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Background: Recent guidelines and clinical trial results emphasize the importance of controlling blood pressure among people with diabetes. We estimated the prevalence of elevated blood pressure among U.S. adults with diagnosed diabetes, and examined the extent to which elevated blood pressure is being treated and controlled.

Methods: The Third National Health and Nutrition Examination Survey (1988–1994), a probability survey of the civilian, non-institutionalized population of the United States, consisted of an interview and physical examination, which included blood pressure measurement. Survey participants included 1507 adults (aged ≥18 years) with self-reported diabetes. Among people with self-reported diabetes, we estimated elevated blood pressure (mean blood pressure of ≥130/85 mm Hg or use of antihypertensive medication); awareness (prior diagnosis of hypertension); treatment (antihypertensive medication use); and control (mean blood pressure of <130/85 or <140/90).

Results: In the 1988–1994 period, 71% (95% confidence interval [CI] = ±4.4%) of all U.S. adults with diabetes had elevated blood pressure. The prevalence of elevated blood pressure increased with age and was high among both men and women and among Mexican Americans, non-Hispanic blacks, and non-Hispanic whites. Among those with elevated blood pressure, 71% (95% CI = ±4.4%) were aware and 57% (95% CI = ±4.2%) were treated, but only 12% (95% CI = ±3.2%) had mean blood pressure <130/85 and 45% (95% CI = ±4.9%) had mean blood pressure <140/90. Control of blood pressure was least common among older people.

Conclusions: All people with diabetes—regardless of age, gender, and race and ethnicity—may benefit from efforts to prevent hypertension. The control of elevated blood pressure is inadequate and broad-based efforts are needed to improve blood pressure control.

Medical Subject Headings (MeSH): blood pressure, diabetes mellitus, epidemiology, hypertension

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death and that of macrovascular and microvascular complications among patients with newly diagnosed diabetes and hypertension. A prospective observational analysis\(^6\) of the UKPDS-HDS data found no upper or lower threshold of systolic blood pressure in the risk of diabetic complications, indicating that any reduction of elevated systolic blood pressure reduced complications and that the nearer to a systolic blood pressure of \(<120\) mm Hg, the lower the risk of complications. Finally, cost-effectiveness studies indicated that tight blood pressure control provided a highly cost-effective means of improving health and reducing the risk of complications among patients with diabetes.\(^7, 8\)

In light of these recent studies, understanding the prevalence of elevated blood pressure in the U.S. population with diabetes and the extent to which it is being treated and controlled is vital for prevention efforts. However, no recent national data describing prevalence of elevated blood pressure and its treatment and control are available. We used the Third National Health and Nutrition Examination Survey (NHANES III) to estimate the prevalence, awareness, treatment, and control of elevated blood pressure among adults with diagnosed diabetes.

**Methods**

The National Center for Health Statistics of the Centers for Disease Control and Prevention conducted the NHANES III between 1988 and 1994 on a representative sample of the civilian, non-institutionalized population of the United States.\(^9\) The survey included an interview and a limited examination within the home, followed by a more extensive physical examination in a mobile examination center (MEC). Of the 39,695 sampled people, 86% (33,994) agreed to be interviewed and examined in their home and 78% (30,818) had subsequent physical examinations at the MEC.\(^9\)

During the home interview, participants were asked if a doctor had told them that they had diabetes and if a doctor or health professional had told them that they had hypertension (high blood pressure). Participants who reported a hypertension diagnosis were asked whether they had been told to take prescribed medicine, control or lose weight, and cut down on salt in their diet because of their hypertension. Those answering that they had been told were asked whether they were now conforming to the specific treatment advice. Blood pressure was measured 3 times at the end of the home interview, and a second set of three blood pressure measurements was obtained during the physical examination at the MEC.\(^9\)

Our analysis was restricted to 1507 participants aged \(\geq 18\) years who reported a history of diabetes during the home interview. Women who had only gestational diabetes were excluded. The number of blood pressure measurements ranged from one to six, and we used the mean of all measurements. We classified participants as having elevated blood pressure if they had mean blood pressure of \(\geq 130/85\) mm Hg or were taking prescription drugs for hypertension. Among those with elevated blood pressure, we estimated awareness, treatment, and blood pressure control. Awareness was defined as a self-report of a prior diagnosis of hypertension, and treatment was defined as self-report of current prescription drug use for hypertension. We also examined two levels of blood pressure control: (1) mean blood pressure \(\geq 130/85\) mm Hg and (2) mean blood pressure \(\geq 140/90\) mm Hg. Because the NHANES III was conducted before the JNC-VI treatment recommendations, we also examined prevalence, awareness, treatment, and control, using a definition of elevated blood pressure conforming to treatment recommendations that were in effect at the time of the survey\(^10, 11\) (i.e., mean blood pressure of \(\geq 140/90\) mm Hg or taking prescription drugs for hypertension).

