

Trends in Prevalence, Awareness, Management, and Control of Hypertension Among United States Adults, 1999 to 2010

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- Objectives** The purpose of this study was to quantify the trends in blood pressure (BP), and the prevalence, awareness, management, and control of hypertension in U.S. adults (≥ 20 years of age) from 1999 to 2010, and to assess the efficacy of current clinical measures in diagnosing and adequately treating hypertensive patients.
- Background** Hypertension is a major independent risk factor for cardiovascular disease and stroke. Recent data indicate a decreasing trend in hypertension prevalence, along with improvements in hypertension awareness, management, and control.
- Methods** The study used regression models to assess the trends in hypertension prevalence, awareness, management, and control from 1999 to 2010 among 28,995 male and female adults with BP measurements from a nationally representative sample of the noninstitutionalized U.S. population (National Health and Nutrition Examination Survey [NHANES] 1999 to 2010), with special attention given to 5,764 participants in NHANES 2009 to 2010.
- Results** In 2009 to 2010, the prevalence of hypertension was 30.5% among men and 28.5% among women. The hypertension awareness rate was 69.7% (95% confidence interval [CI]: 62.0% to 77.4%) among men and 80.7% (95% CI: 74.5% to 86.8%) among women. The hypertension control rate was 40.3% (95% CI: 33.7% to 46.9%) for men and 56.3% (95% CI: 49.2% to 63.3%) for women. From 1999 to 2010, the prevalence of hypertension remained stable. Although hypertension awareness, management, and control improved, the overall rates remained poor (74.0% for awareness, 71.6% for management, 46.5% for control, and 64.4% for control in management); worse still, no improvement was shown from 2007 to 2010.
- Conclusions** From 1999 to 2010, prevalence of hypertension remained stable. Hypertension awareness, management, and control were improved, but remained poor; nevertheless, there has been no improvement since 2007. (J Am Coll Cardiol 2012;60:599–606) © 2012 by the American College of Cardiology Foundation

Hypertension has been well recognized as a major independent risk factor for cardiovascular disease and stroke (1). Furthermore, hypertension has had great impact on health outcomes and disparities (2–5). The National Health and Nutrition Examination Survey (NHANES) provided blood pressure (BP) data to track trends in the prevalence of hypertension in U.S. adults (6,7). However, differences in BP measurement techniques made it impossible to precisely quantify trends in BP and hypertension prevalence in early

NHANES cycles (NHANES I, II) (7). The continuous NHANES (from 1999 to 2010) standardized procedures for BP measurement (8), providing an opportunity for precise quantification of trends in the distribution of BP and prevalence of hypertension. Data from early national surveys revealed a decreasing trend in mean systolic blood pressure (SBP) and hypertension prevalence from 1960 to 1980, and from NHANES I (1971 to 1974) to NHANES III Phase 1 (1988 to 1991). Age-adjusted hypertension prevalence decreased by 15.9% from 36.3% to 20.4%, and hypertension awareness, treatment, and control showed an increasing trend during that period (7). However, hypertension prevalence increased from NHANES III (1988 to 1994) to NHANES 1999 to 2000, with no improvement of awareness, management, and control of hypertension (9). Between 1999 to 2000 and 2007 to 2008, prevalent hypertension remained constant (10). In this study, we assessed whether current clinical approaches have been effective in diagnosing and adequately treating hypertensive patients.

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Abbreviations and Acronyms

BMI = body mass index

BP = blood pressure

DBP = diastolic blood pressure

NHANES = National Health and Nutrition Examination Survey

SBP = systolic blood pressure

We reported the trends in BP, and prevalence, awareness, management, and control of hypertension in the U.S. adult population based on NHANES data from 1999 to 2010.

Methods

NHANES. The NHANES is a cross-sectional nationally representative health and nutrition examination survey conducted by

the National Center for Health Statistics. The study was approved by the National Center for Health Statistics Institutional Ethics Review Board, and all adult participants provided written informed consent (11). NHANES maintains high standards to ensure minimal nonsampling and measurement errors during survey planning, data collection, and processing (11). The survey uses a complex, stratified, multistage probability sample to represent the civilian non-institutionalized U.S. population. The NHANES sampling procedure consists of 4 stages: counties, segments, households, and individuals (12). The participant response rate ranged from 72.9% to 78.3% for interviews, and 68.6% to 72.7% for examinations at mobile examination centers (MECs) among adults (≥ 20 years of age) for each survey cycle through 1999 to 2010. In this report, only adult (≥ 20 years of age) participants with complete BP measurements were included for analysis. We assessed progress in hypertension prevention, diagnosis, and treatment using regression models with a 2-year survey cycle treated as a continuous variable.

Definitions. BP was measured by mercury sphygmomanometer using a standardized protocol (8). Mean SBP and mean diastolic blood pressure (DBP) were calculated by averaging 3 to 4 BP measurements. Hypertension was defined as SBP ≥ 140 mm Hg or DBP ≥ 90 mm Hg, or on antihypertensive medication; pre-hypertension was determined as SBP ≥ 120 mm Hg or DBP ≥ 80 mm Hg, but not meeting the criteria for hypertension (13).

Hypertension awareness, management, and control were analyzed in hypertensive participants based on questionnaires and BP measurements. Awareness was defined as having been informed of hypertension diagnosis; management was defined as taking antihypertensive medication or adopting lifestyle modifications (increasing activity or controlling weight); hypertension control was defined as SBP < 140 mm Hg and DBP < 90 mm Hg, and was also analyzed in hypertensive participants who managed their hypertension (control in management).

Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared, and grouped into 3 categories: < 25 kg/m², 25 to 29.9 kg/m² (overweight), and ≥ 30 kg/m² (obesity). Race/ethnicity was self-reported and was classified as non-Hispanic white,

non-Hispanic black, Mexican American, other Hispanic, and other. Age was categorized as 20 to 39, 40 to 59, and 60+ years based on age at the interview. Education status was classed into not completing high school, high school only, and higher education. Poverty income ratio was used to reflect socioeconomic status, and < 1 was determined to be low income and > 1.85 was high income. Smoking status was classed into nonsmoker (smoked < 100 cigarettes lifetime), past smoker, and current smoker.

