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Factors associated with antihypertensive monotherapy among US adults with treated hypertension and uncontrolled blood pressure overall and by race/ethnicity, National Health and Nutrition Examination Survey 2013-2018

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Background Treating hypertension with antihypertensive medications combinations, rather than one medication (ie, monotherapy), is underused in the United States, particularly in certain race/ethnic groups. Identifying factors associated with monotherapy use despite uncontrolled blood pressure (BP) overall and within race/ethnic groups may elucidate intervention targets in under-treated populations.

Methods Cross-sectional analysis of National Health and Nutrition Examination Surveys (NHANES; 2013-2014 through 2017-2018). We included participants age ≥20 years with hypertension, taking at least one antihypertensive medication, and uncontrolled BP (systolic BP [SBP] ≥ 140 mmHg or diastolic BP [DBP] ≥ 90 mmHg). Demographic, clinical, and healthcare-access factors associated with antihypertensive monotherapy were determined using multivariable-adjusted Poisson regression.

Results Among 1,597 participants with hypertension and uncontrolled BP, age- and sex- adjusted prevalence of monotherapy was 42.6% overall, 45.4% among non-Hispanic White, 31.9% among non-Hispanic Black, 39.6% among Hispanic, and 50.9% among non-Hispanic Asian adults. Overall, higher SBP was associated with higher monotherapy use, while older age, having a healthcare visit in the previous year, higher body mass index, and having heart failure were associated with lower monotherapy use.

Conclusion Clinical and healthcare-access factors, including a healthcare visit within the previous year and co-morbid conditions were associated with a higher likelihood of combination antihypertensive therapy. (Am Heart J 2021;000:1–10.)

From 1999-2000 to 2013-2014, blood pressure (BP) control, defined by <140/90 mmHg, increased from 53.4% to 72.2% among adults with hypertension taking antihypertensive medication in the United States (US).[1] However, by 2017-2018, BP control rates had declined to 64.8% despite the ubiquitous availability of safe, effective, and affordable antihypertensive medications.[1-4] Furthermore, BP control rates among those treated with antihypertensive medication were lower among non-Hispanic Black (53.2%), Hispanic (58.2%), and non-Hispanic Asian (63.7%) adults compared to non-Hispanic White adults (68.2%).[1]

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One potential factor contributing to the recent decline in BP control rates is the failure to intensify the medication regimen beyond a single antihypertensive medication class (ie, monotherapy). Combining antihypertensive medications from different classes at lower doses targets complementary biological pathways and leads to greater BP-lowering efficacy and a safer adverse event profile compared with the alternative approach of intensifying monotherapy.[5] Despite the advantages of combination therapy, in 2016, 40% of US adults with treated uncontrolled hypertension were taking antihypertensive monotherapy only.[5] While antihypertensive monotherapy may be adequate to achieve BP control in some patients, 53% of US adults taking any antihypertensive medication remain undertreated and fail to achieve a guideline-recommended systolic BP (SBP)/diastolic BP (DBP) of ≤130/80 mmHg, while 39% fail to achieve the Seventh Report of the Joint National Committee (JNC-7) goal of ≤140/90 mmHg.[6,7] Participants randomized to the intensive SBP treatment group (<120 mmHg) in the Systolic Blood Pressure Intervention Trial (SPRINT) used an average of one more antihypertensive medication than participants randomized to the standard treatment group (2.8 vs 1.0), and 56.1% were taking three or more antihypertensive medications at their final study visit.[8]

Factors that contribute to US hypertension patients continuing to receive antihypertensive monotherapy despite uncontrolled BP are unclear. Additionally, it is unknown whether the reasons for this phenomenon vary by race/ethnic group. We, therefore, evaluated the association of patient-specific factors and use of antihypertensive monotherapy vs combination therapy among US adults taking antihypertensive medication and uncontrolled BP participating in the National Health and Nutrition Examination Surveys (NHANES), overall and by race/ethnicity.

Methods

Study design and population

We used data collected by the NHANES between 2013 and 2018. NHANES is a nationally-representative multistage sampling of the health status of civilian, non-institutionalized members of the US population.[9] Data were pooled from three consecutive 2-year cycles for the current analysis (2013-2014, 2015-2016, 2017-2018). We used 3 cycles of data to have sufficient sample size to create more stable estimates.[10] We chose not to use earlier years to ensure our estimates were based on contemporary clinical practice. All participants provided informed consent, and the protocol was approved by the National Center for Health Statistics Institutional Review Board.

