National Surveillance Definitions for Hypertension Prevalence and Control Among Adults

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Background—Clear and consistent definitions of hypertension and hypertension control are crucial to guide diagnosis, treatment, and surveillance. A variety of surveillance definitions are in frequent use, resulting in variation of reported hypertension prevalence and control, even when based on the same data set.

Methods and Results—To assess the variety of published surveillance definitions and rates, we performed a literature search for studies and reports that used National Health and Nutrition Examination Surveys (NHANES) data from at least as recent as the 2003 to 2004 survey cycle. We identified 19 studies that used various criteria for defining hypertension and hypertension control, as well as different parameters for age adjustment and inclusion of subpopulations. This resulted in variation of reported age-standardized hypertension prevalence from 28.9% to 32.1% and hypertension control from 35.1% to 64%. We then assessed the effects of varying the definitions of hypertension and hypertension control, parameters for age adjustment, and inclusion of subpopulations on NHANES data from both 2007 to 2008 (n=5645) and 2005 to 2008 (n=10,365). We propose standard surveillance definitions and age-adjustment parameters for hypertension and hypertension control. By using our recommended approach with NHANES 2007 to 2008 data, the age-standardized prevalence of hypertension in the United States was 29.8% (SE, 0.62%) and the rate of hypertension control was 45.8% (SE, 4.03%).

Conclusions—Surveillance definitions of hypertension and hypertension control vary in the literature. We present standard definitions of hypertension prevalence and control among adults and standard parameters for age-adjustment and population composition that will enable meaningful population comparisons and monitoring of trends. (Circ Cardiovasc Qual Outcomes. 2012;5:343-351.)

Key Words: hypertension | epidemiology | surveillance | health policy | prevention

Hypertension (HTN) is a prevalent condition worldwide and a major risk factor for cardiovascular disease.1 Mortality from stroke and ischemic heart disease doubles with each 20-mm Hg increase in systolic blood pressure (SBP) from levels as low as 115 mm Hg, and with each 10-mm Hg increase in diastolic BP (DBP) from levels as low as 75 mm Hg.2 In 2010, the estimated cost of HTN was $76.6 billion in the United States alone.1 Improvement in the awareness, treatment, and control of HTN is essential to reduce associated morbidity and mortality.

Healthy People (HP) is a decennial national plan for disease prevention and health promotion coordinated primarily by the US Department of Health and Human Services and developed with input from federal, state, and local governments, professional societies, businesses, and other groups.3 By using baseline surveillance data, HP 2010 established objectives related to BP, including a reduced proportion of adults with HTN and an increased proportion of adults whose HTN is controlled. HP 2020 was launched in late 2010.4

Clear definitions of HTN and HTN control are crucial to guide diagnosis, treatment, and surveillance to monitor progress toward HP objectives. Hypertension is defined clinically as SBP ≥140 mm Hg or DBP ≥90 mm Hg, averaged over ≥2 readings on ≥2 visits after an initial screening.5 In cross-sectional surveys, BP measurements are generally limited to a single point in time, and alternate definitions of HTN...
WHAT IS KNOWN

- Hypertension is highly prevalent in the US and around the world and its control is suboptimal
- A variety of surveillance definitions for hypertension and hypertension are in frequent use

WHAT THIS ARTICLE ADDED?

- We found a wide variation of prevalence of hypertension and hypertension control when different definitions, inclusion/exclusion criteria and age adjustment schemes were used by examining 19 published studies using NHANES 2003 to 2004 or more recent cycles
- We proposed standard surveillance definitions of hypertension prevalence and control among adults and standard parameters for age-adjustment and population composition to enable meaningful population comparisons and monitoring of trends
- We reported the age-standardized prevalence of hypertension and hypertension control rate for NHANES 2007 to 2008 using the recommended definitions

are thus applied in surveillance studies. Investigators have used a variety of surveillance definitions, resulting in variation of reported HTN prevalence and control, even when based on the same data set.1,6-23

Surveillance cannot rely solely on self-reported history of HTN that can be obtained from interview surveys, but must also include measurement of BP to account for undiagnosed HTN and status regarding control. Surveillance definitions of HTN typically apply the same BP cutoffs as the clinical definition (SBP ≥140 mm Hg or DBP ≥90 mm Hg) to measurements obtained in a single visit. Individuals taking antihypertensive medication are also usually classified as having HTN. To capture individuals with a history of HTN, investigators variably include self-report of ever being told of having HTN or being told on ≥2 occasions of having HTN, reflecting the measurement on 2 subsequent visits in the clinical definition. Exclusion of pregnant women also varies across studies, as does the age range over which prevalence is calculated.

Hypertension control is defined clinically as SBP <140 mm Hg and DBP <90 mm Hg as a result of treatment by lifestyle modification or pharmacological therapy.5 Some guidelines recommend the treatment goals for individuals with diabetes mellitus (DM) and chronic kidney disease (CKD) as SBP <130 mm Hg and DBP <80 mm Hg.5,24,25 The proportion of individuals with controlled HTN may be calculated relative to all individuals with HTN, or only those being treated. Adjustment for the lower HTN control threshold among individuals with DM or CKD also varies in the literature. Hypertension control can be captured in cross-sectional surveys that include BP measurement data and can identify individuals with a history of HTN or those taking antihypertensive medications, whose BP level is lower than the HTN threshold. Individuals with a history of HTN who are not taking medication may have achieved HTN control through lifestyle modification or other nonpharmacological methods.26 They may also simply exhibit variation in BP levels between occasions of measurement.

Differences in data analysis and BP measurement method further contribute to variability in published data. Age adjustment of crude rates to a standard population allows comparison of proportions over time, despite changing age distributions. Because HTN prevalence increases with age, the age groupings and standard population used for adjustment alter the calculated rate.27 The number of BP measurements averaged for each individual also varies in published data.

This article recommends a standard surveillance definition for HTN prevalence and control reached by consensus between the Centers for Disease Control and Prevention and the National Heart, Lung, and Blood Institute of the National Institutes of Health. This definition will enable tracking of HP 2010 and HP 2020 objectives and facilitate consistent comparisons. We first review the literature to examine the variation in reported HTN prevalence and control proportions in published analyses of National Health and Nutrition Examination Surveys (NHANES) data. We then present HTN prevalence and control data from NHANES 2007 to 2008 and 2005 to 2008, and we examine the changes in these results caused by varying several aspects of the definitions and data analysis parameters previously discussed.