Statistical analysis. Statistical analyses were carried out with SAS for Windows version 9.2 (SAS Institute, Cary, North Carolina). According to NHANES Analytic and Reporting Guidelines (11,14), all analyses took into account differential probabilities of selection and the complex sample design, and nonresponse and noncoverage by using sample weights and SAS survey analysis procedures. Standard errors were calculated using Taylor series linearization. Age-adjusted values were adjusted to the standard population (the 2000 Census population) by the direct method using the age groups 20 to 39, 40 to 59, and 60+ years. Linear trends in the distributions of mean SBP and DBP, and prevalence, awareness, management, and control of hypertension between 1999 and 2010 were assessed with regression models with a 2-year survey cycle treated as a continuous variable. Statistical significance was determined as 2-sided $p < 0.05$. To further examine trends in SBP and DBP, selected percentiles of SBP and DBP by sex in NHANES 1999 to 2010 were graphed.

Results

Characteristics. In NHANES 2009 to 2010, 6,218 adults were interviewed, 6,059 were examined at MECs, and 5,764 with complete BP values were included for analysis. From 1999 to 2010, 32,464 adults were interviewed, 30,752 were examined, and 28,995 were included for analysis. The demographic characteristics of adult participants are shown in Table 1. The age-adjusted higher education rate was 58.4% in 2009 to 2010, and there was an overall increase from 1999 to 2010 ($p = 0.004$ for trend). Low income prevalence was 15.0% in 1999 to 2000, and decreased to 10.6% in 2005 to 2006, and then increased to 14.6% in 2009 to 2010. Participants (78.8%) were covered by health insurance in 2009 to 2010, with a 3% decrease from 1999 to 2010 ($p = 0.019$ for trend). Obesity prevalence increased from 30.0% to 35.5% from 1999 to 2010 ($p < 0.001$). Current smokers decreased from 23.8% to 20.5% from 1999 to 2010 ($p = 0.017$ for trend), whereas past smokers remained stable at around 24%.

Mean SBP and mean DBP and trends. Mean SBP and DBP from 1999 to 2010 are shown in Table 2. Age-adjusted mean SBP and DBP were 120 (95% CI: 120 to 121) mm Hg and 70 (95% CI: 69 to 71) mm Hg, respectively, in 2009 to 2010, with a 4 mm Hg decrease in SBP and 3 mm Hg decrease in DBP since 1999 to 2000 ($p < 0.001$ for both trends). There was a significant

Table 1 Age-Adjusted Characteristics of U.S. Adults (≥20 Years): NHANES 1999 to 2010

	1999–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010	p Value*
Education status							
<High school	24.5 (21.8–27.2)	19.3 (17.2–21.4)	18.4 (16.0–20.8)	17.6 (14.8–20.4)	20.3 (17.4–23.3)	18.8 (16.9–20.6)	0.004
High school	25.9 (22.2–29.7)	25.7 (23.9–27.4)	27.0 (24.9–29.1)	25.0 (23.2–26.7)	25.2 (22.5–27.8)	22.9 (20.7–25.0)	0.100
Higher education	49.6 (45.2–54.0)	55.1 (51.9–58.2)	54.6 (51.8–57.4)	57.4 (53.5–61.3)	54.5 (49.7–59.4)	58.4 (55.7–61.1)	0.006
Poverty income ratio							
<1.00	15.0 (12.2–17.7)	13.5 (11.8–15.3)	12.6 (10.2–15.1)	10.6 (9.3–12.0)	14.3 (12.0–16.6)	14.6 (12.7–16.6)	0.721
>1.85	64.8 (58.6–71.0)	68.3 (65.5–71.1)	68.7 (65.1–72.4)	73.0 (69.9–76.1)	68.0 (64.3–71.7)	66.8 (64.1–69.5)	0.362
Smoking status							
Nonsmoker	50.6 (47.6–53.6)	50.5 (47.0–54.1)	49.1 (47.3–50.9)	51.2 (48.7–53.7)	52.9 (49.5–56.4)	55.4 (52.2–58.5)	0.012
Past smoker	25.4 (23.3–27.6)	25.2 (22.7–27.8)	25.3 (23.8–26.8)	25.0 (22.9–27.2)	24.0 (22.6–25.4)	24.1 (21.8–26.5)	0.288
Current smoker	23.8 (21.3–26.3)	24.2 (22.0–26.4)	25.6 (23.3–27.8)	23.8 (21.2–26.4)	23.0 (20.1–25.9)	20.5 (19.0–22.0)	0.017
Health insurance							
Currently married	81.8 (79.2–84.5)	83.4 (81.3–85.5)	82.3 (80.7–83.9)	81.0 (77.5–84.4)	80.4 (78.3–82.4)	78.8 (76.9–80.8)	0.019
Currently married	58.5 (53.9–63.1)	58.7 (56.1–61.2)	57.5 (54.6–60.4)	58.0 (55.4–60.6)	56.3 (53.4–59.2)	55.3 (53.5–57.2)	0.076
BMI (kg/m²)							
<25	35.4 (32.3–38.5)	33.3 (32.0–34.6)	33.4 (31.1–35.6)	33.0 (30.3–35.6)	31.8 (30.0–33.6)	31.1 (28.6–33.7)	0.030
25 to <30	33.7 (31.4–36.0)	33.8 (31.9–35.8)	34.0 (31.8–36.2)	32.8 (31.1–34.5)	33.8 (32.1–35.6)	32.8 (30.8–34.7)	0.382
≥30	30.0 (26.9–33.1)	28.6 (26.4–30.8)	31.4 (29.0–33.7)	33.4 (30.5–36.2)	33.4 (31.2–35.6)	35.5 (33.7–37.3)	<0.001

Values are % (95% confidence interval). *p value for linear trend, assessed with regression models, with 2-year survey cycle treated as a continuous variable, and adjusted for sex, ethnicity, and age group. Age adjusted: use the 20 to 39, 40 to 59, and 60+ years age groups to adjust to the 2000 Census population by the direct method. NHANES = National Health and Nutrition Examination Survey.

decrease for both SBP and DBP among both men and women from 1999 to 2010. Selected percentiles of mean SBP and DBP are presented in Figure 1. High percentiles (75th to 95th) of mean SBP >130 mm Hg showed a notable decreasing trend, especially in women. In 1999 to 2010, age explained 21.7% of the variance in mean SBP ($R^2 = 0.217$; $p < 0.001$). Sex, ethnicity, age group, body weight status, education level, income level, smoking status, and marital status were strongly associated with mean SBP. Similar patterns were observed for mean DBP, except that income level became nonsignificant.

