Trends in the Prevalence, Awareness, Treatment, and Control of Hypertension Among Young Adults in the United States, 1999 to 2014

Yiyi Zhang, Andrew E. Moran

Abstract—Overall hypertension prevalence has not changed in the United States in recent decades although awareness, treatment, and control improved. However, hypertension epidemiology and its temporal trends may differ in younger adults compared with older adults. Our study included 41,331 participants ≥18 years of age from 8 National Health and Nutrition Examination Surveys (1999–2014) and estimated temporal trends of hypertension, awareness, treatment, and control among young adults (age, 18–39 years) compared with middle-age (age, 40–59 years) and older adults (age, ≥60 years).

In 2013 to 2014, 7.3% of the US young adults had hypertension. During 1999 to 2014, young adults saw larger increases in hypertension awareness, treatment, and control than did older adults. However, all of these components of hypertension control were lower among young adults compared with middle-aged or older adults (74.7% younger versus 81.9% middle versus 88.4% older for awareness; 50.0% versus 70.3% versus 83.0% for treatment; and 40.2% versus 56.7% versus 54.4% for control). Worse hypertension awareness, treatment, and control in young adults overall were mostly driven by worse measures in young adult men compared with young adult women. More frequent healthcare visits by young adult women explained ≈28% of the sex-related difference in awareness, 60% of the difference in treatment, and 52% of the difference in control. These findings suggest that improved access to and engagement in medical care might improve hypertension control in young adults, particularly young adult men, and reduce life-time cardiovascular risk.

Key Words: blood pressure ■ body mass index ■ cardiovascular diseases ■ hypertension ■ young adult

Hypertension is a major cardiovascular disease risk factor, costing an estimated $51.2 billion in 2012 to 2013 in the United States.1 Prior studies demonstrated an increase in hypertension prevalence from 1988–1994 to 1999–2000, followed by stable prevalence from 1999–2000 to 2009–2010.2–6 Overall awareness, treatment, and control among adults with hypertension also improved during the same time interval.2–5 Despite this progress, awareness, treatment, and control appeared to be worse among young adults compared with middle-aged and older adults.2–6,8 However, previous studies mainly focused on the overall population and did not examine age-specific hypertension trends; and when they did, the young adult (18–39 years) sample size was small, limiting precise estimates of trends in this age group.6

Pathological changes to the vasculature and myocardium are often caused by cumulative early life exposure to high blood pressure.8,9 High blood pressure in young adulthood is associated with increased risks of cardiovascular disease and mortality decades later, independent of later life blood pressure levels.11,12 High blood pressure is the leading risk factor for stroke, and ≈10% of all strokes occur in individuals 18 to 50 years of age.13–15 In contrast to the decline in overall age-adjusted rates of stroke mortality and hospitalization in the past 2 decades, hospitalization for acute ischemic stroke increased significantly among young adults <45 years of age.2,16,17 Increased prevalence of overweight and obesity among adolescents in recent decades may be leading to a higher young adult hypertension prevalence that will continue into the future.18,19 Therefore, young adulthood represents an important age interval for early hypertension prevention and treatment, which has the potential to reduce short-term and later life cardiovascular disease risk.

Using data from 8 National Health and Nutrition Examination Surveys (NHANES), we examined the prevalence and temporal trends in hypertension, awareness, treatment, and control among US young adults aged 18 to 39 years compared with other adult age groups during the years 1999 to 2014. We also explored factors that may contribute to the age-related differences in hypertension epidemiology, including sex, race/ethnicity, body mass index (BMI), insurance coverage, and healthcare use.
Methods

Study Design and Population
The NHANES, conducted by the National Center for Health Statistics/ Centers for Disease Control and Prevention, constitutes a series of cross-sectional, multistage probability surveys representative of the civilian noninstitutionalized US population. The NHANES has continuously collected data in 2-year cycles since 1999, and we used data from 8 consecutive 2-year surveys from 1999 to 2014 to estimate recent trends in the prevalence of hypertension. Of the 47,356 participants ≥18 years of age who were both interviewed and examined, we excluded 4,651 participants with missing blood pressure measurements and 1,374 women who were pregnant. The final analysis was based on 41,331 participants (20,765 men and 20,566 women). All participants provided written informed consent, and the survey protocols were approved by the National Center for Health Statistics ethics review board.