Methods

Literature Review

We performed a literature search for studies and reports that assessed HTN prevalence and control using NHANES data from the 2003 to 2004 cycle and more recent survey cycles, with inclusion of data no further back than 1999. We searched MEDLINE for scholarly articles using the terms HTN, BP, NHANES, prevalence, control, trends, and epidemiology, together and in several combinations. We also identified published results from government reports and bibliography searches. Relevant data and analysis methods were abstracted and tabulated by 3 of us (M.T.C., H.K.W., and C.G.). Each abstraction was reviewed for accuracy by at least 2 of us, and disagreements were reconciled by consensus.

NHANES

Hypertension prevalence and control were measured using data from the NHANES. Survey design and protocol for BP measurement are described in the methods part of the online-only Data Supplement. The 2005 to 2008 surveys from which the data presented in this article are derived were approved by the National Center for Health Statistics Ethics Review Board, and all participants provided written informed consent. The methods section of the online-only Data Supplement provides details about the NHANES.

Data Analysis

Adults were defined as having HTN if they met any of the following criteria: (1) SBP ≥140 mm Hg, (2) DBP ≥90 mm Hg, or (3) current use of antihypertensive medication. Hypertension prevalence was calculated with all individuals aged ≥18 years in the denominator, excluding pregnant women. Hypertension control was defined as SBP <140 mm Hg and DBP <90 mm Hg in an individual who has been prescribed antihypertensive medication and is taking that medication. The HTN control proportion was calculated with all individuals with HTN in the denominator (aged ≥18 years, excluding pregnant women).
Crude and age-adjusted HTN prevalence estimates are presented with percentage and SEs of percentage (ie, an absolute SE of the estimate and not a relative assessment of the SE). Data are presented from both 1 survey cycle (2 years, 2007–2008) and 2 survey cycles (4 years, 2005–2008) because each survey cycle provides information regarding trends and enlarging the survey population allows for a greater degree of age-adjustment and subpopulation analysis. Estimates of HTN prevalence were age adjusted to the 2000 US standard population using either 3 age groups (18–39, 40–59, and ≥60 years) or 4 age groups (18–39, 40–59, 60–74, and ≥75 years) for 2007 to 2008 data. Based on 2005 to 2008 data, estimates were age adjusted using 4 age groups (18–39, 40–59, 60–74, and ≥75 years), 5 age groups (18–34, 35–44, 45–54, 55–64, and ≥65 years), and 7 age groups (18–29, 30–39, 40–49, 50–59, 60–69, 70–79, and ≥80 years), consistent with HP 2020.28

Age-adjusted rates for HTN control were calculated using the 2000 US standard population and the subpopulation of individuals who had HTN in 3 age groups (18–39, 40–59, and ≥60 years) and 4 age groups (18–39, 40–59, 60–74, and ≥75 years) for 2 years of data (2007–2008). Hypertension control was age adjusted to 4 age groups (18–39, 40–59, 60–74, and ≥75 years) and 5 age groups (18–34, 35–44, 45–54, 55–64, and ≥65 years and 18–49, 50–59, 60–69, 70–79, and ≥80 years) with percentage and SEs of percentage (ie, an absolute SE of the estimate and not a relative assessment of the SE). Statistical analyses were conducted using the SAS System for Windows, release 9.1 (SAS Institute Inc; Cary NC) and SUDAAN, release 9.0 (Research Triangle Institute, Research Triangle Park, NC).

### Results

#### Literature Review

We identified 984 studies for review in the literature search, and 19 met the criteria for inclusion (online-only Data Supplement Figure I). Among the 72 studies we conducted abstract review for at the last stage of literature review, 53 were excluded for the following reasons: 19 reported data from the NHANES that did not include data from the 2003 to 2004 or more recent cycles, 19 did not include data on HTN prevalence or control, 8 did not report data from the NHANES, and 7 included data only from limited subpopulations. The study characteristics are presented in online-only Data Supplement Table I, and the results are presented in online-only Data Supplement Table II.16–22 Three studies reported only HTN prevalence, 6 studies reported only HTN control, and 10 studies reported both HTN prevalence and control. All studies defined HTN by SBP ≥140 mm Hg or DBP ≥90 mm Hg, and all but 1 also used current medication to define HTN. Four studies classified individuals as having HTN if they were ever told that they had high BP (HBP), 3 studies if they were twice told, and 12 studies did not use any criterion related to having been told that they had HTN. Of the 16 studies that reported HTN control, 7 used only treated hypertensive individuals in the denominator, 7 used all hypertensive individuals in the denominator, and 2 reported results using each denominator separately.

The age ranges of individuals included in the studies varied: 6 of the studies included age ≥18 years, 2 included 18 to 74 years, 7 included ≥20 years, 1 included 25 to 84 years, 1 included ≥30 years, 1 included ≥60 years, and 1 included ≥65 years. Two studies focused on HTN in individuals with comorbid DM or CKD. Four studies excluded pregnant women, 13 included pregnant women, and pregnancy exclusion was not relevant to the 2 studies focused on elderly individuals. One study focused on Mexican or Mexican American race/ethnicity. Among studies focused on the general population, 6 adjusted for the lower HTN control threshold in individuals with DM or CKD and 8 did not.

Nine studies reported only crude rates, 6 reported only age-adjusted rates, and 4 reported both crude and age-adjusted rates. Studies that reported age-adjusted rates used the same standard population and age groupings for age adjustment of both HTN prevalence and control. Age groupings varied across studies; each investigator used distinct age groupings, with the exception of 4 studies that used the 3 groupings (18 or 20–39, 40–59, and ≥60 years). The 2000 US standard population was most commonly used for age adjustment, but individual investigators also used 2000 US Census populations. No study used age-adjustment weights based on the subpopulation of individuals with HTN, although this approach was mentioned in the discussion of 1 study.14 Nine studies averaged all available BP measurements for each individual, 3 excluded the first BP measurement and averaged the remaining 2 or 3 BP measurements, and 7 did not specify or were unclear regarding BP averaging.