Prevalence of hypertension and pre-hypertension and trends. Prevalence of hypertension and pre-hypertension is presented in Table 3. The age-adjusted hypertension prevalence and pre-hypertension + hypertension prevalence were 29.5% (95% CI: 27.7% to 31.4%) and 52.6% (95% CI: 50.1% to 55.0%), respectively, in 2009 to 2010, with no significant improvement since 1999 to 2000. The prevalence of pre-hypertension + hypertension only showed a slight decrease in the 60+ years group and women. No improvement in hypertension prevalence or pre-hypertension + hypertension prevalence was observed among other groups. Throughout 1999 to 2010, the 60+ years group had an almost 9-fold higher hypertension prevalence than the 20- to 39-year-old group (about 60% vs 6%). Hypertension prevalence did not differ by sex; however, women had a much lower prevalence of pre-hypertension than men from 1999 to 2010. Ethnicity, age group, body weight status, education level, health insurance coverage, and income level were strongly associated with hypertension prevalence. There was a higher prevalence for non-Hispanic blacks, the overweight and obese, the elderly, and those covered by health insurance; the prevalence was lower for those with higher education.

Awareness, management, and control of hypertension and trends. Hypertension awareness, management, and control are presented in Table 4. The age-adjusted awareness rate was 74.0% (95% CI: 68.6% to 79.4%) in 2009 to 2010, 69.7% (95% CI: 62.0% to 77.4%) among men, and 80.7% (95% CI: 74.5% to 86.8%) among women. From 1999 to 2010, Mexican Americans had lower awareness compared with non-Hispanic blacks and non-Hispanic whites; the 20- to 39-year-old group had the lowest awareness across sex and ethnic groups. In 2009 to 2010, 71.6% (95% CI: 65.7% to 77.5%) of participants managed their hypertension, and the age-adjusted management rate was 65.5% (95% CI: 57.5% to 73.5%) for men and 81.0% (95% CI: 74.2% to 87.9%) for women. Similar to awareness, Mexican Americans and the 20- to 39-year-old group also had lower management rates. The age-adjusted control rate was 36.8% (95% CI: 34.4% to 39.1%) in 1999 to 2010 and 46.5% (95% CI: 41.1% to 51.9%) in 2009 to 2010. Mexican Americans had the lowest control rate, and non-Hispanic whites had the highest control rate. Older participants tended to have better hypertension control than the younger group, except that non-Hispanic white older women had a lower control rate compared with their younger counterparts. In 1999 to 2010, 64.4% (95% CI: 59.9% to 68.9%) of participants attained BP control when managing their hypertension. Among participants who managed their hypertension from 1999 to 2010, men had lower control rate than women; Mexican Americans and non-Hispanic blacks had lower control rates than non-Hispanic whites; and older people had a lower control rate than middle-aged people.

In 1999 to 2010, sex, ethnicity, age group, body weight status, smoking, and health insurance coverage were all strongly associated with hypertension awareness; the awareness

Table 2 Age-Adjusted Mean SBP and DBP Among U.S. Adults (≥20 Years): NHANES 1999 to 2010

	1999–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010	p Value*
Mean SBP							
All	124 (123–125)	123 (123–124)	123 (122–124)	122 (121–123)	122 (121–122)	120 (120–121)	<0.001
20–39 yrs	115 (113–117)	114 (114–115)	114 (114–115)	115 (114–116)	115 (114–115)	114 (114–115)	0.684
40–59 yrs	123 (122–124)	123 (122–125)	124 (122–125)	123 (122–124)	122 (121–123)	120 (119–122)	0.001
60+ yrs	141 (139–143)	140 (138–142)	137 (135–139)	135 (133–137)	133 (132–135)	131 (130–132)	<0.001
Male	125 (124–127)	124 (123–125)	124 (123–126)	124 (123–125)	124 (123–124)	123 (122–123)	0.005
NH white	124 (123–126)	123 (122–125)	124 (122–125)	124 (122–125)	123 (122–124)	122 (122–123)	0.030
NH black	129 (127–130)	130 (129–130)	128 (126–130)	129 (128–130)	126 (124–128)	127 (124–129)	0.031
Mex Am	127 (125–128)	124 (122–126)	124 (122–126)	123 (122–125)	125 (122–128)	125 (124–126)	0.905
Female	123 (121–124)	123 (122–123)	122 (121–123)	121 (120–122)	120 (119–120)	118 (117–119)	<0.001
NH white	121 (120–123)	122 (121–123)	121 (120–122)	120 (119–121)	119 (118–120)	117 (116–118)	<0.001
NH black	128 (126–130)	128 (126–130)	127 (125–130)	126 (124–127)	125 (123–126)	123 (121–126)	0.001
Mex Am	123 (122–125)	121 (121–122)	124 (122–126)	121 (118–123)	120 (117–122)	120 (119–121)	0.002
Mean DBP							
All	73 (72–74)	72 (71–73)	71 (71–72)	70 (70–71)	71 (70–72)	70 (69–71)	<0.001
20–39 yrs	71 (70–72)	70 (69–71)	69 (68–70)	68 (67–69)	69 (68–70)	69 (67–70)	0.001
40–59 yrs	76 (76–77)	76 (75–77)	76 (75–77)	75 (74–76)	75 (74–76)	73 (72–75)	<0.001
60+ yrs	71 (69–72)	70 (69–71)	68 (67–69)	67 (66–68)	68 (68–69)	66 (65–67)	<0.001
Male	75 (74–76)	74 (73–74)	72 (72–73)	72 (71–72)	73 (72–73)	72 (70–73)	<0.001
NH white	75 (74–76)	74 (73–74)	72 (72–73)	71 (71–72)	73 (72–74)	71 (70–72)	<0.001
NH black	76 (75–78)	76 (74–77)	74 (73–75)	74 (73–75)	74 (72–75)	73 (70–75)	0.003
Mex Am	75 (74–76)	72 (70–73)	71 (70–72)	70 (69–71)	72 (71–74)	71 (70–73)	0.118
Female	71 (70–72)	71 (70–72)	70 (69–71)	69 (68–70)	69 (69–70)	68 (67–69)	<0.001
NH white	70 (69–71)	71 (69–72)	70 (69–71)	69 (68–70)	70 (69–71)	68 (67–69)	<0.001
NH black	73 (72–74)	73 (72–74)	72 (70–73)	70 (69–72)	70 (69–71)	71 (69–73)	0.003
Mex Am	70 (69–71)	70 (69–71)	70 (69–71)	68 (67–69)	68 (66–69)	67 (65–68)	<0.001

