72.5 (68.8, 76.2)	66.5 (62.8, 70.2)	67.5 (64.9, 70.1)	68.9 (65.0, 72.8)	0.513	0.057	0.432
Health insurance <sup>b</sup>							
None	59.3 (48.8, 69.7)	46.9 (32.4, 61.5)	58.7 (47.3, 70.1)	—	0.161	0.161	0.799
Private	73.0 (66.0, 80.0)	70.5 (62.7, 78.2)	68.1 (61.3, 74.9)	58.5 (52.1, 65.0)	0.283	0.542	0.393
Medicare	68.5 (62.0, 74.9)	68.3 (57.4, 79.3)	64.7 (58.9, 70.5)	69.2 (62.1, 76.2)	0.815	0.063	0.218
Medicaid	—	61.4 (49.5, 73.4)	48.7 (35.2, 62.1)	—	0.368	0.049	0.557
Other government insurance	53.3 (45.1, 61.5)	62.7 (48.1, 77.3)	66.3 (58.1, 74.4)	69.6 (61.9, 77.4)	0.150	0.189	0.872

<sup>a</sup>High school graduates include participants who reported graduating high school with or without some college education.

<sup>b</sup>Participants with Medicare and other types of insurance were categorized as Medicare. Those without Medicare but private insurance were considered to have private insurance, regardless of whether they had Medicaid or other government insurance.

—Indicates that a result was not statistically reliable due to confidence interval width >30, effective sample size <30, or confidence interval width >130% of the corresponding point estimate.

46.7%, and 46.2%, respectively, (Supplementary Table S6). The age-adjusted proportion of adults who were aware they had hypertension and who were taking antihypertensive medication are shown in Supplementary Tables S7 and S8, respectively. In 2013–2014, 2015–2016, 2017–2020, and 2021–2023, the age-adjusted proportion of adults with hypertension who had controlled BP was 26.5%, 23.3%, 24.3%, and 23.0%, respectively (Supplementary Table S9). In 2013–2014, 2015–2016, 2017–2020, and 2021–2023, the age-adjusted proportion of adults taking antihypertensive medication who had controlled BP was 46.6%, 43.4%, 43.4%, and 39.9%, respectively, (Supplementary Table S10).

## DISCUSSION

In the current analysis of NHANES data, there was no evidence that the proportion of US adults with controlled BP changed from 2017–2020 to 2021–2023. This reflects a pause in the decline in the proportion of US adults with controlled BP that occurred from 2013–2014 to 2017–2020. In addition, the proportion of non-Hispanic Black adults with controlled BP increased from 2017–2020 to 2021–2023. While there was no evidence of

a difference in BP control across race/ethnicity groups in 2021–2023, BP control was less likely among adults 18–44 years of age vs. older US adults, with a family income-to-poverty ratio <1, and without a routine place to receive healthcare.

Several studies have described declines in BP control during the beginning of the COVID-19 pandemic using health system data.<sup>9,17</sup> For example, a study using data from 137,593 patients in 3 large health systems reported a 3.4% decrease in BP control between August 2018–January 2020 and April 2020–November 2020.<sup>9</sup> However, patients included in health system data are not representative of all patients with hypertension and as early as April 2020, maintenance of antihypertensive medication among those with hypertension was recommended by experts in the field.<sup>18</sup> The current study included a general population sample and found no evidence of a decline in BP control between 2017–2020 and 2021–2023. NHANES stopped data collection in March 2020 and did not re-start data collection until August 2021. Therefore, estimates for NHANES 2021–2023 reflect BP control from approximately 1.5 to 3.5 years after the onset of the pandemic in the United States, a period when wellness visits had rebounded to near pre-pandemic levels for non-Hispanic Black, non-Hispanic White, and Hispanic adults.<sup>19</sup>