Of the 17,057 NHANES participants ≥20 years old who were interviewed and examined during the 3 calendar periods, first we excluded 1,569 participants who did not have three BP measurements taken during their medical evaluation (Figure 1). We then excluded 9,718 participants who did not self-report a prior diagnosis of hypertension. Of the remainder, we then excluded 1,373 participants missing information about antihypertensive medication use in the pill bottle review. We further excluded 2,800 participants with hypertension taking antihypertensive medication and controlled BP defined as SBP < 140 mmHg and DBP < 90 mmHg. Finally, none of the remaining participants were pregnant and thus no additional exclusion was necessary. The final sample included 1,597 participants.

Data collection

NHANES uses trained interviewers to administer standardized questionnaires in participants' homes. Following the interview, participants were invited to mobile examination units for clinical data collection, including BP, height, weight, urine, and blood samples. Age, sex, race/ethnicity, household income, employment status, marital status, education, health insurance, access to a usual health care facility, health care visits within the past year, smoking status (current, former, never), and history of chronic conditions were self-reported. We included self-reported race/ethnicity using the fixed NHANES categorization into non-Hispanic White, non-Hispanic Black, Hispanic, non-Hispanic Asian. We calculated body mass index (BMI) as weight in kilograms divided by height in meters squared. We defined chronic kidney disease (CKD) using self-report, an estimated glomerular filtration rate (eGFR) <60 mL/min/1.73 m^2 using the CKD-EPI equation, or a urinary albumin-to-creatinine ratio >30 mg/g.[11] We defined leisure-time physical activity and a Dietary Approaches to Stop Hypertension (DASH) adherence score using similar as Booth III et al.[12] BP measurements were performed by trained physicians following a standardized protocol. Participants rested for 5 minutes, were fitted for the appropriate cuff size, then had 3 consecutive measures spaced via 30-seconds via mercury sphygmomanometer. The three BP measurements were averaged for the current analysis. Uncontrolled BP was defined as a mean SBP ≥ 140 mmHg or a mean DBP ≥ 90 mmHg, consistent with the guidelines for clinical practice during most of the years encompassed in this study.[13]

Antihypertensive medication use

Antihypertensive medication information was obtained from the in-home questionnaire and determined based upon an affirmative response to the questions, "Have you ever been told by a doctor that you had hypertension, also called high BP?" and "Are you now taking prescribed medicine for high BP?" Specific medication details were obtained by the pill bottle review, during which participants' pill bottles were inventoried for prescription

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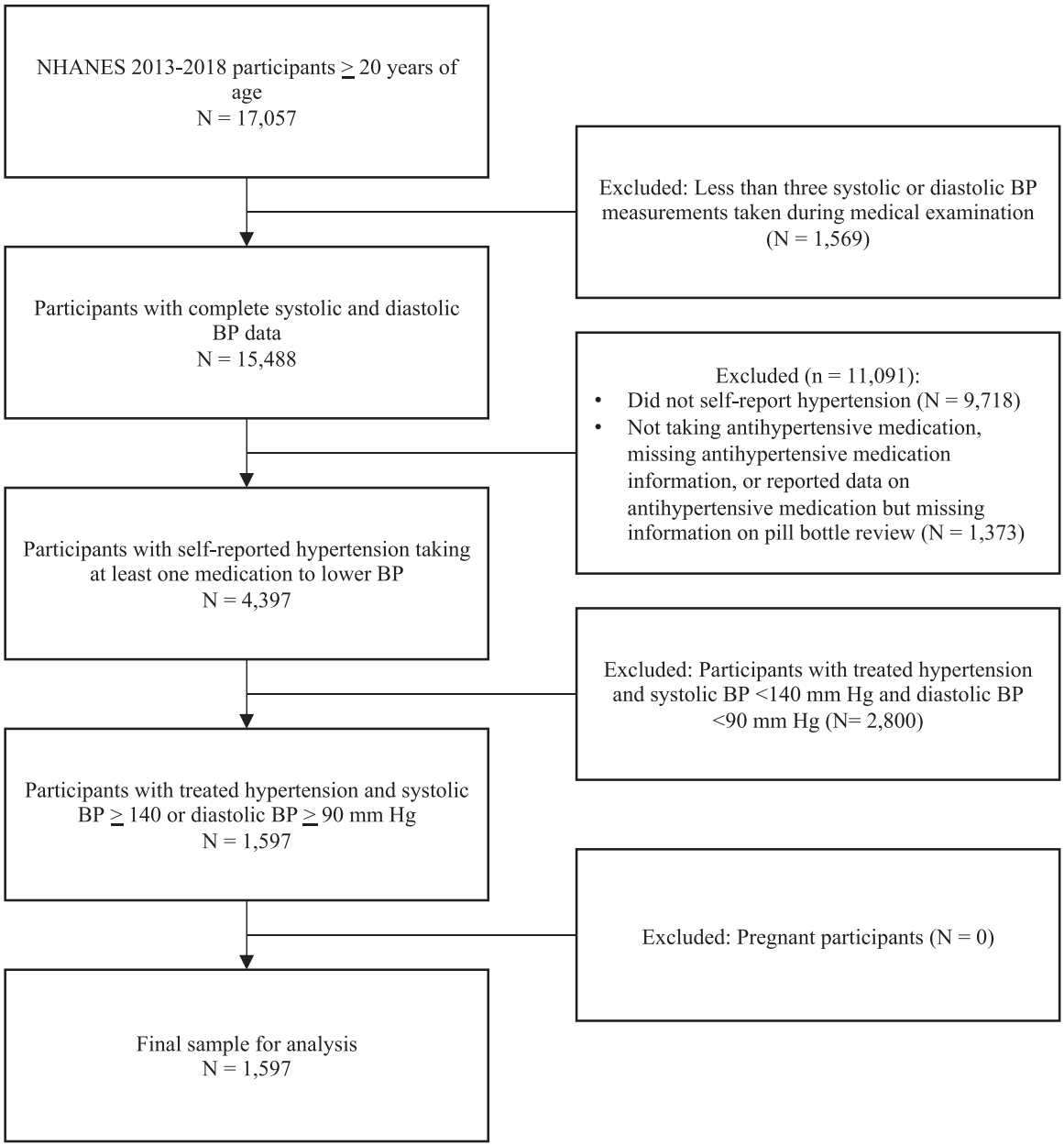
Figure 1