The different definitions, populations, and data analysis parameters previously described resulted in variation in reported HTN prevalence and control proportions, even with all studies relying on NHANES data. Among studies focused on the adult population, crude HTN prevalence varied from 28.9% to 49.9%,16,22 and age-adjusted HTN prevalence varied from 28.9% to 32.1%.6,22 Studies focused on subpopulations reported HTN prevalence from 14% (Mexican and Mexican American men) to 70.8% (adults ≥65 years).15,18 Studies that classified individuals as having HTN if they had been told of HBP on 1 or 2 occasions reported higher...
prevalence proportions than studies that used only measured BP and current medications. Among studies focused on the adult population, crude HTN control varied from 37% to 52.9%,12,21 and age-adjusted HTN control varied from 35.1% to 64%.6,10 Studies focused on subpopulations reported HTN control from 29.6% (adults ≥30 years with HTN and DM) to 63.9% (adults with HTN taking medication).9,13

NHANES

A total of 6228 individuals aged ≥18 years were sampled in 2007 to 2008, of whom 233 were not interviewed or examined, 295 were missing BP measurements (SBP and DBP), and 55 were pregnant women. Excluding these, there were 5645 individuals available for analysis. In the 2005 to 2006 survey, there were 5563 individuals aged ≥18 years, of whom 229 were not interviewed or examined, 277 were missing BP measurements, and 337 were pregnant women (pregnant women were purposefully oversampled in this cycle), yielding 4720 individuals for analysis. Thus, there were 10 365 individuals for the 2 cycles combined, 2005 to 2008.

The crude HTN prevalence among US adults based on NHANES 2007 to 2008 was 30.7% (Table 2). Age adjustment with 3 age groups, including individuals who have ever been told of HBP, increased HTN control to 36.2%. Adjusting to 4 age groups, as previously described, to the subpopulation of individuals with HTN results in HTN control of 48.4% (Table 3). Returning to age adjustment with 4 age groups to the subpopulation of individuals with HTN also yields an HTN control of 48.4%, with an SE of 1.49% (Table 3). Age adjustment with the same 4 age groups to the 2000 US standard population results in HTN control of 45.8% and increases the SE to 4.03% (Table 3). Age adjustment with 3 age groups, as previously described, to the subpopulation of individuals with HTN results in HTN control of 48.4% (Table 3). Age adjustment with 4 age groups, as previously described, to the subpopulation of individuals with HTN also yields an HTN control of 48.4%, with an SE of 1.49% (Table 3). Age adjustment with the same 4 age groups to the 2000 US standard population results in HTN control of 45.8% and increases the SE to 4.03% (Table 3). Returning to age adjustment with 4 age groups to the subpopulation of individuals with HTN, including individuals who have ever been told of HBP, increased HTN control to 55.4% (Table 3). Including only those individuals who have been told on ≥2 occasions of HBP attenuated this increase in HTN control to 50.4% (Table 3). These additional individuals are not taking antihypertensive medication and have a BP <140/90 mm Hg. Excluding the first BP measurement increased HTN control to 50.0% (Table 3). Inclusion of pregnant women resulted in HTN control of 48.4% (Table 3).

The crude HTN prevalence among US adults based on NHANES 2005 to 2008 was 30.4% (Table 4). Age adjustment with 4 groups, as previously described, to the 2000 US

<table>
<thead>
<tr>
<th>Hypertension Prevalence</th>
<th>Crude % (SE)</th>
<th>Age Adjusted With 3 Age Groups, % (SE)*</th>
<th>Age Adjusted With 4 Age Groups, % (SE)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>RD for hypertension‡</td>
<td>30.7 (0.89)</td>
<td>29.6 (0.65)</td>
<td>29.8 (0.62)</td>
</tr>
<tr>
<td>RD including pregnant women</td>
<td>30.4 (0.9)</td>
<td>29.5 (0.65)</td>
<td>29.7 (0.62)</td>
</tr>
<tr>
<td>RD including individuals who have ever been told§</td>
<td>36.2 (1.04)</td>
<td>35.1 (0.71)</td>
<td>35.2 (0.78)</td>
</tr>
<tr>
<td>RD including individuals who have been told twice</td>
<td>34.0 (0.99)</td>
<td>33.0 (0.66)</td>
<td>32.9 (0.73)</td>
</tr>
<tr>
<td>RD excluding first blood pressure measurement¶</td>
<td>30.4 (0.89)</td>
<td>29.3 (0.63)</td>
<td>29.4 (0.60)</td>
</tr>
</tbody>
</table>

NHANES indicates National Health and Nutrition Examination Surveys; RD, recommended definition.

*Percentages were age adjusted to the 2000 US standard population (age groups of 18–39, 40–59, and ≥60 years).
†Percentages were age adjusted to the 2000 US standard population (age groups of 18–39, 40–59, 60–74, and ≥75 years).
‡The RD for hypertension was systolic blood pressure (SBP) ≥140 mm Hg, diastolic blood pressure (DBP) ≥90 mm Hg, or taking antihypertensive medication, averaging all blood pressure measurements.
§Defined as SBP ≥140 mm Hg, DBP ≥90 mm Hg, taking medication, or ever been told that they have hypertension.
¶If there were 2 measurements, exclude the first measurement; if there were all 3 measurements, average the second and third measurements.
Table 3.  Crude and Age-Adjusted Hypertension Control Among Those With Hypertension: NHANES 2007–2008 (n=2113)

