US Trends in Prevalence, Awareness, Treatment, and Control of Hypertension, 1988-2008

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Context Hypertension is a major risk factor for cardiovascular disease and treatment and control of hypertension reduces risk. The Healthy People 2010 goal was to achieve blood pressure (BP) control in 50% of the US population.

Objective To assess progress in treating and controlling hypertension in the United States from 1988-2008.

Design, Setting, and Participants The National Health and Nutrition Examination Survey (NHANES) 1988-1994 and 1999-2008 in five 2-year blocks included 42 856 adults aged older than 18 years, representing a probability sample of the US civilian population.

Main Outcome Measures Hypertension was defined as systolic BP of at least 140 mm Hg and diastolic BP of at least 90 mm Hg, self-reported use of antihypertensive medications, or both. Hypertension control was defined as systolic BP values of less than 140 mm Hg and diastolic BP values of less than 90 mm Hg. All survey periods were age-adjusted to the year 2000 US population.

Results Rates of hypertension increased from 23.9% (95% confidence interval [CI], 22.7%-25.2%) in 1988-1994 to 28.5% (95% CI, 25.9%-31.3%; $P<.001$) in 1999-2000, but did not change between 1999-2000 and 2007-2008 (29.0%; 95% CI, 27.6%-30.5%; $P=.24$). Hypertension control increased from 27.3% (95% CI, 25.6%-29.1%) in 1988-1994 to 50.1% (95% CI, 46.8%-53.5%; $P=.006$) in 2007-2008, and BP among patients with hypertension decreased from 143.0/80.4 mm Hg (95% CI, 141.9-144.2/79.6-81.1 mm Hg) to 135.2/74.1 mm Hg (95% CI, 134.2-136.2/73.2-75.0 mm Hg; $P=.02/P<.001$). Blood pressure control improved significantly more in absolute percentages between 1999-2000 and 2007-2008 vs 1988-1994 and 1999-2000 (18.6%; 95% CI, 13.3%-23.9%; vs 4.1%; 95% CI, –0.5% to 8.8%; $P<.001$). Better BP control reflected improvements in awareness (69.1%; 95% CI, 67.1%-71.1%; vs 80.7%; 95% CI, 78.1%-83.0%; P for trend=.03), treatment (54.0%; 95% CI, 52.0%-56.1%; vs 72.5%; 95% CI, 70.1%-74.8%; $P=.004$), and proportion of patients who were treated and had controlled hypertension (50.6%; 95% CI, 48.0%-53.2%; vs 69.1%; 95% CI, 65.7%-72.3%; $P=.006$). Hypertension control improved significantly between 1988-1994 and 2007-2008, across age, race, and sex groups, but was lower among individuals aged 18 to 39 years vs 40 to 59 years ($P<.001$) and 60 years or older ($P<.001$), and in Hispanic vs white individuals ($P=.004$).

Conclusions Blood pressure was controlled in an estimated 50.1% of all patients with hypertension in NHANES 2007-2008, with most of the improvement since 1988 occurring after 1999-2000. Hypertension control was significantly lower among younger than middle-aged individuals and older adults, and Hispanic vs white individuals.

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Hypertension is a prevalent condition affecting approximately 65 million individuals in the United States based on a preliminary report from the National Health and Nutrition Examination Survey (NHANES) 2005-2006 and coincident US population estimates.[1,2] Given the prevalence and impact of hypertension on health outcomes and disparities,[3-6] several national initiatives developed programs, guidelines, and policies to facilitate hypertension prevention, detection/awareness, treatment, and control.[7-10] Hypertension control (defined as systolic blood pressure [BP] of <140 mm Hg and diastolic BP of <90 mm Hg) increased from 10% in NHANES II (1976-1980) to 31.0% in 1999-2000.[11,12] Another NHANES analysis reported that hypertension control increased from 25.0% in 1999-2000 to 33.1% in 2003-2004.[13] A preliminary NHANES 2005-2006 report noted approximately 44% of all adults with hypertension achieved systolic BP of less than 140 mm Hg and diastolic BP of less than 90 mm Hg.[1]

The reports indicate progress toward the Healthy People 2010 national objective of controlling BP in 50% of all individuals with hypertension.[1,8,9,11-13] However, differences in defining hypertension control and variable age-adjustments limit the capacity to assess changes over time.[12,13] Moreover, BP data from NHANES 2007-2008 were recently released.

See also p 2082 and Patient Page.

Our study examined changes in hypertension prevalence, awareness, treatment, and control for all adults combined and for subsets by age, race/ethnicity, and sex across NHANES 1988-1994 and 1999-2008.

METHODS

NHANES 1988-1994 and 1999-2008 were conducted by the US Centers for Disease Control and Prevention National Center for Health Statistics. NHANES volunteers were selected using stratified, multistage probability sampling of the noninstitutional-

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ized US population. All adults provided written informed consent; the study was approved by the National Center for Health Statistics Institutional/Ethics Review Board.[14,15]

Definitions

Race/ethnicity was determined by self-report and categorized as non-Hispanic white (white), non-Hispanic black (black), Hispanic, and other (American Indian, Native Alaskan, Asian or Pacific Islander, and other race not specified).[11,12]

Blood pressure in NHANES 1988-1994 and 1999-2008 was measured by physicians trained in the method using mercury sphygmomanometry and appropriately sized arm cuffs after volunteers rested 5 minutes seated.[14-19] Individuals without recorded BP were excluded. In determining mean BP for individuals, the first BP was used if only 1 measurement was obtained. The second BP was used if 2 readings were taken; second and third values were averaged when available.[13,15-19] The percentage of individuals with 3 systolic BP readings varied from 81.5% in 2003-2004 to 99.3% in 1988-1994. The percentage of individuals with 1 systolic BP ranged from 0.2% in 1988-1994 to 7.6% in 2003-2004. The percentage of individuals with 3 diastolic readings was 0.2% to 0.6% lower than for systolic BP and the percentage of individuals with 1 measurement was 0.1% to 0.3% higher.

