

## Trends in Blood Pressure Among Adults With Hypertension United States, 2003 to 2012

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See Editorial Commentary, pp 25–26

**Abstract**—The aim of this study is to describe trends in the awareness, treatment, and control of hypertension; mean blood pressure; and the classification of blood pressure among US adults 2003 to 2012. Using data from the National Health and Nutrition Examination Survey 2003 to 2012, a total of 9255 adult participants aged  $\geq 18$  years were identified as having hypertension, defined as measured blood pressure  $\geq 140/90$  mmHg or taking prescription medication for hypertension. Awareness and treatment among hypertensive adults were ascertained via an interviewer administered questionnaire. Controlled hypertension among hypertensive adults was defined as systolic blood pressure  $< 140$  mmHg and diastolic blood pressure  $< 90$  mmHg. Blood pressure was categorized as optimal blood pressure, prehypertension, and stage I and stage II hypertension. Between 2003 and 2012, the percentage of adults with controlled hypertension increased ( $P$ -trend  $< 0.01$ ). Hypertensive adults with optimal blood pressure and with prehypertension increased from 13% to 19% and 27% to 33%, respectively ( $P$ -trend  $< 0.01$  for both groups). Among hypertensive adults who were taking antihypertensive medication, uncontrolled hypertension decreased from 38% to 30% ( $P$ -trend  $< 0.01$ ). Similarly, a decrease in mean systolic blood pressure was observed ( $P$ -trend  $< 0.01$ ); however, mean diastolic blood pressure remained unchanged. The trend in the control of blood pressure has improved among hypertensive adults resulting in a higher percentage with blood pressure at the optimal or prehypertension level and a lower percentage in stage I and stage II hypertension. Overall, mean systolic blood pressure decreased as did the prevalence of uncontrolled hypertension among the treated hypertensive population. (*Hypertension*. 2015;65:54–61. DOI: 10.1161/HYPERTENSIONAHA.114.04012.) • [Online Data Supplement](#)

**Key Words:** blood pressure ■ epidemiology ■ hypertension ■ prevention and control ■ therapeutics

Hypertension is a major and modifiable risk factor for cardiovascular disease and stroke.<sup>1,2</sup> The mortality from both ischemic heart disease and stroke, a major consequence of hypertension, doubles with each 20 mmHg increment of systolic blood pressure (SBP) or 10 mmHg increment of diastolic blood pressure (DBP).<sup>2</sup> Studies have demonstrated that adequate hypertension treatment and control result in reduced morbidity and mortality of cardiovascular disease and strokes.<sup>3,4</sup> Farley et al<sup>3</sup> predicted that for every 10% increase in hypertension treatment 14000 deaths would be avoided per year in those aged  $< 80$  years. In randomized trials of mild to moderate hypertension and their meta-analyses, drug therapies achieved a prolonged reduction in BP, of 3 to 5 mmHg, which produced statistically significant and clinically important decreases in stroke (42% reduction) and coronary heart disease (16% reduction).<sup>5,6</sup>

In the United States, the prevalence of hypertension increased from 1988 to 1994 to 1999 to 2000<sup>7,8</sup> but remained unchanged

from 1999 to 2000 to 2009 to 2010.<sup>8–10</sup> Hypertension awareness, treatment, and control increased from 1988 to 1994 to 2009 to 2010.<sup>11,12</sup> Despite improved management of hypertension over this time period, control of hypertension among hypertensive adults remains lower than the Healthy People 2020 goal of 62.1%.<sup>13</sup> Only half of adults with hypertension controlled their blood pressure level to  $< 140/90$  mmHg in 2009 to 2010.<sup>9,10</sup> Furthermore, disparities exist in hypertension among different groups.<sup>14–16</sup> There is a higher percentage of undiagnosed and uncontrolled hypertension among non-Hispanic blacks and Mexican Americans.<sup>11</sup> Reducing health disparities among different groups of the population is 1 of 2 overarching goals of Healthy People 2020.<sup>13,17</sup>

This report has 3 objectives:

1. To present trends in awareness, treatment, and control of hypertension among adults who have hypertension from 2003 to 2012, the most recent publicly available 10-year

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The National Health and Nutrition Examination Survey (NHANES) data period.

2. To present trends in mean blood pressure, and blood pressure categories (optimal blood pressure, prehypertension, stage I hypertension, and stage II hypertension) among hypertensives.
3. To evaluate trends in uncontrolled hypertension among adults who were taking prescription medication for hypertension in the United States from 2003 to 2012.

## Methods

NHANES is a complex, multistage, area probability sample representative of the United States noninstitutionalized civilian population.<sup>18</sup> The interview, conducted in the home included questions on health and sociodemographic characteristics. After participating in the interview, respondents were invited to a mobile examination center where standardized physical examinations were conducted, including blood pressure measurements.