<table>
<thead>
<tr>
<th>Hypertension Control</th>
<th>Crude % (SE)</th>
<th>Age Adjusted With 3 Age Groups (HTN Subpopulation), % (SE)*</th>
<th>Age Adjusted With 4 Age Groups (HTN Subpopulation), % (SE)†</th>
<th>Age Adjusted With 4 Age Groups (2000 US Standard), % (SE)‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>RD for hypertension§</td>
<td>48.4 (1.55)</td>
<td>48.4 (1.56)</td>
<td>48.4 (1.49)</td>
<td>45.8 (4.03)</td>
</tr>
<tr>
<td>RD including pregnant women</td>
<td>48.4 (1.55)</td>
<td>48.4 (1.56)</td>
<td>48.4 (1.49)</td>
<td>45.8 (3.03)</td>
</tr>
<tr>
<td>RD including individuals who have been told twice¶</td>
<td>56.2 (1.39)</td>
<td>55.4 (1.39)</td>
<td>55.4 (1.30)</td>
<td>59.9 (1.96)</td>
</tr>
<tr>
<td>RD including individuals who have been told twice¶</td>
<td>50.8 (1.57)</td>
<td>50.5 (1.48)</td>
<td>50.4 (1.48)</td>
<td>53.1 (2.32)</td>
</tr>
<tr>
<td>RD excluding first blood pressure measurement#</td>
<td>50.0 (1.48)</td>
<td>50.0 (1.47)</td>
<td>50.0 (1.41)</td>
<td>46.5 (3.02)</td>
</tr>
</tbody>
</table>

NHANES indicates National Health and Nutrition Examination Surveys; HTN, hypertension; RD, recommended definition.

*Age-adjusted HTN control rates were calculated using the subpopulation of persons who have HTN (age groups of 18–39, 40–59, and ≥60 years).
†Age-adjusted HTN control rates were calculated using the subpopulation of persons who have HTN (age groups of 18–39, 40–59, 60–74, and ≥75 years).
‡Age adjusted to the 2000 US standard population (age groups of 18–39, 40–59, 60–74, and ≥75 years).
§The RD for hypertension was systolic blood pressure (SBP) ≥140 mm Hg, diastolic blood pressure (DBP) ≥90 mm Hg, or taking antihypertensive medication, averaging all blood pressure measurements.
¶Defined as SBP ≥140 mm Hg, DBP ≥90 mm Hg, taking medication, or ever been told that they have hypertension.
#If there were 2 measurements, exclude the first measurement; if there were all 3 measurements, average the second and third measurements.

Discussion

A uniform surveillance definition of HTN prevalence and control is required for monitoring and evaluation, for HP objectives and other purposes. A review of the literature demonstrated variation in the definitions, populations, data analysis parameters, and results based on NHANES data. Thus, we propose a standard approach to HTN prevalence and control among adults uniquely suited to monitor population trends over time based on NHANES data. We recommend that the definitions of HTN prevalence and control used in the HP 2010 Operational Definition be used as the standard surveillance definitions (Table 6).

In data analysis, we recommend that results of up to 3 BP measurements obtained by American Heart Association–recommended protocol should be averaged. Crude rates for HTN prevalence and control should be reported to allow assessment of current burden along with age-adjusted rates to enable comparisons over time and between population subgroups with different age distributions. Hypertension prevalence and control should be age adjusted to the 2000 US standard population using 4 age groups (18–39, 40–59, 60–74, and ≥75 years) with 2 years of data from a single survey cycle. Age adjustment of aggregated data from multiple survey cycles may use more age groupings, such as 7 for

Table 4.  Crude and Age-Adjusted HTN Prevalence: NHANES 2005–2008 (n=10 365)

<table>
<thead>
<tr>
<th>HTN Prevalence</th>
<th>Crude % (SE)</th>
<th>Age Adjusted With 4 Age Groups, % (SE)*</th>
<th>Age Adjusted With 7 Age Groups, % (SE)†</th>
<th>Age Adjusted With 5 Age Groups, % (SE)‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>RD for HTN§</td>
<td>30.4 (0.74)</td>
<td>29.5 (0.57)</td>
<td>29.2 (0.62)</td>
<td>29.2 (0.61)</td>
</tr>
<tr>
<td>RD including individuals who have ever been told¶</td>
<td>36.0 (0.86)</td>
<td>35.1 (0.75)</td>
<td>35.0 (0.78)</td>
<td>34.9 (0.82)</td>
</tr>
<tr>
<td>RD including individuals who have been told twice¶</td>
<td>33.7 (0.82)</td>
<td>32.7 (0.69)</td>
<td>32.6 (0.71)</td>
<td>32.5 (0.76)</td>
</tr>
<tr>
<td>RD excluding first BP measurement#</td>
<td>30.1 (0.70)</td>
<td>29.2 (0.54)</td>
<td>29.1 (0.56)</td>
<td>28.9 (0.59)</td>
</tr>
</tbody>
</table>

HTN indicates hypertension; NHANES, National Health and Nutrition Examination Surveys; RD, recommended definition.

*Percentages were age adjusted to the 2000 US standard population (age groups of 18–39, 40–59, 50–59, 60–69, 70–79, and ≥80 years).
†Percentages were age adjusted to the 2000 US standard population (age groups of 18–39, 40–59, 50–59, 60–69, 70–79, and ≥80 years): Healthy People 2020.
‡Percentages were age adjusted to the 2000 US standard population (age groups of 18–34, 35–44, 45–54, 55–64, and ≥65 years): Healthy US (≥20 y).
§The RD for hypertension was systolic blood pressure (SBP) ≥140 mm Hg, diastolic blood pressure (DBP) ≥90 mm Hg, or taking antihypertensive medication, averaging all blood pressure measurements.
¶Defined as SBP ≥140 mm Hg, DBP ≥90 mm Hg, taking medication, or ever been told that they have HTN.
#If there were 2 measurements, exclude the first measurement; if there were all 3 measurements, average the second and third measurements.
Table 5. Crude and Age-Adjusted HTN Control Among Those With HTN: NHANES 2005–2008 (n=5744)

<table>
<thead>
<tr>
<th>HTN Control</th>
<th>Age Adjusted With 4 Age Groups (HTN Subpopulation), % (SE)*</th>
<th>Age Adjusted With 5 Age Groups (HTN Subpopulation), % (SE)**</th>
<th>Age Adjusted With 5 Age Groups (HTN Subpopulation), % (SE)**</th>
<th>Age Adjusted With 5 Age Groups (2000 US Standard), % (SE)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>RD for HTN</td>
<td>46.0 (1.12)</td>
<td>45.9 (1.08)</td>
<td>46.1 (1.06)</td>
<td>45.9 (1.06)</td>
</tr>
<tr>
<td>RD including individuals who have ever been told¶</td>
<td>55.4 (1.00)</td>
<td>53.6 (0.96)</td>
<td>53.6 (1.03)</td>
<td>53.6 (0.97)</td>
</tr>
<tr>
<td>RD including individuals who have been told twice#</td>
<td>51.2 (1.15)</td>
<td>51.0 (1.09)</td>
<td>51.1 (1.13)</td>
<td>50.9 (1.09)</td>
</tr>
<tr>
<td>RD excluding first BP measurement**</td>
<td>47.3 (1.13)</td>
<td>47.2 (1.07)</td>
<td>47.3 (1.06)</td>
<td>47.2 (1.06)</td>
</tr>
</tbody>
</table>

HTN indicates hypertension; NHANES, National Health and Nutrition Examination Surveys; RD, recommended definition.