Values are mm Hg (95% confidence interval). *p value for linear trend, assessed with regression models, with 2-year survey cycle treated as a continuous variable, and adjusted for sex, ethnicity, and/or age group when appropriate. Age-adjusted: use the 20 to 39, 40 to 59, and 60+ years age groups to adjust to the 2000 Census population by the direct method.

DBP = diastolic blood pressure; Mex Am = Mexican American; NH = non-Hispanic; SBP = systolic blood pressure; other abbreviations as in Table 1.

rate was lower in men, Mexican Americans, the younger group, those with normal body weight, and no health insurance, but higher in past smokers. The same pattern was observed in hypertension management and control. Additionally, marital status was also strongly associated with hypertension control, with currently married persons having better control rates. Overall, awareness, management, and control of hypertension were significantly increased from 1999 to 2010. However, awareness, management, and control rates remained poor in 2009 to 2010, with rates of 74.0% for awareness, 71.6% for management, 46.5% for control, and 64.4% for control in management. Compared with 2007 to 2008, hypertension prevalence and pre-hypertension + hypertension prevalence remained constant ($p = 0.36$ for both) in 2009 to 2010, and both men and women showed no improvement. Hypertension awareness, management, control, and control in management also showed no improvement ($p = 0.89, 0.21, 0.92,$ and $0.095,$ respectively), which was evident among both men and women.

Discussion

From 1999 to 2010, age-adjusted mean SBP decreased by 4 mm Hg ($p < 0.001$ for trend), especially for women (5 mm Hg; $p < 0.001$ for trend). Mean DBP displayed a similar pattern, with a significant decrease of 3 mm Hg ($p < 0.001$ for trend), and was significant for both men and women

($p < 0.001$ for both). Prevalence of hypertension among U.S. adults (≥20 years old) remained at a high level of around 30%, whereas pre-hypertension prevalence decreased in non-Hispanic black men (5.7%; $p = 0.023$ for trend). Awareness, management, and control of hypertension were significantly improved in almost all sex/ethnic groups, but remained poor, and did not improve from 2007 to 2010. Therefore, effective prevention, detection, management, and control of hypertension should continue to be important goals for health policy, public health, and medical care decision makers, as well as advocates and individuals at risk for hypertension (15).

Trends in mean SBP and DBP. Our findings on trends in mean SBP and mean DBP, and prevalence of hypertension were consistent with other studies (10,15). From 1999 to 2010, mean SBP and mean DBP both decreased significantly by 4 and 3 mm Hg, respectively (both trends, $p < 0.001$). It was reported (10) from 1988 to 2008 that SBP decreased in individuals with hypertension, but increased among individuals without hypertension ($p = 0.02$), which might have been caused by the adverse diet and lifestyle of nonhypertensive people. In our study, we found that mean SBP did not decrease among nonhypertensive participants ($p = 0.173$ for all, $p = 0.268$ for men, and $p = 0.274$ for women), but mean DBP showed a 2 mm Hg decrease

