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Differences in Hypertension and Stage II Hypertension by Demographic and Risk Factors, Obtained by Two Different Protocols in US Adults: National Health and Nutrition Examination Survey, 2017–2018

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Abstract

BACKGROUND—To compare prevalence of hypertension and stage II hypertension assessed by 2 blood pressure (BP) observation protocols.

METHODS—Participants aged 18 years and older ($n = 4,689$) in the National Health and Nutrition Examination Survey (NHANES 2017–2018) had their BP measured following 2 protocols: the legacy auscultation protocol (AP) and oscillometric protocol (OP). The order of protocols was randomly assigned. Prevalence estimates for hypertension (BP $\geq 130/80$ mm Hg or use of medication for hypertension) and stage II hypertension (BP $\geq 140/90$ mm Hg) were determined overall, by demographics, and by risk factors for each protocol. Ratios ($OP\% \div AP\%$) and kappa statistics were calculated.

RESULTS—Age-adjusted hypertension prevalence was 44.5% (95% confidence interval [CI]: 41.1%–48.0%) using OP and 45.1% (95% CI: 41.5%–48.7%) using AP, prevalence ratio = 0.99 (95% CI = 0.94–1.04). Age-adjusted stage II hypertension prevalence was 15.8% (95% CI: 13.6%–18.2%) using AP and 17.1% (95% CI: 14.7%–19.7%) using OP, prevalence ratio = 0.92 (95% CI = 0.81–1.04). For both hypertension and stage II hypertension, the prevalence ratios by demographics and by risk factors all included unity in their 95% CI, except for stage II hypertension in adults 60+ years (ratio: 0.88 [95% CI: 0.78–0.98]). Kappa for agreement between protocols for hypertension and stage II hypertension was 0.75 (95% CI = 0.71–0.79) and 0.67 (95% CI = 0.61–0.72), respectively.

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DISCLOSURE

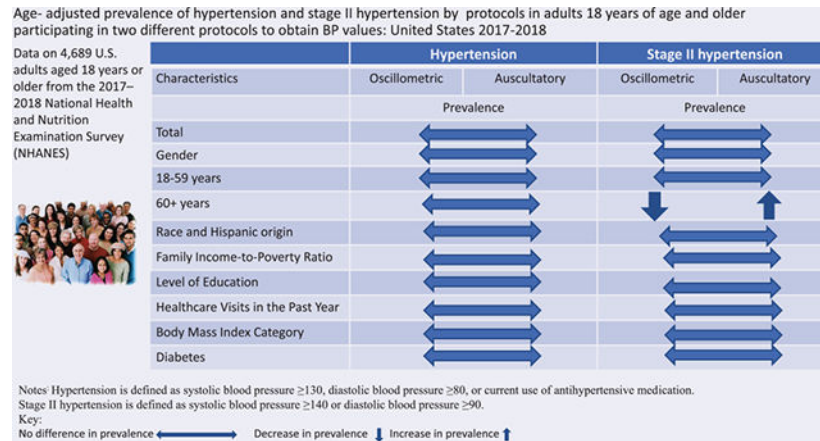
The authors declared no conflict of interest.

SUPPLEMENTARY MATERIAL

Supplementary data are available at *American Journal of Hypertension* online.

CONCLUSIONS—In adults and for nearly all subcategories there were no significant differences in prevalence of hypertension and stage II hypertension between protocols, indicating that protocol change may not affect the national prevalence estimates of hypertension and stage II hypertension.

Graphical Abstract



Keywords

auscultation protocol; blood pressure; comparison; hypertension; hypertension stage II; NHANES; oscillometric protocol