Prevalent hypertension was defined as mean systolic BP of at least 140 mm Hg, mean diastolic BP of at least 90 mm Hg,[20-23] or both, and/or affirming that participants were currently taking prescription medication to lower BP.[11-14]

Awareness of hypertension was determined by patients with hypertension responding affirmatively to the question, "Have you ever been told by a doctor or other healthcare professional that you had hypertension, also called high blood pressure?"[11-14]

Treatment of hypertension was established by participants responding yes to the question, "Because of your hypertension/high blood pressure, are you now taking prescribed medicine?"[11-14]

Control of hypertension was defined as systolic BP of less than 140 mm Hg and diastolic BP of less than 90 mm Hg based on the Fourth and Fifth Reports of the Joint National Committee (JNC) on Detection, Evaluation, and Treatment of High Blood Pressure.[20,21] The Sixth and Seventh JNC Reports retained the same definition of hypertension control except for lower goals in high-risk subsets, including patients with diabetes.[22,23] Recent evidence does not strongly support a systolic BP goal of less than 140 mm Hg for patients with diabetes[24]; therefore, our study focuses exclusively on the goal of systolic BP of less than 140 mm Hg and diastolic BP of less than 90 mm Hg.

Diabetes Mellitus

Diabetes mellitus was defined by a positive response to any of the questions, "Have you ever been told by a doctor that you have diabetes?"; "Are you now taking insulin?"; "Are you now taking diabetes pills to lower your blood sugar?" The definition did not include patients with only fasting plasma glucose of 126 mg/dL or higher (ie, undiagnosed diabetes).[12,13]

Data Analysis

NHANES Analytic and Reporting Guidelines were followed.[25,26] SUDAAN version 10.0.1 (Research Triangle Institute, Research Triangle Park, North Carolina) accounts for NHANES complex sampling design, estimates mean values and percentages, and provides 95% confidence intervals (CIs) (Taylor series linearization).

All surveys were age-adjusted to the US 2000 census. In 2000, 42% of adults were aged 18 to 39 years, 36% were aged 40 to 59 years, and 22% were 60 years or older, with weights of 0.42, 0.36, and 0.22, respectively, which were used in calculating prevalence. For calculating awareness, treatment, and control, additional weights were calculated, because hypertension prevalence varies by age group. The proportion of adults with hypertension aged 18 to 39 years, 40 to 59 years, and 60 years or older in each NHANES period was multiplied by their respective year 2000 weight for all adults. Weights were calculated by dividing the quotient for each age group by the sum of quotients for all 3 age groups in each survey.

Weighted linear regression to test time trends from 1988-2008 was performed using estimated mean values or percentages from SUDAAN as dependent variables and analyzed with SAS version 9.2 (SAS Institute Inc, Cary, North Carolina). Reciprocals of variances were used as weights. Time was an independent and continuous variable in regression models for all patients with hypertension combined and each subgroup. To designate the NHANES period, 1991 was used for 1988-1994 and 1999, 2001, 2003, 2005, and 2007 for subsequent surveys. For comparisons among the 3 age and race/ethnicity groups, the Scheffe test was used to adjust for multiple comparisons. For the 18- to 39-years age group only, weighted paired *t* tests comparing 1988-1994 and 2007-2008 were used.

According to NHANES Analytic and Reporting Guidelines,[25,26] applied in prior reports,[12,13] mean estimates with coefficients of variation (CEV) of more than 0.30 are unreliable. Our main analyses examined changes over NHANES 1988-2008. *P* values for time trends are not presented when the weighted least square linear regression CEV exceeded 0.30 or when the CEV for variables in weighted *t* tests were more than 0.30. $P<.05$ defined statistical significance. An eTable (available at http://www.jama.com) shows sample sizes for each age group. Data are presented as means and 95% CIs.

RESULTS

All Adults

Mean age increased with time between 1988-1994 and 2007-2008 (*P* for trend = .02) (TABLE 1). The proportion of white individuals decreased marginally ($P=.05$), black individuals did not change ($P=.85$), and Hispanic individuals increased ($P=.006$). Among

all adults, mean systolic BP did not change ($P=.76$) and mean diastolic BP decreased ($P=.03$).

Among individuals without hypertension, mean systolic BP increased from 113.3 mm Hg (95% CI, 112.9-113.7 mm Hg) in 1988-1994 to 114.8 mm Hg (95% CI, 114.1-115.6 mm Hg) in 2007-2008 (P for trend=.02). Mean diastolic BP did not decrease significantly over time (70.7 mm Hg; 95% CI, 70.2-71.2 mm Hg; vs 69.2 mm Hg; 95% CI, 68.4-69.9 mm Hg; P for trend=.06).

The proportion of adults with stage 1 hypertension (either systolic or diastolic BP or both in the range of 140-159/90-99 mm Hg; $P=.36$), prehypertension (systolic/diastolic BP, 120-139/80-89 mm Hg; $P=.11$), and normal BP (<120/<80 mm Hg, $P=.74$) did not change (Table 1). Data were insufficient to evaluate changes in stage 2 hypertension (systolic/distolic BP, ≥160/≥100 mm Hg). Mean body mass index (BMI, calculated as weight in kilograms divided by height in meters squared) increased over time ($P<.001$), the percentage of normal weight individuals (BMI <25.0) decreased ($P=.002$), and the percentage of obese (BMI ≥30.0) ($P<.001$) and individuals with self-identified diabetes increased ($P=.01$). The prevalence of hypertension increased from 1988-2008 ($P=.01$) and between 1988-1994 and 1999-2000 ($P<.001$) but did not change from 1999-2008 ($P=.24$) (FIGURE 1).