*Age-adjusted HTN control rates were calculated using the subpopulation of persons who have high blood pressure (age groups of 18–39, 40–59, 60–69, and ≥75 years).
†Age-adjusted HTN control rates were calculated using the subpopulation of persons who have high blood pressure (age groups of 18–34, 35–44, 45–54, 55–64, and ≥65 years); Healthy US (≥20 years).
‡Age-adjusted HTN control rates were calculated using the subpopulation of persons who have high blood pressure (age groups of 18–49, 50–59, 60–69, 70–79, and ≥80 years).
§Age adjusted to the 2000 US standard population (age groups of 18–49, 50–69, 60–79, and ≥80 years); Healthy People 2020.
¶The RD for hypertension was systolic blood pressure (SBP) ≥140 mm Hg, diastolic blood pressure (DBP) ≥90 mm Hg, or taking antihypertensive medication, averaging all blood pressure measurements.
#Defined as SBP ≥140 mm Hg, DBP ≥90 mm Hg, taking medication, or ever been told that they have hypertension.
**If there were 2 measurements, exclude the first measurement; if there were all 3 measurements, average the second and third measurements.

HTN prevalence (18–29, 30–39, 40–49, 50–59, 60–69, 70–79, and ≥80 years) and 5 for HTN control (18–49, 50–59, 60–69, 70–79, and ≥80 years) used in HP 2020 (Table 6).13

Application of the recommended definition to NHANES 2007 to 2008 data revealed HTN prevalence and control of 29.8% and 45.8%, respectively. Health People 2010 established the objective of a reduced HTN prevalence to 14% from a baseline prevalence of 26% based on data from NHANES 1988 to 1994.14 The current HTN prevalence reflects an increase from the baseline and a trend in the opposite direction of the objective; however, HTN prevalence has been stable at ~30% since 1999.7 The HP 2010 objective for HTN control was an increase to 68% from a baseline of 25% based on data from NHANES 1988 to 1994. The current HTN control rate reflects an encouraging trend, although it remains short of the objective. The HP 2010 objectives were set with age adjustment using the same 7 age groups (18–29, 30–39, 40–49, 50–59, 60–69, 70–79, and ≥80 years) for HTN prevalence and 5 age groups (18–49, 50–59, 60–69, 70–79, and ≥80 years) for HTN control, as previously described, to the 2000 US standard population.

Monitoring HTN prevalence and control in the general population raises several considerations. Although clinical definitions of HTN rely on BP measurements repeated on several visits to establish a diagnosis, cross-sectional surveys capture BP at a single visit. The recommended surveillance definitions for HTN prevalence and control are formulated with the methodological and logistical constraints of cross-sectional studies in mind. Surveillance measures are distinct from clinical measures and serve the purpose of following population trends, rather than an individual patient, over time. Individuals classified as having HTN by the clinical and surveillance definitions would be expected to differ.

The surveillance definitions also include individuals who are taking medications as treatment for HTN. These individuals are presumed to have been prescribed medication as a result of satisfying the clinical definition of HTN. Individuals...
with HTN who are not taking antihypertensive medication may thus represent new cases or have some barrier to taking medication (eg, failure to prescribe, lack of understanding, unable to obtain, or refusal). The recommended surveillance definition for HTN control uses current antihypertensive medication use as a marker of HTN in an individual with a BP lower than the HTN threshold ($< 140/90$ mm Hg).

There are several nonpharmacological therapies for HTN, and lifestyle modification is featured in the current Joint National Committee report 7,5,26 The recommended surveillance definition does not include individuals who have met the clinical definition of HTN and achieved BP control by nonpharmacological means and may, therefore, underestimate HTN prevalence and control. The population with HTN controlled by nonpharmacological means may be captured by expanding the HTN definition to include individuals who have ever been told of HBP or, more consistent with the clinical definition, have been told on $\geq 2$ occasions that they have HBP. Past analysis of NHANES III (1988–1991) data reveals sufficient validity of self-reported HTN relative to Joint National Committee report 7 guidelines in non-Hispanic white and non-Hispanic black women with a medical visit in the past year, but similar validation has not been repeated with subsequent iterations of NHANES.35 Self-report of chronic conditions, including HTN, has also been validated in other population surveys.36

Specific subgroups also pose unique challenges to HTN prevalence and control surveillance. Although HTN in pregnancy is an important problem that can affect maternal and fetal health, the recommended definition excludes pregnant women because of differences in the underlying etiology and natural history of HTN in this subpopulation.37 Some guidelines for HTN control in individuals with comorbid DM or CKD recommend a lower BP threshold ($< 130/80$ mm Hg).5,24,25 However, the evidence base for these recommendations is controversial, with recent randomized controlled trials demonstrating that achieving lower BP thresholds may not reduce cardiovascular mortality or morbidity.6,42 An additional randomized controlled trial is under way to assess the impact of lower HTN control thresholds in a broader population.40

The recommended surveillance definition does not address DM or CKD populations directly, because the ability to reliably detect these comorbidities varies across cross-sectional surveys, including NHANES. Indeed, using different formulae for calculating the estimated glomerular filtration rate, either the Modification of Diet in Renal Disease formula or the Chronic Kidney Disease Epidemiology Collaboration formula, to classify CKD status in epidemiological studies yields different results.41 Recent analyses of HTN control below the lower BP threshold of $130/80$ mm Hg in individuals with DM and CKD, based on NHANES data, indicate that adjusting for these groups would result in decreased HTN control in the general population (online-only Data Supplement Tables I and II).11,13

Differences in data analysis may also contribute to apparent differences in measures of HTN prevalence and control. Hypertension varies with age, and crude prevalence rates thus reflect the age distribution of the survey sample.27 To enable meaningful comparisons and assess temporal trends, rates are adjusted to a standard population, but different age groupings and standard populations yield different adjusted rates. Hypertension control may be age adjusted to a standard population representative of the overall population or representative of the subpopulation of individuals with HTN. Using a standard representative of the overall population will inflate the younger age groupings relative to the subpopulation of individuals with HTN.