Brachial upper-arm blood pressure (BP) measurements have traditionally been obtained in National Health and Nutrition Examination Survey (NHANES) following an auscultatory protocol (AP) using a stethoscope and wall-mounted mercury gravity sphygmomanometer.¹ Mercury-contaminated devices have a risk of spills, and these devices have been phased out of clinical use.² Alternative BP devices based on automatic oscillometric protocols (OPs) are increasingly used in clinical trials and epidemiological studies.^{3,4} During the 2017–2018 NHANES survey cycle, BP was obtained using both AP and OP for participants aged 18 years and older, however only adults aged 18 years and older results are presented in this report, with the protocol order randomly assigned. Previous analyses compared mean BP values obtained by these 2 protocols, a more recent analysis assessed the variation by protocol in prevalence ratios for stage I high BP ($\geq 130/80$ mm Hg), and although the mean systolic BP and diastolic BP obtained by AP and OP differed, the prevalence of stage I high BP did not differ.^{5–7} The current report compares hypertension categories (hypertension and stage II hypertension) using the 2017 American College of Cardiology/American Heart Association (ACC/AHA) hypertension guidelines to define high BP.^{8,9} The study had 2 overall objectives: (i) to compare the prevalence of hypertension and stage II hypertension assessed with the AP and OP protocols and (ii) to compare individual-level agreement between protocols for hypertension and stage II hypertension.

METHODS

Study population

NHANES is a cross-sectional national health and nutrition survey of the civilian, noninstitutionalized US population, conducted by the National Center for Health Statistics (NCHS), part of the Centers for Disease Control and Prevention. The survey operates continuously, and data are typically released in 2-year cycles. Descriptions of the sample design and data collection methods for NHANES are available on the survey website.¹⁰ Survey participants were interviewed in their homes and then examined in the NHANES mobile examination center (MEC). This methodology study was conducted as part of the NHANES MEC data collection in 2017–2018. The NCHS Research Ethics Review Board approved all survey protocols and consent was obtained from all MEC examined participants in this study.

Sample selection and item-level response rate

During the NHANES 2017–2018 cycle, 11,027 eligible participants aged 18 years and older from screened households were identified, of which 5,856 were interviewed, and 5,533 were examined in the MEC (50.2% MEC response rate out of the 11,027 eligible participants). Each participant was randomly assigned to a BP protocol order, and all BP measurements were obtained during a single MEC examination visit. The BP protocols were not done consecutively; instead, they were separated by other examination components conducted in the MEC. Of the 5,533 participants eligible to participate in the study, 166 were missing BP data obtained with both protocols, 561 had only AP values, and 117 had only OP values. These exclusions ($n = 844$) resulted in a final analytic sample of 4,689, reflecting 84.7% of the 5,533 eligible participants. The final analytic sample presented in this paper varies from the previous methodology study reported sample ($n = 4,477$), which restricted the sample to individuals with 3 BP determinations for both protocols.⁷ In contrast, in this study any individual with 1+ BP determination was included.

Equipment

Each protocol used a device and its corresponding cuffs to take BP measurements. The Omron HEM-907XL is a digital upper-arm electronic BP measurement device designed for clinical settings.⁶ The Omron device is validated by both the Association for the Advancement of Medical Instrumentation (AAMI) and the International Protocol of the European Society of Hypertension for taking BP measurements in populations aged 13 years and older.^{5,11,12} In addition, the device can accommodate various cuff sizes, including a child, adult, large adult, and extra-large adult.⁶ The clinical wall-mounted mercury gravity sphygmomanometer (Baumanometer) was used as the reference comparison device to the Omron HEM-907XL. Like the Omron device, the mercury device accommodated various cuff sizes, including a child, adult, large adult, and extra-large adult.¹³

Protocols

Participants were seated in a chair with back support for both protocols, with both feet resting comfortably on the floor and both forearms supported on a level surface at heart

level. The appropriately sized BP cuff was selected based on the participant's measured mid-arm circumference.^{13,14} Participants were asked to rest quietly in a seated position for 5 minutes before taking BP measurements. The AP was conducted exclusively by the physicians. The physician determined the maximum inflation level before taking the BP measurements, and then the physician obtained 3 consecutive BP measurements, waiting 30 seconds between the measurements.¹³ The OP was conducted exclusively by health technicians. After 5 minutes of rest, the device automatically obtained 3 consecutive BP measurements 60 seconds apart.¹⁴ The change from 30 seconds (AP) to 60 seconds (OP) aligned the OP with national and international standards of obtaining BP.¹⁵

The average of up to 3 brachial systolic and diastolic BP values was used in both protocols. However, if a participant only had one reading, the single reading was used ($n = 29$ for AP and $n = 8$ for OP).

