Implications of New Hypertension Guidelines in the United States

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Abstract—The American Heart Association Task Force released a scientific statement in 2007 for the treatment of hypertension in the prevention of coronary artery disease (CAD). These guidelines recommend more aggressive control of blood pressure (BP) among those at high risk for CAD: individuals with diabetes mellitus, chronic kidney disease, cardiovascular disease, congestive heart failure, or a 10-year Framingham risk score ≥10%. These individuals are advised to maintain a BP <130/80 mm Hg. We estimated the burden of uncontrolled BP among those at an increased risk of CAD using the updated task force guidelines. We used a cross-sectional analysis of National Health and Nutrition Examination Survey 2005–2008 participants. Participants were 24 989 adults aged 18 to 85 years. Using the old definition of hypertension (>140/90 mm Hg), 98 million (21%) Americans have hypertension. Using the updated guidelines, an additional 52 million (11%) American adults now have elevated BP requiring treatment, for a total of 150 million adults (32%). Adults with diabetes mellitus have the greatest population burden of uncontrolled BP (50.6 million), followed by adults with chronic kidney disease (43.7 million) and cardiovascular disease (43.3 million). Although individuals at a higher risk for CAD are more likely to be aware of their hypertension and to be taking antihypertension medication, they are less likely to have their BP under control. Additional efforts are needed in the treatment of elevated BP, especially among individuals with an increased risk of CAD. (*Hypertension*. 2011;58:361-366.)

Key Words: hypertension ■ sex ■ race ■ CDC ■ Centers for Disease Control and Prevention ■ NHANES ■ National Health and Nutrition Examination Study

Approximately 30% of adults in the United States have hypertension defined as blood pressure (BP) >140/90 mm Hg.[1–4] The effect of BP on risk of cardiovascular disease morbidity and mortality is robust and continuous, and every millimeter of mercury increase in BP is important.[5–7] Recent clinical trials have underlined the importance of lowering BP to <140/90 mm Hg to reduce cardiovascular events.[8] In light of evidence that individuals with underlying subclinical or clinical coronary artery disease (CAD) have a higher risk of poor health outcomes related to inadequate BP control, the American Heart Association (AHA) Task Force released a scientific statement in 2007 for the treatment of hypertension in the prevention and treatment of CAD.[9]

These guidelines recommend more aggressive control of BP among those at high risk for CAD: individuals with diabetes mellitus, chronic kidney disease, CAD or CAD risk equivalent, or a 10-year Framingham risk score (FRS) ≥10%. For this high-risk group, maintaining BP <130/80 mm Hg is recommended. For individuals with left ventricular dysfunction, the treatment goal is even more strict, BP <120/80 mm Hg. These guidelines are more stringent than previous Joint National Committee, Kidney Disease Outcomes Quality Initiative, and American Diabetes Association recommendations.[8,10,11]

Using data from the National Health and Nutrition Examination Survey (NHANES) 2005–2008, we explored the characteristics of US adults who would now be classified as hypertensive according to the AHA task force's updated BP treatment goals and definitions. In addition, we compared BP control by CAD risk group, sex, and race/ethnicity.

Methods

The NHANES 2005–2008 is a nationally representative sample of noninstitutionalized individuals. Ascertainment and survey design have been described.[12] Briefly, NHANES is a complex, multistage survey that is representative of the United States and oversamples

minorities (non-Hispanic blacks and Mexican Americans), children, and the elderly. Participants completed an interview and physical examination. NHANES data were collected through a standardized household interview, followed by a physical examination in a mobile examination center. After excluding children and adolescents (<18 years), pregnant women, individuals who had missing or invalid BP measurements, and individuals who were missing prescription drug information, the final analytic sample included 24 989 adults aged 18 to 85 years.

BP was measured by a physician in the NHANES mobile examination center using a mercury sphygmomanometer. After the participant rested for 5 minutes, 3 consecutive measurements of BP were taken. If only 1 of the 3 measurements was obtained, that reading was used. If >1 measurement was obtained, the first reading was excluded from the average. If only 2 measurements were obtained, the second reading was used. If all readings but 1 were 0, the non-0 reading was used.[13] We defined hypertension as average systolic BP ≥140 mm Hg, average diastolic BP ≥90 mm Hg, or physician diagnosis of hypertension.

