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# Blood Pressure Cuff Sizes for Adults in the United States: National Health and Nutrition Examination Survey, 2015–2020

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## Abstract

**BACKGROUND:** Hypertension, defined as blood pressure (BP) ≥130/80 mm Hg or antihypertensive medication use, affects approximately half of US adults, and appropriately-sized BP cuffs are important for accurate BP measurement and hypertension management.

**METHODS:** This cross-sectional study analyzed 13,038 US adults (≥18y) in the National Health and Nutrition Examination Survey 2015-March 2020 cycles. Recommended BP cuff sizes were categorized based on mid-arm circumference: small adult (≤26 cm), adult (>26 to ≤34 cm), large adult (>34 to ≤44 cm), and extra-large adult (>44 cm). Analyses were weighted and proportions were extrapolated to the US population.

**RESULTS:.—**Among US adults (246 million), recommended cuff sizes were: 6% (16 million) small adult, 51% adult (125 million), 40% large adult (98 million), and 3% extra-large adult (8 million). Among adults with hypertension (116 million), large or extra-large cuffs were needed by over half (51%) overall, including 65% of those aged 18–34 and 84% of those with obesity (BMI ≥30 kg/m$^2$). By race/ethnicity, the proportion needing a large or extra-large cuff was 57% of non-Hispanic Black adults, 54% of Hispanic adults, 51% of non-Hispanic White adults, and 23% of non-Hispanic Asian adults. Approximately 40% of adults with hypertension in Medicare needed a large or extra-large cuff, compared to 54% for private insurance and 53% for Medicaid.

**CONCLUSIONS:.—**Over half of US adults with hypertension need a large or extra-large BP cuff.

### Keywords

Blood pressure; hypertension; disease management

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## INTRODUCTION

Nearly half of adults in the United States have hypertension, which is a leading risk factor for cardiovascular disease (CVD), stroke, and CVD-related mortality.[1] Optimal diagnosis and management of hypertension require accurate BP measurement in the clinical setting,[2] and outside of the clinical setting, self-measured blood pressure (SMBP) monitoring is an evidence-based strategy to improve hypertension control when used with additional clinical support.[3,4]

For the accurate measurement of BP, both within and outside of the clinic setting, an appropriately-sized upper arm BP cuff is essential.[5]

BP cuffs must be sized and shaped appropriately for the arm being measured, and persons with obesity may require both larger and more conically-shaped cuffs.[6] From 1999–2000 to 2017–2018, the prevalence of obesity among adult men increased over 15 percentage points, and among women, over 8 percentage points.[1] Because of increasing rates of obesity, the need for larger cuff sizes for BP measurement may be increasing over time.[7,8] The purpose of this study is to determine the estimated number and percentage of US adults, with and without hypertension, who would need small adult, regular adult, large adult, and extra-large adult BP cuffs.

## METHODS

The National Health and Nutrition Examination Survey (NHANES) is a nationally representative survey of civilian, noninstitutionalized persons in the United States, and it includes interviews and physical examinations that include blood pressure measurement. This study combined cross-sectional data from the 2015–2020 cycles of NHANES. Due to the COVID19 pandemic, NHANES suspended operations in March 2020. Because the partial data collected for the 2019–2020 cycle were not nationally representative, the National Center for Health Statistics (NCHS) combined the partial 2019–2020 cycle with 2017–2018, to create the 2017-March 2020 pre-pandemic cycle. This analysis combines the 2015–2016 and 2017-March 2020 pre-pandemic cycles; examination sampling weights were adjusted accordingly. Of 14,700 adult participants (aged ≥ 18 years) in these cycles, we excluded those who were pregnant (n=157), missing arm circumference (n=717), or missing hypertension status (n=788), yielding an analytic sample of 13,038. NHANES was approved by the NCHS research ethics review board and participants gave informed consent.