Outcome variables

Hypertension was defined as a participant having at least one of the following: systolic BP of 130 mm Hg or greater, diastolic BP of 80 mm Hg or greater, or participant-reported current medication use for high BP.^{8,9} Stage II hypertension was defined as systolic BP of 140 mm Hg or greater or diastolic BP of 90 mm Hg or greater.⁸

Independent variables

Covariates included in both analyses were gender, age group (years), race and Hispanic origin, family income-to-poverty ratio, level of education, healthcare visits in the past year, body mass index category, and diabetes. Each covariate included is associated with hypertension. Moreover, many official publications include these stratifications so understanding the impact of the change in methods may inform future work.^{9,16-18}

Demographics—Age was categorized as 18–39, 40–59, and 60 years and over. Self-reported data on race and Hispanic origin were classified as non-Hispanic (NH) White, NH Black, NH Asian, Hispanic, and other/multi-racial. Individuals reporting “other/multi-racial” were included in the overall analyses but not reported separately due to small numbers in this group.

Income—Family income-to-poverty ratio is the ratio of a family's income to its appropriate poverty guidelines established by the US Department of Health and Human Services.¹⁹ Three categories of approximately equal number of participants in each category were used for these analyses: <1.30, 1.30 to <3.50, and 3.50+. Larger family income-to-poverty ratios indicate higher income, adjusted for the size of a family.

Education level—Education level was self-reported based on response to the question, “What is the highest grade or level of school you have completed or the highest degree you have received?”²⁰ Response categories included: high school or less, more than high school or some college, and college graduate.

Healthcare utilization and health outcomes—The frequency of visits to a healthcare provider was self-reported based on the answer to the home interview question: “During the past 12 months, how many times have you seen a doctor or other health care professional about your health at a doctor’s office, a clinic, a hospital emergency room, at home, or some other place?”²⁰ The frequency of visits was categorized as 0–1, 2–3, and 4 or more.

During the physical examination in the MEC, standardized measurements of weight and height were obtained.²¹ Body mass index was calculated as weight divided by height in meters squared (kg/m^2) and was categorized using criteria established by the National Institutes of Health²² as underweight ($<18.5 \text{ kg}/\text{m}^2$), normal weight ($18.5\text{--}24.9 \text{ kg}/\text{m}^2$), overweight ($25.0\text{--}29.9 \text{ kg}/\text{m}^2$), and obesity ($\geq 30.0 \text{ kg}/\text{m}^2$). Underweight was included in the overall analysis but was not reported separately due to small numbers.

Diabetes was defined by participant self-report of ever having been told by a doctor or healthcare provider that he/she has diabetes or a glycosylated hemoglobin $\geq 6.5\%$.²³

Analytic sample and statistical analysis

There was a difference between those included ($n = 4,689$) and excluded ($n = 844$) by race and Hispanic origin. Excluded participants tended to more likely to be Hispanic (20.4%, 95% confidence interval [CI]: 15.5–26.1) and less likely to be NH White (9.9%, 95% CI: 6.8–13.8) ($P < 0.001$). Excluded participants also tended to be younger (18–39) and have a family income-to-poverty ratio less than 1.3 although these differences were near different ($P = 0.05$). See Supplementary Table S1 online for more details.

All statistical analyses were performed using survey procedures in SAS 9.4 for Windows (SAS Institute, Cary, NC) and SAS callable SUDAAN 11.0 software (Research Triangle Institute, Research Triangle Park, NC). All estimates were weighted using the MEC sample weights and incorporated sampling design information; the sample weights accounted for the unequal probabilities of selection resulting from the complex sample design, survey nonresponse, and the planned oversampling of selected population subgroups. Reweighting due to item nonresponse did not change any conclusions so the original MEC sample weights were used for all analyses. The calculated variance estimates accounted for the complex survey design by using Taylor series linearization.