Flowchart showing the eligibility criteria for evaluation of antihypertensive monotherapy use in US adults with hypertension using antihypertensive medication, NHANES 2013-2018. *NHANES*, National Health and Nutrition Examination Surveys.

and nonprescription medications and supplements reported to have been taken in the previous 30 days. Antihypertensive medications were categorized by class: aldosterone receptor antagonist, α-blocker, angiotensin converting enzyme inhibitor (ACEI), angiotensin receptor blocker (ARB), beta-blocker, calcium channel blocker (CCB), centrally acting agent (eg, clonidine), direct vasodilator, diuretic, and renin inhibitor. For ease of presentation, ACEI and ARB were grouped together, and diuretics (ie, thiazide, loop, and potassium-sparing) were grouped together. Dose information was not available for the current analysis.

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Statistical analysis

Age- and sex- adjusted prevalence of antihypertensive monotherapy use overall, and by race/ethnicity, were calculated over the pooled time-period from 2013 to 2018. We also calculated prevalence of monotherapy by subgroups of age, sex, and race-ethnicity and medication class (ie, ACEI/ARB, CCB, thiazide diuretic, beta-blocker, and other). Participant factors included in the analysis were selected based upon a priori analyses and literature review.[1,5,] Factors of participants taking antihypertensive monotherapy were calculated and reported overall and by race/ethnicity, with non-Hispanic White serving as the reference group for all race/ethnicity comparisons. Differences in participant factors by race/ethnicity were assessed by linear regression for continuous variables and logistic regression for binary variables.

To determine patient factors associated with the use of antihypertensive monotherapy, we calculated prevalence ratios (PRs) and 95% confidence intervals (CIs) for each factor of interest using Poisson regression with robust error variance. Monotherapy use was modeled as the dichotomous dependent variable and the factor of interest was modeled as the independent variable. Analyses were performed for participants overall and stratified by race/ethnicity adjusting for all of the following variables: age (mean and by groups defined by 20-44 years, 45-54 years, 55-64 years, 65-74 years, and ≥75 years), sex, marriage status, education, household income, health insurance (none, private, public), having a usual health care facility, having a healthcare visit within the past year, smoking status, BMI (mean and by group <18.5 kg/m^2, 18.5 to <25 kg/m^2, 25 to <30 kg/m^2, and ≥30 kg/m^2), individual comorbidities (diabetes mellitus, coronary heart disease [CHD], CKD, stroke, heart failure), SBP (mean and categorized as <140 mmHg, 140-159 mmHg, and ≥160 mmHg), and DBP (mean and categorized as <90 mmHg, 90-99 mmHg, ≥100 mmHg). Missingness remained less than 10% per observation. Based upon NHANES recommendations, we performed a complete case analysis.