Recommended BP cuff sizes were categorized based on mid-arm circumference: small adult (≤26 cm), regular adult (>26 to ≤ 34 cm), large adult (>34 to ≤ 44 cm) extra-large adult (>44 cm). These categories were adapted from American Heart Association and American Medical Association guidance,[5,9] although cuff manufacturers may use different sizing. A sensitivity analysis examining the need for cuff sizes <22cm and >42cm was also performed, given that 22–42cm is a commonly used cuff size for many manufacturers. Mid-arm circumference was measured on the right arm of all participants during the Mobile Examination Center (MEC) visit, although 71 adults had their BP measured on their left arm in our analytic sample.

Up to three brachial BP readings were taken by trained staff, with the cuff appropriate for a participant's arm measurements, while participants were in a sitting position after at least 5 minutes of rest. Average (mean) systolic BP (SBP) and diastolic BP (DBP) readings were calculated; for participants with only one complete BP reading (<1% of the sample), that single measurement was used in place of an average.[10] Hypertension was defined as mean SBP ≥130 mm Hg, mean DBP ≥80 mm Hg, or self-reported use of antihypertensive medication. Beginning in the 2017–2018 NHANES cycle, blood pressure was measured by oscillometry, while previous cycles used sphygmomanometers; there were no statistically significant differences in hypertension prevalence between the two protocols, and NHANES guidance indicates that data can be combined across cycles.[11]

Other covariates included age group (18–34, 35–64, ≥65 years), sex, race and ethnicity (non-Hispanic White, non-Hispanic Black, Non-Hispanic Asian, Hispanic, and Other), body mass index (BMI = weight(kg)/height(m)$^2$) (<25, 25≤BMI<30, ≥30 kg/m$^2$), and health insurance type (private, Medicare, Medicaid, other public, none). We also examined a subgroup of women of reproductive age (18–44 years). Descriptive statistics were conducted and weighted to the United States population (in millions), and all analyses used appropriate sample weights and accounted for the complex sample design of NHANES.

## RESULTS

Among US adults (246 million), cuff sizes were: 6% (16 million) small adult, 51% (125 million) regular adult, 40% (98 million) large adult, and 3% (8 million) extra-large adult (Table 1). Over half of men (53%) and one third of women (34%) required a large or extra-large cuff, while only 2% of men and 10% of women needed a small cuff.

Among adults with hypertension (116 million), over half (51%, 59 million) needed a large or extra-large cuff, including over half (53%, 5 million) of women of reproductive age, nearly two thirds (65%, 9 million) of young adults aged 18–34, and 84% (51 million) of those with obesity (BMI ≥30). Across race and ethnicity groups, the highest proportion needing a large or extra-large cuff was among non-Hispanic Black persons (57%), followed by Hispanic persons (54%), non-Hispanic White persons (51%), and non-Hispanic Asian persons (23%); the largest proportion needing a small cuff was among non-Hispanic Asian persons (10%; other groups were 3–4%). Approximately 40% of adults with hypertension in Medicare needed a large or extra-large cuff (8 million), compared to 54% of those with private health insurance (37 million) and 53% of those with Medicaid (4 million).

In a sensitivity analysis (Supplemental Table 1), we examined adults whose arm circumferences fell outside of the commonly-used manufacturing size of 22–42cm. Among all adults, 0.3% (0.8 million) had arm circumference <22cm, while 6.4% (15.8 million) had arm circumference >42cm. Among adults with hypertension, 0.1% (0.2 million) had arm circumference <22cm, while 8.6% (10 million) had arm circumference >42cm.

## DISCUSSION

In this nationally representative sample, over half of US adults with hypertension had an arm circumference that would require a large or extra-large BP cuff, including 65%

of young adults and 84% of those with obesity. Using inappropriately sized cuffs has been shown to result in clinically meaningful differences in BP: cuffs that were larger than recommended yield lower systolic BP readings by −3.8 mm Hg, while cuffs that were smaller than recommended resulted in higher readings by 4.8 mm Hg.[12] These differences due to inappropriately sized cuffs resulted in substantial misclassification of hypertension, including 22% missed diagnoses among participants using too large of a cuff, and 39% overdiagnosis of hypertension when using too small of a cuff.[12] In addition to the importance of cuff size, cuffs for persons with larger arm circumferences, especially circumferences greater than 42 cm, function best when shaped conically, to better match the shape of the upper arm.[6] Using a cuff that is appropriately sized and fitted is important for the most accurate diagnosis and management of hypertension.[2,13]

