ORIGINAL ARTICLE

Does Age Matter? Association Between Usual Source of Care and Hypertension Control in the US Population: Data From NHANES 2007–2012

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BACKGROUND
The positive role of having a usual source of care (USOC) on the receipt of preventative services is known. However, associations between USOC and hypertension control and the differential association across age groups is unknown in the US population.

METHODS
We used data from the National Health and Nutrition Examination Survey (NHANES) from 2007 to 2012. Multivariable logistic regression was used to evaluate the association between having a USOC and hypertension control. The differential effect of USOC on hypertension control by age was assessed using predicted marginal effects across age groups in the multivariable logistic model.

RESULTS
In adjusted analyses, those with a USOC had higher odds of hypertension control (odds ratio = 3.89, 95% confidence interval (CI): 2.15–6.98). The marginal effect of having a USOC is associated with a 30 percentage point higher probability of controlled blood pressure compared to those without a USOC (marginal probability = 0.30, 95% CI: 0.19–0.41). The marginal effect of USOC on hypertension control varied by age groups, with a statistically significantly lower marginal effect of USOC on hypertension seen among those older than 74 years of age (marginal probability = 0.27, 95% CI: 0.18–0.36) and younger than 35 years of age (marginal probability = 0.23, 95% CI: 0.14–0.33).

CONCLUSION
Having a USOC is significantly associated with improved hypertension control in the US population. The variation in the association across age groups has important implications in targeting age-specific anti-hypertensive strategies to reduce the burden of hypertension in the US population.

Keywords: age; blood pressure; hypertension; usual source of care.

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Approximately 80 million US adults have hypertension with just over half controlled.[1] Because hypertension is a major risk factor for the development of heart failure, stroke, and coronary artery disease, controlling hypertension is critical for reducing morbidity, mortality, and costs.[1–4]

The burden of hypertension in older Americans is particularly striking. Nearly 3 out of 4 individuals aged >74 years have hypertension, and with each decade of life, the stroke mortality rate is significantly greater for those with hypertension than those with normal blood pressure.[2,3,5,6]

Elucidating the impact of having access to a usual source of care (USOC) on hypertension control has important policy implications in the organization of care and management of chronic disease. Observational studies have examined the association between having a USOC and the receipt of preventative care and found positive associations between regular sources of care and mammograms, flu vaccination, cholesterol checks, and blood pressure checks.[7–10]

Beyond blood pressure *checks*, there are few studies that have examined the relationship between structural access to care (i.e., insurance or a USOC) and *treatment* or *control* of blood pressure.[11,12] An older study using National Health and Nutrition Examination Survey (NHANES) III data from the late 1980s and early 1990s found that having private health insurance and using the same facility or provider for healthcare was associated with higher odds of blood pressure control.[11] In another study, having a USOC was associated with a higher prevalence of *treatment* for hypertension in adults, but hypertension control was not examined.[12]

Given major changes in the treatment landscape and population demographics over the past 25 years, it is important to re-examine the relationship between structural access to care

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and hypertension control. Thus, this study has 3 major objectives: (i) to evaluate whether having a USOC is associated with hypertension control in the US population, (ii) to assess if the effect of USOC on hypertension varies by age group, and (iii) to analyze age group behaviors and USOC type utilization. Assessing the link between USOC and hypertension control, and differences in the association by age, is an important step in understanding what effect increasing structural access to care may have on the US hypertensive population.

METHODS AND MEASURES

Data source

This cross-sectional study design uses health interview and medical exam data from the NHANES from 2007 to 2012. NHANES uses a complex, multistage sampling design to select a representative sample of the civilian noninstitutionalized population in the United States.[13] The physical exam component contains data on blood pressure, height, and weight that is gathered at a mobile exam center. In addition, the NHANES questionnaires assess comorbidities, self-reported health status, dietary and health habits, and information on USOC.

The NHANES sample for this study is restricted to the hypertensive population (i.e., those who currently taking blood pressure medication or had systolic blood pressure 140 or diastolic 90 at the time of the mobile exam component). This restricted subsample is consistent with other studies assessing hypertension outcomes.[11,12]

Measures

Trained professionals measured blood pressure using sphygmomanometry and appropriately sized arm cuffs after 5 minutes seated rest. Blood pressure measurements were taken 3 consecutive times and averaged after discarding the first measurement.[13]

"Hypertension control" is defined as average systolic blood pressure less than 140 mm Hg and diastolic less than 90 mm Hg.[2] Newer JNC8 criteria were not used because clinicians during the time period of this study would not have been using the new targets for the older population.[3] Treatment for hypertension was defined by one's response to: "Are you taking blood pressure medication?"

