Trends in Hypertension Prevalence, Awareness, Treatment, and Control in Older U.S. Adults: Data from the National Health and Nutrition Examination Survey 1988 to 2004

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OBJECTIVES: To describe hypertension trends in U.S. adults aged 60 and older using National Health and Nutrition Examination Survey (NHANES) data.

SETTING: NHANES III (1988–1994) and NHANES 1999 to 2004.

DESIGN: Cross-sectional nationally representative health examination survey.

PARTICIPANTS: Participants in NHANES III (n = 5,093) and NHANES 1999 to 2004 (n = 4,710).

MEASUREMENTS: Blood pressure (BP).

RESULTS: In 1999 to 2004, 67% of U.S. adults aged 60 and older years were hypertensive, an increase of 10% from NHANES III. Between 1988 to 1994 and 1999 to 2004, hypertension control increased for men from 39% to 51% ($P < .05$) but remained unchanged for women (35% to 37%; $P > .05$). Non-Hispanic black men and women had higher prevalences of hypertension than non-Hispanic whites (odds ratio (OR) = 2.54, 95% confidence interval (CI) = 1.90–3.40 and OR = 2.07, 95% CI = 1.31–3.26, respectively), but men were less likely to have controlled BP (OR = 0.60, 95% CI = 0.41–0.86). Mexican-American men and women were less likely than non-Hispanic whites to have controlled BP (OR = 0.55, 95% CI = 0.33–0.91 and OR = 0.63, 95% CI = 0.40–0.98, respectively). Women and men aged 70 and older were significantly less likely to control their hypertension than those aged 60 to 69. In addition, women aged 70 and older were significantly less aware and treated. Having BP measured within 6 months was significantly associated with greater awareness, greater treatment in men and women, and greater control in women. A history of diabetes mellitus or chronic kidney disease (CKD) was significantly associated with less hypertension control.

CONCLUSION: There was a significant increase in hypertension prevalence from 1988 to 2004. Hypertension control continues to be problematic for women, persons aged 70 and older, non-Hispanic blacks and Mexican Americans, and individuals with diabetes mellitus and CKD. **J Am Geriatr Soc 55:1056–1065, 2007.**

Key words: hypertension; prevalence; therapy; prevention and control; aged; JNC 7; NHANES

High blood pressure (BP) is a modifiable risk factor for cardiovascular disease (CVD). The higher the BP, the greater the risks are for heart attack, heart failure, stroke, and kidney disease.[1–3] Conversely, lower BP was associated with greater probability of survival to age 85 and survival to age 85 free of major comorbidities.[4] The prevalence of hypertension increases with age; for example, 13% of non-Hispanic white men aged 70 to 79 had stage 2 hypertension according to Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 5) criteria (systolic BP 160–179 mmHg, diastolic BP 100–109 mmHg), versus just 7% of non-Hispanic white men aged 50 to 59.[1] One study, using Framingham Heart Study data, showed that the residual lifetime risk for developing hypertension was 90% in participants aged 55 and 65.[5] The age-related increase was mainly in systolic hypertension, especially isolated systolic hypertension (systolic BP $\geq$140 mmHg and diastolic BP $<$90 mmHg).[6,7]

Age; sex; race/ethnicity; socioeconomic factors; access to and use of health care; and risk factors such as diabetes mellitus, chronic kidney disease (CKD), CVD, and obesity influence hypertension control and awareness rates.[8–13] Of the risk factors, JNC 7 singles out diabetes mellitus and CKD for a more-stringent definition of hypertension control (levels of 130/80 mmHg), because both are strongly linked to all CVDs.[1]

The objectives of the present study were twofold. The first was to report trends over time in hypertension

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prevalence, awareness, treatment, and control in U.S. adults aged 60 and older according to selected demographic and risk factors using data from two independent national surveys: NHANES III (1988–1994) and 1999 to 2004 of the current NHANES. The second objective was to provide current statistics on the associations between hypertension, hypertension awareness, treatment, and control and selected demographic factors, individuals' access to and use of health care, and health risk factors. The NHANES 1999 to 2004 data were used to produce these latter estimates. The population of adults aged 60 and older was focused on because of its general public health significance and because, for the first time, there are sufficient data for the analysis of prevalence trends over time for individuals aged 75 and older. Also, these two NHANES surveys represent the largest and most recent national cross-sectional data available on hypertension in older Americans. They therefore provide more-stable, more-reliable estimates of prevalence and the population burden of this important, treatable disorder.

METHODS

Survey Description

The National Health and Nutrition Examination Survey (NHANES) of the National Center for Health Statistics, Centers for Disease Control and Prevention, is composed of a sequential series of cross-sectional, nationally representative health examination surveys of the U.S. civilian noninstitutionalized population. A complex, stratified, multistage probability cluster-sampling design is used in the surveys.[14] Participants are interviewed in their homes to obtain information on health history, health behaviors, and risk factors. Subsequently, they undergo a physical examination at a mobile examination center (MEC). The procedures to select the sample and conduct the interview and examination have been previously specified.[14] This study is based on analysis of BP examination data and self-reported data regarding BP treatment for U.S. adults aged 60 and older in two independent NHANES samples: NHANES III (1988–1994) and 1999 to 2004 of the current NHANES. The latter represents the first 6 years of an ongoing, continuous survey. Informed consent is obtained from all participants, and the institutional review board of the National Center for Health Statistics has approved the protocol.