Prior studies have suggested that the need for larger BP cuff sizes may be increasing.[7,8] Consistent with this pattern, we observed that 59% of men and 42% of women with hypertension in 2015–2020 needed a large or extra-large BP cuff, while Ostchega *et al.* reported that 52% of men and 38% of women with hypertension required a large or extra-large (thigh) cuff in 2007–2010.[7] However, it should be noted that our study used a more inclusive definition of hypertension, based on the 2017 ACC/AHA guideline with a threshold of ≥130/80 mmHg compared to ≥140/90 mmHg, and thus our proportion with hypertension reflects a larger segment of the US population. Overall, we estimated that 105 million US adults would need a large or extra-large sized cuff, including 59 million adults with hypertension.

The population differences we observed, including greater need for large and extra-large sized cuffs among young adults, those with hypertension or obesity, and non-Hispanic Black persons, are consistent with prior research.[7,8] In the present study, the prevalence of needing large or extra-large sized cuffs was nearly 10% higher in non-Hispanic Black adults compared to non-Hispanic White adults (52% vs 43%). Non-Hispanic Black persons develop hypertension at younger ages and are more likely to have poorly controlled hypertension compared to non-Hispanic Whites.[1] Ensuring that appropriately-sized BP cuffs are used could help improve the accuracy of BP measurements for screening and management among populations at higher risk of hypertension and associated cardiovascular disease.[1]

In addition, we observed the need for large or extra-large sized cuffs among approximately one-third of all women of reproductive age. Over 3 decades from 1989–2018, hypertensive disorders of pregnancy increased by 149%, while chronic hypertension increased by 182% as a risk factor among US pregnancies.[14] In light of these concerning trends, it is important for women of reproductive age to have their blood pressure screened and hypertension managed, both inside and outside of the clinical setting, using appropriately-sized BP cuffs as part of routine and prenatal care.

Outside of the clinical setting, an ample supply of appropriately-sized BP cuffs is also needed for SMBP monitoring devices. Approximately 39–54% of patients with hypertension report using an SMBP monitoring device,[15–17] yet there is little information regarding their choice of BP monitors, whether they obtained appropriately-sized cuffs, and whether they

received any education regarding BP measurement. As of March 2021, only 4/29 devices listed for home use on the US BP Validated Device Listing (VDL, www.validatebp.org) offered an extra-large BP cuff, with variable arm circumference accommodations (45–54 cm), and these devices were relatively expensive, costing $100 or more.[18] As of July 2021, 34 states provided some level of Medicaid coverage for SMBP monitoring devices and 26 states provided some level of Medicaid coverage for separate SMBP cuffs, the latter important for people needing cuffs larger than regular adult size. Improved coverage of SMBP devices, as well as coverage of separate cuffs, could help reduce costs for patients.[19]

A key strength of this study is the use of a nationally representative dataset, NHANES, which included arm circumference and BP measurement conducted according to protocol by trained assessors. These data were used to estimate the number of adults, in millions, who need varying cuff sizes; in addition to the utility of these data for healthcare providers and policymakers, device manufacturers can use these national arm circumference data to drive product development and availability of appropriately-sized cuffs.

This analysis had limitations. Primarily, we used cuff size recommendations based on American Heart Association / American Medical Association guidance. However, manufacturers use differing size ranges that may not be aligned with the cuff size recommendations used for cutoffs in this analysis. Many validated devices from major manufacturers on the VDL come with variable size cuffs that cover a range from regular to large. For example, a common size is 22–42cm, yet nearly 9% of US adults with hypertension have mid-arm circumferences above this range. In addition, the prevalence of hypertension in NHANES is based on the average of up to 3 BP measurements taken at a single visit; this could overestimate hypertension prevalence in some participants, as some adults may have had lower BP measurements if taken on a second or third visit. Consequently, some additional adults may have "white coat hypertension" (i.e. high BP at the visit without high out-of-visit BP). Finally, NHANES is representative of the non-institutionalized civilian US population, and thus our data cannot be extrapolated to cuff sizes needed in other populations, such as nursing home residents.