**Table 5.** Factors associated with blood pressure control in 2021–2023

Characteristic	Among all US adults with hypertension		Among US adults taking antihypertensive medication	
	PR (95% CI) Model 1	PR (95% CI) Model 2	PR (95% CI) Model 1	PR (95% CI) Model 2
Age group, y				
18–44	1 (reference)	1 (reference)	1 (reference)	1 (reference)
45–64	1.48 (1.21, 1.80)	1.44 (1.17, 1.77)	0.99 (0.86, 1.15)	1.00 (0.86, 1.17)
65–74	1.57 (1.29, 1.92)	1.31 (0.96, 1.77)	0.97 (0.84, 1.13)	0.92 (0.72, 1.16)
≥75	1.14 (0.94, 1.38)	0.94 (0.69, 1.27)	0.71 (0.60, 0.83)	0.68 (0.54, 0.87)
Sex				
Men	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Women	1.01 (0.92, 1.11)	1.00 (0.90, 1.10)	1.00 (0.93, 1.08)	1.01 (0.93, 1.09)
Race-ethnicity				
Non-Hispanic White	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Non-Hispanic Black	0.97 (0.80, 1.18)	0.97 (0.83, 1.13)	0.90 (0.78, 1.04)	0.91 (0.81, 1.02)
Non-Hispanic Asian	1.02 (0.71, 1.45)	1.01 (0.73, 1.40)	1.02 (0.81, 1.27)	1.02 (0.83, 1.26)
Hispanic	0.94 (0.74, 1.19)	1.07 (0.87, 1.32)	0.93 (0.75, 1.16)	1.02 (0.88, 1.18)
Other including more than one race	0.91 (0.66, 1.26)	0.95 (0.75, 1.19)	1.01 (0.86, 1.20)	1.03 (0.90, 1.17)
Education				
Less than high school	1 (reference)	1 (reference)	1 (reference)	1 (reference)
High school graduate <sup>a</sup>	1.12 (0.92, 1.38)	1.11 (0.97, 1.27)	1.13 (0.96, 1.32)	1.10 (0.98, 1.22)
College graduate	1.17 (0.89, 1.53)	1.12 (0.91, 1.39)	1.22 (1.04, 1.43)	1.13 (1.01, 1.26)
Income-to-poverty ratio				
<1	1 (reference)	1 (reference)	1 (reference)	1 (reference)
1 to <2	1.16 (0.86, 1.57)	1.17 (0.94, 1.46)	1.07 (0.89, 1.30)	1.06 (0.93, 1.21)
2 to <4	1.14 (0.89, 1.46)	1.17 (1.01, 1.36)	1.13 (0.97, 1.31)	1.12 (1.00, 1.26)
4+	1.26 (0.93, 1.72)	1.30 (1.08, 1.56)	1.28 (1.06, 1.55)	1.27 (1.09, 1.48)
Routine place to go for healthcare				
No	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Yes	2.46 (1.70, 3.56)	2.28 (1.55, 3.36)	1.31 (0.93, 1.84)	1.24 (0.93, 1.67)
Health insurance <sup>b</sup>				
None	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Private	1.59 (1.01, 2.51)	1.30 (0.94, 1.79)	1.31 (0.88, 1.95)	1.19 (0.91, 1.55)
Medicare	1.84 (1.11, 3.05)	1.68 (1.19, 2.38)	1.34 (0.83, 2.16)	1.36 (0.95, 1.93)
Medicaid	2.02 (1.01, 4.01)	1.98 (1.25, 3.12)	1.34 (0.73, 2.46)	1.43 (0.94, 2.16)
Other government insurance	1.84 (1.18, 2.88)	1.54 (1.09, 2.18)	1.39 (0.92, 2.11)	1.33 (0.99, 1.80)

Model 1 included adjustment for age group and gender; Model 2 included adjustment for age group, gender, race/ethnicity, education, family income-to-poverty ratio, having a routine place to receive healthcare and type of health insurance.

Abbreviation: PR, prevalence ratio.

<sup>a</sup>High school graduates include participants who reported graduating high school with or without some college education.

<sup>b</sup>Participants with Medicare and other types of insurance were categorized as Medicare. Those without Medicare but private insurance were considered to have private insurance, regardless of whether they had Medicaid or other government insurance.