Those with hypertension who reported being told by a health professional that they have hypertension were considered aware of their disease. Hypertensive adults were considered treated if they reported use of a prescribed medicine for hypertension. As recommended in the AHA task force guidelines,[14] among hypertensive persons, control was defined as BP <140/90 mm Hg for the average CAD risk population. For higher CAD risk subgroups of the population, including individuals with a FRS ≥10%, chronic kidney disease, diabetes mellitus, or cardiovascular disease, control was defined as maintaining systolic BP <130 mm Hg and a diastolic BP <80 mm Hg. For individuals with congestive heart failure, control was defined as maintaining systolic BP <120 mm Hg and diastolic BP <80 mm Hg.

CAD risk was assessed by 10-year FRS.[15] Chronic kidney disease was defined as physician diagnosis of weak or failing kidneys or a calculated creatinine clearance score of <60 mL/min estimated using the Cockcroft and Gault equation using adjusted body weight.[16] Diabetes mellitus was defined as physician diagnosis of diabetes mellitus (other than gestational diabetes) or measured glycohemoglobin >7.0%. Cardiovascular disease was defined as report of angina, coronary heart disease, myocardial infarction, stroke, or peripheral vascular disease (minimum ankle brachial index <0.90 for participants aged ≥40 years). Participants aged <40 years were assumed to not have peripheral vascular disease. Congestive heart failure was defined by self-report of physician diagnosis. Participants could be included in multiple disease groups. Those without any of these conditions but with an FRS ≥10% and none of the above conditions were grouped together. Finally, participants with FRS <10% and none of the above conditions were considered to be part of the average risk population. Participants reported current medication use during the examination using the Computer Assisted Self Interview system. This software includes consistency checks, including range checks, valid response checks, and checks for logistical relationships. A list of prescription medications used for hypertension control was developed from the NHANES prescription files with drug use information[17] and reviewed for accuracy by a physician (C.B.E.).

Participants self-reported sex, race/ethnicity, age, education, income, and health insurance status during an interview in their home. Height and weight were measured by trained staff in the mobile examination center, and body mass index was calculated as weight in kilograms divided by height in meters squared. Poverty level was defined based on US Census Bureau income criteria that vary by family size and composition and in accordance with the Office of Management and Budget. Thresholds are updated annually for inflation with the Consumer Price Index.

Statistical Methods

For our adjusted analyses, we considered the following to be potential confounders (or risk factors for uncontrolled BP): age, body mass index, sex, race/ethnicity, education, income, whether income is below poverty level, insurance status, and medication use. We

included each in our model one by one, and if the variable changed the odds ratio (OR) estimate by ≥10%, we retained that variable in our model. We also examined correlations between potential confounders to check multicollinearity. We combined the sample weights provided by NHANES to correct for unequal probability of selection and nonresponse[18] across study periods to create a sample representative of the US population for 2005–2008. We calculated the age-standardized prevalence of hypertension using the 2000 US Census population and 7 age groups. Analyses were conducted using SAS-callable SUDAAN 10 (RTI International Inc, Research Triangle Park, NC), which produces variance estimates for complex survey designs.[19] For analyses of race/ethnicity, we excluded those identifying as Hispanic other than Mexican American and other race/multiracial because of small cell counts when stratified by risk group. We used the Taylor series linearization to estimate the variances of proportions. This study was approved by the Memorial Hospital Committee for Human Subjects in Research, and all of the study subjects gave informed consent.

Results

Ninety-eight million or 21% of US adults have hypertension defined as physician diagnosis or measured BP ≥140/90 mm Hg. An additional 52 million, or 11%, have uncontrolled BP using the updated AHA task force guidelines, for a total of 150 million (32%) US adults. Eighty-seven percent of average-risk US adults with hypertension (defined as BP ≥140/90 mm Hg) have been diagnosed by a physician (Table 1), and 78% are taking antihypertensive medications.