Data Collection
NHANES included a standardized questionnaire administered in the home by a trained interviewer and a detailed physical examination at a mobile examination center. Race/ethnicity was self-reported by participants during in-person interviews and categorized as non-Hispanic white, non-Hispanic black, Mexican-American, and other (including multiracial). Health insurance status (yes/no) and the total number of healthcare visits to a doctor’s office, clinic, hospital emergency room, at home, or some other places in the prior year (none, 1–3 times, ≥4 times) were self-reported by the participants. BMI was calculated as weight in kilograms divided by height in meters squared.

Blood pressures were measured in the mobile examination center by trained physicians following a standard protocol. After resting quietly in a seated position for 5 minutes, 3 consecutive blood pressure readings were obtained by the auscultatory method using a mercury sphygmomanometer and appropriate cuff size determined from an upper arm circumference measurement. If a blood pressure measurement was interrupted or incomplete, a fourth attempt was made. All available readings were used to calculate the mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) for each participant. Hypertension was defined as an SBP ≥140 mm Hg, or a DBP ≥90 mm Hg, or current use of blood pressure–lowering medications. Pre-hypertension was defined as an SBP 120 to 139 mm Hg or a DBP 80 to 89 mm Hg among those without hypertension.2 Awareness of hypertension was defined as an affirmative response to the question “Have you ever been told by a doctor or health professional that you had hypertension, also called high blood pressure?” Treatment of hypertension was defined as affirmative responses to both questions “Because of your high blood pressure/hypertension, have you ever been told to take prescribed medicine?” and “Are you now taking prescribed medicine for high blood pressure?” Controlled hypertension was defined as an SBP <140 mm Hg and DBP <90 mm Hg among those with hypertension.

Statistical Analyses
We used mobile examination center survey sampling weights to account for the complex survey design of NHANES and to produce estimates representative of the civilian noninstitutionalized US population. Age-standardized weighted prevalence of hypertension and the percentage of awareness, treatment, and control of hypertension were calculated for each age group (18–39, 40–59, ≥60 years of age). For hypertension and pre-hypertension, prevalence estimates were age standardized to the 2000 US Census population using appropriate weights to allow comparisons across different survey cycles. For awareness, treatment, and control, estimates were age standardized to the age distribution of the subgroup of participants who had hypertension.22 We used logistic regression to examine the differences in hypertension prevalence by age group. Tests for trends across survey cycles were calculated by including the midpoint of each survey period as a continuous variable in the logistic regression. We also examined the prevalence of hypertension, awareness, treatment, and control further stratified by sex and race/ethnicity. Relative SEs were calculated for each estimate, and estimates with relative SE ≤30% were considered reliable estimates.

We used multivariable logistic regression models to examine whether differences in the distribution of sex, race/ethnicity, BMI, health insurance, and healthcare use may contribute to the differences in trends by age group. We first fit an unadjusted model with hypertension, pre-hypertension, awareness, treatment, and control, respectively, as the outcome variable and age, survey period, and age-by-survey interaction as covariates. We then fit an adjusted model by including sex, race/ethnicity, BMI, health insurance, and healthcare visits as covariates in the regression model. We computed the predicted prevalence for the unadjusted and adjusted models to determine the extent to which sex, race/ethnicity, BMI, health insurance status, and healthcare visit frequency may explain the differences by age groups. In addition, to calculate the total number of noninstitutionalized US adults with hypertension in 2013 to 2014, we multiplied the prevalence estimates from NHANES 2013 to 2014 (not age adjusted to the 2000 US Census) by the corresponding population totals from the Current Population Surveys. All statistical analyses were performed using STATA version 14 (StataCorp LP, College Station, TX).