Data from 5 consecutive 2-year cycles of NHANES from 2003 to 2004 to 2011 to 2012 were used. The survey sample during this time period included 28 607 adults aged  $\geq 18$  years who were both interviewed and examined. During the five 2-year survey cycles from 2003 to 2004 to 2011 to 2012 from 73% to 81% of the survey participants were interviewed and 70% to 77% completed the examination. Pregnant women ( $n=747$ ), adults with missing or invalid values for all 3 blood pressure measurements ( $n=1479$ ) and adults without hypertension as defined below ( $n=17\,126$ ) were excluded from analysis. A total of 9255 adults who were identified as having hypertension were included in the analysis.

Blood pressure measurements were obtained in the mobile examination center by trained physicians following a standard protocol. Appropriate blood pressure cuff sizes were used for participants based on measurement of midarm circumference. All blood pressure readings were obtained at a single examination visit. The average of  $\leq 3$  brachial SBP and DBP readings was used for SBP and DBP values.<sup>18</sup> If there were only 1 or 2 readings, a single reading or the average of 2 readings were included in the analysis. The percentage of individuals with 3 SBP readings varied from 81% in 2003 to 2004 to 98% in 2011 to 2012. Hypertension was defined as SBP $\geq 140$  mmHg or DBP $\geq 90$  mmHg or currently taking medication to lower blood pressure.<sup>2,19</sup> Awareness of hypertension was defined by an affirmative response to the question "Have you ever been told by a doctor or health professional that you had hypertension, also called high blood pressure?" Currently taking prescription medication to lower blood pressure among adults with hypertension was defined by affirmative responses to the following questions: (1) "Because of your high blood pressure/hypertension, have you ever been told to take prescribed medicine?" and (2) "Are you now following this advice to take prescribed medicine?" Controlled hypertension was defined based on SBP $< 140$  mmHg and DBP $< 90$  mmHg among those with hypertension. Individuals with hypertension were categorized as follows: optimal blood pressure (SBP $< 120$  mmHg and DBP $< 80$  mmHg), prehypertension (SBP=120–139 mmHg or DBP=80–89 mmHg), stage I hypertension (SBP=140–159 mmHg or DBP=90–99 mmHg) and stage II hypertension (SBP $\geq 160$  mmHg or DBP $\geq 100$  mmHg). The grouping was determined according to the Joint National Committee 7 guidelines.<sup>2,19</sup> Participants were categorized using the higher value of either average of SBP or average of DBP. Among those taking prescription medication for hypertension, SBP $\geq 140$  mmHg, or DBP $\geq 90$  mmHg were regarded as uncontrolled hypertension. Body mass index (BMI) was calculated as measured weight in kilograms divided by height in meters squared and categorized into 4 groups:  $< 18.5$  kg/m<sup>2</sup> (underweight), 18.5 to 24.9 kg/m<sup>2</sup> (normal weight), 25.0 to 29.9 kg/m<sup>2</sup> (overweight), and  $\geq 30$  kg/m<sup>2</sup> (obese).

## Statistical Analysis

The SEs were estimated using Taylor Series Linearization. Age-adjusted prevalence of awareness, treatment, and control of hypertension were calculated using the direct method and were adjusted to the age distribution of the subpopulation of patients who had

hypertension in 2007 to 2008 using 3 age groups: 18 to 39 years, 40 to 59 years, and  $\geq 60$  years.<sup>20</sup> To test for linear trends within and across survey periods, the null hypothesis of no linear or quadratic trend was examined using orthogonal polynomials. All differences reported are statistically significant ( $P < 0.05$ ). Mobile examination center survey sample weights adjusted for differential selection probabilities, non-response and noncoverage, were used to produce estimates representative of the noninstitutionalized, civilian US population. A relative SE $\leq 30\%$  was considered as a reliable estimate. Statistical analyses were conducted using the SAS System for Windows (release 9.3; SAS Institute Inc, Cary, NC) and SUDAAN (release 11.0; Research Triangle Institute, Research Triangle Park, NC).