Improved control of hypertension is a national priority and is a key focus in national initiatives such as Million Hearts® and Healthy People 2030. Efforts may be needed to improve education about cuff selection and availability of larger cuff sizes, given that over half of US adults with hypertension need a large or XL-sized cuff.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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**Table 1**

Blood Pressure cuff sizes among all adults, and adults with hypertension -- NHANES 2015–2020

| | Sample | Population | Small | | | Adult | | | Large | | | Extra-Large | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **All Adults** | **n** | **N[a] (millions)** | **%** | **(se)** | **N (millions)** | **%** | **(se)** | **N (millions)** | **%** | **(se)** | **N (millions)** | **%** | **(se)** | **N (millions)** |
| Total | 13,038 | 246.1 | 6.4 | (0.3) | 15.6 | 50.7 | (0.8) | 124.7 | 39.7 | (0.8) | 97.7 | 3.3 | (0.2) | 8.1 |
| Age | | | | | | | | | | | | | | |
| 18–34 | 3,546 | 71.3 | 9.0 | (0.6) | 6.4 | 49.0 | (1.1) | 35.0 | 38.6 | (1.2) | 27.5 | 3.4 | (0.5) | 2.4 |
| 35–64 | 6,476 | 125.6 | 4.6 | (0.3) | 5.8 | 48.0 | (1.2) | 60.3 | 43.4 | (1.2) | 54.5 | 3.9 | (0.4) | 5.0 |
| ≥65 | 3,016 | 49.3 | 6.9 | (0.7) | 3.4 | 59.7 | (1.4) | 29.4 | 32.0 | (1.3) | 15.8 | 1.4 | (0.3) | 0.7 |
| Sex | | | | | | | | | | | | | | |
| Men | 6,484 | 121.4 | 2.2 | (0.2) | 2.7 | 45.3 | (1.3) | 55.0 | 49.4 | (1.3) | 60.0 | 3.2 | (0.3) | 3.8 |
| Women | 6,554 | 124.7 | 10.4 | (0.5) | 13.0 | 55.9 | (1.0) | 69.7 | 30.3 | (0.9) | 37.8 | 3.4 | (0.3) | 4.2 |
| WRA (18–44y)[b] | 2,782 | 53.3 | 12.4 | (0.7) | 6.6 | 54.1 | (1.0) | 28.8 | 29.8 | (1.1) | 15.9 | 3.7 | (0.4) | 2.0 |
| Race-Hispanic Origin | | | | | | | | | | | | | | |
| NH White | 4,486 | 157.9 | 6.1 | (0.3) | 9.6 | 51.3 | (1.2) | 81.0 | 39.6 | (1.2) | 62.5 | 3.0 | (0.4) | 4.8 |
| NH Black | 3,175 | 27.3 | 5.2 | (0.5) | 1.4 | 42.8 | (1.0) | 11.7 | 45.5 | (1.2) | 12.4 | 6.5 | (0.4) | 1.8 |
| NH Asian | 1,509 | 13.6 | 13.5 | (0.8) | 1.8 | 67.4 | (1.2) | 9.2 | 18.5 | (1.1) | 2.5 | 0.5 | (0.3) | 0.1 |
| Hispanic | 3,288 | 37.7 | 5.7 | (0.6) | 2.1 | 49.2 | (1.0) | 18.6 | 42.5 | (0.9) | 16.0 | 2.6 | (0.4) | 1.0 |
| Other | 580 | 9.6 | 6.5 | (1.4) | 0.6 | 43.9 | (3.4) | 4.2 | 44.8 | (3.2) | 4.3 | ~ | | |
| Body Mass Index[c] | | | | | | | | | | | | | | |
| BMI <25.0 | 3,556 | 68.3 | 22.4 | (0.8) | 15.3 | 76.2 | (0.7) | 52.1 | 1.4 | (0.3) | 0.9 | 0.0 | (0.0) | 0.0 |