Adjustment to the 2000 US standard population resulted in a decreased estimate of HTN control in our data relative to adjustment to the subpopulation of individuals with HTN: 45.8% versus 48.4% (Table 3). This is consistent with lower levels of HTN control in younger age groups.6,42 We presented weights for the hypertensive subpopulation in NHANES 2007 to 2008 (Table 1) that should, where appropriate, be used as a standard for adjustment in future investigations focused on HTN control alone. Use of these weights resulted in a decreased SE. Analyses that compare HTN control with control of other diseases or health measures will need to use a common standard population and age groups to permit meaningful comparisons of multiple health indicators.

Although each NHANES 2-year cycle provides information about recent trends, aggregating data from multiple survey cycles increases the number of study subjects and enables more reliable assessment of subpopulations and age adjustment using more subgroups. The current NHANES BP measurement protocol and standardization effectively minimizes variability from observer and technical error.43 The use of automated BP measurement devices is increasingly common. In the NHANES 2007 to 2008 and 2009 to 2010 surveys, 1 such device was tested in parallel with the protocol previously described to assess the accuracy and consistency of measurements by the device for potential use in future surveys.44

The BP measurements obtained by physicians have been elevated relative to measurements obtained by nurses.45 The NHANES relies on repeated BP measurement by physicians specifically trained to use proper technique. Excluding the first BP measurement and averaging the subsequent measurements in an attempt to adjust for this “white coat effect” resulted in a small decrease in HTN prevalence, but a relatively larger increase in HTN control. This suggests that individuals being treated with antihypertensive medication may experience a greater elevation of the initial BP reading than those not being treated. Egan and colleagues performed a similar analysis with a sample of NHANES 2007 to 2008 data and found a significant decrease in both SBP and DBP values between the first and second BP readings ($- 2.6/ - 0.8$ mm Hg) and the first BP reading and the average of the next 2 BP readings ($- 3.6/ - 1.1$ mm Hg).7 The degree to which exclusion of the first BP measurement controls for the white coat effect is unclear because the BP of the study subjects in other settings (eg, ambulatory or home) is unknown and all measurements are obtained by a physician in a single visit. Although this analysis focused on NHANES data, surveillance data related to BP may be derived from several national surveys, each with unique strengths and limitations. The National Ambulatory Medical Care Survey is an annual sampling of physician office visits with BP measurement and
The recommended definitions for HTN prevalence and control and their application to NHANES data have several limitations that suggest areas for improvement. The reliance on medication use in the recommended definitions may exclude nonpharmacological control of HTN. Lifestyle change is an important component of HTN control, and validation of HTN self-report may permit future analyses to include individuals who have been told on ≥2 occasions of HBP by a health care provider. This article does not address HTN awareness or treatment; however, these are important measures that also vary in the published literature by the definitions used and merit future consideration.

This article recommends a standard surveillance definition of HTN prevalence and control for assessment of temporal trends and progress toward HP objectives based on national cross-sectional survey data. Application of this definition to NHANES 2007 to 2008 data demonstrates that HTN prevalence has increased relative to the HP 2010 baseline and is tracking in the opposite direction of the objective, although it has remained stable during the past decade. Hypertension control has increased from the HP 2010 baseline, although it remains short of the objective. Improvements in HTN prevalence and control consistent with HP objectives are important to reduce the burden of associated diseases.

Acknowledgments

The recommended surveillance definitions for HTN prevalence and control are the result of collaboration among the Centers for Disease Control and Prevention’s Division for Heart Disease and Stroke Prevention and National Center for Health Statistics, and the National Institutes of Health’s National Heart, Lung, and Blood Institute. All authors participated in conference calls and corresponded by e-mail regarding the recommended definitions. Multiple manuscript drafts were circulated to all offices for review and comment. Special thanks to Nancy Sonnenfeld (National Center for Health Statistics), who assisted in early discussions of the manuscript.

Disclosures

None.

References


National Surveillance Definitions for Hypertension Prevalence and Control Among Adults
Matthew T. Crim, Sung Sug (Sarah) Yoon, Eduardo Ortiz, Hilary K. Wall, Susan Schober,
Cathleen Gillespie, Paul Sorlie, Nora Keenan, Darwin Labarthe and Yuling Hong

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SUPPLEMENTAL MATERIAL
Supplemental Methods:

**NHANES**

The National Health and Nutrition Examination Surveys (NHANES), a series of cross-sectional surveys that have been conducted by the National Center for Health Statistics (NCHS) since 1959. Beginning in 1999, the surveys have been conducted continuously with data released in two-year cycles. The study sample was selected to be representative of the civilian, non-institutionalized US population using a complex, multistage, probability sampling with oversampling of specific subgroups for more reliable and precise subgroup data.\(^1\) The surveys are unique in that information was collected through physical examinations conducted in mobile examination centers (MEC), laboratory studies, and questionnaires administered in households. Thus, estimates of disease prevalence can be made utilizing clinically-based assessments and can include undiagnosed as well as diagnosed disease.

The protocol for BP measurement was strictly standardized in accord with the American Heart Association recommended protocol, has remained unchanged since 1999, and includes detailed quality control procedures.\(^2\) BP measurements were conducted in the MEC by a physician using a manual sphygmomanometer with the survey participant in a seated position with the back supported and both feet on the floor after five minutes of rest. Three consecutive BP readings were obtained using the same arm with a thirty-second interval between measurements. A fourth attempt was made if a measurement was interrupted or unobtainable; thus, up to three measurements were available for analysis. Physicians performing the BP measurement completed a training program designed by
Shared Care, Inc, were evaluated for competence, and received detailed instructions addressing cuff size selection and other details.  