A Satterthwaite-adjusted Wald chi-square test²⁴ was used to examine the statistical difference in covariates. Prevalence estimates of hypertension and stage II hypertension were calculated overall and by selected covariates. The 95% CIs of prevalence estimates were calculated using the Korn and Graubard method.²⁵ Effective sample size, absolute and relative 95% CI width, and degrees of freedom were evaluated to determine the reliability of prevalence estimates according to the NCHS Data Presentation Standards for Proportions.²⁶ Prevalence estimates of hypertension and stage II hypertension were age adjusted by the direct method to the 2000 US census population, using age groups 18–39, 40–59, and 60 years and older.²⁷

A weighted and age-adjusted ratio was computed with AP as the reference for each of the above prevalence estimates (hypertension and stage II hypertension). Established as

the legacy protocol, the AP has historically been considered the gold standard and it is the gold standard for the sensitivity analyses. Ratios with a 95% CI not including one were considered statistically significant. The weighted individual-level agreement was determined using sensitivity and specificity. Sensitivity, or the “True Positive rate,” is the percent of predicted positive hypertensives and stage II hypertensives among actual positives. Specificity, or the “True Negative rate,” is the predicted percent negative among hypertensives and stage II hypertensives who are negative. Kappa statistics were also calculated to evaluate individual-level agreement; a kappa statistic between 60% and 80% was considered a good agreement.²⁸

RESULTS

Randomization

Of the final analytic weighted sample, 49.1% had BP measurements obtained using the OP protocol first and 50.9% had BP measurements obtained using the AP protocol first (data not tabulated). The weighted distributions of gender, age (18–39, 40–59, 60+ years), self-reported race and Hispanic origin, family income-to-poverty ratio, level of education, healthcare visits, and diabetes were not associated with randomization order (data not tabulated). However, body mass index was associated with the randomization order (Supplementary Table S2 online), more persons in the underweight/normal weight were in OP first group and more persons with overweight categories and obesity were in AP first group ($P < 0.01$).

Sample characteristics

The mean age (\pm SE) was 47.6 (± 0.66) years, and 51.1% (95% CI: 48.8–53.5) were female (Supplementary Table S3 online). For age categories, 37.1% (95% CI: 33.8–40.4), 34.1% (95% CI: 31.1–37.3), and 28.8% (95% CI: 24.9–33.0) were aged 18–39, 40–59, and 60 years and over, respectively. As for race and Hispanic origin, 63.9% (95% CI: 58.0–69.5), 11.0% (95% CI: 7.7–15.2), 5.5% (95% CI: 3.8–7.6), and 14.7% (95% CI: 10.9–19.2) were NH White, NH Black, NH Asian, and Hispanic. Also, 20.1% (95% CI: 18.4–21.9) had a family income-to-poverty ratio < 1.3 ; 39.0% (95% CI: 35.4–42.7) had less than a college education, 33% (95% CI: 30.4–35.8) had 0 to 1 healthcare visits in the past year, 43.1% (95% CI: 39.1–47.3) had obesity, and 13.6% (95% CI: 12.3–15.1) had diabetes.

Between-protocol agreement for hypertension and stage II hypertension

Table 1 shows the age-adjusted prevalence of hypertension for both protocols and the prevalence ratios (OP% \div AP%). Overall, the age-adjusted hypertension prevalence was 44.5% (95% CI: 41.1%–48.0%) using OP, 45.1% (95% CI: 41.5%–48.7%) using AP, and the prevalence ratio was 0.99 (95% CI: 0.94–1.04). Table 2 shows the age-adjusted prevalence of stage II hypertension for both protocols and the prevalence ratios (OP% \div AP%). Overall, the age-adjusted stage II hypertension prevalence was 15.8% (95% CI: 13.6%–18.2%) using OP, 17.1% (95% CI: 14.7%–19.7%) using AP, and the prevalence ratio was 0.92 (95% CI: 0.81–1.04). The prevalence ratios for overall hypertension and stage II hypertension were not different from 1 as the 95% CIs included unity.

In the univariate analyses, the prevalence ratios for hypertension and stage II hypertension were not different from 1 (the 95% CIs included unity), except stage II hypertension for individuals aged 60+ years (prevalence ratio: 0.88 [95% CI: 0.78–0.98]). Lastly, although most of the CIs cross 1, the overall pattern of lower prevalence of for stage II hypertension by OP compared with AP was evident. The point estimate for the ratios and their 95% CIs are graphically presented in Tables 1 and 2 and tabulated values are in Supplementary Table S4 online.