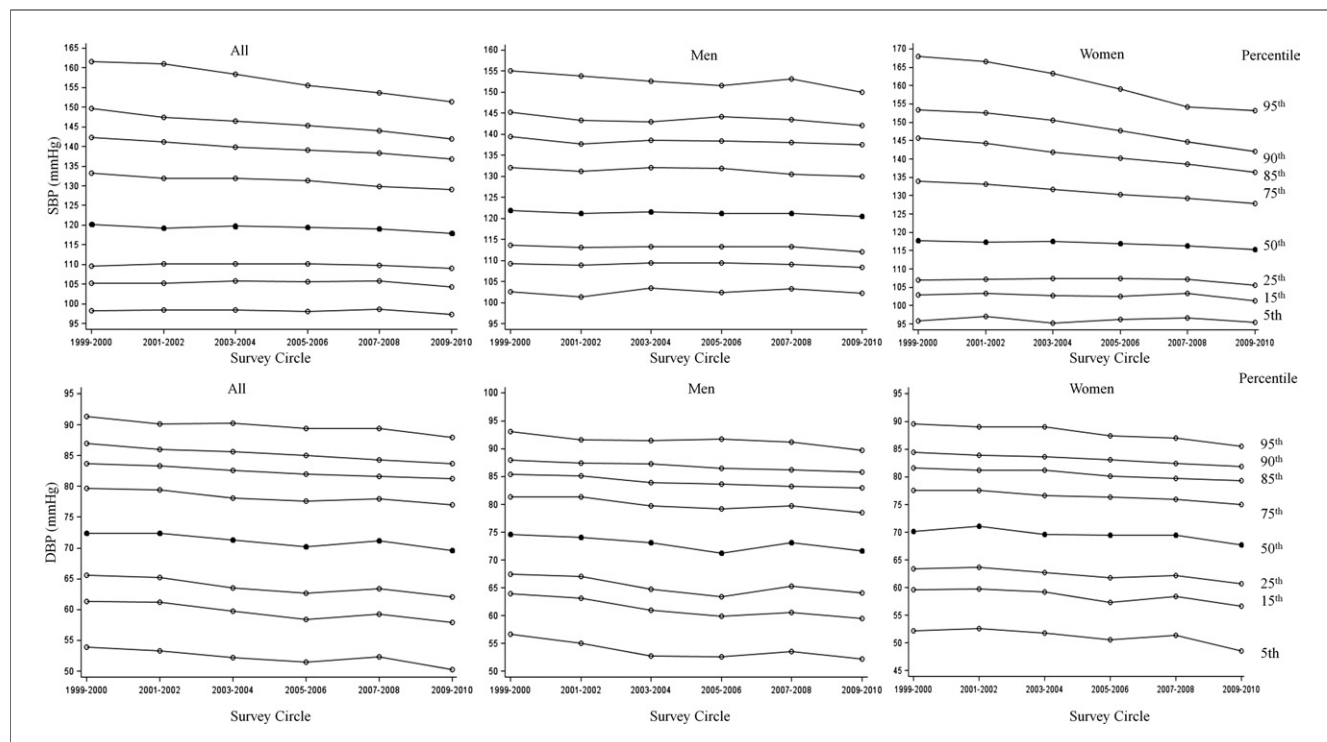


Figure 1 Select Percentiles for Mean SBP and DBP Among U.S. Adults From 1999 to 2010

High percentiles (75th to 95th) of mean systolic blood pressure (SBP) >130 mm Hg showed a notable decreasing trend, especially in women. DBP = diastolic blood pressure.

($p < 0.001$ for all, and men and women) from 1999 to 2010. The high percentiles (75th to 95th) of mean SBP >130 mm Hg showed a notable decreasing trend, especially in women, whereas lower percentiles did not decrease, reflecting the improvement in hypertension control from 1999 to 2010, which brought down BP among hypertensive people. The relatively stable trends in lower percentiles also suggested that prevalence of hypertension had no improvement, and prevention of hypertension had little success.

Trends in prevalence of hypertension and pre-hypertension. Despite the downward trends in mean SBP and mean DBP, hypertension prevalence remained constantly high, affecting 30% of the U.S. adult (≥ 20 years of age) population in 1999 to 2010. This stable trend was consistent with other studies (10,15,16). We also found that ethnicity, age group, body weight status, education level, and marital status were strongly associated with hypertension prevalence. Increased hypertension prevalence was observed in non-Hispanic blacks, the overweight and obese group, those with lower education, and participants not currently married. Flegal et al. (17–19) showed that obesity prevalence remained stable, with a possible slight increase from 1999 to 2010. From 1999 to 2010, among participants with complete BP measurements, obesity prevalence increased by 5.5% ($p < 0.001$ for trend) from 30.0% (95% CI: 26.9% to 33.1%) to 35.5% (95% CI: 33.7% to 37.3%), which might partially explain the lack of improvement in hypertension prevalence. Factors

other than obesity were also likely to contribute to the adverse trend in hypertension prevalence, such as increasing consumption of dietary sodium, the increasingly sedentary lifestyle, and the suboptimal levels of health literacy among the general U.S. population (20,21). Therefore, improving diet and lifestyle (10,22) for the entire population might have some impact on improving hypertension prevention (23) and help to reverse the adverse trend in hypertension prevalence.

Trends in awareness, management, and control of hypertension. There were significant improvements in awareness, management, and control of hypertension from 1999 to 2010 in almost all gender/ethnicity groups. However, non-Hispanic black and Mexican-American women did not show any significant increase in awareness ($p = 0.182$ and $p = 0.076$, respectively), and non-Hispanic black men showed no significant increase in control in management ($p = 0.707$). Nonetheless, the awareness, management, and control rates remained poor in 2009 to 2010 (74.7% for awareness, 72.3% for management, 45.1% for control, and 61.9% for control in management); what is worse, these rates showed no improvement from 2007 to 2010. These subtle improvements can be ascribed to the heavy campaign of programs, guidelines, and policies to facilitate hypertension prevention, detection and/or awareness, treatment, and control by several national initiatives (24–27), although it also reflected the relatively small success achieved by these initiatives. Additionally, disparities were evident among sex, age groups, and ethnicity. Men, young

Table 3 Age-Adjusted Prevalence of Hypertension and Pre-Hypertension among U.S. Adults (≥20 Years): NHANES 1999 to 2010