Sample

In NHANES III, 6,596 (79%) of the 8,375 persons aged 60 and older who were eligible for the survey were interviewed, and 5,302 (63%) received the physical examination. All participants aged 60 and older who received the physical examination (n = 5,302) were invited to undergo assessment for BP. Data on BP or report of current antihypertensive therapy status were missing for 209 persons (4%). Thus, complete information on BP was available for 2,477 men and 2,616 women in NHANES III. Of the 7,726 persons aged 60 and older who were eligible for the 1999 to 2004 NHANES survey, 5,607 (73%) were interviewed, and 4,984 (65%) received the physical examination. All participants aged 60 and older who received the physical examination (n = 4,984) were invited to undergo assessment of BP. Cuff BP measurements were missing for 274 persons (5%); thus, complete information on BP was available for 2,329 men and 2,381 women.

Outcome

The average of up to three brachial systolic and diastolic BP readings was used as the participants' systolic and diastolic BP values. All BP readings were obtained at a single examination visit. Trained physicians measured BP the MEC following a standard protocol that was similar for NHANES III and NHANES 1999 to 2004.[15] Appropriate BP cuff sizes were used for participants based on measurement of mid-arm circumference. Treatment of hypertension was defined as an answer of "yes" to the question, "Are you now taking prescribed medication?" in the BP section of the household questionnaire.[15]

An individual was defined as having hypertension if at least one of the following conditions was satisfied: systolic BP of 140 mmHg or greater, diastolic BP of 90 mmHg or greater, or the participant reported currently taking medication to lower high BP.

Hypertension awareness and control were classified as follows:

(1) Aware: Participant answered "yes" to the household interview question "Have you ever been told by a doctor or health professional that you had hypertension, also called high blood pressure?" If the individual answered "no" or reported that they never had their BP taken, they were considered unaware.
(2) Treated: The participant reported that he or she was currently taking medication to lower high blood pressure.
(3) Treated/Controlled Hypertension: Currently taking prescription medication for high blood pressure and systolic BP less than 140 mmHg and diastolic BP less than 90 mmHg. For individuals with diabetes mellitus or with chronic kidney disease (CKD) according to the JNC 7 recommendations, hypertension control was defined more stringently. Specifically, BP in subjects with diabetes mellitus was considered to be controlled if the measured BP was equal or less than 130/80 mmHg; similarly, for CKD, BP was considered to be controlled if BP levels were less than 130/80 mmHg.[1]

Finally, using the new JNC 7 guidelines, the following prevalences were estimated: normal BP (systolic BP $<$120 mmHg and diastolic BP $<$ 80 mmHg), prehypertension (systolic BP 120–139 mmHg or diastolic BP 80–89 mmHg), Stage 1 hypertension (systolic BP 140–159 mmHg or diastolic BP 90–99 mmHg), and Stage 2 hypertension (systolic BP $\geq$160 mmHg or diastolic BP $\geq$100 mmHg).[1] The hypertension category classification is determined according to highest BP category, whether systolic or diastolic. Because the suggested classifications do not take into consideration the pharmacological treatment for hypertension, some categories (prehypertension and normal BP) include normotensive individuals whose BP is adequately controlled by medication, as well as hypertensives whose BP is only partially controlled by pharmacological treatment.

Other Variables of Interest

Information on age and race/ethnicity was assessed using a questionnaire.[15] Age was categorized into the following groups: 60 to 69, 70 to 79, and 80 and older. Race/ethnicity, based on self-reported information, was classified as non-Hispanic white, non-Hispanic black, and Mexican American. Individuals not fitting the above self-classification were classified as other. Estimates are not shown separately for persons in the "other" racial/ethnic group, although these persons are included in the totals and strata for other variables analyzed.

Having health insurance was defined as responding "yes" to the following household interview question: "Are you covered by health insurance or some other kind of health care plan? Include health insurance obtained through employment or purchased directly as well as government programs like Medicare and Medicaid that provide medical care or help pay medical bills." In 1999 to 2004, 69% of men and 75% of women aged 65 and older reported being covered by Medicare. In comparison, in NHANES III, 76% of men and 76% of women were covered by Medicare (a statistically significant change for men across the two surveys, $P < .05$).

Number of healthcare visits were defined using the response to the question, "During the past 12 months, how many times have you seen a doctor or other healthcare professional about your health at a doctor's office, a clinic, hospital emergency room, at home, or some other place?"[15] The response to the household interview question, "About how long has it been since you last had your blood pressure taken by a doctor or other health professional?" was used to define the variable last BP reading.

Height in centimeters and weight in kilograms were measured in the MEC following a standard protocol. Body mass index (BMI) was calculated as weight in kilograms over height in meters squared (kg/m^2) and was categorized using criteria established by the National Institutes of Health as less than 25.0 kg/m^2, 25.0 to 29.9 kg/m^2, and 30 kg/m^2 or greater.[16] A participant was defined as having diabetes mellitus if they reported during the household interview ever having been told by a doctor that they had diabetes mellitus. Chronic kidney condition (CKD) was defined as reduced excretory function (a glomerular filtration rate calculated using the abbreviated Modification of Diet in Renal Disease Study formula based on serum creatinine, age, and race) or the presence of albuminuria (>300 mg/d or 200 mg/g creatinine).[1,17] Participants were defined as having CVD if a doctor had told them that they had congestive heart failure, if they had a stroke, if they had a heart attack, or if they had a history of angina pectoris according to the questionnaire. Angina pectoris was measured using the Rose Questionnaire for NHANES 1988 to 1994 and 2001 to 2004 or by answering "yes" to the question "Has a doctor or other health professional ever told you that you had angina, also called angina pectoris?" in NHANES 1999 to 2000.[15] The CVD conditions were summed to provide an ordinal CVD variable ranging from none to more than two CVD conditions.

