Implications of New Hypertension Guidelines in the United States

Monica L. Bertoia, Molly E. Waring, Priya S. Gupta, Mary B. Roberts, Charles B. Eaton

Abstract—The American Heart Association released a scientific statement based on available clinical trials and expert opinion in 2007 for the treatment of hypertension to prevent coronary artery disease. These guidelines recommend more aggressive control of blood pressure (BP <130/80 mm Hg) among those at high risk for coronary artery disease, individuals with diabetes mellitus, chronic kidney disease, coronary artery disease or coronary artery disease risk equivalent, or a 10-year Framingham risk score ≥10%. Based on newer clinical trial data, the 2011 American College of Cardiology Foundation/American Heart Association (AHA) hypertension guidelines for the elderly recommend a less aggressive approach of <145/90 mm Hg in those over the age of 80 years. We estimated the burden of uncontrolled BP among those at an increased risk of coronary artery disease using the both the 2007 AHA and the 2011 American College of Cardiology Foundation/AHA hypertension guidelines. We used a cross-sectional analysis of National Health and Nutrition Examination Survey 2005–2008 participants. Participants were 10198 adults aged 18 to 85 years. Using the 2011 American College of Cardiology Foundation/AHA hypertension guidelines (≥140/90 mm Hg), 72 million Americans (35%) have hypertension. Using the 2007 AHA guidelines, an additional 7 million American adults (5%) have elevated BP requiring treatment, for a total of 79 million adults (40%). Although individuals at a higher risk for coronary artery disease 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 coronary artery disease. (Hypertension. 2012;60:639-644.)

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 or physician diagnosis.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 have a higher risk of poor health outcomes related to inadequate BP control, the American Heart Association (AHA) released a scientific statement in 2007 for the treatment of hypertension in the prevention and treatment of coronary artery disease.9

These guidelines recommend more aggressive control of BP among those at high risk for coronary artery disease, including individuals with diabetes mellitus, chronic kidney disease, coronary artery disease or coronary artery disease 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 7, Kidney Disease Outcomes Quality Initiative, and American Diabetes Association recommendations.8,10,11 However, in response to data from the Hypertension in the Very Elderly Trial and the reappraisal of European Guidelines on Hypertension Management,12 the American College of Cardiology Foundation (ACCF) and the AHA released an expert consensus statement in 2011 that recommends less stringent guidelines for the very elderly.13

The 2011 ACCF/AHA hypertension guidelines recommend maintaining a BP of <145/90 mm Hg among individuals aged ≥80 years and <140/90 mm Hg for individuals <80 years, regardless of risk for coronary artery disease.13

Using data from the National Health and Nutrition Examination Survey (NHANES) 2005–2008, we explored the characteristics of US adults who are classified as hypertensive using both sets of hypertension goals and definitions. We compared BP control by coronary artery disease risk group, sex, and race/ethnicity. Finally, we estimated the current burden of hyperten-
Table 1. Prevalence of Hypertension and Characteristics of Each Coronary Artery Disease (CAD) Risk Group Among U.S. Adults, NHANES 2005 to 2008, % and 95% CI, Using the 2007 AHA Hypertension Guidelines