	1999–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010	p Value*
Hypertension							
All	29.6 (26.7–32.4)	29.0 (27.3–30.8)	30.7 (28.5–32.9)	29.9 (28.0–31.8)	30.6 (29.2–32.0)	29.5 (27.7–31.4)	0.763
20–39 yrs	7.6 (4.5–10.7)	6.7 (5.6–7.8)	7.2 (5.6–8.8)	7.3 (5.4–9.1)	8.2 (6.4–9.9)	7.0 (5.5–8.6)	0.862
40–59 yrs	30.2 (26.3–34.1)	29.3 (25.6–33.0)	33.1 (28.7–37.5)	31.2 (27.6–34.8)	32.2 (29.7–34.7)	30.3 (26.3–34.3)	0.696
60+ yrs	66.1 (62.2–69.9)	66.9 (63.4–70.4)	67.2 (63.9–70.5)	66.5 (63.3–69.8)	66.5 (62.9–70.0)	66.7 (63.1–70.2)	0.948
Male	29.1 (24.9–33.2)	27.6 (25.1–30.1)	31.6 (28.5–34.6)	30.7 (28.1–33.4)	31.2 (29.6–32.7)	30.5 (27.9–33.1)	0.218
NH white	28.1 (23.3–33.0)	26.4 (24.1–28.7)	30.8 (27.0–34.6)	30.2 (26.9–33.4)	31.4 (29.2–33.5)	29.8 (26.4–33.1)	0.141
NH black	38.0 (35.3–40.7)	41.2 (37.9–44.5)	39.8 (35.8–43.9)	42.4 (36.8–48.0)	38.9 (33.5–44.3)	39.6 (37.1–42.2)	0.676
Mex Am	27.4 (23.8–30.9)	23.1 (19.7–26.5)	27.1 (23.2–31.0)	21.1 (17.7–24.5)	27.6 (22.2–33.0)	26.3 (22.5–30.2)	0.882
Female	29.7 (27.4–32.0)	30.1 (28.4–31.7)	29.7 (27.3–32.0)	28.9 (27.2–30.5)	29.9 (28.2–31.6)	28.5 (26.6–30.3)	0.286
NH white	27.4 (24.3–30.6)	28.5 (26.6–30.5)	28.2 (25.5–30.9)	27.0 (25.2–28.9)	28.7 (26.1–31.4)	26.9 (24.1–29.7)	0.529
NH black	40.8 (37.6–44.1)	42.6 (37.9–47.3)	41.7 (37.3–46.1)	42.4 (39.7–45.1)	43.8 (40.2–47.3)	43.1 (37.8–48.4)	0.382
Mex Am	27.8 (24.2–31.4)	23.7 (21.8–25.6)	29.5 (25.4–33.6)	23.2 (19.7–26.6)	26.0 (23.3–28.7)	27.7 (25.0–30.3)	0.637
Pre-hypertension + hypertension							
All	55.8 (52.7–59.0)	54.0 (52.0–56.0)	55.7 (53.2–58.1)	54.9 (52.3–57.5)	54.2 (51.7–56.7)	52.6 (50.1–55.0)	0.128
20–39 yrs	33.5 (28.4–38.5)	30.3 (27.7–32.8)	30.2 (27.1–33.2)	32.4 (28.8–35.9)	31.4 (27.5–35.3)	31.0 (29.2–32.9)	0.707
40–59 yrs	59.2 (54.1–64.3)	58.4 (54.6–62.2)	63.7 (59.5–68.0)	60.8 (57.1–64.5)	58.4 (54.5–62.3)	56.0 (51.5–60.6)	0.262
60+ yrs	88.7 (86.4–91.0)	87.6 (85.1–90.1)	86.3 (83.9–88.8)	83.9 (80.3–87.6)	86.4 (84.5–88.2)	83.8 (80.7–87.0)	0.011
Male	62.6 (58.0–67.1)	59.1 (55.2–63.0)	61.7 (58.0–65.5)	61.7 (58.7–64.7)	60.6 (57.4–63.8)	59.7 (56.8–62.6)	0.557
NH white	61.2 (55.8–66.5)	58.1 (54.3–62.0)	61.7 (57.0–66.5)	60.9 (56.9–64.8)	61.4 (57.8–65.1)	59.9 (56.2–63.6)	0.915
NH black	70.2 (65.1–75.3)	72.5 (69.0–75.9)	68.4 (63.0–73.8)	73.6 (69.2–78.0)	65.4 (59.8–71.0)	66.1 (61.8–70.4)	0.080
Mex Am	64.2 (58.6–69.7)	56.2 (51.0–61.5)	54.3 (47.0–61.6)	58.1 (53.6–62.6)	60.5 (51.2–69.8)	59.4 (55.4–63.4)	0.930
Female	48.9 (46.4–51.4)	48.9 (47.0–50.8)	49.5 (47.4–51.7)	48.1 (45.3–50.9)	47.8 (45.3–50.2)	45.4 (42.8–48.0)	0.025
NH white	46.8 (43.4–50.1)	47.1 (44.6–49.6)	47.7 (45.1–50.3)	47.5 (43.8–51.3)	46.4 (42.9–50.0)	43.5 (40.4–46.5)	0.079
NH black	59.3 (55.4–63.2)	60.7 (57.8–63.6)	61.2 (57.2–65.2)	59.8 (55.9–63.7)	59.4 (53.7–65.1)	62.5 (55.7–69.2)	0.625
Mex Am	48.1 (45.2–51.0)	42.6 (39.4–45.8)	48.6 (44.4–52.9)	42.7 (37.5–48.0)	43.8 (35.4–52.3)	43.4 (40.8–46.1)	0.156

Values are % (95% confidence interval). *p value for linear trend, assessed with regression models, with 2-year survey cycle treated as a continuous variable, and adjusted for sex, ethnicity, and/or age group when appropriate. Age-adjusted: use the 20 to 39, 40 to 59, and 60+ years age groups to adjust to the 2000 Census population by the direct method. Abbreviations as in Tables 1 and 2.

people, and Mexican Americans had lower hypertension awareness, management, and control rates. For men, the middle-aged group had a better control rate. However, in non-Hispanic whites and Mexican Americans, control rates decreased with age. For participants who managed their hypertension, Mexican Americans and non-Hispanic blacks had lower control rates compared with non-Hispanic whites, and older people had lower control rates than younger and middle-aged people. Age-related differences in control might be explained by increased prevalence of treatment-resistant hypertension in older people (28). Because hypertension is a major risk factor for cardiovascular events in the elderly, improving control in this population would be extremely beneficial (29,30). These findings suggest that public health efforts should be directed toward increasing awareness, management, and control among men, Mexican Americans, and young people, while increasing control and treatment of hypertension in minority groups and older people. Behavioral telephone intervention and home BP monitoring were found to be effective to promote BP control in a clinical trial by Bosworth et al. (31), and more large randomized trials would further validate the efficacy of such intervention.

Clinical implications. Our findings had several clinical implications. First, there was no improvement in hypertension prevalence. To decrease hypertension prevalence, effec-

tive population-based strategies should be taken for hypertension prevention through advocating healthful eating and lifestyle in the entire population. Preventive population-level interventions tailored to the built environment and the food environment might lead to health benefits for the entire population (18). Second, awareness, management, and control of hypertension remained poor, with no improvement from 2007 to 2010. Therefore, strategies should be initiated to further improve hypertension detection, treatment, and control, especially in minority groups. Additionally, men, Mexican Americans, and 20 to 39 year olds had lower hypertension awareness, management, and control rates. Non-Hispanic blacks, Mexican Americans, and older people were less likely to achieve BP control when treating hypertension, suggesting that more efforts should be made to increase hypertension detection, management, and control in men, Mexican Americans, and the younger group, and to increase hypertension control among minority and elderly patients receiving hypertension treatment.