The NHANES sampling weights and the complex sampling design were applied in all calculations to obtain nationally-representative estimates. All analyses were performed using R v.4.04 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Monotherapy prevalence and participant characteristics overall

Among 1,597 US adults with hypertension taking antihypertesnive medication and uncontrolled BP the age- and sex-adjusted prevalence of monotherapy use was 42.6%. The proportion of those on monotherapy vs combination therapy that were non-Hispanic Asian adults, younger, and current smokers was higher (Table I). Additionally, adults taking monotherapy had a lower average BMI and SBP, as well as a higher DBP, compared to adults taking combination therapy. There were no evidence of differences in the median DASH diet score index between participants taking monotherapy and combination therapy. Participants on combination therapy were more likely to have a poor physical activity level, and participants taking monotherapy were more likely to have an ideal physical activity level. Participants of 30.9% taking combination therapy were using a fixed-dose combination product.

Monotherapy prevalence and participant characteristics by race/ethnicity

The age- and sex-adjusted prevalence of monotherapy use was 45.4% among non-Hispanic White adults, 31.9% among non-Hispanic Black adults, 39.6% among Hispanic adults, and 50.9% among non-Hispanic Asian adults. The majority of participants of all race-ethnicities on monotherapy were taking an ACEI or ARB (Supplemental Table SI).

Compared to non-Hispanic White adults, a lower proportion of non-Hispanic Black adults were married, a high school graduate, had private insurance, or had CHD and CKD (Table II). A higher proportion of non-Hispanic Black adults were currently employed, had a household income <$20,000, had no- or public- insurance, and were current smokers. Non-Hispanic Black adults had a lower average age and a higher average BMI and DBP. A lower proportion of Hispanic adults, compared to non-Hispanic White adults, were a high school graduate, had private insurance, or had CKD, and a higher proportion had a household income <$20,000 or no- or public-insurance. Hispanic adults additionally had a lower average age. Compared to non-Hispanic White adults, a lower proportion of non-Hispanic Asian adults were high school graduates, had private insurance, access to a usual health care facility, or had a health care visit within the previous year. A higher proportion were married, employed, and had public insurance. Non-Hispanic Asian adults additionally had a lower average BMI and a higher DBP.

The characteristics of participants on monotherapy, overall and by race/ethnicity are provided in Supplemental Figures S1 and S2, respectively.

Factors associated with monotherapy overall

Following multivariable adjustment, SBP of 140 to 159 mmHg vs <140 mmHg was associated with a greater prevalence of monotherapy (PR 1.65, 95% CI 1.15, 2.38) overall (Figure 2). In contrast, non-Hispanic Black vs non-Hispanic White (PR 0.73, 95% CI 0.61, 0.89), ≥75 years old vs 20 to 44 years old (PR 0.60, 95% CI 0.38, 0.94), a health care visit within the previous year (PR 0.71, 95% CI 0.56, 0.90), BMI ≥ 30 kg/m^2 vs 18.5 to <25 kg/m^2 (PR 0.80, 95% CI 0.65, 0.97), and heart failure (PR 0.50, 95%

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Table I. Characteristics of US adults with uncontrolled hypertension taking antihypertensive monotherapy vs combination therapy, NHANES 2013-2018