## Results

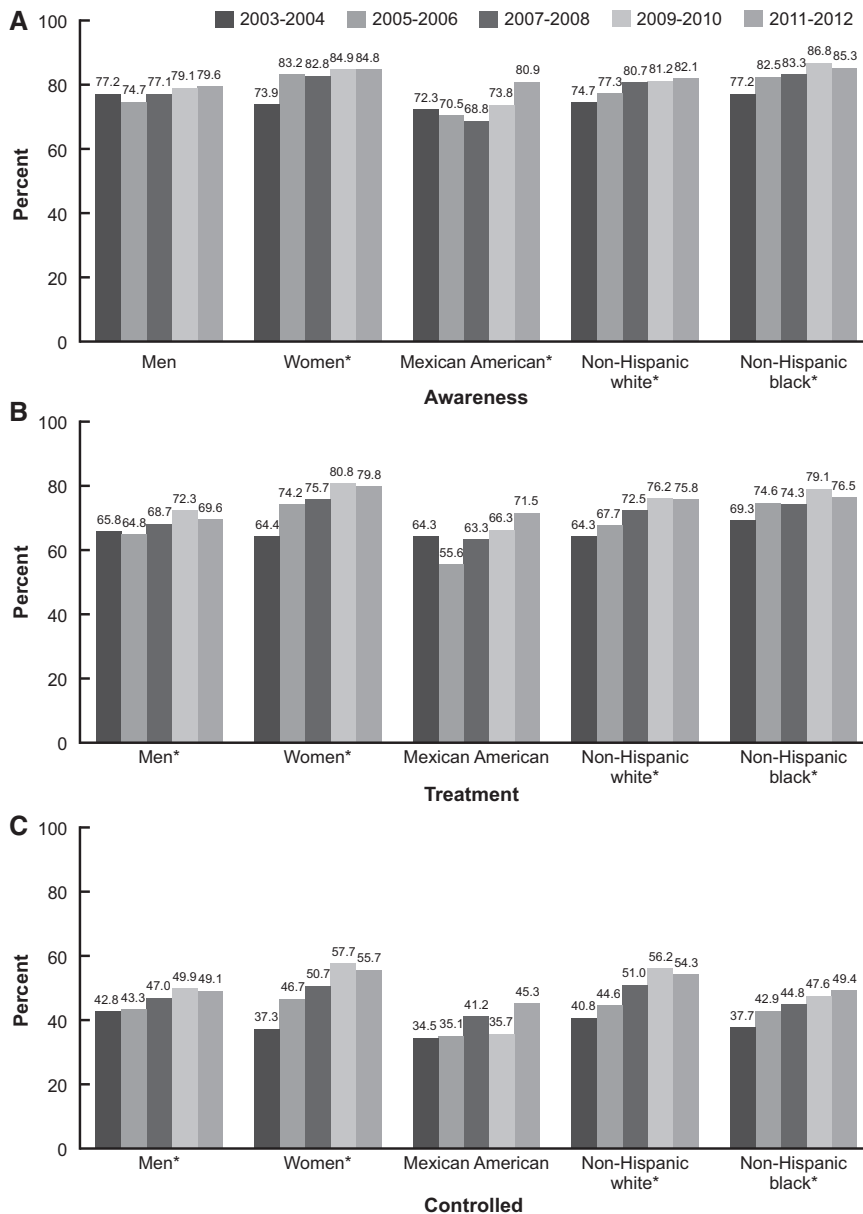
Awareness among hypertensive adults increased from 75.2% in 2003 to 2004 to 82.1% in 2011 to 2012, and treatment rates increased from 65.0% to 74.5% during the same interval ( $P$ -trend  $< 0.05$  for both awareness and treatment; Figure; Table S1 in the online-only Data Supplement). The Figure presents sex, race, and Hispanic origin stratified trends in awareness, treatment, and control of hypertension among hypertensive adults from 2003 to 2012. Increases in awareness and treatment were seen for all demographic groups except among men for awareness.

Overall, controlled hypertension among adults with hypertension increased from 39.4% in 2003 to 2004 to 51.8% between 2003 to 2004 and 2011 to 2012 ( $P$ -trend  $< 0.01$ ). The controlled rates of hypertension increased from 42.8% for men and 37.3% for women in 2003 to 2004 to 49.1% and 55.7% in 2011 to 2012 ( $P$ -trend  $< 0.05$  for men and  $P$ -trend  $< 0.01$  for women). Control among non-Hispanic whites and non-Hispanic blacks increased from 2003 to 2004 (40.8% and 37.7%, respectively) to 2011 to 2012 (54.3% and 49.4%, respectively;  $P$ -trend  $< 0.05$  for both groups; Figure; Table S1).

Table 1 presents the percentage of hypertensive adults in the following blood pressure ranges: SBP $< 120$  and DBP $< 80$  mmHg (optimal blood pressure), SBP=129 to 139 mmHg and DBP $< 90$  mmHg or SBP $< 140$  mmHg and DBP=80 to 89 mmHg (prehypertension), SBP=140 to 159 mmHg and DBP $< 100$  mmHg or SBP $< 160$  mmHg and DBP=90 to 99 mmHg (stage I hypertension), and SBP $\geq 160$  mmHg or DBP $\geq 100$  mmHg (stage II hypertension). The percentage of hypertensives in the optimal blood pressure range increased from 12.8% to 18.6% in the 10-year period ( $P$ -trend  $< 0.01$ ). There were increases in the percentage of hypertensives with optimal blood pressure among men and women, those 40 to 59 and  $\geq 60$  years, non-Hispanic whites and adults with BMI=25 kg/m<sup>2</sup> and over between 2003 to 2004 and 2011 to 2012 ( $P$ -trend  $< 0.05$  for all groups).