Individuals who are at an increased risk of CAD, including those with chronic kidney disease, diabetes mellitus, cardiovascular disease, and congestive heart failure, are more likely to be aware of their hypertension than individuals in the average risk population (Table 1 and Figure 1). Compared to adults with hypertension in the average risk population, antihypertensive medication use was more common among adults with hypertension and an elevated risk for CAD. According to the 2007 AHA task force guidelines, an additional 4.4 million adults with FRS ≥10% have uncontrolled BP, as well as an additional 3.8 million with chronic kidney disease, 5.8 million with diabetes mellitus, 3.1 million with cardiovascular disease, and 0.9 million with congestive heart failure. Despite increased awareness and treatment of hypertension, individuals with a higher risk of CAD are more likely to have uncontrolled BP compared with the average risk population. This difference is apparent when using both older and newer criteria for control, although the prevalence of uncontrolled BP among those with a higher risk of CAD is magnified by the more stringent 2007 AHA task force recommendations.

Among the average risk population, men and women have a similar prevalence of uncontrolled BP according to the updated AHA guidelines (12.0% and 12.2%, respectively; Figure 2). However, among individuals with an FRS ≥10%, women have a much greater prevalence of uncontrolled BP (80%) than men (55%). Among other subgroups of the population that are at an increased risk of CAD, women are also more likely to have uncontrolled BP; however, these differences are not as large.

Non-Hispanic blacks have the highest prevalence of uncontrolled BP in the average-risk population, as well as in all subgroups of the population that are at an increased risk for

Table 1. Prevalence of Hypertension and Characteristics of Each CAD Risk Group Among US Adults, National Health and Nutrition Examination Survey 2005–2008, Percentage and 95% CI

Hypertension Status	Average Risk Population	FRS ≥10% Only	CKD	DM	CVD	CHF
Sample size (n=24 989)	10 199	2332	6031	6612	5646	2227
Weighted N (472 072 672), in millions	242.0	42.9	81.9	94.2	85.5	30.9
Hypertension (old guidelines)*	34 (31 to 37)	66 (62 to 70)	79 (75 to 82)	79 (75 to 82)	82 (79 to 85)	83 (77 to 88)
Hypertension awareness†	87 (85 to 90)	88 (84 to 91)	94 (92 to 96)	95 (93 to 97)	95 (93 to 97)	96 (92 to 98)
Use of antihypertensive medication‡	78 (74 to 81)	86 (81 to 91)	95 (93 to 96)	96 (94 to 97)	95 (93 to 97)	98 (94 to 99)
Uncontrolled hypertension (old guidelines)§	12 (11 to 14)	31 (27 to 35)	32 (28 to 37)	32 (28 to 36)	32 (27 to 37)	32 (25 to 40)
Hypertension (new guidelines)‖	34 (31 to 37)	77 (73 to 80)	83 (79 to 87)	85 (82 to 88)	85 (82 to 88)	86 (79 to 90)
Uncontrolled blood pressure (new guidelines)	12 (11 to 14)	59 (54 to 63)	53 (48 to 58)	54 (50 to 58)	51 (46 to 55)	50 (42 to 59)
Male	37 (36 to 38)	87 (82 to 90)	33 (29 to 36)	45 (40 to 50)	52 (48 to 57)	56 (48 to 64)
Race/ethnicity						
Non-Hispanic white	83 (79 to 86)	88 (84 to 91)	83 (77 to 88)	75 (67 to 81)	85 (80 to 89)	79 (71 to 85)
Non-Hispanic black	10 (8 to 14)	9 (6 to 12)	13 (9 to 19)	19 (14 to 26)	12 (9 to 17)	19 (13 to 26)
Mexican American	7 (5 to 9)	3 (2 to 5)	4 (2 to 7)	6 (4 to 9)	3 (2 to 5)	3 (2 to 5)
Age in y, mean (SE)	44 (0.4)	62 (0.6)	69 (0.5)	61 (0.6)	67 (0.5)	67 (0.7)
Socioeconomic status						
Education						
Less than high school	15 (13 to 17)	20 (16 to 25)	31 (26 to 38)	29 (25 to 33)	29 (25 to 34)	36 (28 to 46)
Household income						
Less than $20 000	15 (13 to 18)	16 (10 to 25)	36 (24 to 51)	24 (17 to 32)	31 (24 to 39)	28 (16 to 43)
$20 000 to $44 999	27 (23 to 31)	33 (25 to 42)	43 (33 to 55)	37 (29 to 46)	39 (32 to 47)	48 (32 to 65)
$45 000 to $74 999	25 (22 to 28)	26 (17 to 38)	9 (5 to 17)	18 (13 to 24)	17 (12 to 23)	17 (7 to 35)
$75000 or more	32 (28 to 38)	25 (18 to 34)	11 (5 to 22)	20 (15 to 27)	13 (9 to 19)	8 (3 to 16)
Family income below poverty level	12 (10 to 14)	8 (5 to 11)	14 (11 to 18)	17 (14 to 21)	18 (13 to 23)	18 (13 to 24)
Insured	84 (82 to 86)	90 (87 to 93)	96 (94 to 97)	93 (92 to 95)	95 (92 to 96)	94 (90 to 97)