	Monotherapy($N = 645$)	Combination therapy($N = 952$)	*P*-value
Race/ethnicity			
Non-Hispanic White	66.6 (59.9, 72.7)	63.0 (57.5, 68.1)	.12
Non-Hispanic Black	14.6 (10.8, 19.3)	20.1 (16.4, 24.4)	.005
Hispanic	9.5 (6.8, 13.1)	9.8 (7.1, 13.2)	.87
Non-Hispanic Asian	5.9 (4.1, 8.4)	4.1 (2.8, 6.0)	.042
Female sex	54.7 (50.2, 59.1)	57.6 (53.5, 61.6)	.34
Age, mean	62.8 (61.5, 64.1)	66.5 (65.2, 67.8)	<.001
20-44	9.7 (7.5, 12.6)	5.6 (3.9, 8.0)	-
45-54	41.4 (36.7, 46.3)	33.5 (28.5, 38.9)	-
55-64	25.0 (21.6, 28.9)	23.2 (19.4, 27.5)	-
65-74	24.3 (19.8, 29.4)	28.5 (23.8, 33.8)	-
≥75	24.5 (20.1, 29.6)	32.4 (27.4, 37.8)	-
Married	58.6 (52.6, 64.3)	60.0 (55.5, 64.4)	.64
High school graduate	85.3 (81.8, 88.2)	81.8 (78.0, 85.0)	.09
Employed	38.2 (33.2, 43.5)	33.1 (27.8, 38.7)	.17
Household income <$20,000	19.2 (14.8, 24.5)	20.3 (16.9, 24.2)	.65
Insurance status			
None	6.7 (4.8, 9.3)	7.2 (4.9, 10.5)	.69
Private	55.6 (49.6, 61.4)	54.2 (49.0, 59.4)	.67
Public	37.7 (32.5, 43.3)	38.5 (34, 43.3)	.81
Access to usual health care facility	95.5 (93.5, 96.9)	97.3 (95.2, 98.5)	.16
Health care visit within previous year	96.8 (94.3, 98.2)	98.5 (97.9, 98.9)	.027
Current smoker	19.8 (15.4, 25.2)	12.4 (9.6, 16.0)	.013
DASH Diet score index, median (IQR)*	1.5 (1.0, 2.5)	1.5 (1.0, 2.5)	.360
Physical activity†			
Poor	51.7 (45.0, 58.3)	62.5 (57.7, 67.0)	.008
Intermediate	16.4 (12.9, 20.6)	16.6 (12.9, 21.2)	.930
Ideal	32.0 (25.5, 39.2)	20.9 (16.8, 25.7)	.009
Body mass index (kg/m^2), mean	30.9 (30.2, 31.6)	31.8 (31.1, 32.4)	.044
<18.5	0.8 (0.3, 1.9)	1.1 (0.5, 2.5)	-
18.5 to <25	19.4 (15.8, 23.7)	15.0 (12.1, 18.4)	-
25 to <30	32.7 (28.1, 37.6)	29.2 (25.6, 33.1)	-
≥30	47.1 (42.4, 51.9)	54.7 (50.3, 59.1)	-
Diabetes	22.6 (17.5, 28.7)	32.2 (27.7, 37.0)	.016
Coronary heart disease	7.8 (4.7, 12.6)	12.2 (9.3, 15.8)	.06
Chronic kidney disease	46.1 (40.8, 51.5)	57.2 (52.8, 61.5)	.005
Stroke	5.8 (4.1, 8.2)	10.4 (8.1, 13.1)	.009
Heart failure	3.0 (1.8, 4.9)	9.3 (7.3, 11.8)	<.001
Systolic BP (mmHg), mean	152.0 (150.7, 153.3)	154.2 (152.9, 155.4)	.022
<140 mmHg	8.4 (5.8, 12)	8.0 (5.4, 11.5)	-
140-159 mmHg	70.9 (66.2, 75.1)	64.7 (60.7, 68.5)	-
≥160 mmHg	20.7 (17, 25.1)	27.3 (24.4, 30.5)	-
Diastolic BP (mmHg), mean	76.9 (74.9, 79)	74.2 (72.5, 76)	.021
<90 mmHg	75.1 (69.3, 80.2)	82.3 (77.3, 86.4)	-
90-99 mmHg	20.6 (16.2, 25.9)	13.8 (10.3, 18.3)	-
≥100 mmHg	4.2 (2.4, 7.5)	3.9 (2.4, 6.1)	-
Fixed-dose combination use	2.2 (1.0, 5.0)‡	30.9 (26.5, 35.6)	<.001

Numbers in table are column percentages (95% confidence interval) or means (95% confidence interval).
ACEI, angiotensin converting enzyme inhibitor; *ARB*, angiotensin-II receptor blocker; *BP*, blood pressure; *NHANES*, National Health and Nutrition Examination Survey; US, United States.

* Calculated from the Dixon's DASH diet index, which ranges from 1 (worst adherence to DASH diet) to 9 (best adherence to DASH diet). The DASH diet consists of increased intake of fruits, vegetables, low-fat dairy products, whole grains, and nuts/seeds/legumes; reduced intake of fats/oils, sugar-sweetened beverages, meat/poultry/fish) and reduced sodium consumption. The food group intake from the 2 d of 24-h dietary recalls were averaged, then converted to the Dixon's DASH diet index using the Food Patterns Equivalent Database.[29]

† Calculated from the number of minutes of vigorous or moderate activity from self-reported frequency, duration, and level of exertion for leisure-time activities.[30] Ideal: ≥75 vigorous min per activity or ≥150 min of moderate-vigorous activity per week. Intermediate: 1 to 74 vigorous min per activity or 1 to 149 min of moderate-vigorous activity per week. Poor: 0 min of moderate-vigorous activity per week.

‡ Thirty-four individuals taking diuretic monotherapy were taking a fixed-dose combination product with a potassium-sparing diuretic and a thiazide diuretic in the same pill.

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Table II. Characteristics of US adults with uncontrolled hypertension taking antihypertensive medication, by race/ethnicity, NHANES 2013-2018

Factor	Non-Hispanic White (*N* = 576)	Non-Hispanic Black (*N* = 505)	Hispanic (*N* = 312)	Non-Hispanic Asian (*N* = 144)
Female sex	56.4 (51.9, 60.9)	58.7 (55.0, 62.4)	55.7 (48.9, 62.4)	54.8 (44.5, 64.7)
Age, mean	67.0 (65.7, 68.3)	60.0 (58.7, 61.3)*	61.3 (58.9, 63.8)*	64.0 (61.0, 66.9)
20-44	5.2 (3.4, 7.8)	13.1 (10.5, 16.1)	11.1 (6.9, 17.3)	6.3 (2.3, 16.4)
45-54	31.5 (26.7, 36.7)	49.0 (43.7, 54.3)	45.9 (39.5, 52.4)	44.2 (34.4, 54.6)
55-64	21.2 (17.6, 25.4)	29.4 (25.4, 33.8)	29.0 (24.5, 33.9)	34.0 (23.6, 46.2)
65-74	28.8 (24.2, 33.9)	19.6 (16.3, 23.5)	26.1 (20.0, 33.3)	24.2 (16.3, 34.2)
≥75	34.6 (29.6, 40.0)	18.3 (14.8, 22.3)	16.9 (11.9, 23.3)	25.3 (14.1, 41.0)
Married	61.9 (55.9, 67.5)	45.5 (40.9, 50.1)*	61.7 (56.0, 67.1)	77.1 (69.6, 83.2)*
High school graduate or equivalent	90.1 (87.0, 92.6)	76.0 (72.0, 79.7)*	53.1 (43.2, 62.7)*	72.5 (62.3, 80.8)*
Employed	32.5 (26.9, 38.6)	42.7 (38.9, 46.6)*	33.6 (25.9, 42.3)	45.1 (35.2, 55.3)*
Household income <$20,000	15.5 (11.5, 20.6)	30.1 (24.9, 35.8)*	27.7 (21.0, 35.6)*	21.4 (10.6, 38.5)
Insurance status				
None	4.9 (2.7, 8.7)	11.8 (8.2, 16.7)*	12.3 (7.9, 18.8)*	7.2 (3.9, 12.8)
Private	63.4 (56.9, 69.4)	41.6 (36, 47.5)*	34.5 (27.3, 42.4)*	42.0 (31.5, 53.4)*
Public	31.7 (27.0, 36.8)	46.6 (41.4, 51.8)*	53.2 (46.8, 59.5)*	50.8 (39.1, 62.3)*
Access to usual health care facility	97.4 (95.3, 98.6)	96.0 (93.5, 97.6)	96.4 (93.6, 98.0)	91.6 (86.0, 95.1)*
Health care visit within previous year	98.5 (96.8, 99.3)	96.9 (95.4, 97.9)	97.5 (95.1, 98.8)	92.4 (86.9, 95.7)*
Current smoker	14.5 (11.1, 18.9)	20.8 (16.6, 25.7)*	10.9 (6.6, 17.5)	7.1 (3.0, 15.7)
DASH Diet Score index, median (IQR)†	1.5 (1.0, 2.5)	1.0 (0.5, 2.0)	2.0 (1.0, 3.0)*	3.0 (2.0, 3.9)*
Physical activity‡				
Poor	55.9 (50.1, 61.6)	58.6 (52.9, 64.1)	66.9 (58.8, 74.0)*	55.7 (45.6, 65.4)
Intermediate	16.8 (13.2, 21.2)	16.4 (13.1, 20.4)	14.1 (10.0, 19.5)	18.2 (12.7, 25.5)
Ideal	27.3 (22.0, 33.2)	24.9 (21.2, 29.1)	19.0 (14.0, 25.3)*	26.0 (18.1, 35.9)
Body mass index (kg/m^2), mean	31.4 (30.6, 32.1)	32.8 (32, 33.5)*	31.9 (30.8, 33.0)	26.3 (25.6, 26.9)*
<18.5	1.2 (0.5, 2.5)	1.2 (0.5, 2.6)	-	0.5 (0.1, 4.4)
18.5 to <25	15.7 (12.3, 19.7)	15.7 (11.8, 20.4)	10.4 (7.9, 13.7)	43.6 (33.9, 53.7)
25 to <30	31.4 (27.7, 35.3)	24.5 (21.1, 28.3)	36.5 (29.2, 44.6)	39.4 (30.6, 48.8)
≥30	51.8 (46.5, 57.0)	58.7 (55.1, 62.2)	53 (44.7, 61.1)	16.6 (11.3, 23.7)
Co-morbid conditions				
Diabetes	27.2 (22.5, 32.4)	30.6 (26.0, 35.5)	30.6 (24.9, 36.9)	28.7 (20.2, 39.1)
Coronary heart disease	11.2 (7.7, 15.9)	6.6 (4.5, 9.6)*	11.0 (7.2, 16.4)	6.8 (3.5, 12.9)
Chronic kidney disease	54.6 (50.1, 59.0)	47.3 (42.5, 52.3)*	42.5 (35.7, 49.7)*	49.6 (40.3, 58.9)
Stroke	8.5 (6.3, 11.4)	8.4 (6.3, 11.1)	6.6 (4.4, 9.8)	4.3 (1.6, 11.2)
Heart failure	5.3 (3.5, 7.9)	9.6 (7.3, 12.6)*	9.1 (5.8, 13.9)	2.7 (1.0, 7.2)
Systolic BP (mmHg), mean	152.9 (151.6, 154.2)	154.5 (152.7, 156.3)	153.6 (151.3, 155.9)	153.8 (151.2, 156.4)
<140 mmHg	7.5 (5.3, 10.5)	10.5 (7.7, 14.1)	8.2 (3.7, 17.1)	5.1 (2.2, 11.7)
140-159 mmHg	68.9 (64.9, 72.7)	61.2 (56.1, 66.0)	68.1 (59.7, 75.4)	68.2 (58.7, 76.4)
≥160 mmHg	23.5 (20.4, 27.0)	28.4 (23.8, 33.5)	23.7 (17.3, 31.5)	26.6 (19.3, 35.6)
Diastolic BP (mmHg), mean	73.9 (71.9, 75.8)	79.3 (77.2, 81.4)*	76.5 (73.6, 79.4)	76.9 (75.1, 78.7)*
<90 mmHg	81.7 (77.6, 85.2)	72.2 (66.8, 76.9)	77.4 (66.8, 85.4)	82.1 (72.5, 88.8)
90-99 mmHg	15.3 (12.3, 19.0)	21.3 (17.4, 25.9)	16.3 (10.2, 25.1)	16.3 (9.7, 26.3)
≥100 mmHg	3.0 (1.5, 5.9)	6.5 (3.8, 10.9)	6.2 (3.5, 11.0)	1.6 (0.4, 5.7)