Results
In 2013 to 2014, unadjusted hypertension prevalence was 31.6 (29.6%–33.6%) in the overall adult population, 7.3% (95% confidence interval, 6.2%–8.5%) in those aged 18 to 39 years, 32.7% (29.6%–35.7%) in those aged 40 to 59 years, and 65.6% (61.6%–69.6%) in those aged ≥60 years (Figure 1). This equates to an estimated 75.1 million adults ≥18 years of age with hypertension (6.7, 27.7, and 40.3 million among those 18–39, 40–59, and ≥60 years of age, respectively). In addition, 2714 million (23.4%) adults aged 18 to 39 years, 229 million (27.1%) aged 40 to 59 years, and 125 million (20.3%) aged ≥60 years were pre-hypertensive.

Age-standardized prevalence of hypertension remained unchanged from 1999 to 2014, whereas there was a decrease in pre-hypertension and increases in the awareness, treatment, and control of hypertension in all age groups (Figure 2; Table S1 in the online-only Data Supplement). Young adults aged 18 to 39 years saw the largest reduction in pre-hypertension, from 32.2% in 1999 to 2000 to 23.4% in 2013 to 2014. Awareness, treatment, and control of hypertension improved the most among young adults during the same period, from 52.1% to 74.7% for awareness, from 27.7% to 50.0% for treatment, and from 14.1% to 40.2% for control of hypertension, respectively. Despite these improvements, hypertension awareness and management remained significantly lower among young adults compared with those ≥40 years. These age-related differences were not explained by the different distributions of sex, race/ethnicity, and BMI (data not shown) but partly explained by health insurance status and healthcare use (Figures S1 and S2). Lower likelihood of health insurance coverage and fewer healthcare visits in young adults explained 11% and 21% of the age-related difference in awareness, 8% and 11% of the difference in treatment, and 12% and 26% of the difference in control, respectively, in 2013 to 2014. Of note, although the overall control rate of hypertension was lower among young adults, when treated, young adults were more likely to achieve blood pressure control compared with older adults (80.4% versus 65.5% in 2013–2014).
When further stratified by sex, temporal trends in hypertension prevalence, awareness, treatment, and control in men and women were similar to those observed in the overall population (Figure 3). However, young adult men had a substantially higher prevalence of pre-hypertension compared with young adult women (33.6% versus 12.8% in 2013–2014). Awareness, treatment, and control were also much lower in young adult men (68.4% versus 86.0% for awareness; 43.7% versus 61.3% for treatment; and 33.7% versus 51.8% for control, respectively, in 2013–2014). Young adult women reported on average more healthcare visits than men (Figure S3). More frequent healthcare visits in women explained ≈28% of the sex-related difference in awareness, 60% of the difference in treatment, and 52% of the difference in control in

![Figure 1. Prevalence and total number (in millions) of noninstitutionalized US adults with hypertension in 2013 to 2014.](image1)

![Figure 2. Age-standardized weighted prevalence (95% confidence interval) of hypertension, pre-hypertension, awareness, treatment, and control by age.](image2)
2013 to 2014 (Figure S4). In contrast, health insurance status explained little of the differences in hypertension awareness (5%), treatment (8%), and control (8%) between young adult men and women.

When stratified by race/ethnicity, non-Hispanic blacks had a higher prevalence of hypertension compared with non-Hispanic whites or Mexican-Americans across the years (Figure S5). Among adults ≥40 years of age, awareness and treatment were higher in non-Hispanic blacks, but the prevalence of controlled hypertension was lower compared with non-Hispanic whites. Hypertension awareness, treatment, and control stratified by race/ethnicity could not be reliably compared for participants aged 18 to 39 years because of small numbers.