All Patients With Hypertension

Mean age ($P=.86$) and the proportion of men and women ($P=.73$) did not change over time (TABLE 2). The proportion of self-identified white or black patients with hypertension did not change, and data were insufficient to assess changes in proportion of Hispanic individuals with hypertension. Systolic and diastolic BP decreased between 1988-1994 and 2007-2008 (P for trend=.02 and P for trend<.001, respectively). The proportion of patients with stage 1 hypertension ($P=.002$) and stage 2 hypertension ($P=.03$) decreased, but the proportion of patients with prehypertension ($P=.005$) and normal BP increased. Mean BMI increased over time ($P=.01$), as did the proportion of obese individuals ($P=.04$) and individuals with diabetes ($P=.006$).

Awareness increased from 1999-2008 ($P=.009$) and 1988-2008 ($P=.03$) but was not different between 1988-1994 and 1999-2000 ($P=.88$). The percentage of individuals with hypertension who received treatment increased over time ($P=.004$), along with the percentage of patients whose hypertension treatment controlled their BP ($P=.006$). Improvements in awareness, treatment, and proportion of patients who were treated and whose BP was controlled was associated with an increase

Table 1. Characteristics of All US Adults in the NHANES 1988-1994 and 1999-2008[a]

Characteristics	Mean or % (95% Confidence Interval) by Years						*P* for Trend
	1988-1994 (n = 17 250)	1999-2000 (n = 4755)	2001-2002 (n = 5251)	2003-2004 (n = 4902)	2005-2006 (n = 5028)	2007-2008 (n = 5670)	
Mean age, y	43.8 (42.9-44.6)	43.9 (43.1-44.7)	44.4 (43.4-45.5)	44.9 (43.8-46.0)	45.5 (43.8-47.2)	45.8 (44.8-46.8)	.02
Sex, %							
Men	47.6 (46.7-48.5)	48.4 (46.8-50.1)	48.3 (47.2-49.4)	48.8 (47.1-50.4)	48.4 (47.4-49.5)	48.3 (47.1-49.5)	.11
Women	52.4 (51.5-53.3)	51.6 (49.9-53.2)	51.7 (50.6-52.8)	51.2 (49.6-52.9)	51.6 (50.5-52.7)	51.7 (50.5-52.9)	
Race/ethnicity, %							
White	75.8 (73.2-78.3)	70.7 (64.5-76.3)	72.5 (67.3-77.3)	73.2 (65.0-80.0)	72.1 (66.0-77.5)	69.4 (61.3-76.5)	.05
Black	11.1 (9.9-12.5)	10.7 (7.6-14.8)	10.8 (7.7-14.9)	11.3 (7.9-15.9)	11.1 (7.7-15.9)	11.4 (7.9-16.2)	.85
Hispanic	5.2 (4.4-6.1)	14.7 (9.3-22.6)	12.9 (8.4-19.3)	11.3 (7.3-17.2)	11.6 (8.9-14.9)	13.5 (9.8-18.4)	.006
Other	7.9 (6.4-9.7)	3.9 (2.4-6.1)	3.8 (2.8-5.2)	4.3 (3.0-5.9)	5.2 (4.1-6.7)	5.7 (4.1-7.9)	[b]
Mean BP, mm Hg							
Systolic	120.0 (119.3-120.8)	122.4 (120.9-123.9)	121.9 (120.9-122.9)	122.2 (121.1-123.2)	121.7 (120.7-122.7)	120.9 (120.1-121.7)	.76
Diastolic	72.9 (72.4-73.4)	72.6 (71.7-73.4)	72.0 (71.2-72.9)	70.9 (70.2-71.7)	70.0 (69.3-70.7)	70.6 (69.9-71.4)	.03
BP, mm Hg, %							
≥160/≥100	4.7 (4.1-5.3)	5.5 (4.4-7.0)	5.1 (4.4-5.9)	5.1 (4.3-6.1)	4.3 (3.6-5.2)	3.4 (3.0-3.9)	[b]
140-159/90-99	11.9 (11.1-12.8)	13.1 (11.7-14.6)	12.2 (11.1-13.5)	12.2 (10.4-14.2)	11.8 (10.4-13.2)	11.4 (10.4-12.6)	.36
120-139/80-89	32.2 (31.1-33.3)	37.1 (35.1-39.2)	35.5 (33.8-37.3)	36.5 (34.5-38.6)	35.8 (33.8-37.8)	35.8 (33.3-38.4)	.11
<120/<80	51.2 (49.5-53.0)	44.2 (41.1-47.4)	47.2 (44.6-49.7)	46.3 (43.6-48.9)	48.2 (45.6-50.8)	49.4 (46.7-52.1)	.74
Mean BMI	26.4 (26.2-26.6)	27.8 (27.3-28.3)	27.9 (27.5-28.2)	28.0 (27.7-28.3)	28.4 (27.8-28.9)	28.5 (28.1-28.8)	<.001
BMI, %							
<25.0	46.1 (44.4-47.8)	37.2 (33.8-40.8)	35.7 (34.2-37.2)	34.7 (32.6-36.8)	33.9 (30.9-37.0)	32.8 (30.8-34.9)	.002
25.0-29.9	32.1 (31.0-33.2)	33.3 (30.7-36.0)	34.7 (32.5-37.0)	34.0 (31.6-36.5)	32.7 (30.9-34.6)	33.9 (32.3-35.6)	.30
≥30.0	21.8 (20.5-23.1)	29.5 (26.4-32.8)	29.6 (27.4-31.9)	31.4 (28.9-33.9)	33.4 (30.2-36.7)	33.2 (30.9-35.6)	<.001
Diabetes, %	5.3 (4.8-5.8)	5.9 (4.9-7.1)	6.4 (5.6-7.3)	7.0 (5.8-8.3)	7.6 (6.7-8.7)	8.9 (7.5-10.5)	.01