<table>
<thead>
<tr>
<th>Hypertension Status</th>
<th>Average Risk Population</th>
<th>FRS ≥ 10% Only</th>
<th>Chronic Kidney Disease (CKD)</th>
<th>Diabetes Mellitus (DM)</th>
<th>Cardiovascular Disease (CVD)</th>
<th>Congestive Heart Failure (CHF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size (10 198)</td>
<td>6430</td>
<td>1041</td>
<td>1345</td>
<td>1233</td>
<td>1001</td>
<td>324</td>
</tr>
<tr>
<td>Weighted N (204 179 366)</td>
<td>144 mil</td>
<td>19.1 mil</td>
<td>18.2 mil</td>
<td>17.6 mil</td>
<td>15.5 mil</td>
<td>4.5 mil</td>
</tr>
<tr>
<td>Hypertension*</td>
<td>23 (22–25)</td>
<td>70 (66–74)</td>
<td>77 (74–80)</td>
<td>78 (74–81)</td>
<td>80 (77–84)</td>
<td>83 (78–87)</td>
</tr>
<tr>
<td>Hypertension awareness†</td>
<td>80 (77–83)</td>
<td>78 (72–83)</td>
<td>89 (86–92)</td>
<td>92 (90–94)</td>
<td>92 (89–94)</td>
<td>93 (86–96)</td>
</tr>
<tr>
<td>Use of anti-hypertensive medication‡</td>
<td>56 (51–60)</td>
<td>75 (68–80)</td>
<td>88 (85–90)</td>
<td>88 (85–90)</td>
<td>87 (83–90)</td>
<td>93 (88–96)</td>
</tr>
<tr>
<td>Uncontrolled blood pressure§</td>
<td>10 (9–11)</td>
<td>57 (53–61)</td>
<td>52 (49–56)</td>
<td>52 (49–56)</td>
<td>52 (48–55)</td>
<td>51 (44–58)</td>
</tr>
<tr>
<td>Male</td>
<td>46 (44–47)</td>
<td>90 (87–92)</td>
<td>29 (26–32)</td>
<td>49 (44–53)</td>
<td>53 (48–58)</td>
<td>58 (51–64)</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic White</td>
<td>78 (73–81)</td>
<td>86 (82–90)</td>
<td>82 (76–87)</td>
<td>70 (63–77)</td>
<td>83 (79–87)</td>
<td>78 (71–83)</td>
</tr>
<tr>
<td>Non-Hispanic Black</td>
<td>12 (10–16)</td>
<td>9 (6–12)</td>
<td>13 (9–18)</td>
<td>20 (15–26)</td>
<td>12 (9–16)</td>
<td>19 (14–25)</td>
</tr>
<tr>
<td>Mexican American</td>
<td>10 (8–13)</td>
<td>5 (4–6)</td>
<td>5 (4–8)</td>
<td>10 (7–14)</td>
<td>4 (3–6)</td>
<td>3 (2–6)</td>
</tr>
<tr>
<td>Age in years (mean, SE)</td>
<td>40 (0.3)</td>
<td>59 (0.6)</td>
<td>67 (0.6)</td>
<td>58 (0.6)</td>
<td>65 (0.6)</td>
<td>66 (0.8)</td>
</tr>
<tr>
<td>Socioeconomic status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>Less than high school</td>
<td>16 (14–18)</td>
<td>21 (18–25)</td>
<td>29 (24–34)</td>
<td>30 (26–33)</td>
<td>30 (27–34)</td>
</tr>
<tr>
<td>Household income</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than $20 000</td>
<td>15 (13–17)</td>
<td>17 (12–22)</td>
<td>35 (23–49)</td>
<td>22 (17–30)</td>
<td>28 (23–34)</td>
<td>28 (19–39)</td>
</tr>
<tr>
<td>$45 000–$74 999</td>
<td>25 (23–28)</td>
<td>25 (20–30)</td>
<td>12 (7–19)</td>
<td>21 (15–30)</td>
<td>18 (13–24)</td>
<td>16 (8–30)</td>
</tr>
<tr>
<td>$75 000 or more</td>
<td>32 (28–37)</td>
<td>25 (18–34)</td>
<td>11 (6–20)</td>
<td>23 (17–29)</td>
<td>16 (13–20)</td>
<td>10 (5–18)</td>
</tr>
<tr>
<td>Family income below poverty level</td>
<td>13 (12–15)</td>
<td>9 (7–11)</td>
<td>12 (10–15)</td>
<td>15 (13–19)</td>
<td>17 (14–21)</td>
<td>17 (12–22)</td>
</tr>
<tr>
<td>Insured</td>
<td>78 (75–80)</td>
<td>83 (80–86)</td>
<td>92 (89–94)</td>
<td>88 (85–90)</td>
<td>91 (88–93)</td>
<td>91 (85–94)</td>
</tr>
</tbody>
</table>

Note: Participants with multiple chronic conditions are grouped into multiple risk groups. CVD = coronary heart disease and/or peripheral vascular disease and/or stroke and/or myocardial infarction.

*Physician diagnosis of hypertension and/or elevated blood pressure according to the 2007 AHA hypertension guidelines (≥140/90 for low-risk individuals; ≥130/80 for FRS ≥10%, CKD, DM, CVD, ≥120/80 for CHF).