Statistical Analyses

All statistical analyses were performed using SAS 9.1 for Windows (SAS Institute, Inc., Cary, NC) and SUDAAN software (Research Triangle Institute, Research Triangle Park, NC). All estimates were weighted; the sample weights accounted for the unequal probabilities of selection resulting from the complex sample design, survey nonresponse, and the planned oversampling of selected population subgroups. Prevalence standard errors (SEs) were estimated with SUDAAN using Taylor series linearization.[14] Age-adjusted prevalence estimates were calculated for race/ethnicity and sex categories using the direct method and the 2000 projected U.S. population, using age groups 60 to 69, 70 to 79, and 80 and older.[18] Statistical hypotheses for no difference between the two surveys (the null hypothesis) were tested at the .05 level using t-statistics. Odds ratios (ORs) and their 95% confidence intervals (CIs) were calculated for all hypothesized covariates associated with hypertension, treatment, and control. All were entered into a fully adjusted series of logistic regression models assessing their independent association with the dependent variables. The covariates were demographic and socioeconomic (race/ethnicity, age, education), healthcare utilization (insurance, number of visits to the doctor, BP checked), and risk factors (BMI, diabetes mellitus, CKD, and CVD). The dependent variables were hypertension status among all having BP determination (yes = 1, no = 0), hypertension awareness among defined hypertensives (yes = 1, no = 0), pharmacologically treated hypertensives among defined hypertensives (yes = 1, no = 0), and treated and controlled hypertensives among pharmacologically treated hypertensives (controlled = 1, not controlled = 0). Because the initial logistic regression modeling showed a significant ($P < .05$) interaction between sex and age and between sex and race/ethnicity in more than one model, separate models for men and women were developed. ORs with a 95% CI not including unity were considered statistically significant. All statistical calculations followed the latest NCHS analytic and reporting guidelines.[14] Statistical tests were considered significant when $P < .05$ (two tails).

RESULTS

Trends in Hypertension Prevalence

Table 1 presents the age-adjusted and age-specific prevalence rates for hypertension for NHANES III (1988–1994) and NHANES 1999 to 2004. A comparison of prevalences across the two time periods for the population aged 60 and older shows that, overall, hypertension increased significantly ($P < .05$) between the two surveys by almost 10% (from 58% to 67%). A significant increase was seen in each age group studied (60–69: from 49% to 60%; 70–79: from 62% to 72%; and ≥80: from 69% to 77%), in both sexes (men: from 54% to 61%; women: from 60% to 72%), and in two race/ethnicity categories (Non-Hispanic whites: from 56% to 66%; non-Hispanic blacks: from 71% to 82%). Also, significant increases were seen in hypertension prevalence across the two surveys in subjects with self-defined diabetes mellitus (from 66.8% to 77.6%) and those with self-reported diagnosed CVD (from 64.1% to 73.2%).

Hypertension Awareness, Treatment, and Control

For NHANES III (1988–1994) and NHANES 1999 to 2004, Table 2 presents age-adjusted and age-specific

Table 1. Demographic Distribution of Hypertension in U.S. Adults Aged 60 and Older: National Health and Nutrition Examination Survey (NHANES) III (1988–1994) and NHANES 1999–2004 (Age-Adjusted, Age-Specific Prevalences and Confidence Intervals (CIs)

	NHANES III (1988–1994)		NHANES 1999–2004	
Characteristic	**n**	**% (95% CI)**	**n**	**% (95% CI)**
Total*	5,093	58 (56–60)	4,710	67† (66–69)
Sex*				
Male	2,477	54 (51–57)	2,329	61† (59–64)
Female	2,616	60 (58–63)	2,381	72† (69–74)
Race/ethnicity				
Non-Hispanic white	2,943	56 (54–59)	2,712	66† (64–68)
Non-Hispanic black	1,019	71 (67–74)	762	82† (78–85)
Mexican American	974	62 (58–66)	987	68† (65–71)
Age *				
60–69	2,211	48 (45–52)	2,089	60† (57–62)
70–79	1,683	62 (60–65)	1,550	72† (69–74)
≥80	1,199	69 (65–73)	1,071	77† (74–79)
Men				
Race/ethnicity				
Non-Hispanic white	1,413	53 (49–56)	1,364	60† (57–63)
Non-Hispanic black	501	68 (62–73)	365	79† (75–82)
Mexican American	500	56 (50–62)	486	63 (59–66)
Age*				
60–69	1,107	48 (43–52)	1,020	57† (53–61)
70–79	791	57 (51–62)	815	64† (60–68)
≥80	579	62 (57–68)	494	67 (63–70)
Women				
Race/ethnicity				
Non-Hispanic white	1,530	59 (56–62)	1,348	70‡ (67–73)
Non-Hispanic black	518	73 (69–79)	397	84† (79–87)
Mexican American	474	67 (63–71)	501	72 (68–76)
Age*				
60–69	1,104	49 (45–53)	1,069	62† (58–66)
70–79	892	67 (63–70)	735	78† (74–81)
≥80	620	73 (67–78)	577	82† (80–85)
Comorbidities				
Told have diabetes mellitus	798	67 (62–71)	881	78† (74–81)
Chronic kidney disease‡	888	73 (68–78)	913	77 (74–80)
Cardiovascular disease§				
1	440	64 (58–70)	691	73† (69–77)
≥2	155	70 (59–79)	232	78 (69–84)

*Includes other race/ethnicity groups not shown.