HTN history and treatment were ascertained by questionnaire with the following question:

- Have you ever been told by a doctor or other health professional that you had hypertension, also called high blood pressure?

If the answer was “yes,” additional questions proceed:

- Were you told on two or more different visits that you had hypertension, also called high blood pressure?

- Because of your high blood pressure/hypertension, have you ever been told to take prescribed medicine?

- Are you now taking a prescribed medicine?

Pregnancy status was assessed by questionnaire with the following question:

- Are you pregnant now?

Pregnancy was defined by patient self-report or positive laboratory testing as detailed previously using the Icon25 hCG test kit (Beckman Coulter Inc, Fullerton, CA). Detailed specifics about these questions and the NHANES survey can be found at NCHS website.
<table>
<thead>
<tr>
<th>Publication</th>
<th>NHANES Survey Period</th>
<th>Age range (years)</th>
<th>Hypertension definition</th>
<th>Ever told or twice told included</th>
<th>Pregnant women excluded</th>
<th>Blood pressure measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bersamin et al.</td>
<td>1999-2004</td>
<td>25-84</td>
<td>Elevated BP or current medication</td>
<td>No</td>
<td>Yes</td>
<td>Exclude 1&lt;sup&gt;st&lt;/sup&gt;, average 2&lt;sup&gt;nd&lt;/sup&gt; and 3&lt;sup&gt;rd&lt;/sup&gt;</td>
</tr>
<tr>
<td>Crews et al.</td>
<td>1999-2006</td>
<td>20+</td>
<td>Elevated BP or ever told</td>
<td>Ever told</td>
<td>Yes</td>
<td>Average up to 3</td>
</tr>
<tr>
<td>Cutler et al.</td>
<td>1999-2004</td>
<td>18+</td>
<td>Elevated BP or current medication</td>
<td>No</td>
<td>Yes</td>
<td>Not explicit, implied average 3</td>
</tr>
<tr>
<td>Egan et al.</td>
<td>1999-2008</td>
<td>18+</td>
<td>Elevated BP or current medication</td>
<td>No</td>
<td>No</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; if only 1 taken, 2&lt;sup&gt;nd&lt;/sup&gt; if 2 taken, 2&lt;sup&gt;nd&lt;/sup&gt; and 3&lt;sup&gt;rd&lt;/sup&gt; averaged when 3 taken</td>
</tr>
<tr>
<td>Fryar et al.</td>
<td>1999-2006</td>
<td>20+</td>
<td>Elevated BP or current medication</td>
<td>No</td>
<td>No</td>
<td>Unspecified</td>
</tr>
<tr>
<td>Gu et al.</td>
<td>1999-2004</td>
<td>18+</td>
<td>Elevated BP, current medication, or told twice</td>
<td>Twice told</td>
<td>Excluded</td>
<td>Average up to 3</td>
</tr>
<tr>
<td>Health, United States, 2008&lt;sup&gt;10&lt;/sup&gt;</td>
<td>1999-2006</td>
<td>20+</td>
<td>Elevated BP or current medication</td>
<td>No</td>
<td>No</td>
<td>Average an unspecified number of readings</td>
</tr>
<tr>
<td>Lloyd-Jones et al.&lt;sup&gt;11&lt;/sup&gt;</td>
<td>2005-2006</td>
<td>20+</td>
<td>Elevated BP, current medication, or told twice</td>
<td>Twice told</td>
<td>No</td>
<td>Unspecified</td>
</tr>
<tr>
<td>Lloyd-Jones et</td>
<td>2003-2006</td>
<td>20+</td>
<td>Elevated BP, current</td>
<td>Twice told</td>
<td>No</td>
<td>Unspecified</td>
</tr>
<tr>
<td>Study</td>
<td>Year: 1999-2004</td>
<td>Age: 18-74</td>
<td>Condition/medication</td>
<td>History</td>
<td>Reference</td>
<td>Average up to:</td>
</tr>
<tr>
<td>------------------------------</td>
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<td>-----------------------</td>
<td>---------</td>
<td>-----------</td>
<td>----------------</td>
</tr>
<tr>
<td>McDonald et al.</td>
<td>1999-2004</td>
<td>65+</td>
<td>Elevated BP or current medication</td>
<td>No</td>
<td>N/A</td>
<td>3</td>
</tr>
<tr>
<td>Morbidity and Mortality: 2007</td>
<td>1999-2004</td>
<td>18-74</td>
<td>Elevated BP or current medication</td>
<td>No</td>
<td>No</td>
<td>Unspecified</td>
</tr>
<tr>
<td>Morbidity and Mortality: 2009</td>
<td>2003-2006</td>
<td>18-74</td>
<td>Elevated BP or current medication</td>
<td>No</td>
<td>No</td>
<td>Unspecified</td>
</tr>
<tr>
<td>Ong et al.</td>
<td>1999-2004</td>
<td>18+</td>
<td>Elevated BP or current medication</td>
<td>No</td>
<td>No</td>
<td>Exclude 1\textsuperscript{st}, average 2\textsuperscript{nd} and 3\textsuperscript{rd}</td>
</tr>
<tr>
<td>Ostchega et al.</td>
<td>1999-2004</td>
<td>60+</td>
<td>Elevated BP or current medication</td>
<td>No</td>
<td>N/A</td>
<td>3</td>
</tr>
<tr>
<td>Ostchega et al.</td>
<td>2005-2006</td>
<td>18+</td>
<td>Elevated BP or current medication</td>
<td>No</td>
<td>No</td>
<td>3</td>
</tr>
<tr>
<td>Ostchega et al.</td>
<td>1999-2004</td>
<td>20+</td>
<td>Elevated BP, current medication, or ever told</td>
<td>Ever told</td>
<td>No</td>
<td>3</td>
</tr>
<tr>
<td>Plantinga LC et al.</td>
<td>1999-2006</td>
<td>20+</td>
<td>Elevated BP, current medication, or ever told</td>
<td>Ever told</td>
<td>No</td>
<td>4</td>
</tr>
<tr>
<td>Suh, D et al.</td>
<td>1999-2004</td>
<td>30+</td>
<td>Elevated BP, current medication, or ever told</td>
<td>Ever told</td>
<td>No</td>
<td>3</td>
</tr>
<tr>
<td>Wong, ND et al.</td>
<td>2003-2004</td>
<td>18+</td>
<td>Elevated BP (for DM or CKD ≥ 130/80 mmHg) or current medication</td>
<td>No</td>
<td>No</td>
<td>4</td>
</tr>
</tbody>
</table>