We calculated estimates for the non-Hispanic white, non-Hispanic black, and Mexican-American populations with diabetes. Because the survey’s sample size for specific racial and ethnic groups is inadequate for reliable estimates of people with diabetes aged 18 to 44, only two age groups (18 to 64 and \(\geq 65\) years) are reported for these populations. To take into account the complex design of the survey, we used SUDAAN software\(^12\) to calculate weighted estimates and their 95% confidence intervals (CIs). We used the direct method to standardize estimates to the age distribution of U.S. adults with diabetes estimated from the NHANES III.

**Results**

**Prevalence and Type of Elevated Blood Pressure**

Among U.S. adults with diabetes (9.1 million), 71.0% (6.4 million) had elevated blood pressure (i.e., blood pressure \(\geq 130/85\) mm Hg or current use of prescription medication for hypertension) (Table 1). The prevalence of elevated blood pressure was high among all age groups, but it increased with age, from 39.6% among people aged 18 to 44 years, to 71.5% among people aged 45 to 64 years, to 83.5% among people aged \(\geq 65\) years. Although the estimated prevalence of elevated blood pressure was consistently higher for women than men across the three age groups, no statistically significant differences were observed. Among non-Hispanic whites and Mexican Americans, prevalence was greater among people aged \(\geq 65\) than among people aged 18 to 44 years. However, among non-Hispanic blacks, the estimated prevalence for people aged \(\geq 65\) was not significantly higher than for those aged 18 to 64.

Age-adjusted estimates of the prevalence of elevated blood pressure were high for both genders and for Mexican Americans, non-Hispanic blacks, and non-Hispanic whites (Figure 1). Although estimates tended to be higher for women than men and for non-Hispanic blacks than Mexican Americans, no statistically significant differences were observed.

The prevalence of elevated blood pressure is reduced from 71.0% (JNC-VI) to 56.7% (95% CI = \(\pm 3.6\%\)) when the older JNC-V definition (blood pressure \(\geq 140/90\) mm Hg or current use of prescription medication for hypertension) is used. When the recent National Kidney Foundation’s\(^13\) target blood pressure of \(\geq 130/80\)
mm Hg is used, the prevalence of elevated blood pressure is 73.2% (95% CI = ±4.2%).

Among adults with diabetes and blood pressure ≥130/85 mm Hg, the distribution of blood pressure varied with age (Figure 2). Among adults aged 18 to 64, 46.1% (95% CI = ±7.6%) had blood pressure between 130/85 mm Hg and 139/89 mm Hg; 38.9% (95% CI = ±8.0%) between 140/90 mm Hg and 159/99 mm Hg; and 14.6% (95% CI = ±4.3%) ≥160/≥100 mm Hg.

In contrast, blood pressure levels were higher among adults aged ≥65: 29.5% (95% CI = ±5.3%) had blood pressures between 130/85 mm Hg and 139/89 mm Hg; 42.5% (95% CI = ±6.1%) between 140/90 mm Hg and 159/99 mm Hg; and 28.0% (95% CI = ±4.6%) ≥160/≥100 mm Hg. A systolic blood pressure of ≥130 with a diastolic blood pressure of <85 was the predominant type of elevated blood pressure, particularly among older adults. This type of blood pressure accounted for 61.6% (95% CI = ±7.9%) and 86.5% (95% CI = ±4.0%) among adults aged 65 and older.