†Hypertension awareness indicates the percentage of total people with elevated blood pressure (≥140/90) that report a physician diagnosis.

‡Use of anti-hypertensive medication among those with diagnosed hypertension.

§Blood pressure control based on recommended blood pressure goals outlined in the 2007 AHA hypertension guidelines (<140/90 for low-risk individuals; <130/80 for FRS ≥10%, CKD, DM, CVD, ≥120/80 for CHF).

Methods

The NHANES 2005–2008 is a nationally representative sample of noninstitutionalized individuals. Ascertainment and survey design have been described. 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 old), pregnant women, individuals who had missing or invalid BP measurements, and individuals who were missing prescription drug information, the final analytic sample included 10189 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 of the readings but 1 were 0, the non-0 reading was used. We defined hypertension as average systolic BP ≥140 mm Hg, average diastolic BP ≥90 mm Hg, or physician diagnosis of hypertension.

Those with elevated BP 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. We used 2 different criteria to define BP control, the 2007 AHA hypertension guidelines and the 2011 ACCF/AHA hypertension guidelines, both based on available clinical data and expert opinion at the time.

Using the 2007 AHA hypertension guidelines, control was defined as BP <140/90 mm Hg for the average coronary artery disease risk population. For higher coronary artery disease 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. BP goals using the 2011 ACCF/AHA hypertension guidelines were <140/90 mm Hg for all individuals <80 years, regardless of coronary artery disease risk. For the elderly, or those aged ≥80 years, the BP goal was <145/90 mm Hg.

Coronary artery disease risk was assessed by 10-year FRS. 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. 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 and reviewed for accuracy by a physician.

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 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 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. 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 variance 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

Seventy-two million or 35% of US adults have hypertension according to the 2011 ACCF/AHA hypertension guidelines, defined as physician diagnosis or measured BP ≥140/90 mm Hg. An additional 7 million or 5% have uncontrolled BP using the 2007 AHA hypertension guidelines, for a total of 79 million US adults (40%). Eighty percent of average-risk US adults with elevated BP (defined as ≥140/90 mm Hg) have been diagnosed by a physician (Table 1), and 56% are taking antihypertensive medications.

Individuals who are at an increased risk of coronary artery disease, 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). Com-
pared with adults with hypertension in the average-risk population, antihypertensive medication use was more common among adults with hypertension and an elevated risk for coronary artery disease. According to the 2007 AHA hypertension guidelines, an additional 4.8 million adults with FRS ≥10% have uncontrolled BP, as well as an additional 4.0 million with chronic kidney disease, 4.0 million with diabetes mellitus, 3.0 million with cardiovascular disease, and 0.8 million with congestive heart failure (Figure 1). Despite increased awareness and treatment of hypertension, individuals with a higher risk of coronary artery disease are more likely to have uncontrolled BP compared with the average-risk population. This difference is apparent when using both the 2011 ACCF/AHA and the 2007 AHA criteria for control, 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 of the subgroups of the population who are at an increased risk for coronary artery disease, and Mexican Americans have the lowest (Figure 3). We did not find any statistically significant differences in odds of having uncontrolled BP by sex after adjusting for confounders (age, body mass index, education, income, antihypertensive medication use, and coronary artery disease risk group). After adjusting for age, body mass index, education, income, medication, and coronary artery disease risk group, Non-Hispanic blacks had a higher odds of having uncontrolled BP compared with Non-Hispanic whites (odds

Table 3. Prevalence of Hypertension and Characteristics of Each Coronary Artery Disease (CAD) Risk Group Among U.S. Adults and Elderly, NHANES 2005 to 2008, % and 95% CI, Using the 2011 ACCF/AHA Hypertension Guidelines