NHANES defines USOC as a place to go when one is ill and needs care; places are listed as hospital outpatient department, outpatient clinic or doctor's office, emergency department, or none.[14] If individuals report no USOC or use the emergency department, they are treated as "no USOC." For some analyses, USOC type is broken down into "traditional" USOC (clinic, doctor's office, or outpatient hospital department), emergency department USOC, and no USOC.

Other variables and their construction are as follows:

1. We include only adults 18 years of age and older and stratify by 10-year intervals to create 6 separate groups.
2. Race/ethnicity is defined as Hispanic, non-Hispanic White, non-Hispanic Black, and "other race" which includes multiracial.
3. We treat married individuals and those living with partner as "married" and all others as "not married."
4. Insurance status is defined as either insured or uninsured.
5. Education is defined as the highest grade completed and is collapsed into 3 categories: (i) those who did not complete high school, (ii) high school graduates, and (iii) college graduates.
6. Income is defined as family income in relationship to federal poverty level (FPL). Specifically, we create 4 mutually exclusive categories: (i) "Poorest"/<150% FPL, (ii) 150–249% FPL, (iii) 250–349% FPL, and (iv) >350% FPL.
7. Self-reported health is defined as *fair*, *poor*, *good*, *very good*, or *excellent* health.
8. Self-reported activity is defined by whether individuals met the American College of Sports Medicine guidelines for aerobic physical activity.[15]
9. Smoking is defined as smoking at least 100 cigarettes in one's lifetime.[16]
10. Comorbidities such as diabetes, heart failure, prior heart attack (myocardial infarction), prior stroke (cerebrovascular accident), and high cholesterol are all defined based on a patient's answers to the following question: "Has a doctor ever told you that you have/had 'X'?"
11. Kidney function was determined by laboratory assessment of creatinine (in mg/dl) and is treated as a continuous variable.
12. Body mass index (BMI) was calculated during the mobile exam center and is defined as a person's weight (in kilogram) divided by their height (in meters) squared. We use the CDC definitions for underweight (BMI < 18.5), normal weight (BMI = 18.5–24.9), overweight (BMI = 25–29.9), and obese (BMI ≥ 30).

Study design and statistical methods

We use survey methods for all weighted bivariate analyses and regression models. Bivariate relationships between covariates and USOC and bivariate associations with hypertension control are assessed using the chi-square test. Unadjusted weighted proportions of those with controlled hypertension are presented by USOC type (e.g., "traditional" USOC, emergency department, and none) and unadjusted weighted proportions of age groups are presented by USOC type. We employed 2 logistic models to analyze the effects of USOC on hypertension control. The first adjusts for demographics and comorbidities and the second adjusts for demographics and comorbidities after imputation of variables with missing data (see below for missing data methods). We test the differential association between age and USOC by testing the equality of the marginal effects of USOC on the probability of hypertension control at each age group in the full multivariate logistic model.[17] Predictions are generated using average probabilities among actual persons in the data and errors are weighted to account for population sampling. We made an *a priori* decision based on our conceptual models to explore the factors potentially responsible for the varying effect of USOC on hypertension control by examining

bivariate relationships with age groups and antihypertensive medication use, follow-up, smoking status, and exercise.

Missing data

Variables with missing data were imputed using multiple imputation with chained equations using age, gender, race/ethnicity, diabetes status, smoking status, and USOC.[18–20] We specified 5 multiply imputed datasets and variables were assumed to be missing at random.[21]

RESULTS

Missing data

Most of the variables had either no missing data or were missing <2%. Only 3 variables were missing approximately 10% (BMI category, income, and hyperlipidemia). All missing data were imputed as described above.

Bivariate analysis

In bivariate analysis, those *without* a USOC were more likely to be younger, of Hispanic ethnicity or non-Hispanic Black, and male. In addition, individuals *without* a USOC were less likely to be married, have insurance, have completed high school, and less likely to report having diabetes, heart failure, prior stroke, or high cholesterol. A higher proportion of antihypertensive medication use and control was seen in those with a USOC (see Table 1).

Figure 1 illustrates the proportion of controlled hypertension by USOC type. Fifty-two percent have controlled hypertension. Only 14% without a USOC have controlled hypertension, compared to 55% with a traditional USOC (*P* < 0.01). Those who use the emergency department as their USOC were less likely to have controlled hypertension than those with a "traditional" USOC (31% vs. 55%, *P* < 0.01).

Figure 2 illustrates the proportion with controlled hypertension by age group. Hypertension control was statistically significantly lower in the youngest (18–34 and 35–44 year olds) and oldest (>74 years old) compared to other age groups. Only 24% of 18–34 year olds, 47% of 35–44 year olds, and 47% of those older than 74 had their blood pressure under control. The proportion with controlled hypertension in the other age groups was 55% (age 45–54), 55% (age 55–64), and 58% (age 65–74).

Whites were more likely than non-Whites to have controlled hypertension (54% vs. 46%, *P* < 0.01). Women were more likely than men to have controlled hypertension (55% vs. 48%, *P* < 0.01). Those with insurance were also more likely to have controlled hypertension than the uninsured (54% vs. 32%, *P* < 0.01). Current smokers were less likely to have controlled hypertension than former and nonsmokers (46% vs. 53%, *P* < 0.01). Obese individuals were also more likely to have controlled hypertension than those with normal weight (57% vs. 39%, *P* < 0.05).

In our age group analyses—examining relationships between age groups and USOC type and behaviors—we found that younger individuals (<35 years old) are statistically significantly *less likely* to have a traditional USOC (72% vs. 92%, *P* < 0.01) and *more likely* to use the emergency department as their USOC (4% vs. 1%, *P* < 0.01) or have no USOC compared to older age groups (24% vs. 6%, *P* < 0.01). The youngest (<35 years old) are statistically significantly *less likely* to be taking blood pressure medication than older groups (15% vs. 71%, *P* < 0.01). The youngest (<35 years old) are also *more likely* to have no visits to their providers in the past year (20% vs. 8%, *P* < 0.01), meet physical activity guidelines (49% vs. 37%, *P* < 0.01), and be current smokers (27% vs. 16%, *P* < 0.01) than older groups. In contrast, the oldest individuals (>74 years old) were *more likely* to visit their providers 2 or more times in the past year (91% vs. 77%, *P* < 0.01) and *more likely* to be taking blood pressure medication (80% vs. 63%, *P* < 0.01) than all younger age groups. The oldest (>74 years old) were *less likely* to be smokers (5% vs. 20%, *P* < 0.01) and meet physical activity guidelines compared to all other age groups (23% vs. 42%, *P* < 0.01).

Multivariable models

Multivariable logistic regression models revealed a significant positive relationship between having a USOC and hypertension control (see Table 2). In the full model adjusting for demographics and comorbidities without imputation, those with a USOC had significantly higher odds of hypertension control than those without a USOC (odds ratio (OR) = 3.89, 95% confidence interval (CI): 2.15–6.98). The magnitude, direction, and significance of the relationship did not change in the imputation model (OR = 3.89, 95% CI: 2.6–5.83).

Individuals older than 74 years of age had a 42% lower odds of hypertension control than 65–74 year olds (OR = 0.58, 95% CI: 0.45–0.76). Non-Hispanic Blacks had a 30% lower odds of hypertension control than Whites (OR = 0.70, 95% CI: 0.59–0.84); Hispanics had a 28% lower odds of hypertension control than Whites (OR = 0.72, 95% CI: 0.56–0.93).

In probability terms, the marginal effect of having a USOC is associated with a 30 percentage point higher probability of controlled blood pressure compared to those without a USOC (marginal probability = 0.30, 95% CI: 0.19–0.41). This marginal effect amounts to an additional 300,000 individuals with controlled hypertension per million in the US hypertensive population. Figure 3 illustrates the marginal effect between USOC and hypertension at each age group. The marginal effect of USOC on the probability of hypertension control in the youngest age group (18–34 year olds) is 0.23 (95% CI: 0.14–0.33) and in the oldest group (>74 year olds), it is 0.27 (95% CI: 0.18–0.36). The marginal effect of USOC on hypertension control in 35–44 year olds is 0.30 (95% CI: 0.19–0.41); among 45–54 year olds, it is 0.31 (95% CI: 0.19–0.43); among 55–64 year olds, it is 0.31 (95% CI: 0.19–0.42); and among 65–74 year olds, it is 0.31 (95% CI: 0.19–0.42). The 7–8 percentage point difference in marginal effect of USOC on hypertension control in the youngest group (compared to all middle age groups) is statistically significantly lower. In terms of the US population, this difference amounts to 70,000–80,000 fewer young individuals with controlled hypertension per million individuals with hypertension. The 3–4 percentage point difference in marginal effect in

Table 1. Characteristics of the NHANES 2007–2012 adult hypertension subsample by USOC

	USOC (n = 6,785) Weighted % = 90.7%	No USOC (n = 868) Weighted % = 9.3%
Age strata, no. (weighted %)		
18–34	504 (7.5%)	226 (28.5%)**
35–44	625 (11.4%)	145 (17.9%)**
45–54	1,012 (19.3%)	186 (26.6%)**
55–64	1,540 (24.4%)	167 (15.5%)**
65–74	1,523 (19.2%)	89 (7.1%)**
>75	1,581 (18.2%)	55 (4.3%)**
Race/ethnicity, no. (weighted %)		
Hispanic	1,359 (8.4%)	327 (23.1%)**
Non-Hispanic White	3,159 (71.9%)	244 (48.9%)**
Non-Hispanic Black	1,789 (14%)	228 (19.6%)**
Other race	478 (5.6%)	69 (8.4%)
Gender		
Male, no. (weighted %)	3,158 (45.7%)	539 (65%)**
Marital status		
Married or partner, no. (weighted %)	3,833 (63.7%)	430 (51.9%)**
Insurance status		
Insured, no. (weighted %)	6,028 (90.9%)	385 (47.5%)**
Education, no. (weighted %)		
Less than high school	2,110 (21.3%)	387 (34.5%)**
High school graduate or some college	3,415 (54.2%)	390 (51.8%)
College graduate	1,243 (24.5%)	90 (13.7%)**
Physical activity, no. (weighted %)		
Meeting physical activity guidelines	2,262 (37.3%)	418 (51.5%)**
Smoking status, no. (weighted %)		
Nonsmoker	3,589 (52.8%)	441 (46.2%)*
Current smoker	1,098 (15.4%)	274 (35.8%)**
Former smoker	2,098 (31.8%)	153 (18%)**
Comorbidities, no. (weighted %)		
Diabetes	1,558 (19%)	71 (6.3%)**
Heart failure	452 (5.7%)	18 (1.3%)**
Prior MI	522 (6.5%)	35 (3.2%)**
Prior stroke	549 (6.6%)	26 (2%)**
Hyperlipidemia	3,218 (52.6%)	169 (33.2%)**
COPD	435 (6.6%)	26 (3.2%)*
BMI category, no. (weighted %)		
Obese	2,848 (46.7%)	295 (41.9%)
Overweight	1,968 (32.8%)	237 (30.7%)
Normal weight	1,220 (19.2%)	164 (24.7%)*
Underweight	74 (1.3%)	19 (2.7%)**
Hypertension treatment and control		
Taking antihypertensive medication, no. (weighted %)	4,746 (70.7%)	182 (20.1%)**
Hypertension controlled, no. (weighted %)	2,836 (54.8%)	97 (17%)**

Total sample size n = 7,653 representing 87,298,349 individuals. Abbreviations: BMI, body mass index; COPD, chronic obstructive pulmonary disease; MI, myocardial infarction; NHANES, National Health and Nutrition Examination Survey; USOC, usual source of care.
*Statistically significant at P <0.05.
**Statistically significant at P <0.01.

the oldest age group (compared to all middle age groups) is statistically significantly lower. This difference amounts to 30,000–40,000 fewer older individuals with controlled hypertension per million in the US hypertension population.

DISCUSSION

In this paper, we discovered several key relationships: (i) a significant positive association between having a USOC and hypertension control in the US population, (ii) a different marginal effect between USOC and controlled hypertension by age group, and (iii) different USOC types and behaviors by age group.

The association between USOC and hypertension control captures the totality of pathways through which structural access may impact hypertension control. There are several mediating pathways through which a USOC may operate to improve hypertension control. First, and likely
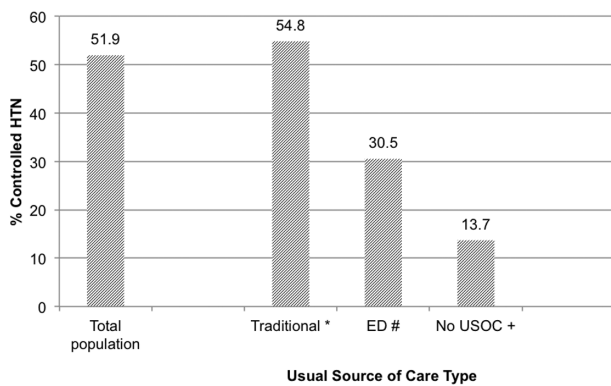