†Glomerular filtration rate <60 mL/min/1.73 m^2 or the presence of albuminuria (>300 mg/d or 200 mg/g creatinine).

‡Statistically significant difference between NHANES III and NHANES 1999–2004 ($P<.05$).

§Self-reported congestive heart failure, heart attack, or angina pectoris.

prevalence trends for hypertensive adults aged 60 and older in three categories: awareness of hypertension, treatment of hypertension, and control in treated hypertensives. Control was defined differently for those with diabetes mellitus and individuals with CKD (diabetes mellitus BP ≤130/80 mmHg; CKD BP <130/80 mmHg).

Between the two surveys, significant ($P<.05$) improvements in hypertension awareness and treatment and in control of treated hypertensives were seen for men aged 60 to 69. The percentage who were aware of their hypertension increased from 68% to 77%, the percentage treated increased from 55% to 70%, and the percentage controlled among those treated rose from 40% to 62%. For men aged 70 to 79 and women aged 80 and older, the percentage of those who were aware of their hypertension and the percentage treated increased significantly between the two survey periods (from 65% to 77% and from 53% to 69%; from 62% to 71% and from 52% to 62% respectively, $P<.05$), although there were no significant changes in the proportion of treated hypertensives who were controlled in

Table 2. Age-Adjusted and Age-Specific Hypertension Awareness, Treatment, and Control in the U.S. Population Aged 60 and Older with Hypertension: National Health and Nutrition Examination Survey (NHANES) III (1988–1994) and NHANES 1999–2004

	NHANES III			NHANES 1999–2004		
	Aware	Treated	Control in Treated*	Aware	Treated	Control in Treated*
Characteristic	Percent (95% Confidence Interval)					
Total‡	70 (68–72)	58 (56–61)	36 (33–39)	74† (72–76)	67† (64–70)	43† (40–46)
Sex‡						
Male	65 (61–68)	52 (49–56)	39 (34–44)	74† (71–77)	68† (64–71)	51† (47–55)
Female	74 (72–77)	62 (59–65)	35 (32–38)	74 (72–77)	67 (64–71)	37 (33–41)
Race/ethnicity						
Non-Hispanic white	70 (68–72)	59 (56–62)	37 (33–40)	74† (72–76)	67† (64–70)	44† (41–48)
Non-Hispanic black	76 (72–80)	65 (60–70)	34 (29–40)	81 (77–84)	76† (72–80)	36 (33–39)
Mexican American	63 (58–68)	48 (41–54)	28 (23–32)	70 (66–74)	61† (58–65)	32 (26–38)
Age‡						
60–69	76 (73–79)	62 (58–66)	43 (38–48)	78 (74–81)	70† (67–74)	53† (49–56)
70–79	69 (66–72)	58 (54–63)	34 (30–38)	74† (70–77)	67† (63–70)	37 (33–42)
≥80	60 (56–64)	50 (46–54)	24 (19–30)	69† (65–72)	62† (57–66)	31 (25–37)
Men						
Race/ethnicity						
Non-Hispanic white	65 (62–69)	53 (49–56)	40 (34–46)	74† (71–78)	67† (63–71)	54† (49–58)
Non-Hispanic black	72 (66–77)	58 (50–65)	33 (26–40)	77 (71–82)	73† (66–78)	37 (31–44)
Mexican American	59 (51–66)	49 (43–55)	31 (23–39)	70† (64–75)	60† (54–66)	36 (27–45)
Age‡						
60–69	68 (62–74)	54 (49–60)	40 (32–48)	77† (71–82)	70† (64–76)	62† (56–67)
70–79	65 (60–70)	53 (48–59)	42 (34–50)	77† (71–82)	68† (64–73)	45 (38–52)
≥80	57 (52–63)	46 (42–51)	31 (23–39)	65 (59–70)	60† (54–65)	37 (31–43)
Women						
Race/ethnicity						
Non-Hispanic white	74 (71–77)	63 (60–67)	36 (32–40)	74 (70–77)	66 (62–70)	38 (33–42)
Non-Hispanic black	78 (73–83)	70 (64–75)	35 (27–43)	84 (78–88)	78† (74–83)	35 (31–39)
Mexican American	65 (60–70)	46 (37–54)	25 (20–31)	70 (64–75)	62† (57–66)	29 (23–36)
Age‡						
60–69	82 (77–86)	68 (63–73)	45 (39–51)	78 (74–82)	71 (66–75)	45 (40–50)
70–79	71 (67–76)	61 (56–67)	30 (25–36)	72 (67–76)	66 (61–71)	32 (26–38)
≥80	62 (57–66)	52 (46–57)	22 (16–28)	71† (66–75)	62† (57–68)	28 (20–37)
Comorbidities						
Told have diabetes mellitus	77 (72–82)	68 (62–74)	21 (16–29)	86† (82–89)	83† (79–87)	33† (28–40)
CKD	79 (74–84)	71 (64–77)	24 (19–30)	81 (76–85)	75 (70–80)	27 (22–33)
Cardiovascular disease						
1	84 (80–87)	75 (69–80)	35 (27–44)	86 (83–89)	78 (73–83)	37 (31–44)
2	88 (80–93)	72 (61–81)	37 (26–49)	93 (87–96)	87 (81–92)	41 (33–49)

*Control was defined as blood pressure ≤130/80 mmHg for those with diabetes mellitus and <130/80 for those with chronic kidney disease (CKD).
†Statistically significant difference between NHANES III and NHANES 1999–2004 ($P<.05$).
‡Includes other race/ethnicity groups not shown.

either of these two groups. In men aged 80 and older, only the percentage of hypertensives treated increased significantly across the two surveys (from 46% to 60%, $P<.05$).