| 25.0 ≤BMI <30.0 | 4,088 | 77.2 | 0.4 | (0.1) | 0.3 | 74.1 | (1.2) | 57.2 | 25.5 | (1.2) | 19.7 | ~ | | 0.0 |
| BMI ≥30.0 | 5,356 | 100.1 | 0.0 | (0.0) | 0.0 | 15.1 | (0.9) | 15.2 | 76.8 | (1.0) | 76.9 | 8.0 | (0.6) | 8.0 |
| Health Insurance[d] | | | | | | | | | | | | | | |
| Any | 10,718 | 211.3 | 6.1 | (0.3) | 13.0 | 50.9 | (0.9) | 107.5 | 39.7 | (0.9) | 83.9 | 3.3 | (0.3) | 6.9 |
| Private | 6,451 | 149.0 | 5.8 | (0.4) | 8.6 | 50.5 | (1.1) | 75.2 | 40.6 | (1.1) | 60.5 | 3.1 | (0.3) | 4.7 |
| Medicare | 1,930 | 26.4 | 6.9 | (0.9) | 1.8 | 56.5 | (1.9) | 14.9 | 33.9 | (1.7) | 8.9 | 2.8 | (0.6) | 0.7 |
| Other Public | 2,337 | 35.9 | 7.2 | (0.6) | 2.6 | 48.5 | (1.4) | 17.4 | 40.2 | (1.5) | 14.4 | 4.2 | (0.6) | 1.5 |
| Medicaid | 1,282 | 17.2 | 8.9 | (0.8) | 1.5 | 47.9 | (1.7) | 8.3 | 38.6 | (1.7) | 6.6 | 4.6 | (0.8) | 0.8 |
| Non-Medicaid | 1,055 | 18.7 | 5.6 | (0.8) | 1.0 | 48.9 | (1.8) | 9.1 | 41.7 | (1.9) | 7.8 | 3.8 | (0.9) | 0.7 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| None | 2,191 | 33.0 | 7.0 | (0.8) | 2.3 | 49.6 | (1.6) | 16.4 | 39.9 | (1.5) | 13.2 | 3.5 | (0.5) | 1.1 |
| | **Sample** | **Population** | **Small** | | | **Adult** | | | **Large** | | | **Extra-Large** | | |
| **Adults with Hypertension** | **n** | **N** | **%** | **(se)** | **N** | **%** | **(se)** | **N** | **%** | **(se)** | **N** | **%** | **(se)** | **N** |
| Total | 6,806 | 116.2 | 4.2 | (0.3) | 4.9 | 44.6 | (1.0) | 51.9 | 46.4 | (1.0) | 53.9 | 4.7 | (0.3) | 5.5 |
| Age | | | | | | | | | | | | | | |
| 18–34 | 658 | 13.4 | 2.4 | (1.0) | 0.3 | 32.6 | (2.4) | 4.4 | 57.1 | (2.3) | 7.6 | 8.0 | (1.2) | 1.1 |
| 35–64 | 3,714 | 65.4 | 3.1 | (0.3) | 2.0 | 40.2 | (1.5) | 26.3 | 50.9 | (1.4) | 33.3 | 5.8 | (0.6) | 3.8 |
| ≥65 | 2,434 | 37.4 | 6.8 | (0.8) | 2.5 | 56.8 | (1.4) | 21.2 | 34.8 | (1.4) | 13.0 | 1.7 | (0.3) | 0.6 |
| Sex | | | | | | | | | | | | | | |
| Men | 3,582 | 60.3 | 1.5 | (0.3) | 0.9 | 39.2 | (1.4) | 23.7 | 54.3 | (1.4) | 32.8 | 4.9 | (0.5) | 3.0 |
| Women | 3,224 | 55.8 | 7.1 | (0.6) | 4.0 | 50.5 | (1.7) | 28.2 | 37.9 | (1.5) | 21.1 | 4.5 | (0.5) | 2.5 |
| WRA (18–44y)[b] | 572 | 9.9 | ~ | | | 43.3 | (2.6) | 4.3 | 46.3 | (2.1) | 4.6 | 7.0 | (1.2) | 0.7 |
| Race-Hispanic Origin | | | | | | | | | | | | | | |
| NH White | 2,363 | 75.6 | 4.4 | (0.5) | 3.3 | 44.3 | (1.5) | 33.5 | 46.8 | (1.4) | 35.4 | 4.5 | (0.5) | 3.4 |
| NH Black | 1,958 | 15.4 | 3.2 | (0.4) | 0.5 | 39.7 | (1.5) | 6.1 | 49.2 | (1.5) | 7.6 | 7.9 | (0.5) | 1.2 |