Figure 1. Proportion of controlled HTN by USOC type. *Traditional USOC includes office, clinic, and hospital outpatient department. #Proportion of population with controlled HTN and ED USOC significantly different from both no USOC (P = 0.002) and traditional USOC (P < 0.001). +No USOC excludes the ED. Abbreviations: ED, emergency department; HTN, hypertension; USOC, usual source of care.
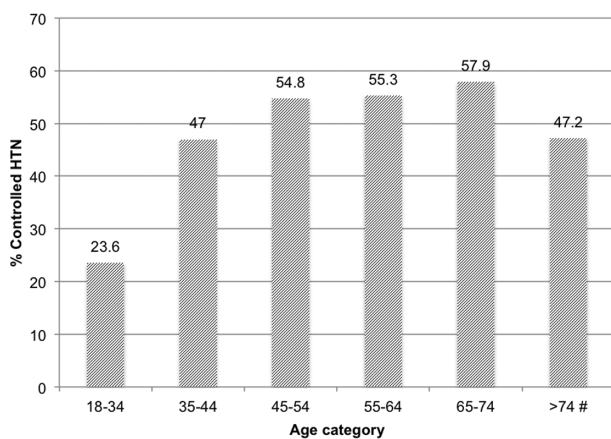

Figure 2. Proportion of controlled HTN by age group. #Proportion of controlled HTN statistically significantly different between age >74 when compared to ages 65–74, 55–64, 45–54, and 18–34 (P < 0.001). No statistically significant difference in proportion of controlled HTN between age ≥75 and age 35–44 (P = 0.27). Abbreviation: HTN, hypertension.

most significant, having a USOC may lead to increased initiation of and adherence to antihypertensive medication use given that trust in one's physician has been associated with improved medication compliance.[22] Second, patients with a USOC may be more likely to follow up with their providers,[23] allowing for titration of antihypertensive medications and discussion of healthy behaviors that lead to improved cardiovascular health. In addition, individuals with other chronic medical issues may be more likely to have a USOC, and management of other comorbidities may increase antihypertensive treatment.[24,25]

The reasons for a *changing* relationship between USOC and hypertension control by age group may be a result of differences in health habits, compliance with medication, or dynamic physiologic changes with aging. Some health and nutrition habits that are associated with good overall physical and mental health may been seen in aging, but there are also potential changes in mobility, cognition, and social support—in addition to changes in vascular physiology—that may negatively impact health and blood pressure control.[26–29] In our age group analyses, older individuals were more likely to follow up, be taking blood pressure medication, and less likely to smoke. Assuming a mediating role for these factors between USOC and hypertension control, these data suggest that other physiologic factors may be playing a more prominent role in diminished marginal effect of USOC on hypertension control in the oldest individuals. This finding would be in alignment with basic science research demonstrating age-related changes in the blood vessels and chronic physiologic changes in the neural and biochemical systems responsible for regulating blood pressure.[30–35] In contrast, the youngest age groups were more likely to use a different setting for their USOC (i.e., the emergency department) that may be less efficient in controlling hypertension long term. In addition, younger individuals were more likely to be current smokers and have no visits to their USOC in the past year and less likely to be taking blood pressure medication. These findings are in agreement with another study showing that infrequent healthcare may be a significant contributor to undiagnosed and/or untreated hypertension in the youngest individuals.[36] Thus, in younger individuals, behavioral factors may play more of a role in the diminished marginal effect of USOC on hypertension control.

Limitations

There are several limitations to this study, given the cross-sectional design, measurement of hypertension, potential endogeneity of USOC, and subpopulation sizes. With a cross-sectional design, the causality underlying the observed relationship between USOC and hypertension control cannot be determined. Although blood pressure was measured by trained professionals, hypertension status and control are based on a single evaluation. Potential white coat hypertension that varies by USOC status could have overestimated or underestimated the effect of USOC on hypertension control. Moreover, if such white coat hypertension varied by age groups, that may have altered the differential marginal effect of USOC on hypertension control across the age groups. In terms of endogeneity, it is possible that those with controlled hypertension may be more