Study limitations. Our report had the following limitations: low hypertension prevalence and small sample size in the younger group (20 to 39 years old) in each 2-year survey cycle made it impossible to perform trend analysis in any 20- to 39-year-old gender/ethnicity subgroups. Hispanics other

Table 4 Age-Adjusted Awareness, Management, and Control of Hypertension Among U.S. Adult Hypertensive Participants: NHANES 1999 to 2010

	1999–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010	p Value*
Awareness							
All	63.8 (57.2–70.4)	63.7 (60.0–67.3)	67.7 (61.8–73.6)	69.2 (64.6–73.8)	74.6 (67.8–81.5)	74.0 (68.6–79.4)	<0.001
20–39 yrs	51.4 (36.2–66.5)	50.0 (43.4–56.7)	54.0 (41.1–66.9)	52.4 (42.6–62.3)	65.5 (50.1–80.9)	58.8 (47.4–70.3)	0.165
40–59 yrs	73.1 (67.2–79.1)	72.1 (66.7–77.5)	75.1 (69.7–80.5)	79.2 (74.7–83.7)	79.1 (74.3–83.8)	84.1 (80.4–87.7)	<0.001
60+ yrs	70.0 (66.3–73.8)	73.4 (70.9–76.0)	79.3 (75.5–83.2)	81.9 (78.6–85.1)	83.2 (80.4–85.9)	84.0 (80.8–87.1)	<0.001
Male	63.3 (57.6–69.0)	56.8 (53.5–60.0)	68.2 (62.3–74.0)	64.2 (59.4–68.9)	68.6 (60.5–76.6)	69.7 (62.0–77.4)	<0.001
NH white	66.0 (60.6–71.3)	57.1 (49.9–64.4)	69.9 (61.5–78.3)	63.3 (56.2–70.4)	72.2 (62.0–82.5)	68.9 (57.3–80.4)	<0.001
NH black	59.4 (44.3–74.6)	67.5 (58.4–76.7)	59.8 (46.2–73.3)	65.3 (57.6–73.1)	61.7 (51.4–72.0)	82.7 (73.4–92.0)	0.002
Mex Am	45.9 (35.1–56.7)	34.0 (27.9–40.0)	67.3 (52.3–82.3)	58.0 (44.5–71.5)	58.1 (52.9–63.3)	62.0 (48.7–75.3)	0.003
Female	61.0 (50.7–71.4)	74.9 (68.4–81.4)	68.6 (58.2–79.1)	84.5 (76.2–92.7)	83.4 (78.2–88.6)	80.7 (74.5–86.8)	<0.001
NH white	59.9 (47.4–72.4)	75.0 (62.4–87.7)	68.2 (52.4–83.9)	91.4 (88.3–94.5)	83.8 (76.6–91.1)	80.2 (71.9–88.4)	<0.001
NH black	75.2 (61.7–88.7)	84.6 (78.7–90.5)	73.0 (59.7–86.4)	84.6 (71.7–97.6)	86.4 (79.2–93.6)	81.5 (69.2–93.8)	0.182
Mex Am	61.1 (39.7–82.4)	58.0 (46.1–69.9)	51.5 (37.8–65.2)	73.7 (50.2–97.2)	66.3 (55.3–77.3)	67.0 (51.5–82.5)	0.076
Management							
All	56.9 (51.3–62.6)	56.2 (53.9–58.5)	59.8 (53.5–66.2)	61.2 (57.5–64.9)	66.9 (62.6–71.2)	71.6 (65.7–77.5)	<0.001
20–39 yrs	37.6 (26.7–48.4)	40.6 (36.0–45.3)	41.4 (26.4–56.4)	38.8 (29.1–48.4)	51.7 (41.8–61.7)	54.7 (43.0–66.4)	0.014
40–59 yrs	70.5 (65.5–75.5)	62.7 (58.0–67.3)	68.2 (61.7–74.8)	73.2 (69.5–76.9)	73.0 (67.7–78.3)	81.1 (76.8–85.3)	<0.001
60+ yrs	68.3 (62.6–74.1)	72.4 (68.6–76.2)	77.9 (75.0–80.7)	80.3 (77.3–83.3)	83.0 (80.0–86.1)	85.3 (82.6–88.0)	<0.001
Male	53.5 (47.0–59.9)	49.7 (46.9–52.5)	58.4 (52.1–64.7)	56.2 (51.6–60.9)	60.0 (54.2–65.8)	65.5 (57.5–73.5)	<0.001
NH white	57.1 (50.2–64.0)	49.8 (43.8–55.8)	59.9 (51.1–68.8)	55.8 (49.1–62.6)	62.4 (54.9–70.0)	64.7 (53.0–76.4)	<0.001
NH black	46.8 (36.4–57.2)	53.4 (46.6–60.2)	53.7 (41.4–66.0)	60.4 (52.5–68.3)	59.6 (48.2–71.0)	72.6 (61.6–83.5)	<0.001
Mex Am	40.7 (26.7–54.7)	25.9 (22.4–29.3)	51.6 (36.8–66.5)	48.2 (35.2–61.1)	54.5 (46.1–62.8)	55.6 (40.1–71.1)	0.006
Female	61.6 (56.0–67.2)	66.4 (60.2–72.6)	64.1 (54.2–74.1)	78.8 (71.6–85.9)	76.6 (71.7–81.5)	81.0 (74.2–87.9)	<0.001
NH white	64.5 (57.9–71.2)	65.0 (50.9–79.1)	64.4 (49.9–78.9)	88.2 (85.3–91.0)	75.8 (66.5–85.1)	80.4 (71.7–89.1)	<0.001
NH black	65.6 (52.7–78.6)	72.6 (64.5–80.7)	65.4 (53.8–77.1)	77.8 (67.1–88.5)	79.3 (74.0–84.7)	85.8 (73.8–97.7)	0.002
Mex Am	52.6 (31.5–73.7)	48.1 (35.2–61.0)	51.6 (41.5–61.6)	66.8 (42.5–91.2)	64.2 (54.2–74.2)	66.6 (53.0–80.2)	0.001
Control							
All	27.5 (22.6–32.4)	33.6 (29.8–37.3)	36.6 (29.3–43.9)	37.6 (33.5–41.7)	46.1 (40.4–51.9)	46.5 (41.1–51.9)	<0.001
20–39 yrs	14.7 (8.8–20.7)	30.0 (22.3–37.6)	30.3 (15.3–45.3)	24.5 (15.9–33.1)	41.2 (29.5–53.0)	33.0 (23.0–43.0)	0.003
40–59 yrs	41.2 (34.6–47.7)	37.1 (31.9–42.2)	41.1 (33.6–48.5)	47.4 (42.6–52.1)	49.9 (45.1–54.7)	55.7 (51.0–60.5)	<0.001