The percentage of adults with hypertension in the prehypertension range was 26.6% in 2003 to 2004 and 33.3% in 2011 to 2012 ( $P$ -trend  $< 0.01$ ). Among women, older adults (aged  $\geq 40$  years), non-Hispanic whites, non-Hispanic blacks, and those who were overweight (BMI=25–29) with hypertension, the percentage with blood pressure in the prehypertension range increased during the 10-year survey period ( $P$ -trend  $< 0.05$ ; Table 1).

Overall, the percentage of hypertensive adults with stage I hypertension decreased from 42.7% in 2003 to 2004 to 35.8% in 2011 to 2012 ( $P$ -trend  $< 0.01$ ). Specifically, the percentage of women, non-Hispanic whites, adults aged 40 to 59 years and adults with BMI=30 and over with stage I hypertension decreased ( $P$ -trend  $< 0.05$ ). There was a decrease in the percentage of adults with stage II hypertension during the same 10-year period from



**Figure. A–C,** Age-adjusted awareness, treatment, and control of hypertension among adults with hypertension by sex and race/ethnicity (other racial/ethnic groups not shown separately), 2003 to 2004 through 2011 to 2012. **A,** Age standardization was computed by the direct method using weights based on the subpopulation of individuals with hypertension in The National Health and Nutrition Examination Survey (NHANES) 2007 to 2008.<sup>20</sup> \**P*-trend <0.05. **B,** Age standardization was computed by the direct method using weights based on the subpopulation of individuals with hypertension in NHANES 2007 to 2008.<sup>20</sup> \**P*-trend <0.05. **C,** Age standardization was computed by the direct method using weights based on the subpopulation of individuals with hypertension in NHANES 2007 to 2008.<sup>20</sup> \**P*-trend <0.05.

17.9% in 2003 to 2004 to 12.3% in 2011 to 2012 (*P*-trend <0.01). Among all adults with hypertension, the percentage with stage II hypertension decreased (*P*-trend <0.01) for the following subgroups: women, adults ≥40 years, non-Hispanic whites, non-Hispanic blacks, and adults with BMI ≥25 (Table 1).

We further analyzed mean blood pressure among hypertensive adults who were taking prescription medication for high blood pressure (Table 2). Overall there was a decrease in the mean SBP (*P*-trend <0.01). However, the mean DBP remained unchanged between 2003 to 2004 and 2011 to 2012. The mean SBP decreased in the 10-year period in all of the following subgroups: men, women, adults aged ≥40 years, non-Hispanic whites, non-Hispanic blacks, and adults with BMI ≥25 (*P*-trend <0.05 for all subgroups).

From 2003 to 2004 to 2011 to 2012, uncontrolled hypertension decreased from 38.1% among hypertensive adults who were taking antihypertensive medication to 29.6% (*P*-trend <0.01). Uncontrolled hypertension for adults aged ≥40 years, women,

non-Hispanic whites, non-Hispanic blacks, and adults with BMI ≥30 has decreased during these 10-years (*P*-trend <0.05 for all groups). Uncontrolled hypertension among adults aged 40 to 59 decreased from 33.5% in 2003 to 2004 to 20.8% in 2011 to 2012 (*P*-trend <0.01). Among women, it decreased from 41.4% to 30.0% during this same interval (*P*-trend <0.01; Table 3).

## Discussion

Between 1988 to 1994 and 2011 to 2012, there have been increases in the awareness and treatment of hypertension among adults who had hypertension. This occurred while the prevalence of hypertension in the adult population did not change<sup>9–11,21</sup> and the control of hypertension has improved.<sup>9,11</sup> In the current analyses, we found that between 2003 and 2012, the percentage of hypertensive adults with optimal blood pressure or in the prehypertension range increased by 6% and 7%, respectively. This increase in hypertensive adults with optimal blood pressure or prehypertension, coupled with a lower

**Table 1. Age-Adjusted Percentage of Hypertensives With Optimal Blood Pressure, Prehypertensive, Stage I Hypertension, and Stage II Hypertension Levels**