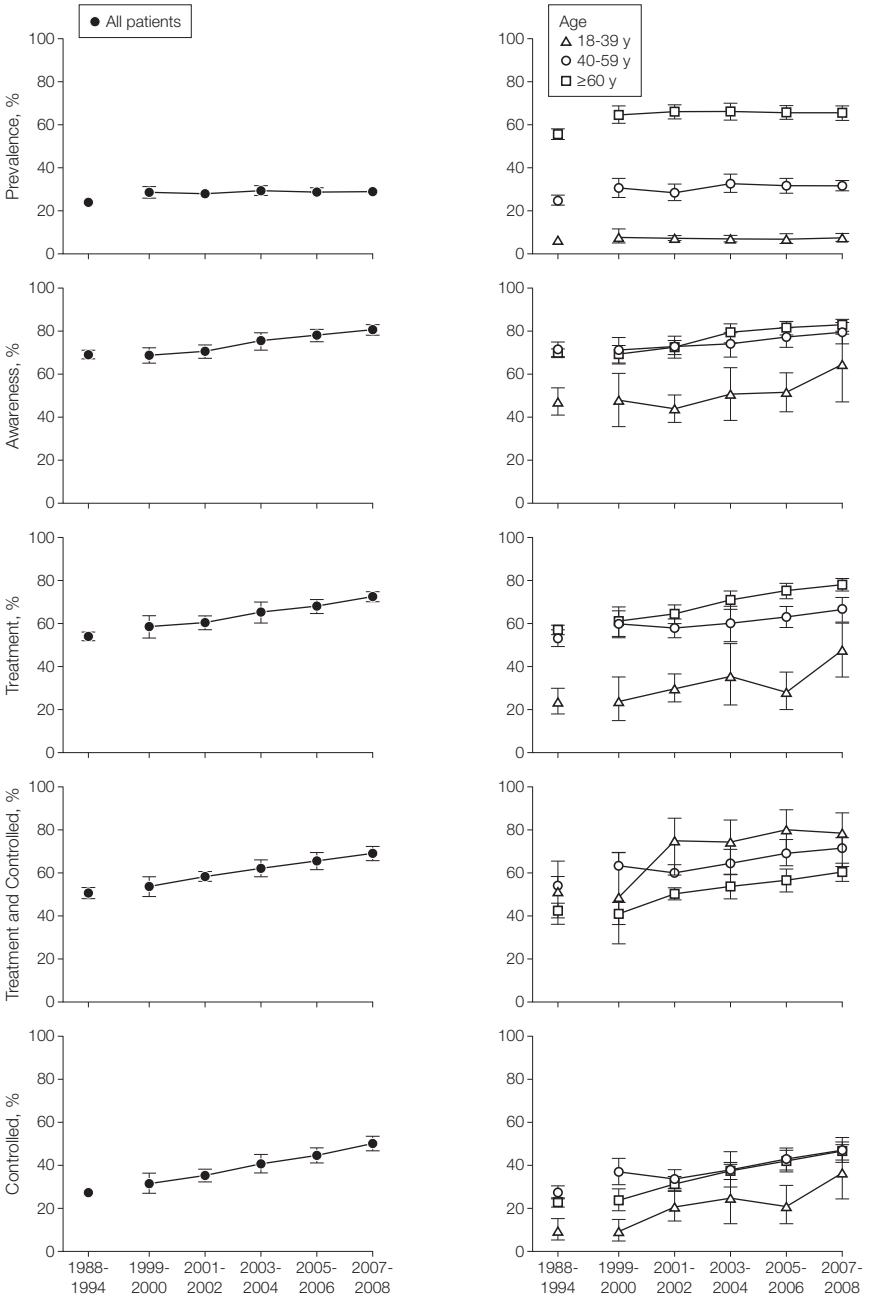
Abbreviations: BMI, body mass index, calculated as weight in kilograms divided by height in meters squared; BP, blood pressure; NHANES, National Health and Nutrition Examination Survey.

[a] *P* for trend denotes statistical significance over the 6 NHANES between 1988 and 2008. Other race/ethnicity included American Indian, Native Alaskan, Asian or Pacific Islander, and other race not specified.

[b] Cannot be reported because the coefficients of variation was more than 0.3.

in BP control to less than 140 mm Hg and less than 90 mm Hg among all patients from 27.3% (95% CI, 25.6%-29.1%) in 1988-1994 to 50.1% (95% CI, 46.8%-53.5%) in 2007-2008 (*P* for trend = .006). However, BP control improved significantly more in absolute percentages between 1999-2000 and 2007-2008 than between 1988-1994 and 1999-2000 (18.6%; 95% CI, 13.3%-23.9%; vs 4.1%; 95% CI, –0.5% to 8.8%; $P < .001$).

Figure 1. Clinical Epidemiology of Hypertension Including Prevalence, Awareness, Treatment, Treatment and Controlled, and Controlled for 1988-1994 and 1999-2008 in 2-Year Blocks by All Patients and Age Group



Data are presented as means with 95% confidence intervals (error bars). For all curves, the statistical significance of change over time between 1988-1994 and 2007-2008 was $P \leq .04$, except for hypertension awareness for individuals aged 18 to 39 years ($P = .36$) and hypertension prevalence, treated, treated and controlled, and controlled for individuals aged 18 to 39 years (insufficient data to reliably calculate significance using weighted linear regression).

To assess the effect of excluding the first BP measurement in determining mean systolic and diastolic values,[13,15-19] data were examined on 1810 individuals with hypertension in NHANES 2007-2008 who had 3 measurements. Blood pressure decreased by 2.6/0.8 mm Hg (95% CI, 2.4-2.9/0.6-1.1 mm Hg; $P < .001/P < .001$) between first and second reading and 3.6/1.1 mm Hg (95% CI, 3.3-3.9/0.9-1.4 mm Hg) between first and mean of the second and third readings ($P < .001/P < .001$).

Clinical Epidemiology of Hypertension by Age Group

Prevalent hypertension increased over time in individuals aged 40 to 59 years ($P = .02$) and 60 years or older ($P = .04$) but could not be assessed for those 18 to 39 years using weighted linear regression (Figure 1). Prevalent hypertension was greater among individuals aged 60 years or older ($P < .001$) and 40 to 59 years ($P < .001$) than for those 18 to 39 years and was more common in those 60 years or older than for 40 to 59 years ($P < .001$). Hypertension awareness increased over time among individuals aged 40 to 59 years ($P = .04$) and 60 years or older ($P = .03$) but not for 18 to 39 years ($P = .36$). Awareness was higher among individuals aged 60 years or older ($P < .001$) and 40 to 59 years ($P < .001$) than for those 18 to 39 years but was not different between the 2 older groups ($P = .72$).

The percentage of patients who were treated for hypertension increased among those aged 40 to 59 years ($P = .01$) and 60 years or older ($P = .03$) but could not be assessed for 18 to 39 years. Treatment rates were higher among individuals aged 60 years or older ($P < .001$) and 40 to 59 years ($P < .001$) vs 18 to 39 years and 60 years or older vs 40 to 59 years ($P = .03$). The proportion of patients who were treated and whose hypertension was controlled increased over time among individuals aged 40 to 59 years ($P = .02$)

and 60 years or older ($P=.04$) but could not be assessed for those 18 to 39 years. The proportion of patients who were treated and whose hypertension was controlled was lower among those 60 years or older than either those 18 to 39 years ($P<.001$) or 40 to 59 years ($P=.008$) but was not different between 18 to 39 years and 40 to 59 years ($P=.23$).

Hypertension control increased over time among individuals aged 40 to 59 years ($P=.009$) and 60 years or older ($P<.001$) but could not be assessed for those 18 to 39 years. Blood pressure control was higher in those individuals aged 60 years or older ($P<.001$) and 40 to 59 years ($P<.001$) vs 18 to 39 years but did not differ between 60 years or older and 40 to 59 years ($P=.62$).

Data were generally insufficient (CEV >0.30) for weighted linear regression in individuals aged 18 to 39 years, but the CEV was less than 0.30 for each of the variables in Figure 1 for 1988-1994 and 2007-2008, which allowed performance of a weighted *t* test. Between the first and last NHANES periods, hypertension prevalence did not change ($P=.24$), whereas awareness ($P=.04$), treatment ($P<.001$), the proportion of patients who were treated and whose hypertension was controlled ($P=.004$), and the rate for hypertension control ($P<.001$) increased.

Clinical Epidemiology of Hypertension by Race and Sex

Prevalent hypertension increased over time in black ($P=.04$) and white ($P=.004$) but not Hispanic ($P=.65$) individuals (FIGURE 2). Prevalent hypertension was greater in black vs white ($P<.001$) and Hispanic individuals ($P<.001$) but not different between white and Hispanic groups ($P=.12$). Hypertension awareness increased among black ($P=.006$), white ($P=.04$), and Hispanic ($P=.03$) individuals and was greater in black vs white ($P=.004$) and Hispanic ($P<.001$) individuals and white vs Hispanic individuals ($P=.03$).

The proportion of patients with hypertension receiving treatment increased among black ($P<.001$), white ($P=.008$), and Hispanic ($P=.01$) individuals. The proportion of individuals who were treated for hypertension was greater among black vs white ($P=.009$) and Hispanic ($P<.001$) and higher in white vs Hispanic ($P=.006$). The proportion of patients who were treated and whose hypertension was controlled increased among white ($P=.004$), black ($P=.02$), and Hispanic ($P=.002$) individuals and was higher in white vs black ($P<.001$) and Hispanic ($P=.02$) but not different in black vs Hispanic ($P=.08$).

Controlled hypertension increased over time among white ($P=.007$), black ($P=.008$), and Hispanic ($P=.003$) individuals. Blood pressure control was greater in white vs Hispanic ($P=.004$) individuals but did not differ between black

Table 2. Characteristics of All Patients With Hypertension in NHANES 1988-1994 and 1999-2008[a]