Among those with hypertension, obesity prevalence increased over time and was particularly high among young adults (Figure 4). The age-standardized prevalence of obesity increased from 65% in 1999 to 2000 to 73% in 2013 to 2014 among those aged 18 to 39 years, from 51% to 57% among those aged 40 to 59 years, and from 35% to 42% among those aged ≥60 years. In 2013 to 2014, the odds ratio for being obese among those with hypertension was 2.87 (95% confidence interval, 1.82–4.51) comparing young adults to those aged ≥40 years, adjusting for sex and race/ethnicity.

**Discussion**

In a representative sample of noninstitutionalized US adults, hypertension prevalence remained unchanged from 1999 to 2014, whereas there was a decrease in pre-hypertension and an increase in the awareness, treatment, and control of hypertension. Despite these improvements, awareness, treatment, and control were worse among young adults 18 to 39 years of age compared with those aged ≥40 years. Worse hypertension awareness, treatment, and control in young adults were mostly driven by lower prevalence of awareness, treatment, and control in young adult men compared with young adult women and were partly explained by fewer healthcare visits in young adult men. These findings suggest that public health and medical care outreach efforts on young adults, particularly young adult men, could prevent hypertension and, potentially, later life cardiovascular disease.
Our study showed that the prevalence of hypertension remained unchanged from 1999–2000 to 2013–2014 in all age groups, consistent with previous findings. In addition, we found that the prevalence of pre-hypertension decreased from 31.1% to 24.0% in the same period, with the largest reduction seen among young adults 18 to 39 years of age. This decline in pre-hypertension was consistent with another recent NHANES report. The exact reason for this decline is unclear; however, we observed a decrease in current smoking in our study with the largest reduction seen among young adults (data not shown), suggesting that decrease in smoking may partly explain the decrease in pre-hypertension. Dietary patterns (eg, sodium and potassium intakes) may have changed as well during this period, but these changes were not reliably measurable in NHANES. Further research is needed to better understand how changes in these factors or others may explain the decline in pre-hypertension in young adults.

Hypertension awareness, treatment, and control increased from 1999–2000 to 2013–2014, with the largest percentage point improvements among young adults. Despite this progress, only 53.9% of the hypertensive adults had their blood pressure controlled in 2013 to 2014, which was substantially lower than the Healthy People 2020 goal of 62.1%. Young adults 18 to 39 years have significantly lower awareness, treatment, and control of hypertension compared with adults aged ≥40 years. Lower prevalence of treatment among young adults might be due, in part, to healthcare providers’ uncertainty and concern about long-term benefits and adverse effects of early pharmacological intervention in this age group. As a case in point, the 2014 National Hypertension Guidelines strongly recommended treating raised DBP in adults aged ≥30 years but only weakly recommended treatment in those aged 18 to 29 years. The best tolerated and safest approach to controlling blood pressure in young adults may be lifestyle modifications, such as reduced sodium intake, weight loss, and physical activity. We were not able to examine young adult uptake of these behaviors in the present analysis or how increased uptake might affect hypertension control. We did observe that although the overall control rate of hypertension was lower among young adults compared with middle-aged or older adults, when treated, young and middle-aged adults were more likely to achieve blood pressure control compared with older adults. This might be explained by a higher proportion of stage 2 hypertension and higher prevalence of comorbidities limiting pharmacological treatment among older adults.

We also observed sex-related differences in pre-hypertension, awareness, and management among young adults, with young adult men having substantially higher prevalence of pre-hypertension and lower awareness, treatment, and control compared with young adult women. Sex-related differences were diminished in those ≥40 years of age. This awareness and treatment gap between younger and older adult men is not a phenomenon unique to the United States: it has also been observed in China, South Korea, and Germany. Young women may be more likely to have their blood pressure checked than young men (eg, during regular gynecological care or pregnancy). Accordingly, when we adjusted for number of healthcare visits in the past year as a surrogate marker of healthcare use, higher number of visits in women explained some of the sex-related differences. These results were consistent with previous NHANES reports, as well as with results from a cross-sectional study of young adults aged 24 to 32 years from the National Longitudinal Study of Adolescent Health, which found that hypertension awareness was ≈2-fold higher in young adults who had seen a provider for routine healthcare in the past 2 years. Taken together, these findings suggest that efforts to improve blood pressure control among young adults, particularly men, should focus on raising awareness, improving screening strategy, and advancing follow-up and subsequent linkage to care. With implementation of the Affordable Care Act, the rate of insurance in US adults aged 19 to 25 years old increased by >10% since 2010, representing an increase of ≈6.1 million young adults with access to a regular source of medical care, and potentially, prevention programs.