| NH Asian | 679 | 5.9 | 10.2 | (1.1) | 0.6 | 66.7 | (2.0) | 4.0 | 22.8 | (1.6) | 1.4 | 0.3 | (0.3) | 0.0 |
| Hispanic | 1,523 | 14.6 | 2.6 | (0.4) | 0.4 | 43.7 | (1.6) | 6.4 | 49.9 | (1.4) | 7.3 | 3.8 | (0.8) | 0.6 |
| Other | 283 | 4.7 | 1.4 | (0.7) | 0.1 | 41.1 | (5.0) | 1.9 | 50.6 | (4.8) | 2.4 | ~ | | |
| Body Mass Index[c] | | | | | | | | | | | | | | |
| BMI <25.0 | 1,286 | 20.2 | 22.7 | (1.7) | 4.6 | 76.4 | (1.7) | 15.5 | 0.9 | (0.3) | 0.2 | ~ | | 0.0 |
| 25.0 ≤BMI <30.0 | 2,133 | 35.7 | 0.8 | (0.3) | 0.3 | 75.4 | (1.4) | 26.9 | 23.8 | (1.4) | 8.5 | ~ | | 0.0 |
| BMI ≥30.0 | 3,360 | 60.0 | ~ | | 0.0 | 15.6 | (1.2) | 9.4 | 75.3 | (1.3) | 45.1 | 9.1 | (0.6) | 5.5 |
| Health Insurance[d] | | | | | | | | | | | | | | |
| Any | 5,886 | 103.7 | 4.1 | (0.3) | 4.3 | 44.9 | (1.0) | 46.6 | 46.3 | (1.0) | 48.1 | 4.6 | (0.4) | 4.8 |
| Private | 3,287 | 69.1 | 3.5 | (0.5) | 2.4 | 42.9 | (1.2) | 29.7 | 48.8 | (1.3) | 33.7 | 4.7 | (0.5) | 3.3 |
| Medicare | 1,535 | 19.7 | 6.7 | (0.9) | 1.3 | 53.6 | (1.9) | 10.5 | 36.6 | (1.7) | 7.2 | 3.1 | (0.7) | 0.6 |
| Other Public | 1,064 | 15.0 | 3.2 | (0.7) | 0.5 | 42.6 | (1.9) | 6.4 | 47.9 | (2.1) | 7.2 | 6.2 | (1.0) | 0.9 |
| Medicaid | 557 | 7.1 | ~ | | | 42.9 | (3.2) | 3.0 | 46.6 | (2.9) | 3.3 | 6.4 | (1.2) | 0.5 |
| Non-Medicaid | 507 | 7.9 | 2.4 | (0.7) | 0.2 | 42.3 | (3.5) | 3.3 | 49.2 | (3.4) | 3.9 | 6.1 | (1.7) | 0.5 |
| None | 885 | 12.1 | 5.2 | (1.4) | 0.6 | 42.5 | (2.5) | 5.1 | 46.6 | (2.2) | 5.6 | 5.7 | (1.1) | 0.7 |

[a]Population N in Millions calculated as the average adult (≥18y) population in 2013, 2015, and 2018, from the American Community Survey (ACS) population counts as provided by NCHS for use with NHANES (https://wwwn.cdc.gov/nchs/nhanes/ResponseRates.aspx)

[b] WRA: Women of Reproductive Age (18–44 years)

[c] Participants missing BMI or Health Insurance are included in the analysis but not reported as a subgroup.

[d] Health Insurance: Other Public insurance includes Medicaid, Military (TriCare), Indian Health Services, CHIP, Medi-Gap, State-sponsored, and other government plans. Participants reporting single-service plans were defined as having no health insurance.

~ Statistically unstable estimates are suppressed, as defined in the NCHS Data Presentation Standards for Proportions (https://www.cdc.gov/nchs/data/series/sr_02/sr02_175.pdf).



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