### Table 1. Elevated blood pressure among adults with diabetes by demographic characteristics

<table>
<thead>
<tr>
<th>Demographic characteristics</th>
<th>Adults with diabetes</th>
<th>Elevated blood pressure</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample number</td>
<td>Population number</td>
<td>% (±95% CI)</td>
<td>Number (1,000,000)</td>
</tr>
<tr>
<td>---------------</td>
<td>---------------------</td>
<td>-------------------------</td>
<td>---</td>
</tr>
<tr>
<td><strong>Gender and age</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1507</td>
<td>9.1</td>
<td>71.0 (±4.4)</td>
</tr>
<tr>
<td>18–44</td>
<td>175</td>
<td>1.6</td>
<td>39.6 (±13.6)</td>
</tr>
<tr>
<td>45–64</td>
<td>519</td>
<td>3.6</td>
<td>71.5 (±6.9)</td>
</tr>
<tr>
<td>≥65</td>
<td>813</td>
<td>3.9</td>
<td>83.5 (±3.1)</td>
</tr>
<tr>
<td>Men</td>
<td>661</td>
<td>4.1</td>
<td>66.4 (±7.1)</td>
</tr>
<tr>
<td>18–44</td>
<td>72</td>
<td>0.7</td>
<td>34.4 (±17.9)</td>
</tr>
<tr>
<td>45–64</td>
<td>235</td>
<td>1.8</td>
<td>67.9 (±10.4)</td>
</tr>
<tr>
<td>≥65</td>
<td>354</td>
<td>1.6</td>
<td>78.4 (±5.6)</td>
</tr>
<tr>
<td>Women</td>
<td>846</td>
<td>5.0</td>
<td>74.7 (±5.7)</td>
</tr>
<tr>
<td>18–44</td>
<td>103</td>
<td>0.9</td>
<td>43.5 (±16.9)</td>
</tr>
<tr>
<td>45–64</td>
<td>284</td>
<td>1.8</td>
<td>75.1 (±9.4)</td>
</tr>
<tr>
<td>≥65</td>
<td>459</td>
<td>2.3</td>
<td>87.0 (±3.8)</td>
</tr>
<tr>
<td><strong>Race/ethnicity and age</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic whites</td>
<td>599</td>
<td>6.8</td>
<td>70.7 (±5.5)</td>
</tr>
<tr>
<td>18–64</td>
<td>189</td>
<td>3.7</td>
<td>59.3 (±9.7)</td>
</tr>
<tr>
<td>≥65</td>
<td>410</td>
<td>3.1</td>
<td>84.2 (±3.4)</td>
</tr>
<tr>
<td>Non-Hispanic blacks</td>
<td>419</td>
<td>1.4</td>
<td>75.4 (±4.9)</td>
</tr>
<tr>
<td>18–64</td>
<td>239</td>
<td>0.8</td>
<td>71.6 (±7.0)</td>
</tr>
<tr>
<td>≥65</td>
<td>180</td>
<td>0.5</td>
<td>82.0 (±5.5)</td>
</tr>
<tr>
<td>Mexican Americans</td>
<td>452</td>
<td>0.5</td>
<td>64.5 (±7.9)</td>
</tr>
<tr>
<td>18–64</td>
<td>243</td>
<td>0.4</td>
<td>56.1 (±12.0)</td>
</tr>
<tr>
<td>≥65</td>
<td>209</td>
<td>0.2</td>
<td>84.0 (±4.0)</td>
</tr>
</tbody>
</table>

a Blood pressure ≥130/85 or current use of prescription medication for hypertension.
b Number of participants with diabetes in Third National Health and Nutrition Examination Survey.
d Includes racial and ethnic groups not shown separately.

Figure 1. Age-adjusted prevalence of elevated blood pressure (≥130/85 mm Hg or current use of prescription medication for hypertension) by gender and race/ethnicity, U.S. adults with diabetes, NHANES III, 1988–1994.

Figure 2. Distribution of blood pressure ≥130/85 mm Hg and blood pressure ≥130/<85, by age, U.S. adults with diabetes, NHANES III, 1988–1994.
than similarly aged women or younger men and were less likely to be aware of their hypertension among adults with diabetes and elevated blood pressures (Table 2). Men aged ≥65 years were less likely to be aware of their hypertension than similarly aged women or younger men and women. Awareness of hypertension among non-Hispanic blacks was similar to that among non-Hispanic whites but greater than awareness among Mexican Americans. When we measured awareness among adults with diabetes and blood pressure ≥140/90 mm Hg or using antihypertensive medication (i.e., blood pressure levels consistent with prior treatment recommendations), we found that awareness was somewhat higher overall (82%, 95% CI=±3.9%).