In 2021–2023, hypertension awareness and BP control were lower among adults aged 18–44 years and those who did not have a routine place to receive healthcare, and BP control was lower among those with a family income-to-poverty ratio <1. Young adults experience adverse social determinants of health, including lack of health insurance, time constraints due to work and family obligations, and lower income, which can make healthcare costs prohibitive and create barriers to early diagnosis and treatment of hypertension.<sup>5,20,21</sup> Expanding access to community-based programs, such as mobile health screenings or workplace wellness programs, and digital health tools including telemedicine and home BP monitors offer avenues for meeting younger populations and those with a low income-to-poverty ratio where they work, live, and play to improve hypertension awareness and BP control.<sup>22–28</sup>

Antihypertensive medication use and BP control increased among non-Hispanic Black adults between 2017–2020 and 2021–2023 and there was no difference in BP control between racial and ethnic groups in 2021–2023, which could signal progress toward reducing disparities in hypertension treatment and management.<sup>3</sup> Initiatives, including Million Hearts, Target: BP, and the Racial and Ethnic Approaches to Community Health program, have promoted hypertension management in Black communities by supporting evidence-based protocols for BP management, culturally tailored patient education, and home BP monitoring.<sup>29–32</sup>

Large health systems have implemented quality improvement programs, based on the Kaiser Permanente Northern California model, centered around team-based care that has achieved high levels of BP control in Black patients.<sup>33</sup> Small federally qualified health centers have also reduced the disparities gap through implementation of the American Medical Association Measure accurately, Act rapidly, Partner with patients program.<sup>34</sup> Widespread dissemination of these initiatives has the potential to further improve BP control and reduce disparities.

BP control among US adults remains low. Randomized trials have demonstrated that most adults can achieve BP goals <140/90 mm Hg.<sup>35</sup> In addition, initiating antihypertensive medication with 2 or more antihypertensive drug classes vs. monotherapy is associated with fewer follow-up healthcare visits and a high rate of BP control.<sup>36</sup> However, antihypertensive monotherapy remains common.<sup>37</sup> Also, prior studies have reported clinical inertia to be common with antihypertensive medication intensification occurring at only 10%–15% of patient visits with uncontrolled BP.<sup>38</sup> In a simulation study, increasing the intensification of antihypertensive medication from 13% to 62% of healthcare visits with uncontrolled BP was projected to increase the proportion of US adults with controlled BP to over 80%.<sup>39</sup>

This study has potential and known limitations. First, the response rates for NHANES has declined over the past decade.<sup>12</sup>

Although survey weights were used to produce estimates representative of the US population, declining participation rates could impact the generalizability of this study's estimates. Second, in contrast to the NHANES 2013–2014, 2015–2016, and 2017–2020 cycles, race/ethnic minority and low socioeconomic groups were not over-sampled in NHANES 2021–2023, which could limit the reliability of conclusions drawn about trends in BP control in these population subgroups.<sup>15</sup> Third, due to the pause in data collection between March 2020 to August 2021, BP levels and BP control among US adults during the initial pandemic period were not estimated. Fourth, each NHANES cycle measured BP during a single visit, and guidelines recommend obtaining an average of BP readings measured during two or more visits for diagnosing hypertension and categorizing BP control.<sup>16,40</sup> Fifth, the sample size in some of the table cells was small, limiting the ability to detect changes in BP control over time.

BP control among US adults with hypertension did not change from 2017–2020 to 2021–2023. Non-Hispanic Black adults experienced an increase in BP control during this period, suggesting short-term progress toward addressing long-standing disparities. However, BP control among US adults with hypertension and those taking antihypertensive medication remains low, emphasizing the need for enhanced hypertension management, particularly among younger adults and those without a routine place to receive healthcare.

## Supplementary Data

Supplementary materials are available at *American Journal of Hypertension* (<http://ajh.oxfordjournals.org>).

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## Conflict of Interest

Paul Muntner receives grant funding and consulting fees from Amgen Inc., unrelated to the topic of the current manuscript.

## Data Availability

NHANES data are publicly available and accessible through the CDC website.

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