Individual-level agreement

Weighted analyses of agreement between OP and AP on the prevalence of hypertension and stage II hypertension, with AP as the reference, are shown in Table 3. Among adults with hypertension, sensitivity values ranged from 70.2% (aged 18–39) to 93.1% (aged 60 years and over), and kappa statistics ranged from 0.60 (aged 18–39) to 0.80 (aged 60 and older). Among adults with stage II hypertension, sensitivity values ranged from 66.2% (aged 18–39) to 82.5% (underweight/normal weight) and kappa statistics ranged from 0.60 (aged 18–39) to 0.79 (underweight/normal weight).

DISCUSSION

Overall, there were no significant differences in prevalence of hypertension and stage II hypertension between AP and OP. The overall agreement in hypertension and stage II hypertension between the 2 protocols was good (between 60% and 80%). This analysis compared US prevalence estimates for hypertension and stage II hypertension according to the use of the older AP to the newer OP, using the BP categories in the 2017 ACC/AHA hypertension guidelines.⁸ These findings indicate that the protocol change may not substantially affect the overall national BP prevalence estimates for US adults. Consequently, our findings may inform surveillance of hypertension in the United States when using the 2017 ACC/AHA hypertension definition with NHANES data, including in the American Heart Association's annual Heart Disease and Stroke Statistics Update.²⁹

The study had 2 objectives: (i) comparing the prevalence of hypertension and stage II hypertension using the 2 protocols and updated clinical guidelines (ii) comparing individual-level agreement for hypertension and stage II hypertension. For the first objective, there was no difference overall or by almost all demographics and hypertension risk factors analyzed. The prevalence of stage II hypertension in adults aged 60 and older, however, was significantly lower as measured by OP than by AP. One explanation for why adults aged 60 and older with stage II hypertension differ by protocol may be related to the auscultatory gap phenomenon. An auscultatory gap is more common among older individuals secondary to increased arterial stiffness.³⁰ During the AP, a physician manually obtained the maximum inflation level to overcome the auscultatory gap phenomena and avoided falsely low estimates of systolic BP. In the OP, the oscillometric BP devices estimate systolic BP and diastolic BP from the mean arterial pressure using a device-specific algorithm.³¹ It is possible that the algorithm may not detect the auscultatory gap, explaining the difference by protocol in stage II hypertension among adults aged 60 and older (AP 33.9%) compared with OP 29.9%.

The individual agreements (OP and AP) for hypertension and stage II hypertension varied for the second objective. The percentage agreement for hypertension had a sensitivity of 86.3% ($\kappa = 0.75$), and the percentage agreement for stage II hypertension had a sensitivity of 69.7% ($\kappa = 0.67$). Overall, the findings suggest that individual-level protocol agreement where AP is the reference is stronger for hypertension than for stage II hypertension. One explanation for the lower individual agreement for stage II hypertension may be attributed to hypervigilance from physicians under the AP condition when observing BP values that are clinically important (i.e., 140 mm Hg systolic and 90 mm Hg diastolic, which was the previous, long-standing cutpoint to define hypertension).³² Indeed, in our earlier study, we reported that the end digit preference for zero was 43.8% for systolic ≥ 90 mm Hg but 19.3% for systolic of 134–142 mm Hg. Essentially, we suggest that the BP observer's mental concentration lessens at the low extremes.³³ This is not the case for oscillometric measurement of BP which is driven by device algorithm.³¹

The study's strength is that it was conducted on a nationally representative sample of the US noninstitutionalized population aged 18 and over. This study had several limitations. First, the OP BP data were collected by 10 equally trained health technicians, with the percent of measurements per technician ranging from 1% to 17% of total OP data collected. Four equally trained physicians collected 99% of the AP BP data; the percent of measurements per physician ranged from 7% to 49% (similarly trained backup physicians collected the additional 1% of data). Accordingly, the variability in examiner (health technician vs. physician) may be a confounding variable. Second, there is a possibility that BP observers of either protocol were not always adhering to standardized data collection protocol, which could have introduced systemic or random bias to their readings. Third, among numerous validated oscillometric BP devices, the Omron 907XL was used in this study; therefore, the results of this study may not be generalized to other valid oscillometric BP devices because each BP device manufacturer has a unique algorithm to calculate systolic and diastolic BP values.^{31,34}