According to race/ethnicity and sex, non-Hispanic white men had a significant ($P<.05$) increase in all categories across the two surveys; specifically, hypertension awareness increased from 65% to 74%, treatment increased from 53% to 67%, and control increased from 40% to 54%. The proportions of those aware and treated also increased significantly for Mexican-American men (from 59% to 70% and from 49% to 60%, $P<.05$), but this group had no change in the proportion of treated hypertensives who were controlled. Non-Hispanic blacks of both sexes significantly increased their treatment of hypertension, from 65% in NHANES III to 76% in the current NHANES. For women, only Mexican-American women had a statistically significant increases in the prevalence of

treatment (from 46% to 62%, $P<.05$), but they had no change in hypertension awareness or control over this time period.

A more-detailed analysis was done for the comorbid risk factors diabetes mellitus, CKD, and CVD. Only among those with self-defined diabetes was there a significant increase in awareness (from 77% to 86%, $P<.05$), treatment (from 68% to 83%, $P<.05$), and control, defined as BP of 130/80 mmHg or less, (from 21% to 33%, $P<.05$) across the two surveys.

Multivariable Analysis of Hypertension Awareness, Treatment, and Control

Using the most-current survey data (NHANES 1999–2004), Table 3 presents, according to sex, the adjusted ORs and 95% CIs for the association between selected covariates in four multivariable logistic models each using one of the four binary outcomes as dependent variable: (1) hypertension status, (2) hypertension awareness in hypertensives, (3) treated hypertension, and (4) hypertension control among those treated. The general set of covariates was significantly ($P<.05$) associated with each of the four binary outcomes, providing a profile of the characteristics of individuals who are classified as having hypertension, of those who are aware or unaware of their hypertension, of those with hypertension who are treated, and of the group that is controlled by treatment.

Some demographic covariates were significantly associated with hypertension status, treatment, and control. Specifically, regardless of sex, non-Hispanic blacks were significantly more likely to be hypertensive than non-Hispanic whites (men, OR = 2.54; women, OR = 2.07). Non-Hispanic black women were significantly more likely to be aware (OR = 1.97) and treated (OR = 2.08) than non-Hispanic white women. Mexican-American and non-Hispanic black men were less likely than non-Hispanic white men to control their hypertension when treated (OR = 0.55 and OR = 0.60, respectively). Men and women aged 70 to 79 and 80 and older were significantly more likely to be classified as hypertensive than individuals in aged 60 to 69 (men, OR = 1.31, OR = 1.56; women, OR = 2.05, OR = 3.20, respectively). Also, women aged 70 to 79 and 80 and older were significantly less likely than those aged 60 to 69 to be aware of hypertension (70–79, OR = 0.56; ≥80, OR = 0.62) and treated (70–79, OR = 0.62; ≥80, OR = 0.63), whereas men aged 80 and older were less likely than those aged 60 to 69 to be aware (OR = 0.53) and treated (OR = 0.57). Also, men aged 70 to 79 and 80 and older were significantly less likely to have their hypertension controlled than those aged 60-69 (OR = 0.52, OR = 0.45, respectively), whereas for women, only those aged 70 to 79 were significantly less likely than those aged 60 to 69 to have their hypertension controlled (OR = 0.65).

Availability and use of health care were significantly associated with hypertension classification, treatment, and control. Men with four or more doctor visits per year were significantly more likely to be aware of their hypertension than those with zero to one doctor visits per year (OR = 1.77). Also men with two to three visits or four or more visits were more likely to be treated (OR = 2.15, OR = 2.36, respectively). Women with more than 1 visit were more likely to be classified as hypertensive, to be aware of their hypertension, and to be treated for hypertension (Table 3). The simple act of having BP checked within the previous 6 months had a significant association with hypertension awareness and treatment for men and women when compared with having had BP checked more than 6 months before. Men and women were significantly more aware (men, OR = 2.32; women, OR = 4.53) and treated (men, OR = 2.14; women, OR = 3.80). Moreover, women who had had a more-recent BP determination (<6 months) were significantly more likely to control their hypertension (OR = 2.71). Having health insurance was associated a greater likelihood of hypertension treatment in men (OR = 2.00), although having health insurance was associated with less control of hypertension in women (OR = 0.44). The latter results were unexpected and were significant even when the definition of control for self-reported diabetes mellitus and CKD were mean systolic BP of less than 140 mmHg and mean diastolic BP of less than 90 mmHg. Therefore, the association between health insurance and hypertension control was further analyzed. Of treated women, 220 (15%) had private insurance only, 415 (29%) had private and Medicare insurance, 476 (33%) had Medicare only, 100 (7%) had no insurance, and the remaining had other government insurance or Medicaid/CHIP. The "control in treated multivariable" model was reanalyzed by entering each term into the model except for "other government insurance." For the private insurance term, the OR was 1.18 (95% CI = 0.71–1.96; $P>.05$); for Medicare and private insurance term, the OR was 1.04 (95% CI = 0.71–1.53; $P>.05$); and for Medicare insurance term, the OR was 0.69 (95% CI = 0.47–1.01; $P>.05$) (data not shown). The results of this analysis are therefore inconclusive, and there are not significant associations between specific types of health insurance and hypertension control.