Blood pressure control is based on recommended blood pressure goals outlined in American Heart Association task force guidelines (<140/90 mm Hg for low-risk individuals; <130/80 mm Hg for Framingham risk score >10%, CKD, DM, CVD; <120/80 for CHF). CVD indicates coronary heart disease and/or peripheral vascular disease and/or stroke and/or myocardial infarction; DM, diabetes mellitus; CKD, chronic kidney disease; CHF, congestive heart failure. Participants with multiple chronic conditions are grouped into multiple risk groups.

*Hypertension is defined as physician diagnosis of hypertension and/or measured blood pressure>140/90 mm Hg.

†Hypertension awareness indicates the percentage of total people with hypertension who reported a physician diagnosis.

‡Data show the use of antihypertensive medication among those with diagnosed hypertension.

§Blood pressure was >140/90 mm Hg.

‖Data show a physician diagnosis of hypertension and/or elevated blood pressure according to American Heart Association task force guidelines (<140/90 mm Hg for low-risk individuals; <130/80 mm Hg for Framingham risk score >10%, CKD, DM, CVD; <120/80 for CHF).

CAD, and Mexican-Americans have the lowest (Figure 3). We did not find any statistically significant differences in odds of having uncontrolled BP by race or sex after adjusting for confounders (age, body mass index, education, income, antihypertensive medication use, and CAD risk group). After adjusting for age, body mass index, education, income, and medication, non-Hispanic blacks had a higher odds of having uncontrolled BP compared with non-Hispanic whites (OR: 1.36 [95% CI: 0.86 to 2.16]); however, with further adjustment for CAD risk group, this OR was reduced to 1.20 (95% CI: 0.79 to 1.81; data not presented in table form). When we stratified our analysis by race and sex (Table 2), we found that non-Hispanic black men were the most likely to have uncontrolled BP compared with white women (OR: 1.76 [95% CI: 0.92 to 3.37]), yet this OR was reduced to 1.16 (95% CI: 0.62 to 2.17) after adjusting for CAD risk group.

Discussion

Despite increased awareness and treatment of hypertension, individuals with a higher risk of CAD have higher rates of uncontrolled BP compared with the average-risk population. These differences are only partly explained by age: the age-standardized prevalence of uncontrolled BP was 13%, 52%, 35%, 46%, 33%, and 35%, for the average risk population, FRS ≥10%, chronic kidney disease, diabetes mellitus, cardiovascular disease, and congestive heart failure risk groups, respectively. Part of this disparity may be due to the updated and more stringent guidelines for BP control among those with a higher FRS, chronic kidney disease, diabetes mellitus, cardiovascular disease, or congestive heart failure. The prevalence of uncontrolled BP among individuals with a higher risk of CAD ranges from 31% to 32% according to the old (≥140/90 mm Hg) definition of hypertension. According to the updated AHA task force guidelines, this range increases to 50% to 59%.
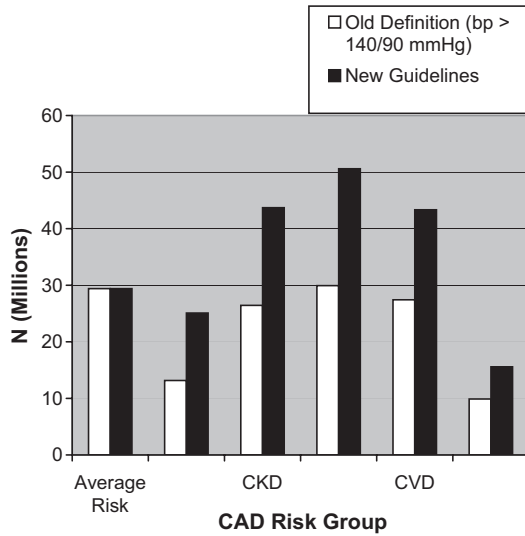
Figure 1. Prevalence of uncontrolled blood pressure according to CAD risk group. White bars represent prevalence of uncontrolled blood pressure according to the old definition of hypertension (>140/90 mm Hg); black bars represent prevalence of uncontrolled blood pressure according to the updated 2007 American Heart Association task force guidelines (<140/90 mm Hg for low-risk individuals; <130/80 mm Hg for FRS >10%, CKD, DM, and CVD; <120/80 mm Hg for CHF). CAD indicates coronary artery disease; FRS, Framingham risk score; CKD, chronic kidney disease; DM, diabetes mellitus; CVD, cardiovascular disease; CHF, congestive heart failure.