Characteristics	2003–2004, % (SE) n=1664	2005–2006, % (SE) n=1518	2007–2008, % (SE) n=2113	2009–2010, % (SE) n=2116	2011–2012, % (SE) n=1844
<b>Optimal blood pressure</b>					
Overall	12.8 (0.9)	14.7 (1.1)	17.9 (1.2)	21.4 (1.1)	18.6 (1.9)*
<b>Sex</b>					
Men	13.5 (1.4)	14.8 (1.6)	15.0 (1.1)	19.8 (1.0)	19.5 (1.7)*
Women	12.6 (1.4)	16.5 (1.3)	21.5 (1.8)	24.2 (2.1)	18.2 (2.4)*
<b>Age, y</b>					
18–39	6.8 (3.7)	4.3 (1.2)	16.3 (3.8)	12.8 (3.5)	10.5 (3.6)
40–59	15.0 (1.8)	19.0 (1.5)	18.1 (1.9)	23.7 (1.9)	24.1 (4.0)*
≥60	12.3 (1.3)	13.4 (1.4)	18.1 (1.6)	21.3 (1.2)	15.8 (1.9)*
<b>Race/ethnicity†</b>					
Whites, non-Hispanic	13.4 (1.2)	15.3 (1.1)	18.4 (1.6)	22.8 (1.4)	20.3 (2.2)*
Blacks, non-Hispanic	13.3 (1.9)	13.3 (1.1)	18.1 (1.5)	19.6 (1.7)	14.6 (1.9)
Mexican Americans	10.6 (1.6)	11.5 (4.1)	14.4 (1.6)	11.6 (1.1)	13.9 (2.2)
<b>BMI, kg/m<sup>2</sup>‡</b>					
18.5 to <25	10.1 (3.0)	13.5 (3.0)	14.4 (2.3)	11.6 (2.6)	15.2 (4.2)
25 to 29	12.0 (1.5)	14.9 (1.6)	15.4 (1.6)	17.5 (2.0)	17.4 (2.7)*
≥30	14.6 (1.3)	15.2 (1.4)	20.8 (1.6)	27.1 (1.4)	20.3 (2.0)*
<b>Prehypertensive level</b>					
Overall	26.6 (1.7)	28.6 (1.4)	30.5 (1.2)	31.6 (1.4)	33.3 (1.4)*
<b>Sex</b>					
Men	29.3 (2.3)	28.5 (1.4)	31.3 (1.9)	30.1 (1.5)	29.6 (1.6)
Women	24.7 (1.6)	30.2 (1.9)	29.2 (1.0)	33.4 (2.1)	37.3 (1.9)*
<b>Age, y</b>					
18–39	22.7 (6.1)	19.2 (3.7)	24.4 (4.3)	19.9 (3.1)	23.9 (3.5)
40–59	26.0 (3.2)	28.2 (2.5)	31.9 (2.0)	32.0 (1.9)	33.7 (2.6)*
≥60	27.8 (1.2)	30.8 (1.6)	30.5 (1.1)	33.6 (1.8)	34.8 (1.7)*
<b>Race/ethnicity†</b>					
Whites, non-Hispanic	27.3 (2.0)	29.1 (2.0)	32.5 (1.3)	33.3 (1.9)	33.6 (2.0)*
Blacks, non-Hispanic	24.4 (2.6)	29.5 (1.7)	26.8 (1.5)	28.0 (2.1)	34.8 (1.6)*
Mexican Americans	23.7 (2.8)	23.7 (2.3)	26.8 (2.3)	24.1 (2.5)	31.4 (5.2)
<b>BMI, kg/m<sup>2</sup>‡</b>					
18.5 to <25	17.1 (2.9)	26.8 (1.6)	22.8 (2.4)	27.7 (3.8)	20.0 (3.7)
25 to 29	27.1 (3.1)	24.9 (2.1)	31.4 (2.3)	30.9 (2.5)	35.8 (2.8)*
≥30	31.2 (2.2)	33.1 (2.3)	34.3 (1.3)	33.6 (1.6)	37.0 (2.1)
<b>Stage I hypertension</b>					
Overall	42.7 (2.1)	41.9 (1.4)	39.4 (1.5)	36.7 (1.8)	35.8 (2.1)*
<b>Sex</b>					
Men	44.2 (2.7)	44.5 (2.1)	40.2 (2.4)	41.0 (1.9)	39.5 (2.4)
Women	39.9 (2.9)	37.3 (1.6)	38.2 (1.4)	31.4 (2.6)	31.9 (2.6)*
<b>Age, y</b>					
18–39	57.6 (5.4)	69.4 (4.1)	52.3 (6.9)	55.8 (5.4)	52.0 (5.6)
40–59	44.9 (3.3)	41.2 (3.0)	40.8 (2.3)	36.2 (2.5)	32.0 (3.3)*
≥60	38.0 (2.0)	37.2 (1.8)	35.9 (1.6)	33.3 (2.1)	35.7 (2.5)
<b>Race/ethnicity†</b>					
White, non-Hispanic	43.9 (2.7)	41.5 (1.7)	38.9 (1.8)	35.1 (2.3)	36.0 (3.1)*
Black, non-Hispanic	37.1 (2.2)	39.9 (2.5)	36.9 (2.1)	38.4 (2.6)	33.3 (1.6)

(Continued)