This study compared 2 different standardized protocols for obtaining BP in a large, national sample of the US civilian noninstitutionalized population aged 18 and over. With one exception (participants aged 60 and older categorized stage II hypertension), the findings showed general agreement between protocols when following the 2017 ACC/AHA hypertension guidelines to obtain standardized BP readings.⁸ Lastly, the analysis is based on publicly released data which is open to further analysis using different BP values categories.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1. Weighted and age-adjusted prevalence of hypertension by protocol and ratio (oscillometric protocol over auscultatory protocol) among adults 18 years of age and older participating in 2 different protocols to obtain BP values: United States 2017–2018

CHARACTERISTIC	N	Oscillometric	Auscultatory	Ratio for Hypertension
Total	4,689	44.5 (41.1, 48.0)	45.1 (41.5, 48.7)	1.0
Gender				
- Male	2,326	49.8 (44.5, 55.1)	51.0 (46.7, 55.4)	1.0
- Female	2,363	39.3 (35.8, 42.8)	39.1 (35.3, 43.1)	1.0
Age Group (years)				
- 18 to 39	1,541	23.0 (19.4, 26.8)	22.4 (19.3, 25.7)	1.0
- 40 to 59	1,421	53.0 (47.1, 58.9)	53.8 (47.7, 59.8)	1.0
- 60 and over	1,727	71.6 (67.7, 75.2)	73.9 (70.3, 77.3)	1.0
Race and Hispanic Origin				
- Non-Hispanic white	1,683	43.0 (37.6, 48.6)	43.2 (38.2, 48.2)	1.0
- Non-Hispanic black	1,094	57.2 (53.8, 60.5)	57.0 (52.6, 61.3)	1.0
- Non-Hispanic Asian	654	45.4 (41.5, 49.3)	48.3 (43.5, 53.2)	1.0
- Hispanic	1,006	41.8 (38.5, 45.2)	43.0 (39.7, 46.3)	1.0
Family Income-to-Poverty Ratio				
- <1.30	1,202	44.4 (40.8, 48.0)	46.2 (41.1, 51.3)	1.0
- 1.30 to <3.50	1,696	45.7 (42.2, 49.2)	47.5 (43.0, 52.1)	1.0
- 3.50 and over	1,253	44.3 (39.0, 49.7)	43.0 (38.4, 47.7)	1.0
Education				
- High school or less	2,059	46.2 (42.8, 49.6)	46.2 (42.2, 50.2)	1.0
- High school/some college	1,536	48.4 (44.0, 52.7)	50.9 (46.8, 55.1)	1.0
- College graduate	1,091	38.8 (31.9, 46.1)	38.0 (31.9, 44.5)	1.0
Healthcare Visits Past Year				
- 0 to 1	1,556	40.0 (34.0, 46.4)	39.7 (32.4, 47.3)	1.0
- 2 to 3	2,156	44.6 (40.1, 49.1)	44.9 (41.1, 48.8)	1.0
- 4 and over	967	48.5 (45.3, 51.7)	49.7 (46.5, 52.9)	1.0
Body Mass Index Category				
- 18.5 to <25.0	1,179	30.6 (24.8, 36.9)	32.0 (25.4, 39.1)	1.0
- 25.0 to <30.0	1,464	40.9 (37.3, 44.7)	40.3 (36.5, 44.2)	1.0
- 30.0 and over	1,934	56.0 (52.4, 59.5)	56.2 (52.1, 60.2)	1.0
Diagnosed Diabetes				
- Yes	848	64.1 (59.2, 68.7)	66.7 (61.4, 71.6)	1.0
- No	3,660	41.8 (38.3, 45.4)	42.0 (38.3, 45.9)	1.0

Notes: Hypertension is defined as systolic blood pressure ≥ 130 , diastolic blood pressure ≥ 80 , or current use of antihypertensive medication. Age adjusted to the US Census 2000 population using age groups 18–39, 40–59, 60, and older with weights 0.420263, 0.357202, and 0.222535. Diabetes defined as self-report or an HbA1c $\geq 6.5\%$.