* BP = Blood pressure; † DM = Diabetes mellitus; ‡ CKD = Chronic kidney disease
### Supplemental Table 2. Literature Review Data Abstraction – Results

<table>
<thead>
<tr>
<th>NHANES Survey Period</th>
<th>Hypertension Prevalence</th>
<th>Hypertension Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crude</td>
<td>Age-adjusted</td>
</tr>
<tr>
<td>1999-2004</td>
<td>Male 14%, Female 16%</td>
<td>&lt; 140/90 mmHg (DM &lt;130/80 mmHg)</td>
</tr>
<tr>
<td>1999-2006</td>
<td>49.9%</td>
<td></td>
</tr>
<tr>
<td>1999-2008</td>
<td>29.0% (07-08)</td>
<td>18-39, 40-59, 60+</td>
</tr>
<tr>
<td>1999-2006</td>
<td>30.5%</td>
<td>20-39, 40-59, 60+</td>
</tr>
</tbody>
</table>
### Hypertension Control Rates by Year and Age Group

<table>
<thead>
<tr>
<th>Year</th>
<th>Control Rate</th>
<th>Age Group</th>
<th>All Hypertensives</th>
<th>Treated Hypertensives</th>
<th>Analysis Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999-2006</td>
<td>29.9%</td>
<td>20-34, 35-44, 45-54, 55-64, 65+</td>
<td>2000 US Standard</td>
<td>30.0% (1999-2000), 29.7% (01-02), 32.5% (03-4), 31.7% (05-06)</td>
<td></td>
</tr>
<tr>
<td>2005-2006</td>
<td>33.3%</td>
<td>&lt; 140/90 mmHg</td>
<td>All hypertensives</td>
<td>45.4%</td>
<td>Analysis focuses on adults &gt; 60 years old.</td>
</tr>
<tr>
<td>2003-2006</td>
<td>33.6%</td>
<td>&lt; 140/90 mmHg</td>
<td>All hypertensives</td>
<td>44.1%</td>
<td></td>
</tr>
<tr>
<td>1999-2004</td>
<td>70.8%</td>
<td>&lt; 140/90 mmHg</td>
<td>Treated hypertensives</td>
<td>48.8%</td>
<td></td>
</tr>
<tr>
<td>1999-2004</td>
<td></td>
<td>&lt; 140/90 mmHg</td>
<td>All hypertensives</td>
<td>37%</td>
<td></td>
</tr>
<tr>
<td>2003-2006</td>
<td></td>
<td>&lt; 140/90 mmHg</td>
<td>All hypertensives</td>
<td>45%</td>
<td></td>
</tr>
<tr>
<td>1999-2004</td>
<td>29.3% (03-04)</td>
<td>18-39, 40-59, 60+</td>
<td>2000 US Standard</td>
<td>36.8% (03-04); 56.6% (03-04); 37.5% (03-04)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>29.6% (03-04)</td>
<td></td>
<td></td>
<td>33.1% (03-04); 63.9% (03-04); 33.2% (03-04)</td>
<td></td>
</tr>
<tr>
<td>1999-2004</td>
<td>67%</td>
<td>60-69, 70-79, 80+</td>
<td>2000 US Standard</td>
<td>36.8% (03-04); 56.6% (03-04); 37.5% (03-04)</td>
<td></td>
</tr>
<tr>
<td>2005-2006</td>
<td>29%</td>
<td>20-39, 40-59, 60+</td>
<td>2000 US Standard</td>
<td>33.1% (03-04); 63.9% (03-04); 33.2% (03-04)</td>
<td></td>
</tr>
<tr>
<td>1999-2004</td>
<td></td>
<td>&lt; 140/90 mmHg</td>
<td>Treated hypertensives</td>
<td>52.5%</td>
<td></td>
</tr>
<tr>
<td>1999-2006</td>
<td></td>
<td>&lt; 140/90 mmHg</td>
<td>All hypertensives, CKD hypertensives</td>
<td>51.7%, 68.8%, 58.6%, 69.2%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(CKD &lt; 130/80 mmHg)</td>
<td></td>
<td>20-39, 40-59, 60-69, 70+</td>
<td>Crude rate calculated by subtracting published &quot;uncontrolled&quot; rate.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Percentages are for uncontrolled HTN.</td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td>Percentage</td>
<td>Blood Pressure</td>
<td>Group</td>
<td>Other Info</td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>------------</td>
<td>----------------</td>
<td>--------------------------------</td>
<td>-----------------------------------------</td>
<td></td>
</tr>
<tr>
<td>1999-2004</td>
<td>29.6%, 33.8%</td>
<td>&lt; 130/80 mmHg</td>
<td>Diabetic hypertensives, Treated diabetic hypertensives</td>
<td>Analysis focuses on diabetics.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30-54, 55-64, 65-74, 65+</td>
<td></td>
</tr>
<tr>
<td>2003-2004</td>
<td>31.4%</td>
<td>&lt; 140/90 mmHg (DM or CKD &lt; 130/80 mmHg)</td>
<td>Treated hypertensives</td>
<td>52.9%</td>
<td></td>
</tr>
</tbody>
</table>

* BP = Blood pressure; † DM = Diabetes mellitus; ‡ CKD = Chronic kidney disease
Supplemental Figure 1. Literature search flowchart

- Literature Sources
  - MEDLINE (n=973)
  - Government Reports (n=9)
  - Bibliography Search (n=2)

- Retrieved
  - n=984

- Duplicates
  - n=15

- Title Review
  - n=969

- Excluded
  - n=897

- Abstract Review
  - n=72

- Excluded
  - n=53

- Included
  - n=19
Supplemental References:


