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Differences in Hypertension Prevalence and Hypertension Control by Urbanization Among Adults in the United States, 2013–2018

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Abstract

BACKGROUND—To examine the associations between urbanization and hypertension, stage II hypertension, and hypertension control.

METHODS—Data on 16,360 US adults aged 18 years or older from the 2013–2018 National Health and Nutrition Examination Survey (NHANES) were used to estimate the prevalence of hypertension (blood pressure (BP) ≥130/80 mm Hg or use of medication for hypertension), stage II hypertension (BP ≥140/90 mm Hg), and hypertension control (BP <130/80 mm Hg among hypertensives) by urbanization, classified by levels of metropolitan statistical areas as large MSAs (population ≥1,000,000), medium to small MSAs (population 50,000–999,999), and non-MSAs (population <50,000).

RESULTS—All prevalence ratios (PRs) were compared with large MSAs and adjusted for demographics and risk factors. The PRs of hypertension were 1.07 (95% confidence interval (CI) = 0.99–1.14) for adults residing in medium to small MSAs and 1.06 (95% CI = 0.99–1.13) for adults residing in non-MSAs. For stage II hypertension, the PRs were higher for adults residing in medium to small MSAs 1.21 (95% CI = 1.06–1.36) but not for adults residing in non-MSAs 1.06 (95% CI = 0.88–1.29). For hypertension control, the PRs were 0.96 (95% CI = 0.91–1.01) for adults residing in medium to small MSAs and 1.00 (95% CI = 0.93–1.06) for adults residing in non-MSAs.

CONCLUSIONS—Among US adults, urbanization was associated with stage II hypertension.

Graphical Abstract

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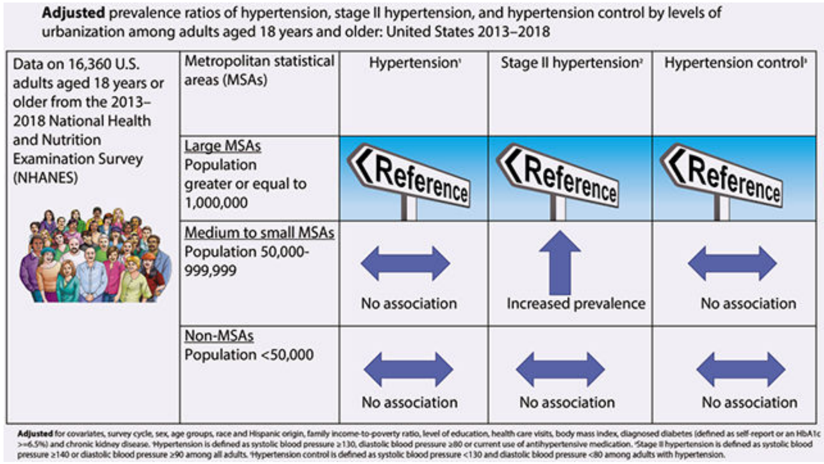
DISCLOSURE
The authors declared no conflict of interest.



Keywords

blood pressure; hypertension; hypertension stage II; hypertension control; NHANES; urbanization

Hypertension is a well-known risk factor for cardiovascular disease. In 2015, it was the number one reason for disability-adjusted life years globally.[1] In the United States, data from the National Health and Nutrition Examination Survey (NHANES) showed the age-adjusted prevalence of hypertension (blood pressure (BP) ≥130/80 or currently taking medication to lower BP) decreased from 47.0% in 1999–2000 to 41.7% in 2013–2014, and then increased to 45.4% in 2017–2018. While men followed a similar pattern, women did not change from during the same timeframe.[2] Additionally, Muntner *et al.* used NHANES data from 10 survey cycles to examine trends in hypertension control spanning from 1999 to 2018. The findings showed that there was an increase from 1999–2000 to 2007–2008. The results also showed the estimated proportion of controlled hypertension plateaued in 2013–2014 at 53.8% and then declined to 43.7% in 2017–2018.[3]

In 2018, coronary heart disease (CHD) was the leading cause (42.1%) of deaths associated with cardiovascular disease in the United States.[4] The physiological link between CHD and hypertension is well established, specifically high BP brings about changes in the structure of the left ventricle resulting in left ventricle remodeling.[5,6] In a meta-analysis, Yildiz *et al.* showed there was more than a 2-fold increase in odds of developing left ventricular hypertrophy with the presence of hypertension.[5] Factors, such as demographics, health care utilization, and health risk factors are all known to be associated with CHD.[7,8] However, an additional factor associated with CHD is place of residence and geographic variation.[9-14] Indeed, the role of urbanicity and geographic variation on the incidence of CHD mortality and morbidity has been recently stressed by the National Heart, Lung, and Blood Institute workshop report that recommended including geographical considerations in cardiovascular research.[15]

Although urbanization is a major risk factor for CHD, few reports have described its association with hypertension in the United States. The Behavioral Risk Factor Surveillance System (BRFSS), a nationwide survey that collects self-reported data, has been used to examine the association between urbanization and hypertension and reported hypertension to be 5% more prevalent in rural areas compared with urban/metropolitan areas.[16,17] In contrast to BRFSS, the NHANES objectively measures BP on participants as part of the medical examination component of the survey. However, there have been only 2 reports of using the NHANES BP measurements (NHANES Epidemiologic Follow-Up Study (1971–1984) and NHANES III (1988–1994)) to determine hypertension and its association with urbanization.[18,19]

Using measured BP data from the 2013–2018 NHANES, the purpose of this analysis is to explore the association between hypertension, stage II hypertension, and hypertension control and urbanization with more recent data.

METHODS

Survey description

The NHANES, conducted by the National Center for Health Statistics (NCHS), is a cross-sectional, nationally representative survey of the US civilian noninstitutionalized population. The survey uses a complex, stratified, multistage probability cluster-sampling design.[20] Participants are interviewed at their homes to obtain information on health history and health behaviors. Subsequently, they undergo a physical examination at a mobile examination center (MEC).[21] Written informed consent is obtained from all adult participants, and the NCHS Research Ethics Review Board approved the NHANES protocol.

Sample

Between 2013–2018 NHANES identified 30,043 individuals aged 18 years and older from screened households who were eligible to participate in the survey. Specifically, the response rates for the different survey cycles were as follows: 64% in 2013–2014 (screened = 9,216; examined = 5,924); 59% in 2015–2016 (screened = 9,800; examined = 5,735); and 50% in 2017–2018 (screened = 11,027; examined = 5,533). Overall, 17,192 individuals were examined between 2013 and 2018. Of those examined, 832 persons were excluded for the following reasons: 190 were pregnant and 642 had missing systolic and diastolic BP data. These exclusions resulted in a final analytic sample of 16,360 participants aged 18 years and older.

Outcome variables

All BP readings were obtained using a Bauman true gravity mercury wall model with standard Bauman cuffs and took place during a single examination visit. Appropriate BP cuff sizes were selected based on the measurement of the participant’s mid-arm circumference. After a 3-minute rest and establishing maximum inflation levels, the participants had their systolic and diastolic BPs (onset of Korotkoff phase 1 [K1] sound and fading of Korotkoff phase 5 [K5] sound) measured; BP measurements were taken 30 seconds apart. The average of up to 3 brachial systolic and diastolic BP readings was used as the participant’s systolic and diastolic BP values. For participants with only 1 reading (n = 53 or 0.32%), that single reading was used. For more details see the procedure manual.[22]

A participant was defined as having hypertension if at least one of the following conditions was satisfied: systolic BP of 130 mm Hg or greater, diastolic BP of 80 mm Hg or greater, or the participant reported currently taking medication for high BP.[2,23] Stage II hypertension was defined as systolic BP of 140 mm Hg or greater, or diastolic BP of 90 mm Hg or greater among the whole adult sample. Hypertension control was defined as systolic BP <130 mm Hg and diastolic BP <80 mm Hg among those with hypertension.[23]

Independent variable

Urbanization—NCHS developed a 6-level urban–rural classification scheme based on the county of residence.[24] Data on county of residence and the county exam location in NHANES can only be obtained through the NCHS Research Data Center or other federal research data center (https://www.cdc.gov/rdc/). The scheme delineated 4 metropolitan and 2 nonmetropolitan classifications for the survey years analyzed.[24] The metropolitan classifications included: (i) large central metropolitan or counties in metropolitan statistical areas (MSAs) with a population of 1 million or more that contain all or part of the area's principal city; (ii) large fringe metropolitan or counties in MSAs with a population of 1 million or more that surrounded the large central metropolitan counties; (iii) medium metropolitan or counties in MSAs with a population of 250,000–999,999; and (iv) small metropolitan or counties in MSAs with a population of <250,000. Nonmetropolitan, or the most rural areas classification, included: (i) micropolitan or counties in MSAs, which contained an urban cluster with 2,500–49,999 population; and (ii) noncore, or nonmetropolitan counties that did not qualify as micropolitan.

To increase the sample size and the degrees of freedom for the subgroup analysis, we condensed the 6-level NCHS scheme into 3 categories: large MSAs (combined large central and fringe metropolitan counties, for a population of 1 million or more); medium to small MSAs (combined medium and small metropolitan counties, for a population <1 million); and non-MSAs (combined micropolitan and noncore counties, for a population of <50,000) as done by previous urbanization studies using NHANES data.[25]

Covariates

Demographics—Age was categorized as 18–39, 40–59, 60–79, and 80 years and over. Data on race and Hispanic origin, which is self-reported in NHANES, were categorized as non-Hispanic white, non-Hispanic black, non-Hispanic 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 among this group.

Income—Family income-to-poverty ratio is the ratio of a family's income to its appropriate poverty guidelines as established by the U.S. Department of Health and Human Services.[26] Four categories of approximately equal numbers of participants in each category were used for these analyses: <1.00, 1.00 to <2.00, 2.00 to <4.00, and ≥4.00. 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?"[27] Response categories included: high school or less, more than high school or some college, and college graduate.

Risk factors

Health care utilization—Frequency of visits to a health care 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?"[27] The frequencies of visits ranged from: 0–1, 2–3, and 4 or more.

Several biophysiological risk factors are associated with hypertension and hypertension control and were included in this analysis as covariates; among them are body mass index (BMI), chronic kidney disease, and diabetes.[4,28] During the physical examination in the MEC, standardized measurements of weight and height were obtained.[27] BMI was calculated as weight over height in meters squared (kg/m^2), and was categorized using criteria established by the National Institutes of Health[28] as underweight (<18.5), normal weight (18.5–24.9), overweight (25.0–29.9), Class I obesity (30.0–34.9), Class II obesity (35.0–39.9) and Class III obesity (≥40).[29] Underweight was included in the overall analysis but was not reported separately due to small numbers among this group.

Diagnosed diabetes was defined based on participant self-reported of ever having been told by a doctor or health care provider that he/she has diabetes (see suggested citation) or a glycated hemoglobin ≥6.5%.[30]

Blood and urine samples were collected in the MEC. Chronic kidney disease was defined based on the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation estimated glomerular filtration rate and the presence of albuminuria (urine creatinine to albumin ratio). Chronic kidney disease was defined as an estimated glomerular filtration rate serum creatinine <60 ml/min per 1.73 m^2 or urine albumin-to-creatinine ratio >30 mg/g.[31]

Statistical analysis

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. The calculated variance estimates accounted for the complex survey design by using Taylor series linearization.

Prevalence of hypertension, stage II hypertension, and hypertension control was calculated by selected covariates. Following the 2017 NHANES analytic guidelines, the 95% confidence intervals (CIs) of prevalence estimates were calculated using the Korn and Graubard method.[32] 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 Standards for Proportions.[33] A Satterthwaite-adjusted Wald chi-square test was used to test for independence of each variable and urbanization.[34] Pairwise comparisons of prevalence of hypertension, stage II hypertension, and hypertension control between the subcategories were tested using a linear contrast. Linear and quadratic trends were tested for survey years, age groups, and BMI using orthogonal polynomial contrasts which tested whether the linear and quadratic effects were zero (SUDAAN's proc descript procedure with polynomial option).[35] Prevalence of hypertension and stage II hypertension was age adjusted by the direct method to the 2000 US census population, using age groups 18–39, 40–59, 60–79, and 80 years and older.[36]

In addition, following the recommendations of Crim *et al.*,[37] we calculated age-adjusted prevalence of hypertension control adjusted to the subpopulation of individuals who had hypertension in NHANES 2007–2016 using age groups 18–39, 40–59, 60–79, and 80 and older. This adjustment was done because hypertension is more prevalent among older individuals and using a standard age adjustment to the US population will over-represent the younger age groupings relative to the subpopulation of individuals with hypertension.[37]

One univariate and 2 multivariate log-linear regression models were used to estimate the unadjusted and adjusted prevalence ratios (PRs) of hypertension, stage II hypertension, and hypertension control by urbanization categories. The univariate models included urbanization as a predictor. The first multivariate model was adjusted for the nonmodifiable demographic confounding variables including age groups, sex, and race and Hispanic origin. The second multivariate models were adjusted for more confounding covariates (survey cycle, sex, age groups, race and Hispanic origin, family income, education, health care visits, BMI, diabetes, and chronic kidney disease) in addition to age groups, sex, and race and Hispanic origin. Unadjusted and adjusted PRs with a 95% CI not including 1.0 were considered statistically significant. We derived PRs in this paper to avoid overestimating the strength of the association of the prevalence odds ratio when the prevalence is high.[38]

RESULTS

Sample characteristics

No statistical differences were found for sex or age group; however, all other covariates were associated with urbanization (Table 1). Non-Hispanic white adults were less likely to live in large MSAs (42.9%) compared with Hispanic (60.5%), non-Hispanic black (62.1%), and non-Hispanic Asian (72.5%) adults. Among adults with the lowest income-to-poverty ratio (family income-to-poverty ratio <1), 45% lived in large MSAs and 19.9% lived non-MSAs. Among adults with the highest family income-to-poverty ratio (≥4), 56.6% lived in large MSAs and 9.2% lived in non-MSAs. College graduates were more likely to live in large MSAs (60.7%) compared with adults with high school or less education (42.9%) and adults with more than high school or some college education (46.3%). About 50.8% adults with 0–1 health care visits in past year lived in large MSAs while 48.1% adults with 4 or more health care visits in past year lived in large MSAs. Among adults categorized as having a normal BMI, 54.7% lived in large MSAs and 11.5% lived in non-MSAs, whereas adults categorized as having Class III obesity (BMI >40), 39.0% lived in large MSAs and 21.2% lived in non-MSAs. Adults diagnosed with diabetes or having chronic kidney disease were less likely to live in large MSAs (44.6% and 46.1%, respectively) compared with those who were not diagnosed with diabetes or having chronic kidney disease (49.9% and 49.7%).

The prevalence of hypertension, stage II hypertension, and hypertension control by urbanization

Hypertension prevalence increased ($P < 0.05$ compared with large MSAs) with decreasing level of urbanization, from 41.1% (95% CI = 39.2%–43.0%) in large MSAs, 45.4% (95% CI = 42.3%–48.5%) in medium to small MSAs, and 48.6% (95% CI = 44.4%–52.8%) in non-MSAs (Table 2). Stage II hypertension prevalence was 14.1% (95% CI = 12.7%–15.6%) in large MSAs, 17.1% (95% CI = 15.2%–19.2%) in medium or small MSAs ($P < 0.01$ compared with large MSAs), and 16.4% (95% CI = 12.0%–21.7%) in non-MSAs which were similar to the prevalence of large MSAs ($P = 0.22$). The prevalence of controlled hypertension was similar between large MSAs (21.0%, 95% CI = 18.6%–23.5%) and medium to small MSAs (20.6%, 95% CI = 17.9%–23.5%), but was higher in non-MSAs (25.9%, 95% CI = 21.3%–31.0%) compared with the reference large MSAs ($P < 0.05$) (Table 3).

Unadjusted and adjusted PRs

Model 1 shows, when compared with large MSAs, the unadjusted PR for hypertension was higher among adults residing in medium to small MSAs (unadjusted PR = 1.12, 95% CI = 1.04–1.12) and non-MSAs (unadjusted PR = 1.24, 95% CI = 1.15–1.33) (Table 4). Similarly, the unadjusted PR for stage II hypertension was higher among adults residing in medium to small MSAs compared with large MSAs (unadjusted PR = 1.24, 95% CI = 1.08–1.41) and non-MSAs (unadjusted PR = 1.28, 95% CI = 1.02–1.59). Hypertension control was higher among adults residing in non-MSAs (unadjusted PR = 1.24, 95% CI = 1.01–1.53) but did not differ among adults residing in medium to small MSAs (unadjusted PR = 0.99, 95% CI = 0.84–1.52) when compared with large MSAs.

Model 2 shows that, after adjusting for age groups, sex, and race and Hispanic origin, the adjusted PR was similar to those of the unadjusted PRs for hypertension (adjusted PR = 1.13, 95% CI = 1.05–1.20 for medium to small MSAs; adjusted PR = 1.19, 95% CI = 1.11–1.28 for non-MSAs) and stage II hypertension (adjusted PR = 1.28, 95% CI = 1.13–1.45 for medium to small MSAs; adjusted PR = 1.25, 95% CI = 1.01–1.55 for non-MSAs). While for hypertension control, the associations changed. Specifically, compared with large MSAs, the adjusted PR for hypertension control became lower for adults residing for medium to small MSAs (adjusted PR = 0.93, 95% CI = 0.88–0.98) and was no longer different for adults residing in non-MSAs (adjusted PR = 0.93, 95% CI = 0.86–1.00).

Model 3 shows the PRs after adjusting for all confounding variables including survey cycle, age group, gender, race and Hispanic origin, family income-to-poverty ratio, level of education, health care visits, BMI, diagnosed diabetes, and chronic kidney disease. For hypertension and stage II hypertension, the PRs decreased, and the associations were attenuated. Specifically, compared with large MSAs, the adjusted PRs for hypertension there were no longer different for adults residing in medium to small MSAs (adjusted PR = 1.07, 95% CI = 0.99–1.14) nor in non-MSAs (adjusted PR = 1.06, 95% CI = 0.99–1.13). As for stage II hypertension, compared with large MSAs, the adjusted PR was higher for adults residing in medium to small MSAs (adjusted PR = 1.21, 95% CI = 1.06–1.36) but not different for adults residing in non-MSAs (adjusted PR = 1.06, 95% CI = 0.88–1.29). As for hypertension control, after adjusting for confounding covariates and compared with large MSAs, the adjusted PRs did not differ among adults residing in medium to small MSAs (adjusted PR = 0.96, 95% CI = 0.91–1.01) and in non-MSAs (adjusted PR = 1.00, 95% CI = 0.93–1.06).

DISCUSSION

Our results showed disparities in the prevalence of hypertension between the urban and rural areas in the United States. This study provides the most recent data on hypertension and urbanization from a large, nationally representative sample of adults based on objective BP measurements using standardized procedures. Additionally, NHANES collects data on clinical risk factors for hypertension which were also assessed using standardized physical and laboratory methods, thus enabling a comprehensive analysis with a broad range of covariates.

Two recent studies have examined the association between hypertension (BP ≥140/90 or currently taking medications for hypertension) and geography in the United States using self-reported hypertension diagnosis.[16,17] Both studies found that age-adjusted prevalence of self-reported hypertension was higher in rural areas when compared with urban areas. Using 2013 BRFSS, researchers reported age-adjusted prevalence of self-reported hypertension of 32.6% in metropolitan counties and 38.1% in nonmetropolitan counties and found that these differences persisted after accounting for county economic status.[16] This study also reported a small but note-worthy increase in hypertension between metropolitan and nonmetropolitan counties after adjustment for other factors. Another study, using the 2017 BRFSS, examined the association between urbanization and hypertension overall and by region and reported an age-adjusted prevalence of self-reported hypertension of 28.5% in large central metro areas and 34.1% in noncore (most rural) areas.[17]

Data from the 2014–2016 National Ambulatory Medical Care Survey (NAMCS), a nationally representative survey of visits to nonfederal, office-based physicians, showed a similar pattern of visits to physicians for hypertension by urbanization. Among adults aged 18 years and older, the percentage of visits among patients with diagnosed hypertension was 34.2% in large metro suburban areas, 37.9% for individuals who resided in small–medium metro areas, and 40.1% for individuals who resided in rural areas.[39] Of note, it is important to consider that visits to nonfederal, office-based physicians may be confounded by access to health care. Although the reported estimates were age adjusted, these estimates were not adjusted for additional covariates. Our age-adjusted prevalence of hypertension, based on measured BP, showed a similar relationship between levels of urbanization and hypertension prevalence, although with higher prevalence estimates (large MSAs 41.1%, medium to small MSAs 45.4%, and non-MSAs 48.6%), but this association was attenuated in the multivariable analysis.

Only 2 US studies using NHANES data have examined the association between hypertension determined by measured BP values and geography. A study using the NHANES I Epidemiological Follow-Up Study (1971–1984) data, reported that the age-adjusted relative odds ratio of hypertension prevalence between 1971 and 1984 were not associated with region or with urbanization level.[18] In another study, NHANES III (1988–1994) to assess the prevalence of hypertension by region and urbanization.[19] Their analysis showed that region (south vs. non-south) rather than level of urbanization was associated with hypertension. Residence in southern regions of the United States were associated with higher prevalence of hypertension among participants aged 40–59 years, specifically among non-Hispanic white men, non-Hispanic black men, and women.[19] These 2 studies are different from our study in 2 ways, 1 study associated hypertension with regions, and both cited studies are dated so no comparison is possible.

For hypertension and hypertension control, we found no differences across urbanization after all covariates were included in the third regression model. The differences of hypertension and hypertension control across urbanization without covariates adjustment may be explained by the differences of confounding factors across urbanization (i.e., the differences in race/ethnicity, poverty ratio, and other confounding variables shown in Table 1). After adjusting covariates, the stage II hypertension was associated with medium to small MSAs.

More studies are needed focusing on these geographical locations. One possibility of incorporating both regionality and urbanization is leveraging electronic health records as was done using in the Yale New Haven Health System.[40] This approach opens the possibility of using concurrently both measured BP and geographical locations. Lastly, the US government has also identified this issue in health and human services 2020 Rural Action Plan that aims to "improve the health outcomes of people in rural communities with cardiovascular disease."[41]

The findings in this report are subject to limitations. NHANES sampling design is not meant to provide individual-level urbanization prevalence estimates. Despite our attempt to increase the sample size and the degrees of freedom by combining the NCHS metropolitan classification into 3 categories, medium to small MSAs or non-MSAs characteristically have a smaller sample size and fewer degrees of freedom which resulted in some estimates and standard errors that did not meet statistical reliability criteria.[24] It is possible that other factors not accounted for in this analysis such as occupational status, neighborhoods, and access to health care may explain this association between stage II hypertension and urbanization and thus when not considered we may miss the wider construct that reflects more complex association that impact health outcome.[9] Additionally, we did not examine in the multivariable logistic model the effect of behavioral covariates associated with hypertension such as smoking or physical activity. Although these behaviors when modified may attenuate the risk for hypertension.[23] We focused in this analysis solely on biophysiological risk factors.

The adjusted PRs of stage II hypertension were higher in medium to small MSAs compared with large MSAs. These analyses support the importance of including urbanization level as an additional demographic variable when estimating hypertension prevalence. Studies utilizing a multivariable framework provide a better understanding of the association of urbanization levels and BP.

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Table 1.

Sample characteristics of adults aged 18 years and older by levels of metropolitan statistical areas (MSAs): United States, 2013–2018

	n [e]	Large MSAs (*n* = 8,884)	Medium to small MSAs (*n* = 5,277)	Non-MSAs[a] (*n* = 2,199)	*P* value[b]
		Percent (95% CI)			
Sex					0.41
Male	7,981	48.9 (38.9–58.9)	37.1 (25.3–50.0)	14.1 (7.6–23.0)	
Female	8,379	49.8 (39.8–59.9)	36.0 (24.5–48.8)	14.2 (7.6–23.4)	
Age					0.16
18–39 years	5,775	50.6 (40.1–61.1)	36.9 (25.1–50.0)	12.5 (6.7–20.5)	
40–59 years	5,175	49.8 (40.2–59.5)	35.7 (24.3–48.5)	14.4 (7.4–24.3)	
60–79 years	4,414	47.6 (36.9–58.3)	36.7 (24.6–50.1)	15.8 (8.5–25.9)	
80 years and older	996	44.6 (33.7–55.9)	38.1 (24.8–52.8)	17.3 (9.1–28.7)	
Race and Hispanic origin[c]					<0.001
Non-Hispanic white (NHW)	5,984	42.9 (32.0–54.3)	40.5 (26.8–55.3)	16.6 (8.2–28.5)	
Hispanic	4,169	60.5 (48.6–71.6)	28.4 (17.8–41.2)	11.1 (5.0–20.5)[d]	
Non-Hispanic black (NHB)	3,543	62.1 (49.3–73.8)	27.3 (17.0–39.7)	10.7 (3.9–22.1)[d]	
Non-Hispanic Asian (NHA)	2,011	72.5 (58.4–83.9)	26.0 (14.5–40.4)	1.6 (0.6–3.2)[d]	
Family income-to-poverty[b] ratio					<0.001
<1	3,199	45.0 (35.5–54.8)	35.0 (23.4–48.1)	19.9 (11.2–31.5)	
1 to <2	3,969	43.0 (32.8–53.5)	37.8 (25.5–51.5)	19.2 (10.6–30.6)	
2 to <4	3,911	45.4 (35.5–55.7)	39.9 (27.0–53.8)	14.7 (7.5–24.8)	
4 or more	3,616	56.6 (44.7–67.9)	34.2 (22.4–47.6)	9.2 (4.6–16.1)	
Level of education[b]					<0.001
High school or less	7,508	42.9 (33.7–52.5)	38.0 (25.9–51.3)	19.1 (10.2–31.1)	
More than high school or some college	4,990	46.3 (36.5–56.4)	38.3 (26.1–51.8)	15.4 (8.5–24.8)	
College graduate	3,847	60.7 (48.5–71.9)	32.7 (21.2–46.0)	6.6 (3.2–11.9)	
Health care visits in past year[b]					<0.05
0–1	5,642	50.8 (41.1–60.5)	36.4 (25.1–49.1)	12.7 (6.8–21.1)	
2–3	4,759	49.4 (39.0–59.9)	36.6 (24.8–49.6)	14.0 (7.4–23.3)	

	n [e]	Large MSAs (n = 8,884)	Medium to small MSAs (n = 5,277)	Non-MSAs[a] (n = 2,199)	P value[b]
		Percent (95% CI)			
4 or more	5,932	48.1 (37.8–58.5)	36.4 (24.5–49.7)	15.5 (8.2–25.7)	
Body mass index (BMI, kg/m^2)[b]					<0.001
Normal (18.5–24.9)	4,447	54.7 (44.5–64.6)	33.8 (22.5–46.7)	11.5 (5.8–19.8)	
Overweight (25.0–29.9)	5,107	51.7 (41.5–61.8)	34.1 (23.1–46.6)	14.2 (7.7–23.2)	
Class I obesity (30.0–34.9)	3,402	44.8 (34.6–55.3)	40.4 (28.0–53.7)	14.8 (7.8–24.7)	
Class II obesity (35.0–39.9)	1,635	46.0 (35.4–56.9)	39.3 (26.6–53.0)	14.7 (7.7–24.6)	
Class III obesity (≥40)	1,295	39.0 (29.3–49.5)	39.8 (26.2–54.6)	21.2 (11.7–33.6)	
*Diagnosed Diabetes[b]					<0.01
Yes	2,660	44.6 (35.0–54.4)	36.9 (24.7–50.4)	18.6 (10.0–30.1)	
No	12,983	49.9 (39.9–60.0)	36.5 (25.0–49.3)	13.6 (7.3–22.3)	
Chronic kidney disease[b]					<0.01
Yes	2,713	46.1 (36.8–55.6)	36.1 (24.6–49.0)	17.8 (10.0–28.2)	
No	12,673	49.7 (39.5–59.8)	36.7 (25.1–49.6)	13.6 (7.3–22.5)	

[a] Degrees of freedom $F < 8$ (degrees of freedom = 7).

[b] P value is from Satterthwaite-adjusted Wald chi-square test of independence.[20]

[c] Sample sizes not adding up to total of 100% since results on non-Hispanic and other groups not shown.

[d] The proportion does not meet NCHS presentation standard for proportions (relative width of Korn and Graubard 95% confidence interval >130%).

[e] Unweighted sample size.

* Diagnosed Diabetes = defined as self-report or an HbA1c ≥6.5%.

Source: 2013–2018 National Health and Nutrition Examination Survey.

Table 2.

Age-adjusted prevalence of hypertension and stage II hypertension among adults 18 years of age and older: United States 2013–2018

		Hypertension		Stage II hypertension	
	n [e]	Prevalence (95% CI)	*P* value [a]	Prevalence (95% CI)	*P* value [a]
Overall [d]	16,360	43.7 (42.4–45.0)		15.5 (14.5–16.6)	
Survey years [d]					
2013–2014	5,657	41.8 (39.8, 43.8)	<0.05, for linear trend	13.7 (11.7, 15.8)	<0.01, for linear trend
2015–2016	5,504	43.7 (41.2, 46.3)		15.2 (13.5, 17.0)	
2017–2018	5,199	45.6 (42.5, 48.7)		17.7 (15.4, 20.2)	
Urbanization [d]					
Large MSAs	8,884	41.1 (39.2, 43.0)	Ref [b]	14.1 (12.7, 15.6)	Ref [b]
Medium to small MSAs	5,277	45.4 (42.3, 48.5)	<0.01	17.1 (15.2, 19.2)	<0.01
Non MSAs	2,199	48.6 (44.4, 52.8) [c]	<0.001	16.4 (12.0, 21.7) [3]	0.22
Demographics [d]					
Sex					
Male	7,981	47.9 (46.0–49.7)	Ref [b]	17.0 (15.5–18.6)	Ref [b]
Female	8,379	39.3 (37.8–40.8)	<0.001	13.9 (13.0–14.9)	<0.001
Age					
18–39 years	5,775	20.4 (18.8, 22.0)	<0.001, for linear trend	5.1 (4.4, 5.8)	<0.01, for linear trend
40–59 years	5,175	51.6 (49.3, 54.0)		17.0 (15.1, 18.9)	
60–79 years	4,414	72.6 (70.0, 75.1)		29.3 (27.3, 31.4)	
80 years and older	996	84.1 (81.7, 86.3)		47.4 (43.2, 51.5)	
Race and Hispanic origin [d]					
Non-Hispanic white	5,984	42.1 (40.2, 44.1)	Ref [b]	14.1 (12.5, 15.7)	Ref [b]
Hispanic	4,169	42.4 (40.9, 43.9)	0.81	16.4 (14.9, 17.9)	<0.05
Non-Hispanic black	3,543	55.1 (53.3, 57.0)	<0.001	23.9 (22.2, 25.5)	<0.001
Non-Hispanic Asian	2,011	42.7 (40.1, 45.3)	0.70	16.5 (14.8, 18.3)	<0.05
Family income-to-poverty ratio [d]					

		Hypertension		Stage II hypertension	
	n [e]	Prevalence (95% CI)	*P* value [a]	Prevalence (95% CI)	*P* value [a]
<1	3,199	45.9 (43.6, 48.2)	Ref [b]	18.9 (16.4, 21.5)	Ref [b]
1 to <2	3,969	46.7 (44.0, 49.5)	0.58	17.2 (15.4, 19.1)	0.20
2 to <4	3,911	45.2 (43.0, 47.3)	0.58	15.1 (13.7, 16.6)	<0.01
4 or more	3,616	40.4 (37.9, 43.0)	<0.001	13.4 (11.5, 15.5)	<0.001
Level of education [d]					
High school or less	7,508	46.3 (44.7, 47.9)	Ref [b]	17.8 (16.1, 19.6)	Ref [b]
More than high school or some college	4,990	47.0 (44.6, 49.4)	0.63	15.9 (14.5, 17.3)	0.56
College graduate	3,847	37.2 (34.9, 39.6)	<0.001	12.4 (10.9, 14.1)	<0.001
Health care utilization [d]					
Health care visits in past year					
0–1	5,642	39.2 (36.7, 41.7)	Ref [b]	17.1 (15.6, 18.7)	Ref [b]
2–3	4,759	42.6 (40.4, 44.8)	<0.05	14.3 (12.9, 15.9)	<0.01
4 or more	5,932	47.6 (45.5, 49.7)	<0.001	15.5 (13.9, 17.2)	0.11
Risk factors					
Body mass index (BMI, kg/m^2) [d]					
Normal (18.5–24.9)	4,447	30.8 (28.4, 33.3)	<0.001, for linear trend	11.9 (10.4, 13.6)	<0.001, for linear trend
Overweight (25.0–29.9)	5,107	40.3 (38.6, 42.1)		14.3 (12.7, 15.9)	
Class I obesity (30.0–34.9)	3,402	50.0 (47.9, 52.1)		15.4 (13.8, 17.2)	
Class II obesity (35.0–39.9)	1,635	57.5 (53.7, 61.2)		21.4 (18.1, 25.0)	
Class III obesity (≥40)	1,295	66.5 (63.0, 69.9)		25.0 (22.1, 28.2)	
*Diagnosed Diabetes [d]					
Yes	2,660	67.2 (64.4, 70.0)	Ref [b]	23.2 (21.2, 25.3)	Ref [b]
No	12,983	41.1 (39.6, 42.6)	<0.001	14.6 (13.4, 15.9)	<0.001
Chronic kidney disease [d]					
Yes	2,713	57.8 (55.1, 60.6)	Ref [b]	25.7 (23.5, 28.0)	Ref [b]
No	12,673	41.5 (39.9, 43.1)	<0.001	13.7 (12.6, 15.0)	<0.001

Notes: Hypertension is defined as systolic blood pressure ≥130, diastolic blood pressure ≥80 or current use of antihypertensive medication. Stage 2 hypertension is defined as systolic blood pressure ≥140 or diastolic blood pressure ≥90. Abbreviations: CI, confidence interval; MSAs, metropolitan statistical areas.

[a] *P* value for trend test or for pairwise comparison.

[b] The reference group for pairwise comparison.

[c] Degrees of freedom <8 (degrees of freedom = 7).

[d] Age-adjusted to the U.S. Census 2000 population using age groups 18–39, 40–59, 60–79, 80 years and older with weights 0.4203, 0.3572, 0.1776, and 0.0449.

[e] Unweighted sample size.

[*] Diagnosed Diabetes = defined as self-report or an HbA1c ≥6.5%.

Source: 2013–2018 National Health and Nutrition Examination Survey.

Table 3.

Age-adjusted prevalence of controlled hypertension among adults 18 years of age and older with hypertension: United States 2013–2018

	n [e]	Age-adjusted % Controlled (95% CI)	*P* value [a]
Overall [d]	8,229	21.7 (20.0–23.4)	
Survey years [d]			
2013–2014	2,630	24.8 (21.6, 28.1)	<0.01, for linear trend
2015–2016	2,755	21.7 (18.1, 25.7)	
2017–2018	2,844	18.9 (16.4, 21.5)	
Urbanization [d]			
Large MSAs	4,280	21.0 (18.6, 23.5)	Ref [b]
Medium to small MSAs	2,736	20.6 (17.9, 23.5)	0.80
Non MSAs	1,213	25.9 (21.3, 31.0) [c]	<0.05
Demographics			
Sex [d]			
Male	4,260	20.4 (18.5–22.5)	Ref [b]
Female	3,969	23.8 (21.6–26.1)	<0.01
Age			
18–39 years	1,173	7.0 (5.2, 9.2)	<0.001, for linear trend
40–59 years	2,796	20.9 (17.9, 24.1)	
60–79 years	3,424	29.6 (26.9, 32.5)	
80 years and older	836	21.7 (17.7, 26.1)	
Race and Hispanic origin [d]			
Non-Hispanic white	3,025	22.9 (20.5, 25.3)	Ref [b]
Hispanic	1,878	17.4 (15.2, 19.8)	<0.01
Non-Hispanic black	2,139	19.5 (17.6, 21.5)	<0.05
Non-Hispanic Asian	881	14.3 (11.9, 17.0)	<0.001
Family income-to-poverty ratio [d]			

	n [e]	Age-adjusted % Controlled (95% CI)	*P* value [a]
<1	1,510	21.5 (18.6, 24.7)	Ref [b]
1 to <2	2,096	20.9 (18.2, 23.7)	0.74
2 to <4	1,997	22.2 (19.4, 25.3)	0.71
4 or more	1,741	22.8 (19.4, 26.4)	0.52
Level of education [d]			
High school or less	3,963	20.8 (18.9, 22.9)	Ref [b]
More than high school or some college	2,525	24.1 (21.5, 26.8)	<0.01
College graduate	1,730	20.0 (17.1, 23.1)	0.61
Health care utilization			
Health care visits in the past year [d]			
0–1	2,148	8.3 (6.9, 9.9)	Ref [b]
2–3	2,392	23.6 (20.6, 26.8)	<0.001
4 or more	3,675	27.9 (25.7, 30.1)	<0.001
Risk factors			
Body mass index (BMI, kg/m^2) [d]			
Normal (18.5–24.9)	1,573	14.5 (12.1, 17.2)	<0.001, for quadratic trend
Overweight (25.0–29.9)	2,558	21.5 (18.5, 24.8)	
Class I obesity (30.0–34.9)	1,962	24.6 (21.8, 27.5)	
Class II obesity (35.0–39.9)	1,035	24.9 (20.8, 29.2)	
Class III obesity (≥40)	900	22.4 (18.5, 26.7)	
*Diagnosed Diabetes [d]			
Yes	2,077	29.9 (26.9, 33.1)	Ref [b]
No	5,804	19.8 (17.7, 22.0)	<0.001
Chronic kidney disease [d]			
Yes	2,077	24.5 (22.2, 26.9)	Ref [b]
No	5,634	21.0 (18.9, 23.3)	<0.001

Note: Hypertension control is defined as systolic blood pressure <130 and diastolic blood pressure <80 among adults with hypertension. Abbreviations: CI, confidence interval; MSAs, metropolitan statistical areas.

[a] *P* value for trend test or for pairwise comparison.

[b] The reference group for pairwise comparison.

[c] Degrees of freedom <8 (degrees of freedom = 7).

[d] Age-adjusted to subpopulation of individuals who had hypertension in NHANES 2007–2016 using age groups 18–39, 40–59, 60–79, 80 years and older with weights 0.1661, 0.4061, 0.3446, and 0.0832.

[e] Unweighted sample size.

[*] Diagnosed Diabetes = defined as self-report or an HbA1c ≥6.5%.

Source: 2013–2018 National Health and Nutrition Examination Survey.

Table 4.

Unadjusted and adjusted prevalence ratios of hypertension, stage II hypertension, and hypertension control by levels of urbanization among adults aged 18 years and older: United States 2013–2018

Models	Urbanization	Prevalence ratio (95% CI) for the outcomes: Hypertension[a]	Stage II hypertension[b]	Hypertension control[c]
Model 1 (unadjusted)	Large MSAs	Reference	Reference	Reference
	Medium to small MSAs	1.12 (1.04–1.12)	1.24 (1.08–1.41)	0.99 (0.84–1.52)
	Non-MSAs	1.24 (1.15–1.33)	1.28 (1.02–1.59)	1.24 (1.01–1.53)
Model 2 (adjusted for age, sex, race, and Hispanic origin)	Large MSAs	Reference	Reference	Reference
	Medium to small MSAs	1.13 (1.05–1.20)	1.28 (1.13–1.45)	0.93 (0.88–0.98)
	Non-MSAs	1.19 (1.11–1.28)	1.25 (1.01–1.55)	0.93 (0.86–1.00)
Model 3 (adjusted, full model)	Large MSAs	Reference	Reference	Reference
	Medium to small MSAs	1.07 (0.99–1.14)	1.21 (1.06–1.36)	0.96 (0.91–1.01)
	Non-MSAs	1.06 (0.99–1.13)	1.06 (0.88–1.29)	1.00 (0.93–1.06)

Note: Model 3: adjusted for covariates, survey cycle, sex, age groups, race and Hispanic origin, family income-to-poverty ratio, level of education, health care visits, body mass index, diagnosed diabetes (defined as self-report or an HbA1c ≥6.5%), and chronic kidney disease. Abbreviations: CI, confidence interval; MSAs, metropolitan statistical areas.

[a] Hypertension is defined as systolic blood pressure ≥130, diastolic blood pressure ≥80 or current use of antihypertensive medication.

[b] Stage II hypertension is defined as systolic blood pressure ≥140 or diastolic blood pressure ≥90 among all adults.

[c] Hypertension control is defined as systolic blood pressure <130 and diastolic blood pressure <80 among adults with hypertension.

Source: 2013–2018 National Health and Nutrition Examination Survey.