Characteristics	Mean or % (95% Confidence Interval) by Years						*P* for Trend
	1988-1994 (n = 5061)	1999-2000 (n = 1534)	2001-2002 (n = 1616)	2003-2004 (n = 1609)	2005-2006 (n = 1498)	2007-2008 (n = 2057)	
Mean age, y	59.3 (58.4-60.2)	58.2 (56.2-60.3)	58.5 (57.4-59.6)	58.7 (57.6-59.7)	59.1 (56.5-61.8)	58.9 (58.2-59.5)	.86
Sex, %							
Men	48.2 (45.8-50.5)	47.8 (44.2-51.5)	45.1 (42.5-47.6)	49.4 (46.0-52.9)	48.4 (45.8-51.0)	47.8 (45.8-49.8)	.73
Women	51.8 (49.5-54.2)	52.2 (48.5-55.8)	54.9 (52.4-57.5)	50.6 (47.1-54.0)	51.6 (49.0-54.2)	52.2 (50.2-54.2)	
Race/ethnicity, %							
White	77.3 (74.6-79.8)	72.4 (64.8-79)	74.3 (67.9-79.7)	75.7 (66.1-83.2)	75.0 (68.2-80.8)	73.3 (63.8-81.1)	.15
Black	14.4 (12.7-16.2)	12.8 (8.5-18.9)	14.3 (9.4-21.2)	13.4 (8.8-19.8)	14.3 (9.9-20.3)	14.2 (8.9-21.9)	.58
Hispanic	3.4 (2.9-3.9)	11.1 (5.7-20.6)	8.4 (4.4-15.5)	7.5 (3.6-14.7)	6.1 (4.2-8.8)	8.8 (5.6-13.3)	b
Other	5.0 (3.6-6.8)	3.6 (1.7-7.8)	3.0 (2.1-4.4)	3.5 (2.2-5.6)	4.6 (3.1-6.9)	3.8 (2.6-5.6)	b
Mean BP, mm Hg							
Systolic	143.0 (141.9-144.2)	142.6 (140.4-144.8)	141.3 (139.9-142.7)	139.5 (138.1-140.9)	137.9 (136.3-139.4)	135.2 (134.2-136.2)	.02
Diastolic	80.4 (79.6-81.1)	77.9 (76.2-79.5)	77.1 (76.2-78.1)	75.6 (74.1-77.1)	74.6 (73.1-76.0)	74.1 (73.2-75.0)	<.001
BP, mm Hg, %							
≥160/≥100	20.7 (19.0-22.4)	20.5 (16.5-25.2)	19.0 (16.3-22)	17.5 (15.1-20.2)	14.8 (12.2-17.9)	11.5 (10.0-13.2)	.03
140-159/90-99	52.5 (50.7-54.3)	48.5 (45.1-51.8)	45.7 (43.3-48.1)	41.8 (37.8-46.0)	40.4 (36.7-44.3)	38.3 (34.8-42.0)	.002
120-139/80-89	18.7 (17.4-20.1)	22.2 (18.2-26.7)	22.8 (20.7-25.2)	26.9 (23.7-30.4)	28.9 (26.0-31.9)	30.1 (26.9-33.4)	.005
<120/<80	8.1 (7.1-9.3)	8.9 (7.2-10.9)	12.5 (10.1-15.3)	13.7 (11.7-16.2)	15.9 (13.5-18.6)	20.2 (17.3-23.3)	b
Mean BMI	29.0 (28.6-29.4)	30.3 (29.6-30.9)	29.9 (29.3-30.5)	30.0 (29.5-30.6)	30.5 (30.0-31.0)	30.7 (30.3-31.1)	.01
BMI, %							
<25.0	27.2 (25.3-29.3)	20.7 (17.7-23.9)	21.8 (19.7-24.2)	20.5 (17.5-23.8)	21.5 (19.1-24.0)	20.6 (18.3-23.2)	.06
25.0-29.9	36.2 (34.1-38.3)	34.0 (30.7-37.5)	36.5 (32.6-40.5)	35.5 (31.5-39.8)	32.9 (29.7-36.3)	32.9 (29.4-36.6)	.16
≥30.0	36.6 (34.0-39.3)	45.3 (41.8-48.9)	41.7 (38.3-45.2)	44.0 (39.7-48.4)	45.6 (42.8-48.5)	46.5 (43.5-49.5)	.04
Diabetes, %	11.9 (10.8-13.1)	13.6 (11.6-15.9)	14.4 (13.0-16.0)	15.9 (14.0-18.1)	17.2 (15.8-18.6)	19.8 (16.5-23.6)	.006

Abbreviations: BMI, body mass index, calculated as weight in kilograms divided by height in meters squared; BP, blood pressure; NHANES, National Health and Nutrition Examination Survey.

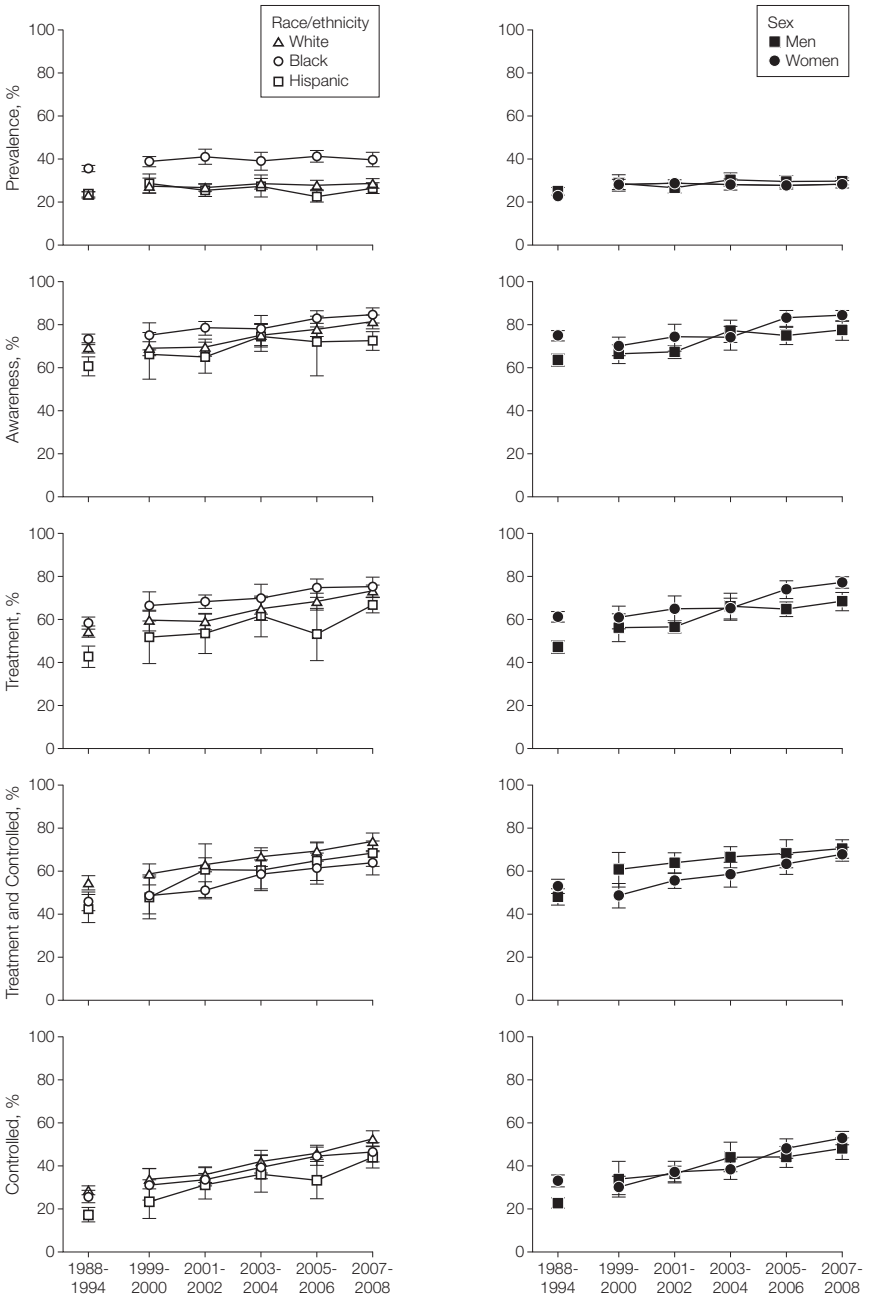
[a] *P* for trend denotes statistical significance over the 6 NHANES between 1988 and 2008. Other race/ethnicity included American Indian, Native Alaskan, Asian or Pacific Islander, and other race not specified.