Table 1. Continued

	2003–2004, % (SE)	2005–2006, % (SE)	2007–2008, % (SE)	2009–2010, % (SE)	2011–2012, % (SE)
Characteristics	n=1664	n=1518	n=2113	n=2116	n=1844
Mexican Americans	40.6 (2.6)	42.9 (4.6)	41.0 (3.3)	46.2 (3.7)	39.7 (5.6)
BMI, kg/m <sup>2</sup> ‡					
18.5 to < 25	47.8 (4.1)	43.2 (3.0)	48.2 (3.4)	46.5 (4.2)	47.4 (4.4)
25 to 29	43.4 (2.6)	45.3 (3.1)	40.4 (2.4)	41.8 (2.8)	37.3 (3.1)
≥30	40.1 (1.9)	38.7 (1.6)	34.6 (1.5)	30.7 (2.2)	31.6 (2.6)*
Stage II hypertension					
Overall	17.9 (1.4)	14.7 (1.0)	12.2 (0.7)	10.3 (0.8)	12.3 (1.4)*
Sex					
Men	13.0 (1.3)	12.1 (1.5)	12.9 (1.3)	9.1 (1.0)	11.4 (1.4)
Women	22.8 (2.1)	16.0 (0.8)	11.1 (0.6)	11.1 (1.1)	12.6 (1.7)*
Age, y					
18–39	13.0 (3.0)	7.2 (2.2)	7.1 (1.6)	11.5 (3.1)	13.6 (2.6)
40–59	14.1 (1.9)	11.6 (1.3)	9.2 (1.4)	8.1 (1.2)	10.2 (1.7)*
≥60	21.9 (1.8)	18.7 (1.4)	15.6 (0.9)	11.8 (0.9)	13.8 (2.0)*
Race/ethnicity†					
Whites, non-Hispanic	15.4 (1.2)	14.1 (1.2)	10.2 (1.0)	8.9 (0.9)	10.1 (1.9)*
Blacks, non-Hispanic	25.2 (2.8)	17.2 (1.4)	18.2 (1.5)	14.0 (2.3)	17.4 (1.8)*
Mexican Americans	25.1 (2.6)	22.0 (2.7)	17.8 (2.3)	18.1 (2.8)	15.0 (6.8)§
BMI, kg/m <sup>2</sup> ‡					
18.5 to <25	25.0 (4.7)	16.6 (1.8)	14.6 (2.1)	14.2 (2.0)	17.4 (2.9)
25 to 29	17.5 (2.1)	14.9 (1.7)	12.9 (1.5)	9.8 (1.4)	9.6 (1.8)*
≥30	14.2 (1.6)	13.0 (1.7)	10.3 (1.1)	8.6 (0.8)	11.1 (1.5)*

Optimal blood pressure: SBP<120 and DBP<80 mmHg, prehypertensive level: SBP=129 to 139 and DBP<90 mmHg or SBP<140 and DBP=80 to 89 mmHg, stage I hypertension: SBP=140 to 159 mmHg and DBP<100 mmHg or SBP<160 and DBP 90 to 99 mmHg, and stage II hypertension: SBP≥160 mmHg or DBP≥100 mmHg. Age standardization was computed by the direct method using weights based on the subpopulation of individuals with hypertension in National Health and Nutrition Examination Survey 2007 to 2008.<sup>20</sup> BMI indicates body mass index; DBP, diastolic blood pressure; and SBP, systolic blood pressure.

\**P*-trend <0.05.

†Other racial/ethnic groups not shown separately.

‡BMI<18.5 not shown separately.

§Relative SE is >30%. Hypertension: SBP≥140 mmHg or DBP≥90 mmHg or currently taking medication to lower high blood pressure.

percentage in stage I and stage II hypertension have resulted in improving rates of controlled hypertension. The increase in the controlled rates among hypertensives might be the result of a higher percentage of hypertensives being treated and increased use of polytherapy. An earlier NHANES study showed that the use of antihypertensive medication among adults with hypertension increased from 63.5% to 77.3% between 2001 and 2010. Concurrently, there was a large increase in the use of multiple antihypertensive agents from 36.8% to 47.7%.<sup>12,22</sup>

The current study found changes in blood pressure over time. Among adults taking medications for hypertension between 2003 and 2012, mean SBP decreased by 4 mmHg without an accompanying change in DBP. A similar pattern in SBP but not in DBP was observed by Egan et al<sup>8</sup> using NHANES data between 1988 to 1994 and 2007 to 2008. In that study, both mean SBP and mean DBP decreased by 8 and 6 mmHg, respectively, in adults with hypertension from 1988 to 1994 to 2007 to 2008.<sup>8</sup> However, Cutler et al<sup>11</sup> presented contrasting trends from NHANES 1988 to 1994 and 2001 to 2004 that indicated no significant change in the mean SBP but

a significant decline in the DBP among treated hypertensives. The discrepancies in the trends between the current study and previous studies could be because of the different time periods. Both previous studies included samples from NHANES III (1988–1994), whereas the time period for the current study was from 2003 to 2012. In the current study, medication use was the only therapy evaluated for blood pressure control. Lifestyle modifications to lower blood pressure, such as low sodium diet, smoking cessation, and increasing physical activity, were not included. It should be noted that previous studies have demonstrated that increasing physical activity and low sodium diet, as well as taking antihypertensive medication, each contributed to reducing blood pressure.<sup>23–25</sup>