The majority (57%) of adults with diabetes and elevated blood pressure used pharmacologic treatment (42%) than for hypertension (Table 2). Men aged ≥65 were more likely to use pharmacologic treatment than similarly aged women or younger men and women. Awareness, Treatment, and Control

About 71% of adults with diabetes and elevated blood pressure were aware (i.e., had been told) that they had hypertension (Table 2). Awareness was high in all age groups and all racial and ethnic groups. Men aged ≥65 years were less likely to be aware of their hypertension than similarly aged women or younger men and women. Awareness of hypertension among non-Hispanic blacks was similar to that among non-Hispanic whites but greater than awareness among Mexican Americans. When we measured awareness among adults with diabetes and blood pressure ≥140/90 mm Hg or using antihypertensive medication (i.e., blood pressure levels consistent with prior treatment recommendations), we found that awareness was somewhat higher overall (82%, 95% CI=±3.9%).
were less likely to use pharmacologic treatment (49%) than non-Hispanic blacks (63%). However, these demographic differences in treatment disappeared when awareness was taken into account, indicating that the demographic differences reflected differences in the awareness or detection of hypertension rather than biases in treatment. When we measured treatment among adults with blood pressure ≥140/90 mm Hg or using antihypertensive medication, treatment was higher (71%, 95% CI=±4.6%).

Only 12% of adults with elevated blood pressure had a mean blood pressure <130/85 mm Hg, and 45% had a mean blood pressure <140/90 mm Hg (Table 2). Blood pressure control was greatest among people aged 18 to 44 years and it decreased with age. This effect of age on control was greater among women than men. When we calculated estimates among adults with blood pressure ≥140/90 mm Hg or using antihypertensive medication, 31% (95% CI=±5.2%) had blood pressure <140/90 mm Hg. When we restricted our measurement of control to those receiving drug therapy, we found that 43% (95% CI=±7.0%) had blood pressure <140/90 mm Hg.

Current Prescribed and Practiced Therapies

Among adults with diabetes and a history of hypertension, the frequency of physician advice for prescription medication, salt reduction, and weight control or weight loss was high, and self-reported practice of this advice was high among adults (Figure 3). Still, when physician advice and patient use were examined in combination, we found that over 20% of adults with self-reported hypertension either were not advised or did not adopt advice on medication and salt reduction, and about 40% were either not advised or did not adopt advice on weight control or loss.

Conclusions

During 1988 to 1994, 71% of the U.S. adult population with diabetes had elevated blood pressure. The prevalence of elevated blood pressure increased with age and was high among both men and women and among Mexican Americans, non-Hispanic blacks, and non-Hispanic whites. Because the NHANES III was conducted prior to JNC-VI treatment recommendations, these data reflect how far we need to go rather than how well standards of care regarding detection, treatment, and control were being met at the time of the survey. Although we found that the majority of adults with diabetes and elevated blood pressure were aware that they had hypertension and were using pharmacologic treatment, we also saw room for improvement in awareness and treatment, particularly among men aged ≥65 and among Mexican Americans. Control of blood pressure among adults with elevated blood pressure was suboptimal, regardless of age, gender, race, or ethnicity; the blood pressure levels used to define elevated blood pressure (≥130/85 or ≥140/90 mm Hg); and whether control was defined at <130/85 or <140/90 mm Hg. Blood pressure control was particularly poor among the middle-aged and elderly. These data indicate that improvements in blood pressure control are needed among all adults with diabetes and hypertension and that additional efforts need to be targeted toward the middle-aged and elderly.

Comparison of published NHANES III results to our data using similar definitions of elevated blood pressure (i.e., blood pressure ≥140/90 mm Hg or use of prescription medication for hypertension) revealed that awareness and treatment of elevated blood pressure were higher among people with diabetes than among all U.S. adults (82% vs 69% for awareness and 71% vs 53% for treatment, respectively). However, greater awareness and treatment efforts did not result in better control. Control of blood pressure among those using antihypertensive drug therapy was suboptimal among people with (43%) and without (45%) diabetes. The discrepancy between treatment and blood pressure control in both populations could arise from a number of factors, including inadequate access to medical care and prescription medications, inappropriate or ineffective treatments, lack of patient adherence to prescription medication and lifestyle modifications, lack of acceptance of hypertension treatment guidelines by providers, lack of provider knowledge of treatment guidelines, or a combination of these and other factors. Although all of these factors have not been thoroughly studied, several reports, both in the United States and abroad, have suggested that improve-
ments in blood pressure control will require changes in physician management of elevated blood pressure. These studies have found that many physicians initiate treatment for hypertension at higher blood pressure thresholds than existing guidelines,15–18 have not heard of or are unfamiliar with blood pressure guidelines,15 are less aggressive in controlling blood pressure in older patients,15,17–19 seldom intensify drug therapy for blood pressure above target levels,17,20,21 are more likely to treat or control elevated diastolic blood pressure than systolic blood pressure,15,21,22 and do not adhere to guidelines when initiating treatment or choosing first-line drug therapy.15,17,18,23