[b] Cannot be reported because the coefficients of variation was more than 0.3.

vs white ($P=.11$) or black vs Hispanic ($P=.09$) individuals.

Prevalent hypertension increased over time in men ($P=.04$) but not women ($P=.10$) and was not different between men and women ($P=.37$). Hypertension awareness increased with time in men ($P=.04$) but not women ($P=.09$) and was greater in women than men ($P=.007$). Hypertension treatment increased with time in women ($P=.03$) and men ($P=.004$) and was higher in women vs men ($P=.001$). The proportion of patients treated and whose hypertension was controlled increased in men ($P<.001$) but only marginally in women ($P=.05$) and was greater in men vs women ($P=.02$). Controlled hypertension increased with time in women ($P=.04$) and men ($P<.001$) but did not differ between groups ($P=.33$).

Figure 2. Clinical Epidemiology of Hypertension Including Prevalence, Awareness, Treatment, Treatment and Controlled, and Controlled for 1988-1994 and 1999-2008 in 2-Year Blocks by Race and Sex



Data are presented as means with 95% confidence intervals (error bars). For all curves, $P \leq .05$ for change over time between 1988-1994 and 2007-2008, except for prevalent hypertension of Hispanic race ($P=.65$), prevalent hypertension in women ($P=.10$), and hypertension awareness in women ($P=.09$).

COMMENT

Hypertension control improved from 27.3% in 1988-1994 to 50.1% in 2007-2008 (P for trend $=.006$). Hypertension control represents the product of awareness, the proportion of aware patients who were treated, and the proportion of treated patients whose BP was controlled (systolic BP of <140 mm Hg and diastolic BP of <90 mm Hg). The progress in BP control reflected increases in awareness ($P=.03$), treatment ($P=.004$), and proportion of patients with hypertension treated and controlled ($P=.006$).

In 2003, achieving the Healthy People 2010 goal of controlling BP in 50% of all patients with hypertension appeared unlikely,[27] given the relatively limited improvement between 1988-1994 and 1999-2000.[11,12] We proposed that increasing BP control from 31% in 1999-2000[12] to 50% by 2010 could be accomplished with substantial but achievable increases in hypertension awareness, treatment, and proportion of patients with hypertension treated and controlled from 69%, 58%, and 53% in 1999-2000 to 80%, 72%, and 70%, respectively. The 2003 projections closely approximated actual 2007-2008 NHANES mean estimates of awareness (80.7%; 95% CI, 78.1%-83.0%), treatment (72.5%; 95% CI, 70.1%-74.8%), and proportion of patients whose hypertension was treated and controlled (69.1%; 95% CI, 65.7%-72.3%). The improvement in hypertension control from 1999-2008 was significantly greater than from 1988-2000 ($P<.001$).

The increase in hypertension control coincided with a significant decrease of systolic and diastolic BP among patients with hypertension between 1988-1994 and 2007-2008 ($P=.02$ and $P<.001$, respectively). Healthy lifestyles are an unlikely explanation for lower BP and better control among patients with hypertension, because eating patterns became less "DASH-like"[28] and obesity increased over time.[29] Obesity is a characteristic of individuals with treatment-resistant hypertension (ie, BP not controlled by ≥3 antihypertensive medications or controlled by ≥4 BP medications).[30] Despite challenges in controlling BP in patients who are obese, control improved significantly in all obese patients but not in all nonobese patients with hypertension from 1999-2004.[14] In addition to a greater percentage of patients receiving treatment, data suggest that patients with hypertension, especially obese individuals, are receiving more BP medications to explain the increase in proportion of patients who were treated and controlled. Our study did not include detailed treatment analyses to assess this possibility.