Risk factors were significantly associated with hypertension classification treatment and control. For both sexes, BMI greater than reference (<25.0) was independently associated with greater likelihood of hypertension, awareness, and treatment (Table 3). BMI of 25.0 to 29.9 was associated with more hypertension control for women (OR = 1.57). Women with self-reported diabetes mellitus had a greater likelihood of being classified as hypertensive (OR = 1.76), had greater awareness (OR = 1.63), were more likely to be treated (OR = 2.08), and were less likely to be controlled than those without diabetes mellitus (OR = 0.54). Similar to women, men with self-reported diabetes mellitus had a greater likelihood of treatment (OR = 2.22) yet less likelihood of BP control (OR = 0.56).

In individuals with CKD, men were more likely to be classified as hypertensive (OR = 2.20), more likely to be aware of hypertension (OR = 1.63), and more likely to be treated (OR = 1.92) but less likely to have their hypertension controlled (OR = 0.49). In women with CKD, hypertension awareness and treatment were more likely (OR = 1.83 and 1.76, respectively), but there were lower odds of BP control (OR = 0.46) than women without CKD. Men who self-reported one or more CVDs were more likely to be hypertensive, be aware, and be treated than those with no self-reported CVD (Table 3). Women with two or more

Table 3. Adjusted Odds Ratios and 95% Confidence Intervals for Hypertension, Awareness, Treatment, and Control* According to Selected Characteristics: U.S. Adults Aged 60 and Older: National Health and Nutrition Examination Survey 1999–2004

	Men				Women			
Characteristic	**Hypertension**	**Aware**	**Treated**	**Control in Treated**	**Hypertension**	**Aware**	**Treated**	**Control in Treated**
Race/ethnicity								
Non-Hispanic white‡								
Non-Hispanic black	2.54† (1.90–3.40)	1.21 (0.78–1.89)	1.39 (0.88–2.20)	0.60† (0.41–0.86)	2.07† (1.31–3.26)	1.97† (1.23–3.17)	2.08† (1.44–3.16)	0.99 (0.70–1.40)
Mexican American	1.04 (0.80–1.34)	0.88 (0.60–1.28)	0.76 (0.50–1.16)	0.55† (0.33–0.91)	1.13 (0.82–1.54)	0.83 (0.59–1.16)	0.84 (0.65–1.07)	0.63† (0.40–0.98)
Age§								
60–69‡								
70–79	1.31 (1.04–1.65)	0.89 (0.54–1.48)	0.78 (0.56–1.10)	0.52† (0.37–0.74)	2.05† (1.56–2.70)	0.56† (0.37–0.84)	0.62† (0.43–0.90)	0.65† (0.47–0.89)
≥80	1.56† (1.18–2.06)	0.53† (0.32–0.88)	0.57† (0.36–0.91)	0.45† (0.28–0.72)	3.20† (2.44–4.18)	0.62† (0.42–0.90)	0.63† (0.44–0.91)	0.61 (0.36–1.05)
Number of doctor visits								
0–1‡								
2–3	1.03 (0.75–1.42)	1.80 (1.00–3.23)	2.15† (1.16–3.95)	0.91 (0.48–1.72)	1.73† (1.05–2.83)	2.28† (1.39–3.74)	2.54† (1.48–4.35)	0.81 (0.42–1.54)
≥4	1.14 (0.79–1.64)	1.77† (1.01–3.11)	2.36† (1.37–4.08)	1.20 (0.70–2.07)	1.77† (1.02–3.06)	2.00† (1.14–3.51)	2.73† (1.60–4.66)	1.06 (0.54–2.09)
BP checked								
<6 months before	1.43 (0.95–2.14)	2.32† (1.48–3.62)	2.14† (1.42–3.23)	1.36 (0.47–3.91)	1.04 (0.65–1.67)	4.53† (2.50–8.19)	3.80† (2.29–6.31)	2.71† (1.05–6.99)
≥6 months before‡								
Insurance								
Yes	1.10 (0.67–1.80)	1.34 (0.66–2.71)	2.00† (1.07–3.71)	1.59 (0.53–4.78)	1.53 (0.97–2.41)	1.09 (0.47–2.50)	1.36 (0.63–2.96)	0.44† (0.23–0.86)
No‡								
Body mass index								
<25.0‡								
25.0–29.9	1.65† (1.23–2.21)	1.59† (1.07–2.35)	1.75† (1.20–2.55)	1.46 (0.94–2.28)	1.36† (1.03–1.78)	1.85† (1.27–2.69)	1.47† (1.12–1.93)	1.57† (1.04–2.37)
≥30.0	1.93† (1.45–2.57)	2.26† (1.38–3.69)	2.30† (1.43–3.69)	1.55 (0.91–2.62)	2.57† (1.80–3.69)	3.56† (2.43–5.21)	2.93† (2.07–4.15)	1.48 (0.97–2.26)
Diabetes mellitus								
Yes	1.29 (0.88–1.88)	1.76 (0.99–3.12)	2.22† (1.37–3.59)	0.56† (0.36–0.87)	1.76† (1.11–2.81)	1.63 (1.00–2.64)	2.08† (1.37–3.16)	0.54† (0.34–0.87)
No‡								
Chronic kidney disease								
Yes	2.20† (1.65–2.93)	1.63† (1.03–2.58)	1.92† (1.28–2.89)	0.49† (0.31–0.75)	1.22 (0.88–1.68)	1.83† (1.23–2.73)	1.76† (1.19–2.56)	0.46† (0.33–0.64)
No‡								
Cardiovascular disease								
0‡								
1	1.21 (0.92–1.56)	2.47† (1.69–3.61)	1.71† (1.21–2.43)	0.70 (0.44–1.10)	1.13 (0.69–1.85)	1.31 (0.78–2.21)	1.29 (0.78–2.13)	0.85 (0.58–1.25)
≥2	1.57 (0.95–2.60)	3.10† (1.26–7.67)	3.03† (1.17–7.85)	0.93 (0.52–1.64)	1.48 (0.75–2.93)	7.06† (2.16–23.04)	2.36† (1.22–4.55)	0.74 (0.36–1.52)