Table 2. Odds ratios and 95% confidence intervals for hypertension control

Covariate	Model 1[a]	Model 2[b]
Usual source of care	3.89 (2.15–6.98)	3.89 (2.60–5.83)
Age strata		
>74	0.58 (0.45–0.76)	0.66 (0.53–0.83)
55–64	1.03 (0.79–1.36)	1.01 (0.80–1.28)
45–54	1.1 (0.84–1.45)	1.14 (0.90–1.45)
35–44	0.84 (0.59–1.22)	0.89 (0.65–1.22)
18–34	0.38 (0.25–0.58)	0.42 (0.29–0.61)
Race/ethnicity		
Hispanic	0.72 (0.56–0.93)	0.72 (0.59–0.87)
Non-Hispanic Black	0.7 (0.59–0.84)	0.75 (0.65–0.87)
Other race	0.86 (0.60–1.23)	0.81 (0.60–1.11)
Male	0.76 (0.66–0.87)	0.73 (0.65–0.83)
Married	1.22 (1.01–1.47)	1.2 (1.02–1.41)
Insured	1.53 (1.09–2.16)	1.67 (1.3–2.15)
Comorbid conditions		
Heart failure	1.3 (0.94–1.83)	1.28 (0.97–1.69)
Diabetes	1.02 (0.81–1.29)	1.15 (0.94–1.40)
Hyperlipidemia	1.55 (1.27–1.90)	1.45 (1.22–1.74)
BMI category		
Obese	2.03 (1.58–2.61)	1.94 (1.52–2.49)
Overweight	1.61 (1.23–2.09)	1.62 (1.26–2.10)
Underweight	0.89 (0.28–2.76)	0.87 (0.35–2.17)

Reference categories for multiple category variables are as follows: age 65–74, White race, normal weight. Not all variables in model shown in table. Abbreviation: BMI, body mass index.

[a]Logistic model controlling for demographics and clinical characteristics.
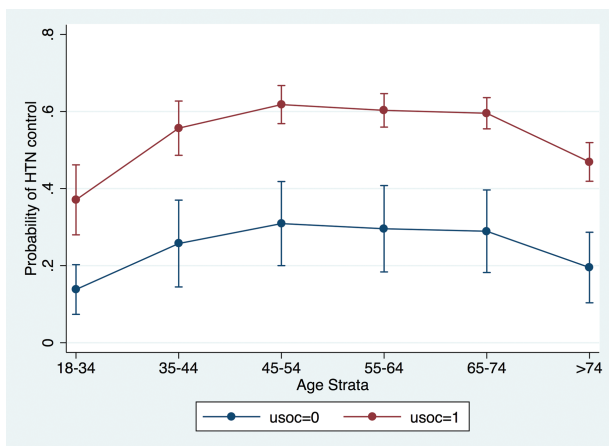
[b]Logistic model after imputation.

Figure 3. Marginal effect of USOC on HTN control by age group. The marginal effect of USOC on the probability of HTN control is statistically significantly lower in the oldest (>74 year olds) and youngest (18–34 year olds) age groups when compared to all other age groups ($P < 0.05$). Abbreviations: HTN, hypertension; USOC, usual source of care.

likely to report a USOC or have other unmeasured factors that would overestimate the association between USOC and hypertension control in the US population. Finally, given the low sample size in the oldest age group without a USOC, statistical power is limited to draw more precise estimates.

Despite these limitations, the study remains robust given the control for major confounders and sensitivity analyses that give a range of potential effect of USOC on hypertension control. In addition, the relationship between USOC and hypertension—and the differential effect of USOC on hypertension across age groups—was consistent across multiple models. Finally, this is a nationally representative sample that has high external validity.

This study supports the positive effect of USOC on hypertension control in the US population and the changing dynamic of a USOC on hypertension control across age groups. The morbidity, mortality, and costs from hypertension in the general US population are enormous, with poor outcomes as people age. Thus, discovering the beneficial role that having a USOC plays in hypertension control across the entire population is key to assist with policy decisions to improve access to regular sources of care. In addition, the varying impact of USOC on hypertension control across age groups may reflect a need to change strategies to control blood pressure in different age groups. Specifically, a focus on improving health behaviors in younger individuals may involve focusing on antihypertensive medication initiation and compliance, regular follow-up, and cessation of smoking. Conversely, given that effect of having a USOC on blood pressure control is diminished in the oldest population, more information is needed to discover what strategies will most effectively improve health outcomes in the oldest and most vulnerable. Given shifting guidelines and newer data from the Systolic Blood Pressure Intervention Trial (SPRINT) suggesting lower blood pressure targets have improved cardiovascular morbidity and mortality outcomes in higher risk patients,[37] it will be important to continue to monitor hypertension control and the cardiovascular sequelae in those most susceptible to poor outcomes.

DISCLOSURE

The authors declared no conflict of interest.

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