Abbreviation: BP, blood pressure.

Source: 2017–2018 National Health and Nutrition Examination Survey.

Age-adjusted prevalence of stage II hypertension by protocol and ratios (oscillometric protocol over auscultatory protocol) among adults 18 years of age and older participating in 2 different protocols to obtain BP values: United States 2017–2018

Table 2.

CHARACTERISTIC	N	Oscillometric	Auscultatory	Ratio for stage II Hypertension
Total	4,689	15.8 (13.6, 18.2)	17.1 (14.7, 19.7)	1.08
Gender				
- Male	2,326	17.5 (14.6, 20.6)	18.5 (15.1, 22.2)	1.06
- Female	2,363	14.1 (11.6, 16.9)	15.6 (13.3, 18.2)	1.11
Age Group (years)				
- 18 to 39	1,541	6.2 (4.6, 8.2)	5.5 (3.9, 7.4)	1.13
- 40 to 59	1,421	18.4 (14.2, 23.2)	20.3 (16.0, 25.1)	1.11
- 60 and over	1,727	29.9 (26.4, 33.6)	33.9 (29.8, 38.2)	1.13
Race and Hispanic Origin				
- Non-Hispanic White	1,683	14.1 (11.1, 17.5)	15.9 (12.9, 19.3)	1.13
- Non-Hispanic Black	1,094	26.9 (23.7, 30.4)	25.8 (21.7, 30.3)	1.04
- Non-Hispanic Asian	654	17.8 (15.0, 21.0)	17.8 (14.7, 21.2)	1.00
- Hispanic	1,006	17.4 (14.5, 20.5)	18.1 (14.4, 22.3)	1.06
Family Income-to-Poverty Ratio				
- <1.30	1,202	19.8 (16.2, 23.7)	21.0 (16.3, 26.4)	1.06
- 1.30 to <3.50	1,696	17.6 (15.0, 20.5)	18.4 (16.4, 20.5)	1.05
- 3.50 and over	1,253	13.3 (9.2, 18.3)	14.1 (10.7, 18.2)	1.06
Education				
- High school or less	2,059	17.4 (14.9, 20.1)	19.1 (15.6, 22.9)	1.09
- High school/some college	1,536	18.0 (14.8, 21.6)	18.8 (16.4, 21.5)	1.05
- College graduate	1,091	11.8 (8.5, 15.8)	13.0 (9.3, 17.6)	1.10
Healthcare Visits Past Year				
- 0 to 1	1,556	17.9 (13.8, 22.6)	18.2 (13.9, 23.3)	1.02
- 2 to 3	2,156	14.7 (11.5, 18.5)	16.4 (13.5, 19.6)	1.12
- 4 and over	967	14.9 (11.5, 18.9)	17.3 (13.4, 21.8)	1.16
Body Mass Index Category				
- Underweight/normal	1,179	13.0 (9.8, 16.8)	12.9 (8.9, 17.8)	1.01
- Overweight	1,464	14.6 (11.6, 18.1)	16.5 (13.3, 20.1)	1.13
- Obesity	1,934	18.3 (15.3, 21.6)	19.7 (17.4, 22.2)	1.08
Diabetes				
- Yes	848	24.7 (20.3, 29.5)	21.2 (18.2, 24.4)	1.16
- No	3,660	14.7 (12.4, 17.3)	16.4 (13.5, 19.5)	1.12

Notes: Stage II hypertension is defined as systolic blood pressure ≥ 140 or diastolic blood pressure ≥ 90 . Age adjusted to the US Census 2000 population using age groups 18–39, 40–59, 60, and older with weights 0.420263, 0.357202, and 0.222535. Diabetes defined as self-report or an HbA1c $\geq 6.5\%$.

Abbreviation: BP, blood pressure.

Source: 2017–2018 National Health and Nutrition Examination Survey.

Table 3.