<table>
<thead>
<tr>
<th>Hypertension Status</th>
<th>Average Risk Population &lt;140/90 mm Hg</th>
<th>FRS ≥10% Only &lt;140/90 mm Hg</th>
<th>Chronic Kidney Disease (CKD) &lt;140/90 mm Hg</th>
<th>Diabetes Mellitus (DM) &lt;140/90 mm Hg</th>
<th>Cardiovascular Disease (CVD) &lt;140/90 mm Hg</th>
<th>Congestive Heart Failure (CHF) &lt;140/90 mm Hg</th>
<th>Elderly (≥80 Years) &lt;145/90 mm Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size (10 198)</td>
<td>6430</td>
<td>1041</td>
<td>1345</td>
<td>1233</td>
<td>1001</td>
<td>324</td>
<td>648</td>
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<tr>
<td>Weighted N (204 179 366)</td>
<td>144 mil</td>
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<td>8.1 mil</td>
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<tr>
<td>Hypertension*</td>
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Note: Participants with multiple chronic conditions are grouped into multiple risk groups.
CVD = coronary heart disease and/or peripheral vascular disease and/or stroke and/or myocardial infarction.
*Hypertension is defined as physician diagnosis of hypertension and/or measured blood pressure ≥140/90 mm Hg among individuals <80 y/≥145/90 among individuals 80 y or older.
†Hypertension awareness indicates the percentage of total people with elevated blood pressure (≥140/90 mm Hg among individuals <80 y/≥145/90 among individuals 80 y or older) that report a physician diagnosis.
‡Use of anti-hypertensive medication among those with diagnosed hypertension.
§Blood pressure ≥140/90 mm Hg in individuals <80 y and blood pressure ≥145/90 mm Hg in individuals 80 y or older.
Although NHANES data have been used to examine BP control among US adults, this is the first study to our knowledge that investigates this important public health issue using the 2007 AHA hypertension guidelines. Although previous studies examined BP control only among those taking BP medications (eg, References 4 and 23), we examined BP control among all adults with or without a diagnosis of hypertension. Our study has additional strengths: NHANES is a large nationally representative sample, which allows 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 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.27 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.

**Discussion**

Despite increased awareness and treatment of hypertension, individuals with a higher risk of coronary artery disease have higher rates of uncontrolled BP compared with the average risk population, using the 2007 AHA hypertension guidelines. These differences are only partly explained by age: the age-standardized prevalence of uncontrolled BP was 13%, 30%, 33%, 47%, 35%, and 34% for the average-risk population, FRS ≥10%, chronic kidney disease, diabetes mellitus, cardiovascular disease, and congestive heart failure risk groups, respectively. The prevalence of uncontrolled BP among individuals with a higher risk of coronary artery disease ranges from 31% to 33% according to the 2011 ACCF/AHA hypertension guidelines (≥140/90 mm Hg). According to the 2007 AHA hypertension guidelines, this range is 51% to 57%.

This cross-sectional analysis cannot tell us whether higher CAD risk is a consequence of uncontrolled BP or if 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.

We did not find any statistically significant association between sex and odds of having uncontrolled BP according to 2007 AHA hypertension guidelines in adjusted models; however, non-Hispanic blacks had a higher odds of uncontrolled BP compared with non-Hispanic whites. When sequential models were used to examine the effect of age, body mass index, education, income, antihypertension medication use, and coronary artery disease risk group individually, coronary artery disease risk group appeared to be the most important positive confounder. This is not surprising, because the criteria for BP control are more stringent in the presence of these disorders.

Current recommendations for BP control in the elderly are conflicting; therefore, it is difficult to estimate the true burden of hypertension in this subgroup. More clinical trial evidence within this age group is needed. Updated AHA guidelines and Joint National Committee 8 guidelines are forthcoming and may provide additional insight into optimal BP recommendations for this group of individuals who represent a growing proportion of the total US population.


**Novelty and Significance**

**What Is New?**

- We estimate the burden of elevated BP among those at high risk of coronary artery disease.

**What Is Relevant?**

- The 2007 AHA hypertension guidelines recommend that individuals with high risk of coronary artery disease maintain a BP <130/80 mm Hg. The 2011 ACCF/AHA guidelines recommend less stringent control (<140/90 mm Hg), especially in the elderly (<145/90 mm Hg).

**Summary**

Using the 2011 ACCF/AHA guidelines, 72 million or 35% of US adults have hypertension. Using the 2007 AHA guidelines, an additional 7 million American adults (5%) have elevated BP requiring treatment, for a total of 79 million adults (40%).
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