Numbers in table are column percentages (95% confidence interval) or means (95% confidence interval).
ACEI, angiotensin converting enzyme inhibitor; *ARB*, angiotensin-II receptor blocker; *BP*, blood pressure; *NHANES*, National Health and Nutrition Examination Survey; *US*, United States.

* Indicates *P*-value < .05 compared to non-Hispanic White participants.

† Calculated from the Dixon's DASH diet index, which ranges from 1 (worst adherence to DASH diet) to 9 (best adherence to DASH diet). The DASH diet consists of increased intake of fruits, vegetables, low-fat dairy products, whole grains, and nuts/seeds/legumes; reduced intake of fats/oils, sugar-sweetened beverages, meat/poultry/fish) and reduced sodium consumption. The food group intake from the 2 d of 24-h dietary recalls were averaged, then converted to the Dixon's DASH diet index using the Food Patterns Equivalent Database.[28]

‡ Calculated from the number of minutes of vigorous or moderate activity from self-reported frequency, duration, and level of exertion for leisure-time activities.[29] Ideal: ≥75 vigorous min per activity or ≥150 min of moderate-vigorous activity per week. Intermediate: 1 to 74 vigorous min per activity or 1 to 149 min of moderate-vigorous activity per week. Poor: 0 min of moderate-vigorous activity per week.