60+ yrs	27.4 (22.7–32.0)	34.1 (31.3–37.0)	40.4 (36.5–44.2)	44.6 (40.1–49.1)	48.4 (44.4–52.5)	54.9 (50.9–58.9)	<0.001
Male	28.3 (22.0–34.7)	28.2 (24.0–32.4)	37.1 (29.6–44.5)	34.3 (29.8–38.8)	40.9 (34.8–47.0)	40.3 (33.7–46.9)	<0.001
NH white	32.3 (26.1–38.4)	29.9 (24.0–35.8)	39.3 (28.9–49.8)	35.0 (27.8–42.3)	45.0 (38.5–51.5)	42.8 (35.6–50.1)	<0.001
NH black	22.7 (14.0–31.4)	28.1 (23.2–33.1)	29.8 (21.9–37.7)	32.4 (24.9–40.0)	31.5 (22.0–41.0)	36.2 (24.8–47.6)	0.009
Mex Am	11.3 (8.6–14.0)	9.9 (5.4–14.5)	31.7 (21.2–42.2)	29.1 (19.6–38.6)	37.2 (30.8–43.6)	22.7 (15.5–29.9)	<0.001
Female	27.6 (20.9–34.3)	43.9 (36.9–50.8)	38.7 (27.8–49.6)	52.1 (41.9–62.2)	54.0 (46.1–61.9)	56.3 (49.2–63.3)	<0.001
NH white	29.3 (19.7–38.9)	47.1 (32.9–61.4)	41.5 (25.4–57.6)	70.4 (68.6–72.2)	58.5 (48.7–68.4)	60.1 (50.1–70.1)	<0.001
NH black	23.2 (16.4–30.0)	37.9 (29.8–45.9)	33.0 (25.6–40.4)	44.9 (34.5–55.3)	47.6 (38.4–56.9)	49.8 (40.2–59.4)	<0.001
Mex Am	31.4 (10.7–52.1)	31.0 (16.2–45.8)	26.9 (15.3–38.6)	30.8 (11.1–50.4)	36.9 (16.2–57.6)	38.4 (19.4–57.3)	<0.001
Control in management							
All	46.5 (38.6–54.5)	62.1 (55.5–68.8)	63.4 (56.0–70.8)	62.0 (55.5–68.4)	70.5 (64.9–76.1)	64.4 (59.9–68.9)	<0.001
20–39 yrs	39.2 (23.4–55.1)	73.8 (57.4–90.1)	73.1 (58.3–87.9)	63.2 (48.2–78.1)	79.7 (67.2–92.1)	60.4 (50.2–70.6)	0.087
40–59 yrs	58.4 (50.6–66.1)	59.1 (54.0–64.3)	60.2 (53.4–66.9)	64.7 (58.3–71.1)	68.4 (64.4–72.4)	68.8 (64.1–73.4)	<0.001
60+ yrs	40.0 (34.5–45.6)	47.1 (44.3–49.9)	51.9 (46.9–56.8)	55.5 (51.2–59.9)	58.3 (54.2–62.5)	64.4 (61.1–67.6)	<0.001
Male	50.7 (39.7–61.7)	57.7 (47.2–68.2)	65.4 (57.5–73.2)	60.4 (50.7–70.2)	69.8 (63.6–76.0)	59.9 (52.9–66.8)	0.001
NH white	54.0 (41.2–66.7)	60.9 (48.3–73.5)	67.1 (55.0–79.1)	62.9 (48.2–77.5)	74.1 (68.1–80.0)	65.0 (57.2–72.8)	0.006
NH black	46.2 (22.5–69.9)	55.2 (42.0–68.4)	55.9 (40.6–71.3)	53.7 (42.9–64.5)	51.5 (35.5–67.5)	49.7 (30.0–69.4)	0.707
Mex Am	22.2 (17.0–27.4)	49.2 (24.0–74.4)	57.7 (48.8–66.7)	55.0 (28.4–81.5)	69.4 (55.7–83.2)	38.5 (24.9–52.1)	0.045
Female	43.4 (29.8–57.1)	67.4 (61.1–73.7)	61.8 (52.3–71.3)	66.1 (56.9–75.4)	71.2 (64.0–78.4)	69.4 (63.6–75.3)	0.001
NH white	41.3 (19.5–63.1)	74.4 (71.4–77.3)	65.7 (54.1–77.2)	77.8 (74.9–80.7)	78.7 (76.6–80.8)	74.8 (66.1–83.5)	<0.001
NH black	33.9 (20.8–47.0)	53.1 (41.3–64.9)	48.2 (32.9–63.6)	57.9 (44.7–71.0)	60.3 (49.6–71.0)	57.9 (52.0–63.8)	<0.001
Mex Am	62.2 (52.7–71.7)	72.3 (63.3–81.3)	66.1 (59.2–73.0)	47.6 (26.5–68.8)	56.6 (26.1–87.0)	59.7 (32.8–86.5)	0.031

Values are % (95% confidence interval). *p value for linear trend, assessed with regression models, with 2-year survey cycle treated as a continuous variable, and adjusted for sex, ethnicity, and/or age group when appropriate. Age-adjusted: use the 20 to 39, 40 to 59, and 60+ years age groups to adjust to the 2000 Census population by the direct method.

Abbreviations as in Tables 1 and 2.

than Mexican Americans were not over sampled in 1999 to 2006, and any analysis on Hispanic groups before 2007 to 2008 was unreliable; thus, we only reported trends in Mexican Americans.

Conclusions

In 2009 to 2010, the prevalence of hypertension was 30.5% among men and 28.5% among women. From 1999 to 2010, hypertension prevalence remained constantly high; hypertension awareness, management, and control were significantly improved, but remained poor, and did not improve from 2007 to 2010. Strategies should be taken to improve hypertension prevention in the whole population, to increase hypertension detection, management, and control among men, Mexican Americans, and young people, and to increase control of hypertension among older people and minority groups receiving hypertension treatment.

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