This cross-sectional analysis cannot tell us whether higher CAD risk is a consequence of uncontrolled BP or whether BP is more difficult to control in individuals with risk factors for CAD. Longitudinal studies are needed to answer this question. It is likely that BP is more difficult to control in some high-risk populations, for example, in patients with kidney disease and diabetes mellitus. In addition, individuals with a high risk of CAD must achieve a more stringent goal of <130/80 mm Hg rather than <140/90 mm Hg.
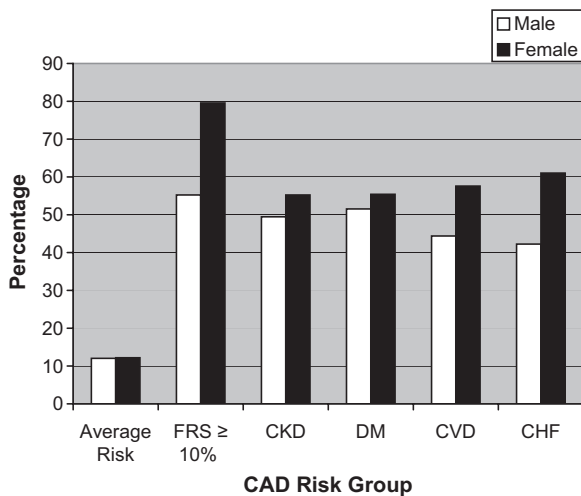

Figure 2. Percentage of US adults with uncontrolled blood pressure according to the 2007 American Heart Association task force recommendations, stratified by sex. White bars represent men and black bars represent women. FRS indicates Framingham risk score; CKD, chronic kidney disease; DM, diabetes mellitus; CVD, cardiovascular disease; CHF, congestive heart failure.

Figure 3. Percentage of Americans with uncontrolled blood pressure according to the 2007 American Heart Association task force recommendations, stratified by race/ethnicity. White bars represent non-Hispanic white adults, gray bars represent non-Hispanic black/black adults, and black bars represent Mexican American adults. FRS indicates Framingham risk score; CKD, chronic kidney disease; DM, diabetes mellitus; CVD, cardiovascular disease; CHF, congestive heart failure.
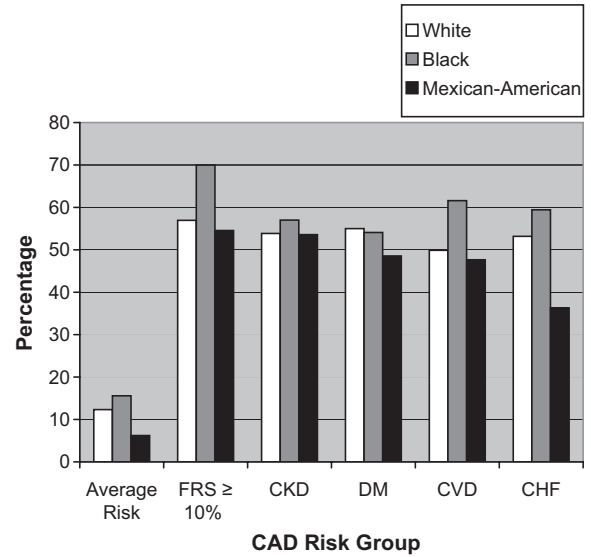
We did not find any statistically significant association between race/ethnicity or sex and odds of having uncontrolled BP in adjusted models. The differences in odds of having uncontrolled BP by race/ethnicity and sex in the unadjusted models is largely explained by varying prevalence of CAD, diabetes mellitus, and kidney disease. When sequential models were used to examine the effect of age, body mass index, education, income, antihypertension medication use, and CAD risk group individually, CAD risk group appeared to be the most important positive confounder. This is not surprising, because the criteria for hypertension control are more stringent in the presence of these disorders.