Figure 4. Age-standardized weighted prevalence of overweight and obesity among participants with hypertension.
did not explain low hypertension awareness, treatment, or control in young adult men, suggesting that low preventive services uptake may be more important than insurance status in this group.

For young adult men without access to care or infrequent preventive care visits, hypertension awareness, treatment, and control may only be improved outside of traditional clinical settings. School or worksite-based health screening may reach young adults more successfully.37 Young men may respond more favorably and link to primary care if blood pressure screening is performed by trained and trusted laypeople, like barbers.38 Future studies are needed to assess the effectiveness of these strategies in improving awareness and control of hypertension among young adult men.

A few limitations of this study need to be considered. Blood pressure was measured during a single visit and may result in misclassification of some of the participants. Hypertension awareness, medication use, insurance coverage, and number of healthcare visits were based on self-report and potentially subject to recall bias. Although we assessed health insurance status, we were not able to assess the quality of preventive services covered by participants’ insurance plans. In addition, our study only evaluated medication use for blood pressure control. Lifestyle modifications, such as low sodium intake or physical activity, were not examined in the present analysis. Although our study included a large sample size, the number of young adults who had hypertension was relatively small in each survey cycle. Therefore, hypertension awareness, treatment, and control could not be reliably estimated by race/ethnicity for some of the survey cycles. The strength of our study includes the use of nationally representative data, the rigorous study protocol, and quality-control procedures of NHANES. The large sample size and 16 years of data also allowed us to estimate age-specific trends with high precision.

**Perspectives**

The prevalence of hypertension remained unchanged from 1999 to 2014 among US young adults, along with improvements in hypertension awareness, treatment, and control. However, despite this progress, young adults lag behind older adults in hypertension awareness, treatment, and control. Worse hypertension awareness and management among young adults appeared to be mostly driven by deficits in young adult men, not by women, which may be explained, in part, by limited healthcare access or less frequent medical care use in young adult men. These findings highlight important gaps in today’s approach to blood pressure control and primary prevention of cardiovascular disease, as well as potential opportunities for reducing future burden of cardiovascular disease and advancing cardiovascular health in the coming decades as today’s young adults transition into middle and late adulthood. Further research is needed to better understand and address age and sex gaps in hypertension awareness and control and quantify the expected future benefits of controlling blood pressure in today’s young adults.

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**Disclosures**

None.

**References**


What Is New?

- Hypertension awareness, treatment, and control improved in US young adults in the past 15 years but remained substantially lower compared with middle-aged and older adults.

- Young adult men had worse hypertension awareness, treatment, and control compared with young adult women.

What Is Relevant?

- In 2013 to 2014, 6.7 million US young adults had hypertension, of whom only 50% were treated and 40% controlled.

Summary

There remain important quality gaps in today’s approach to blood pressure control in young adults. Public health efforts to improve blood pressure control among young adults, particularly men, should focus on raising awareness and improving outreach in medical, worksite, and community settings.
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Trends in the Prevalence, Awareness, Treatment, and Control of Hypertension among Young Adults in the United States, 1999-2014

Yiyi Zhang, PhD,Andrew E Moran, MD, MPH

1 Division of General Medicine, Columbia University, New York, NY

Correspondence: Andrew E. Moran, MD, MPH, Columbia University Division of General Medicine, Presbyterian Hospital, 9th Fl. East, Rm. 105, 622 West 168th St., New York, NY 10032, Tel: 212-305-2569, Email: aem35@cumc.columbia.edu

Brief title: Trends in hypertension among U.S. young adults

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Total number of figures: 4
Table S1. Age-standardized weighted prevalence (standard error) of hypertension, and awareness, treatment, and control of hypertension per 100 adults in the US general population

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<th>Age groups</th>
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<th>P-trend</th>
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<td>(n = 4,686)</td>
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<td></td>
<td>40-59</td>
<td>12,490</td>
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<tr>
<td><strong>Treatment (among participants with hypertension)</strong></td>
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<td>All Age (years)</td>
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<td>59.1 (2.7)</td>
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<td>27.7 (5.7)</td>
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<td>62.8 (3.2)</td>
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<td><strong>P-value</strong></td>
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<td>&lt;0.001</td>
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</tbody>
</table>

| **Controlled (among participants treated for hypertension)** | | | | | | | | |
| All Age (years) | 9,949 | 6,121 | 53.1 (2.5) | 58.9 (1.2) | 62.4 (2.3) | 65.8 (1.8) | 68.3 (1.4) | 70.1 (1.2) | 70.3 (1.9) | 73.0 (1.5) |
| 18-39 | 418 | 301 | 50.9 (10.9) | 80.0 (6.4) | 77.3 (5.9) | 81.5 (6.4) | 82.7 (5.3) | 71.2 (5.7) | 78.1 (5.4) | 80.4 (5.1) | 0.13 |
| 40-59 | 2,784 | 1,942 | 65.6 (3.5) | 63.0 (2.6) | 66.9 (3.2) | 71.6 (3.2) | 73.8 (1.8) | 72.4 (2.4) | 79.1 (3.1) | 80.7 (2.6) | <0.001 |
| ≥60 | 6,747 | 3,878 | 43.5 (2.4) | 51.6 (1.3) | 55.9 (2.6) | 58.2 (2.2) | 61.3 (2.0) | 68.1 (1.4) | 61.9 (2.7) | 65.5 (1.8) | <0.001 |
| **P-value** | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |

| **Controlled (among all participants with hypertension)** | | | | | | | | |
| All Age (years) | 14,229 | 6,121 | 31.4 (2.4) | 34.8 (1.5) | 39.7 (2.2) | 43.7 (1.5) | 48.3 (1.6) | 53.1 (1.7) | 51.8 (2.4) | 53.9 (2.6) |
| 18-39 | 1,053 | 301 | 14.1 (2.9) | 28.7 (3.9) | 30.4 (7.3) | 23.9 (4.3) | 40.6 (6.0) | 32.8 (5.0) | 34.4 (5.5) | 40.2 (3.9) | <0.001 |
| 40-59 | 4,174 | 1,942 | 40.8 (3.4) | 37.1 (2.6) | 41.1 (3.7) | 47.4 (2.4) | 49.9 (2.4) | 55.7 (2.4) | 57.7 (3.9) | 56.7 (4.7) | <0.001 |
| ≥60 | 9,002 | 3,878 | 27.4 (2.3) | 34.1 (1.4) | 40.4 (1.9) | 44.6 (2.3) | 48.4 (2.0) | 54.9 (2.0) | 50.6 (2.5) | 54.4 (1.9) | <0.001 |
| **P-value** | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
Figure S1. Age-standardized weighted prevalence of health insurance and healthcare visits among participants with hypertension, by age group.
Figure S2. Unadjusted and adjusted prevalence of hypertension, and awareness, treatment, and control of hypertension by age.
Figure S3. Age-standardized weighted prevalence of health insurance and healthcare visits among participants with hypertension, by age and sex.
Figure S4. Unadjusted and adjusted prevalence of hypertension awareness, treatment, and control by sex among young adults 18-39 years of age.
Figure S5. Age-standardized weighted prevalence (95% CI) of hypertension, prehypertension, awareness, treatment, and control by age and race.

Estimates with relative standard error > 30% were not shown in the plot.
Figure S6. Age-standardized weighted mean systolic and diastolic blood pressure among the overall population and those treated for hypertension.