Overall, the percentage of uncontrolled hypertension among adults who were taking prescribed medication for hypertension decreased by ≤8% in the 10-year period. This decline was most prominent, in women, adults aged ≥40 years, non-Hispanic whites, non-Hispanic blacks, and obese adults. Nevertheless, uncontrolled hypertension rates among most groups of treated hypertensive adults in the US remained close to or >30% in



**Table 2. Age-Adjusted Mean Systolic Blood Pressure and Diastolic Blood Pressure Among Hypertensive Adults Who Were Taking Prescription Medication for Hypertension by Demographic Characteristics**

Characteristics	2003–2004	2005–2006	2007–2008	2009–2010	2011–2012
Mean systolic blood pressure, mm Hg					
	n=1102	n=1040	n=1532	n=1617	n=1387
Overall	135.3	132.9	131.1	129.9	131.0*
Sex					
Men	133.0	131.0	130.5	123.0	129.2*
Women	137.0	134.2	131.6	129.5	132.3*
Age, y					
18–39	126.5	127.2	124.8	129.0	126.4
40–59	131.2	127.9	126.7	127.3	126.4*
≥60	140.2	138.0	135.8	132.1	135.5*
Race/ethnicity†					
White, non-Hispanic	133.6	131.6	130.0	128.6	129.9*
Black, non-Hispanic	139.0	137.2	134.3	132.7	134.3*
Mexican American	141.7	135.7	133.7	138.7	133.8
BMI, kg/m <sup>2</sup> ‡					
18.5 to <25	139.5	133.0	132.6	134.1	132.7
25 to 29	135.4	132.5	131.2	132.5	130.8*
≥30	133.4	132.5	130.2	127.2	130.3*
Mean diastolic blood pressure, mm Hg					
	n=1077	n=1027	n=1517	n=1605	n=1382
Overall	71.9	71.5	71.4	69.3	71.4
Sex					
Men	73.9	72.8	73.9	71.0	72.2
Women	71.2	71.3	70.2	69.2	71.8
Age, y					
18–39	80.3	74.9	76.7	76.8	79.4
40–59	76.7	76.7	76.5	74.9	75.8
≥60	67.6	67.6	67.3	64.8	67.9
Race/ethnicity†					
White, non-Hispanic	71.5	71.6	71.3	69.3	71.8
Black, non-Hispanic	74.6	73.9	73.6	72.9	73.5
Mexican American	73.0	70.6	71.9	72.0	72.1
BMI, kg/m <sup>2</sup> ‡					
18.5 to <25	73.1	72.4	72.0	70.2	71.9
25 to 29	72.8	72.3	72.5	71.2	72.9
≥30	72.2	72.0	71.6	69.2	72.0

Age standardization was computed by the direct method using weights based on the subpopulation of individuals with hypertension in National Health and Nutrition Examination Survey 2007 to 2008.<sup>20</sup> BMI indicates body mass index.

\**P*-trend <0.05.

†Other racial/ethnic groups not shown separately.

‡BMI<18.5 not shown separately.

2011 to 2012 except among adults aged 18 to 39 and 40 to 59 years. Interestingly, healthy weight adults had a higher uncontrolled rate (34.1%) than obese adults (27.7%; BMI ≥ 30 kg/m<sup>2</sup>). A clinical study reported that apparent treatment-resistant hypertension existed in ≈30% of all treated patients with ≥3 antihypertensive medications in the United States. This uncontrolled hypertension was more likely faced by individuals who were older in age, men, non-Hispanic blacks, Hispanics, and those who had other comorbidities, such as diabetes mellitus,

kidney disease, and obesity.<sup>22,26</sup> However, obese adults in the present study showed an improvement in the control of their hypertension during this 10-year interval. Other possible reasons for uncontrolled hypertension could be linked to patient compliance, cost of treatment, or inactions by the physician. The issue of uncontrolled hypertension among hypertensives warrants further investigations.