Although NHANES data have been used to examine hypertension control among US adults[1–3,20–25] this is the first study to our knowledge that investigates this important public health issue using the 2007 AHA task force's updated BP goals. Whereas previous studies examined BP control only among those with hypertension (eg, see References 4 and 22), we examined BP control among all adults. Our study has additional strengths: NHANES is a large nationally representative sample, which allows for estimation of the national burden of uncontrolled BP, and BP was measured using a standardized protocol.

One limitation of this study is the use of self-reported measures of chronic kidney disease, diabetes mellitus, cardiovascular disease, and heart failure. We did, however, have data on creatinine clearance for chronic kidney disease and glycohemoglobin for diabetes mellitus, which was used to supplement our measures of disease status. We also used self-reported physician diagnosis to define hypertension. Others have defined hypertension as a combination of self-reported physician diagnosis and antihypertensive medication use. Our definition is more sensitive (inclusive), which could

Table 2. ORs and 95% CIs for Uncontrolled Blood Pressure According to the 2007 American Heart Association Task Force Guidelines, Stratified by Race/Ethnicity and Sex

Race/Ethnicity and Sex Group	Age Adjusted		Model 1*		Model 2†	
	OR	95% CI	OR	95% CI	OR	95% CI
White women	1.0 (reference)		1.0 (reference)		1.0 (reference)	
White men	1.19	0.91 to 1.55	1.06	0.65 to 1.72	0.78	0.45 to 1.35
Black women	1.37	1.08 to 1.73	1.16	0.77 to 1.74	0.99	0.69 to 1.41
Black men	1.65	1.21 to 2.26	1.76	0.92 to 3.37	1.16	0.62 to 2.17
Mexican American women	1.24	0.92 to 1.68	1.32	0.72 to 2.41	1.02	0.55 to 1.92
Mexican American men	1.34	0.95 to 1.90	0.76	0.42 to 1.36	0.46	0.19 to 1.11

OR indicates odds ratio.

*Model adjusted for age, body mass index, education, income, and antihypertension medication use.

†Model adjusted for age, body mass index, education, income, antihypertension medication use, and coronary artery disease risk group.

potentially overestimate the number of individuals with hypertension if some individuals falsely report a physician diagnosis. Another limitation of this study is the lack of information on lifestyle (nonpharmacologic) modifications for hypertension, such as weight loss or dietary modification. In addition, we did not have information about whether participants had to pay for their antihypertensive medication. Individuals who must pay for their medication are less likely to have their BP under control.[26] Finally, only participants aged ≥40 years underwent ankle brachial index measurement, and we assumed that participants <40 years did not have peripheral vascular disease. Most younger adults with peripheral vascular disease also have another form of cardiovascular disease, minimizing this potential misclassification.

Perspectives

BP control is an important and cost-effective way to reduce hospitalizations and cardiovascular events, such as heart failure and stroke.[27] Antihypertensive medications can delay or prevent the development of hypertension,[28] and recent clinical trials have demonstrated that maintaining BP <140/90 mm Hg reduces the risk of cardiovascular events.[8] Given the benefits of successful clinical intervention, the high cost of treating cardiovascular disease, and the aging US population, control of BP among adults, particularly among those at high risk of CAD, needs to be a national priority. The impact of the new millions of hypertensive individuals certainly poses a substantial economic burden, as well as a burden on clinicians. Examination of the economic burden of uncontrolled BP is warranted, especially related to the sex and racial disparities observed in this study.

Disclosures

None.

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