Weighted individual-level agreement on hypertension, stage II hypertension, and hypertension control between auscultation (AP) and oscillometric (OP) protocols, United States 2017–2018 adults aged 18 and over

Observations	Hypertension			Stage II hypertension		
	Sensitivity %	Specificity %	Kappa (95% CI)	Sensitivity %	Specificity %	Kappa (95% CI)
Total	86.3	88.8	0.75 (0.71–0.79)	69.7	94.9	0.67 (0.61–0.72)
Gender						
Men	85.6	86.7	0.72 (0.66–0.78)	68.4	93.8	0.64 (0.57–0.70)
Women	87.1	90.4	0.78 (0.73–0.82)	71.0	95.9	0.70 (0.63–0.77)
Age group						
18–39 years	70.2	90.6	0.60 (0.54–0.67)	66.2	97.3	0.60 (0.49–0.70)
40–59 years	85.7	85.0	0.71 (0.64–0.77)	67.8	94.2	0.64 (0.55–0.74)
60 years and over	93.1	89.6	0.80 (0.75–0.86)	71.8	91.6	0.65 (0.57–0.73)
Race and Hispanic origin						
Non-Hispanic White	86.8	88.7	0.76 (0.70–0.81)	68.5	95.6	0.67 (0.58–0.76)
Non-Hispanic Black	90.5	86.9	0.77 (0.74–0.81)	78.1	90.9	0.68 (0.64–0.72)
Non-Hispanic Asian	82.9	89.6	0.73 (0.68–0.77)	68.5	93.1	0.62 (0.50–0.73)
Hispanic	81.0	90.3	0.72 (0.64–0.80)	68.4	94.7	0.64 (0.57–0.71)
Family income-to-poverty ratio						
Less than 1.3	83.3	90.4	0.74 (0.69–0.79)	73.5	95.1	0.70 (0.65–0.75)
1.3 to less than 3.5	86.1	89.2	0.75 (0.68–0.82)	70.9	93.7	0.66 (0.58–0.73)
3.5 or more	87.5	87.4	0.75 (0.67–0.82)	68.1	95.4	0.66 (0.56–0.75)
Level of education						
High school or less	87.3	87.9	0.75 (0.70–0.80)	69.6	94.4	0.66 (0.58–0.74)
More than high school/some college	85.6	89.1	0.75 (0.68–0.81)	70.2	93.7	0.65 (0.56–0.75)
College graduate	85.7	89.4	0.75 (0.67–0.83)	69.2	96.6	0.69 (0.62–0.76)
Healthcare visits in the past year						
0–1	78.7	87.0	0.66 (0.58–0.73)	75.1	95.3	0.70 (0.63–0.78)
2–3	89.4	90.1	0.79 (0.75–0.84)	68.0	95.0	0.66 (0.58–0.73)
4 or more	87.9	89.4	0.76 (0.69–0.84)	66.7	94.1	0.64 (0.55–0.72)
Body mass index category						

Observations	Hypertension			Stage II hypertension		
	Sensitivity %	Specificity %	Kappa (95% CI)	Sensitivity %	Specificity %	Kappa (95% CI)
Underweight/normal	81.6	93.7	0.76 (0.71–0.81)	82.5	97.3	0.79 (0.70–0.89)
Overweight	86.8	88.3	0.75 (0.70–0.80)	67.2	94.9	0.65 (0.57–0.74)
Obesity	88.4	83.9	0.72 (0.65–0.79)	66.5	93.3	0.62 (0.54–0.69)
Diabetes						
Yes	92.7	85.1	0.73 (0.63–0.84)	79.9	90.6	0.70 (0.61–0.80)
No	84.6	88.9	0.74 (0.69–0.78)	67.0	95.3	0.65 (0.59–0.71)

Notes: AP is the gold standard. Sensitivity (True Positive rate) = percent of predicted positive among actual positive. Specificity (True Negative rate) = percent of predicted negative among actual negative. Hypertension is defined as systolic blood pressure ≥ 130 , diastolic blood pressure ≥ 80 , or current use of antihypertensive medication. Stage II hypertension is defined as systolic blood pressure ≥ 140 or diastolic blood pressure ≥ 90 . Diabetes = defined as self-report or an HbA1c $\geq 6.5\%$.

Abbreviation: CI, confidence interval.

Source: 2017–2018 National Health and Nutrition Examination Survey.