Systolic BP decreased over time in individuals with hypertension but increased among individuals without hypertension ($P=.02$). Adverse changes in nutrition and obesity are likely contributors to higher BP among individuals without hypertension.[14,23] The prevalence of hypertension is an important public health concern with a Healthy People 2010 goal of 16%.[9] Prevalent hypertension increased between 1988-1994 and 1999-2000 ($P<.001$), but did not change between 1999-2000 and 2007-2008 ($P=.24$), and remains much higher than the national goal.[9] From one-fifth to four-fifths of the increase in prevalent hypertension between 1988-1994 and 1999-2004 was attributed to higher BMI.[14]

Time trends in hypertension prevalence, awareness, treatment, and control among all individuals with hypertension were documented in most demographic subsets in our study. Sample size was generally inadequate among individuals aged 18 to 39 years for weighted linear regression to assess changes over the 6 NHANES 1988-2008 groups. Sample sizes for this group were adequate for weighted *t* tests comparing 1988-1994 with 2007-2008 and showed significant improvement in the proportion treated ($P<.001$), patients with hypertension treated and controlled ($P=.004$), and the proportion whose hypertension was controlled ($P<.001$). Awareness and treatment were greater in patients with hypertension aged 60 years or older ($P<.001$) and 40 to 59 years ($P<.001$) vs those 18 to 39 years. Our findings coincide with another NHANES report that adults aged 20 to 39 years were less aware of hypertension than older individuals.[31] Poverty and health insurance were not characteristics of individuals who were unaware of their hypertension, although they were more likely to receive only 0 to 1 health care visits in the prior year. In our study, individuals with hypertension aged 18 to 39 years were more likely to attain control when treated vs those 60 years or older ($P<.001$). Data suggest efforts to improve BP control in younger adults should focus on raising awareness and linkage to a primary care medical home.

Among patients aged 60 years or older, hypertension awareness and treatment were relatively high, whereas the proportion of patients with hypertension treated and controlled was lower compared with those 18 to 39 years ($P<.001$) and 40 to 59 years ($P=.008$). Although our study did not focus on treatment details, older age is a key patient characteristic in treatment-resistant hypertension.[30] Strategies for enhancing treatment effectiveness (proportion of patients with hypertension treated and controlled) emerge as an important factor for improving hypertension control among individuals older than 60 years. While BP control is important, treatment of hypertension in older patients reduces cardiovascular events, even when mean treated systolic BP remained higher than 140 mm Hg.[32,33]

Hypertension awareness, treatment, proportion of patients with hypertension treated and controlled, and the proportion with hypertension controlled improved over time in white, black, and Hispanic groups, but significant disparities persist. The greater prevalence of hypertension in black vs white ($P<.001$) or Hispanic ($P<.001$) individuals is well documented.[1,6,11,12] Awareness of hypertension was higher among black vs white ($P=.004$) and Hispanic ($P<.001$) individuals, and white vs Hispanic individuals ($P=.03$). Similarly, treatment rates were higher in black vs white ($P=.009$) and Hispanic ($P=.006$) individuals, and white vs Hispanic ($P=.006$) individuals. A different pattern emerged for the proportion of patients whose hypertension was treated and controlled, with higher rates among white vs black ($P<.001$) or Hispanic ($P=.02$) individuals. Data suggest that initiatives to improve BP control among Hispanic individuals should emphasize screening and referral to a primary care medical home, whereas more emphasis on treatment effectiveness is needed for black individuals.

Hypertension awareness and treatment are higher in women than in men, and the proportion of patients treated and controlled was higher in men vs women. NHANES data suggest that raising hypertension awareness and treatment is important for men, whereas controlling hypertension in patients who are treated is a higher priority for women.

Our study has limitations. Sample size for detecting changes among individuals aged 18 to 39 years was limited and required *t* tests of the first and last NHANES surveys rather than weighted linear regression encompassing all 6 surveys used for all other demographic groups. The guidelines recommend confirming stage 1 (mild) hypertension at follow-up visits.[20-23] Blood pressure on a single NHANES assessment may overestimate prevalent hypertension. Blood pressure was measured by a physician and typically provided higher values than measurements by nurses, which would tend to overestimate prevalent hypertension and underestimate control. Because out-of-office BP is not available in most NHANES participants, we excluded the initial reading, which is of-

ten the highest value, whenever 2 or more BP measurements were available. Blood pressure decreased significantly between first and second reading and between first and mean of the second and third reading, which served to attenuate the physician BP effect. Despite limitations, BP has been consistently measured during NHANES 1988-2008. Methods for assessing prevalence, awareness, treatment, and control were also consistent, which strengthens the validity of comparisons over time.

In conclusion, hypertension control improved, with most of the progress toward the Healthy People 2010 goal of controlling BP in 50% of all individuals with hypertension occurring between 1999 and 2008.[9] However, prevalent hypertension is not decreasing toward the national goal of 16% and will likely remain high unless adverse trends in population nutrition and BMI occur or pharmacological approaches to hypertension prevention are adopted.[28,29,34]

Hypertension control improved, despite adverse changes in nutrition and BMI,[28,29] and reflects increases in awareness, treatment, and patients who were treated attaining target BP, in all individuals with hypertension combined and all age, race, and sex subgroups. However, demographic disparities exist. Broad-based efforts to improve awareness, treatment, and proportion of patients treated and controlled are important for increasing BP control in all groups. Complementary programs to raise awareness and treatment among 18 to 39 years, Hispanic, and male groups and to increase the proportion of patients treated and controlled among 60 years or older, black, and female groups are important for improving hypertension control and reducing disparities.

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Study concept and design: Egan.
Acquisition of data: Zhao.
Analysis and interpretation of data: Egan, Zhao, Axon.
Drafting of the manuscript: Egan, Zhao.
Critical revision of the manuscript for important intellectual content: Egan, Zhao, Axon.
Statistical analysis: Egan, Zhao.
Obtained funding: Egan.
Study supervision: Egan.

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