There are several limitations that merit comment. Not all hypertensive adults in the US are included because the sample

**Table 3. Age-Adjusted Percentages of Uncontrolled Hypertension Among Adults Who Were Taking Prescription Medication for Hypertension by Demographic Characteristics**

Characteristics	2003–2004, % (SE) n=1102	2005–2006, % (SE) n=1040	2007–2008, % (SE) n=1532	2009–2010, % (SE) n=1617	2011–2012, % (SE) n=1387
Overall	38.1 (2.3)	34.5 (1.8)	31.5 (1.4)	29.9 (1.2)	29.6 (1.4)*
Sex					
Men	33.9 (2.5)	31.2 (3.0)	30.1 (1.7)	31.3 (2.0)	29.1 (2.3)
Women	41.4 (2.9)	37.3 (2.1)	32.7 (1.6)	28.4 (1.5)	30.0 (2.3)*
Age, y					
18–39	22.7 (6.0)	18.5 (6.1)	17.3 (5.3)	28.9 (5.7)	21.0 (4.7)
40–59	33.5 (3.3)	28.7 (3.3)	26.3 (1.8)	27.7 (2.4)	20.8 (3.3)*
≥60	44.7 (2.6)	42.3 (2.1)	38.5 (1.9)	31.9 (1.4)	38.1 (2.6)*
Race/ethnicity†					
White, non-Hispanic	35.5 (2.6)	32.0 (2.1)	28.8 (2.5)	26.2 (1.3)	27.9 (2.2)*
Black, non-Hispanic	44.6 (3.3)	42.5 (2.9)	39.1 (2.4)	39.6 (2.5)	35.3 (2.5)*
Mexican American	44.0 (3.7)	35.2 (4.8)	33.7 (3.4)	46.3 (3.3)	33.8 (5.5)
BMI, kg/m <sup>2</sup> ‡					
18.5 to <25	48.8 (5.7)	32.5 (2.9)	34.1 (2.7)	34.5 (3.6)	34.1 (4.8)
25 to 29	35.5 (3.4)	36.3 (3.4)	30.2 (2.4)	33.6 (3.3)	29.9 (3.3)
≥30	36.2 (2.6)	33.6 (3.0)	29.8 (2.0)	26.0 (1.7)	27.7 (2.1)*

Age standardization was computed by the direct method using weights based on the subpopulation of individuals with hypertension in National Health and Nutrition Examination Survey 2007 to 2008.<sup>20</sup> BMI indicates body mass index.

\**P*-trend <0.05.

†Other racial/ethnic groups not shown separately.

‡BMI<18.5 not shown separately.

design is limited to noninstitutionalized patients. Not all hypertensive adults in the US are included because the sample design is limited to noninstitutionalized patients. Hypertension was defined by blood pressure measured on a single visit. Thus, hypertension status may have been incorrectly assigned to some individuals. Misclassification may be because of self-reported information, especially information on the use of anti-hypertensive medication. The estimated uncontrolled BP rate among those taking medication is slightly different from the numbers presented in an earlier study.<sup>27</sup> In that study, hypertension treatment was based on the prescription medication questionnaire and the BP control included disease-specific cut points (BP<140/90 mmHg in general, or BP<130/80 mmHg in those with diabetes mellitus or chronic kidney disease). Furthermore, the results were crude estimates without any age adjustment. The present analyses were not able to evaluate resistant hypertension because NHANES is a cross-sectional study conducted on the general population that is not designed to measure the resistance to the treatment of hypertension. The number of Mexican Americans varied considerably over time and is less in 2011 to 2012 than previous years. Although most of the point estimates for Mexican Americans met the relative SE reliability criterion ( $\leq 30\%$ ) and the sample size requirements for the estimation the smaller sample size and relatively higher relative SEs, particularly for specific years, may have reduced the ability to detect a trend overtime.

Between 2003 to 2004 and 2011 to 2012, hypertension awareness, treatment, and control have increased among hypertensive adults. The percentages of hypertensive adults with blood pressure in the optimal or prehypertension range

have increased. In addition, the overall mean SBP has decreased in certain subgroups among those taking medication for hypertension in particular women, those aged 40 to 59 years and non-Hispanic blacks. Although the results are encouraging, continued efforts in the control of hypertension are still warranted to reach the Healthy People 2020 goals for improving the health of the general public.

## Perspectives

From 2003 to 2012, the improved trends in awareness, treatment, and control of high blood pressure among hypertensive adults contributed to decrease the percentage in stage I and stage II hypertension and to decrease in mean SBP in this group. Despite the increase in control of hypertension among hypertensive adults in this 10-year period, overall 30% of adults who were taking prescription medication for hypertension have remained as uncontrolled hypertensives in 2011 to 2012. These results should encourage primary care physicians and other public healthcare professionals to continue and expand their efforts to control high blood pressure.

## Disclosures

None.

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## Novelty and Significance

### What Is New?

- Results from the current analysis include the latest 10 years' worth of data using the National Health and Nutrition Examination Survey.
- The article presents trends in mean blood pressures among the treated hypertensive population.

### What Is Relevant?

- Hypertension awareness, treatment, and control improved among hypertensives in the past 10 years.

- Overall mean systolic blood pressure has decreased in certain subgroups among those taking medication for hypertension.
- In the past 10-year period, stage I and stage II hypertension among hypertensives decreased.

### Summary

The trend in the control of blood pressure has improved among hypertensive adults. Overall, mean systolic blood pressure decreased but mean diastolic remained unchanged.