* Control for diabetes mellitus blood pressure ≤130/80, for chronic kidney disease <130/80.
† Statistically significant.
‡ Reference group.
§ Includes other race/ethnicity groups not shown.

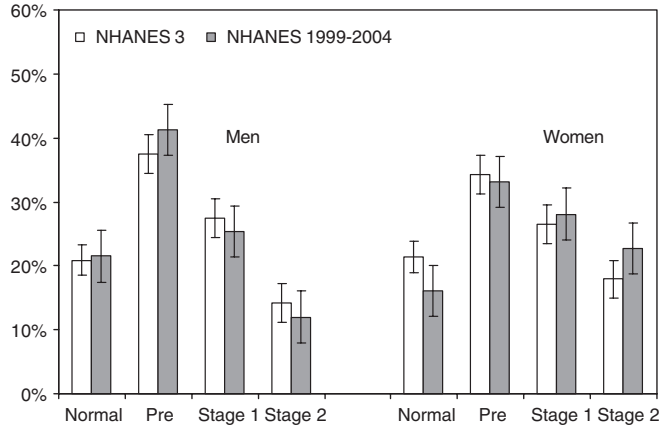

Figure 1. The age-adjusted and age-specific prevalence distributions and 95% confidence intervals (CIs) for blood pressure classification groups according to the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure, U.S. population aged 60 and older, National Health and Nutrition Examination Survey (NHANES) 1988 to 2004. All estimates are calculated irrespective of hypertension awareness, treatment, and control status. Normal blood pressure (BP) (systolic BP <120 mmHg and diastolic BP <80 mmHg), prehypertension (systolic BP 120–139 mmHg or diastolic BP 80–89 mmHg), Stage 1 hypertension (systolic BP 140–159 mmHg or diastolic BP 90–99 mmHg), and Stage 2 Hypertension (systolic BP $\geq$160 mmHg or diastolic BP $\geq$100 mmHg).

self-reported CVDs were more likely to be aware of hypertension (OR = 7.06), although this latter estimate may be unstable because of the wide 95% CI (2.16–23.4). Finally, women with two or more CVDs were more likely to have their hypertension treated (OR = 2.36).

U.S. Hypertension Prevalence Using the JNC 7 Classification Criteria

Figure 1 presents the general distribution of hypertension status for the U.S. population aged 60 and older according to JNC 7 classification guidelines. Data are presented for both survey periods (NHANES III and NHANES 1999–2004), irrespective of hypertension awareness or treatment status. Comparisons across the two surveys demonstrate a significant ($P<.05$) increase in Stage 2 hypertension for women (from 18% to 23%) but not for men, although in, men, there was a significant ($P<.05$) increase in prehypertension in the group aged 60 to 69 (from 39% to 47%; $P<.05$, data not shown).

Overall among hypertensives, in NHANES III (1988–1994), 65% (SE = 1.35) of classified hypertensives had isolated systolic hypertension (SBP $\geq$ 140 mmHg and DBP <90 mmHg), compared with 58% (SE = 1.05) in NHANES 1999 to 2004 ($P<.05$). Nine percent (SE = 0.65) of subjects in NHANES III were classified with both systolic and diastolic hypertension (SBP $\geq$140 mmHg and DBP $\geq$90 mmHg), compared with 7% (SE = 0.7) in NHANES 1999 to 2004. One percent (SE = 0.26) of subjects in NHANES III had isolated diastolic hypertension (SBP <140 mmHg and DBP $\geq$90 mmHg), compared with 0.74% (SE = 0.18) in NHANES 1999 to 2004.

DISCUSSION

The emerging picture for hypertension in the population of older Americans based on NHANES 1999 to 2004 survey data are multifaceted and include encouraging and discouraging results.

During 1999 to 2004, the most recent NHANES survey period, some 67% of U.S. adults aged 60 and older were classified with hypertension. This is a significant increase of 10% from the earlier NHANES III survey conducted from 1988 to 1994. The trend toward a greater prevalence of hypertension is general, affecting women, men, and all age groups, although, for men with hypertension across the two surveys periods, there were significant improvements in the rates of hypertension awareness and treatment and in hypertension control; men aged 60 and older have achieved the 2010 national health objective of 50% of persons with hypertension having controlled their BP.[19] In contrast, there were no significant changes for women with hypertension in these categories across the surveys, with women still under 50% BP control in 1999 to 2004.