Although further research is needed on how to improve the management of blood pressure in healthcare settings, a logical first step would be for the medical, scientific, and public health communities to promote existing treatment guidelines and educate the public, healthcare providers, and patients about the necessity for treatment and control of elevated blood pressure. Also, healthcare systems should use their policies, protocols, and patient and provider education efforts to ensure appropriate detection and treatment of people with elevated blood pressure and to make blood pressure control an integral component of patient care. Furthermore, the control of hypertension among people with diabetes may be more difficult than in the general population because of the older age of the population with diabetes, the existence of complications, and the need for multiple drug combinations. Thus, specific guidelines for the treatment and management of elevated blood pressure among patients with diabetes may be needed.24

According to our population-based data, high systolic blood pressure accounted for the majority of elevated blood pressure cases and was particularly high for older adults. The Coordinating Committee of the National High Blood Pressure Education Program recently issued a clinical advisory recommending a major paradigm shift in the diagnosis and treatment of hypertension among older Americans.25 Because of the mounting evidence of the importance of systolic blood pressure control in reducing cardiovascular disease risk among older people, the high prevalence of elevated systolic blood pressure among older people, and the poor control of hypertension in this age group, the committee urged that systolic blood pressure be used as the major criterion for the diagnosis and management of hypertension, that age-adjusted blood pressure targets be discouraged, and that a new national initiative be established to improve the current low rates of systolic blood pressure control in the middle-aged and elderly.

The NHANES III data indicate that all adults with diabetes (regardless of age, gender, race, or ethnicity) may benefit from targeted efforts to prevent hypertension. Because of the high prevalence of elevated blood pressure among people with diabetes and because hypertension is often present at the time of diagnosis of diabetes,26 people with diabetes may also benefit from hypertension prevention efforts targeting those at high risk of developing diabetes, as well as from population-wide approaches to reduce blood pressure. According to the National High Blood Pressure Education Program Working Group,27 the most efficacious primary prevention efforts appear to be weight loss, reduction in sodium intake, increased physical activity, and avoidance of excessive alcohol consumption. Furthermore, a recent, randomized clinical trial showed that a diet rich in fruits and vegetables and low in saturated and total fats significantly lowered blood pressure in participants who were both normotensive and hypertensive.28,29 These population-wide approaches may also prove important to the primary prevention of both cardiovascular disease and diabetes.

Strengths and Limitations

Because the NHANES III used a standardized blood pressure measurement protocol to take multiple blood pressure measurements on two occasions from a representative sample of the civilian, non-institutionalized population of the United States, data from this survey are the best available data for estimating the prevalence of elevated blood pressure and the extent to which it is being treated and controlled in the U.S. population.14 In evaluating or interpreting the results of this NHANES III analysis, we must take into account a few considerations. As previously stated, the survey was conducted prior to the published results of several important clinical trials and the latest JNC guidelines; thus, awareness, treatment, and control of blood pressure may have improved since the survey. The sample size is inadequate for reliable gender and race/ethnic estimates of elevated blood pressure among those aged 18 to 44 years. Because people with undiagnosed diabetes were not included in our analysis, our estimates are representative only of the U.S. population with diagnosed diabetes. Finally, since the data from the NHANES III are representative only of the civilian non-institutionalized population, they exclude certain groups, such as occupants of nursing homes, military personnel, and prison inmates.

Public Health Implications

Our report clearly shows that the prevalence of elevated blood pressure in the U.S. population with diabetes is unacceptably high. People with diabetes may benefit from hypertension prevention efforts targeted at people with diabetes, people at high risk of developing diabetes, and the communities in which they live. Our report also clearly shows that control of elevated blood pressure among people with diabetes is inadequate. Because recent studies have documented the substan-
tial benefits and cost effectiveness of blood pressure control among people with diabetes, effective intervention efforts are urgently needed to improve blood pressure control, particularly among the middle-aged and elderly with diabetes.

References