Despite the near universal availability of health insurance for most of the sample (Medicare for ages $\geq$65), women, minorities of both sexes (non-Hispanic blacks and Mexican Americans), the old, and the very old continue to have problems with awareness, treatment and control.

A number of variables directly addressed healthcare availability and utilization. Men with health insurance were twice as likely to be treated for hypertension. As for women, the results are somewhat puzzling; health insurance is associated with decreased hypertension control. It is not clear whether this result has to do with the small comparison group of individuals having no health insurance (7%), with the possibility that having Medicare alone may contribute to these results or with the findings suggesting that healthcare providers may approach CVD in women differently than in men, specifically. A recent study of physicians' awareness and adherence to the 2004 American Heart Association women's prevention guidelines can provide some insight into the problem. The physicians surveyed downgraded the cardiovascular risk status of women significantly compared with men and were less likely to suggest preventative measures for women than men. Moreover, only 8% of primary care physicians, 13% of obstetrician/gynecologists, and 17% of cardiologists were aware that more women than men die annually of cardiovascular diseases.[20] Another contributor may be lack of awareness that heart disease persists as the leading cause of death in women in the higher-risk population. For example, in 2005, only 38% of African-American women and 34% of Hispanic women, compared with 62% of white women, were aware of the fact that heart disease and heart attack are leading cause of death in women. In the same survey, white women were significantly more aware of the definition of healthy BP ($<$120/80) than were blacks or Hispanics (52% vs 40% and 37%).[21] More research needs to be done on this subject.

Having BP measured in the previous 6 months was associated with awareness and treatment in men and aware-

ness, treatment, and control in women. Similarly, visits to a healthcare provider was associated with treatment in men and with awareness and treatment in women. It is not clear why number of visits was not associated with hypertension control, whereas the simple act of taking BP within 6 months resulted in almost three times greater hypertension control in women. The latter finding raises the possibility that frequent BP monitoring may result in better hypertension control in women, although longitudinal studies would need to be done to evaluate whether this type of intervention would result in better long-term BP control, because this cross-sectional survey, by definition, cannot assess the possible effects of lead-time bias.

Individuals with a BMI greater than 25.0 of either sex were more likely to be classified as hypertensive, be aware of their hypertension, and be treated. Women with BMI of 25.0 to 29.9 were 50% more likely to be controlled. These data suggest that healthcare providers and the public understand the relationship between greater weight and hypertension well. Although, individuals with a self-reported history of diabetes mellitus across the surveys had 12% better hypertension control, for both men and women in this category, hypertension control is still a concern. In contrast with self-reported diabetes mellitus, individuals with CKD had no significant changes in hypertension control and, similar to those with self-reported diabetes, had a lower likelihood of hypertension control.

In 1999 to 2004, Stage 1 hypertension represented 25% of cases in men and 28% in women; in contrast to those with Stage 2 hypertension (the SHEP study), no randomized prospective clinical trails have been done to assess the benefit of treatment in this category.[22] Although having decreased significantly between the two surveys, isolated systolic hypertension represents the most common observed hypertension. This finding supports the recommendation of the JNC 7 that systolic BP should be the primary target for the diagnosis and management of older people with hypertension.

A previous study surveyed a national sample of physicians involved in geriatric care (412 (38%) responded) regarding management of geriatric hypertension. Fifty-eight percent of those surveyed stated that they would not start pharmacological therapy if systolic BP were greater than 140 mmHg in patients aged 85 and older.[23] Indeed, some recent studies have shown that in the very old (≥80), high BP may actually be associated with better survival,[24] although other studies have suggested otherwise.[25–28] Nevertheless, the present study is not the appropriate forum to weigh in on the controversy of treatment of hypertension in the very old (≥80), our goal being to compare recent NHANES surveys and provide population-based prevalence data.

The findings in this report are subject to some limitations. First, the NHANES sample includes only the noninstitutionalized population and does not include persons in nursing homes, hospitals, and other institutions. Second, the cross-sectional study design provides only a one-time assessment of BP; therefore, the results may overestimate or underestimate the prevalence of hypertension for specific individuals. Third, misclassification of individuals could occur if they provide inaccurate information, for example, reporting being unaware of a prior diagnosis of hypertension when in fact they were previously told by their medical provider. Similarly, individuals who were taking antihypertensive medications but did not acknowledge taking medications to lower their BP and were normotensive at examination time were classified as normotensives. Moreover, treatment was narrowly defined as the use of medications; other treatment methods included in the JNC 7 recommendations are lifestyle modifications such as weight loss and exercise.[1]

This is the first large-scale national study based on a more-stringent BP control definition recommended by the JNC 7 for self-reported diabetes mellitus and CKD.[1] The results of the study indicate that there is still significant work to be done in the United States with respect to hypertension education, treatment, and control. The study results also suggest the specific population subgroups that should be targeted for improved hypertension screening and management. Most particularly, the results show that there is a significant recent increase in hypertension prevalence in older U.S. adults. Also, the overall control rates for hypertension remain low, especially in women, minorities, individuals with a history of diabetes mellitus or CKD, and the elderly.

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Author Contributions: Each of the authors participated in the conceptual design of the study, acquisition and quality control of the data, statistical analysis and interpretation of the data, and the preparation of the manuscript.

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