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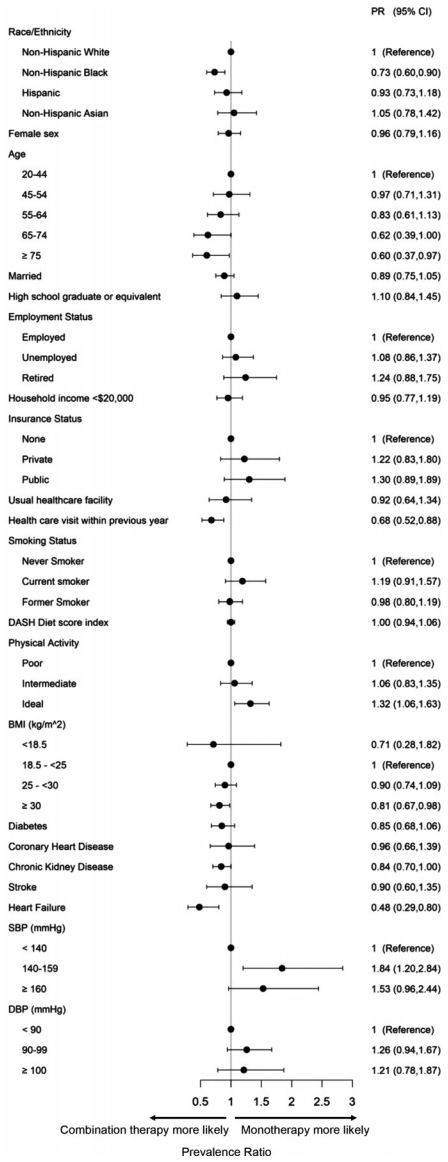
Figure 2



Factors associated with antihypertensive monotherapy vs combination therapy among US adults with hypertension taking antihypertesnive medication and uncontrolled BP (≥140 mmHg or ≥90 mmHg), NHANES 2013-2018. To the left of one (ie, less than one) represents a lower likelihood to receive monotherapy, to the right of one (ie, greater than one) represents a higher likelihood to receive monotherapy. All models are adjusted for sex, age, marriage status, education, household income, health insurance, usual health care facility, healthcare visit within previous year, smoking status, BMI, individual comorbidities (diabetes mellitus, coronary heart disease, chronic kidney disease, stroke, heart failure), SBP, and DBP. Abbreviations: *BMI*, body mass index; *CI*, confidence interval; *DBP*, diastolic blood pressure; *NHANES*, National Health and Nutrition Examination Surveys; *PR*, prevalence ratio; *SBP*, systolic blood pressure.

CI 0.29, 0.84) were associated with a lower prevalence of monotherapy.

Factors associated with monotherapy by race/ethnicity

Among non-Hispanic White adults, SBP between 140 to 159 mmHg vs <140 mmHg was associated with a higher prevalence of monotherapy (PR 1.91, 95% CI 1.06, 3.46), while having a health care visit within the previous year (PR 0.62, 95% CI 0.43, 0.88) was associated with a lower prevalence of monotherapy (Figure 3). Among non-Hispanic Black adults, no factors were associated with a higher prevalence of monotherapy. Age 55 to 64 and 65 to 74 vs 20 to 44 years (PR 0.65, 95% CI 0.44, 0.98 and PR 0.51, 95% CI 0.30, 0.87, respectively), CKD (PR 0.68, 95% CI 0.49, 0.94), and heart failure (PR 0.20, 95% CI 0.06, 0.69) were associated with a lower prevalence of monotherapy. Among Hispanic adults, the only factors associated with monotherapy were diabetes (PR 0.67, 95% CI 0.50, 0.91) and heart failure (PR 0.12, 95% CI 0.03, 0.54). Among non-Hispanic Asian adults, household income <$20,000 (PR 0.57, 95% CI 0.37, 0.89) was associated with a lower prevalence of monotherapy.

Discussion

In the current analysis of US adults with treated uncontrolled hypertension, antihypertensive monotherapy use was most common among non-Hispanic Asian adults (50.9%) and least common among non-Hispanic Black adults (31.9%). Clinical and healthcare-access factors, including a healthcare visit within the previous year and certain co-morbid conditions (ie, heart failure) were associated with a higher likelihood of combination antihypertensive therapy.

To restore what had been until recently a favorable upward national trend toward improved BP control rates, increased use of combination antihypertensive medications is necessary. Prior research demonstrated that even when intensified to higher doses, antihypertensive monotherapy is insufficient to achieve BP goals for many patients, which is consistent with typical dose-response curves in which BP response plateaus at higher monotherapy doses.[14] For example, In the Antihypertensive and Lipid-Lowering Treatment to Prevent Heart Attack Trial (ALLHAT) only 39% of participants achieved BP control with monotherapy at 1 year.[15] This decreased to 26% at 5 years, and findings were similar between Black and non-Black participants.[15,16] Additionally, in SPRINT where the study design necessitated treatment intensification toward fixed BP goals, only 10.5% of participants in the intensive treatment group and 31.1% in the standard treatment group were taking monotherapy at their final study visit.[8] In the current analysis, having an SBP of 140 to 159 mmHg, but not >160 mmHg, was associated with a higher likelihood of monotherapy compared

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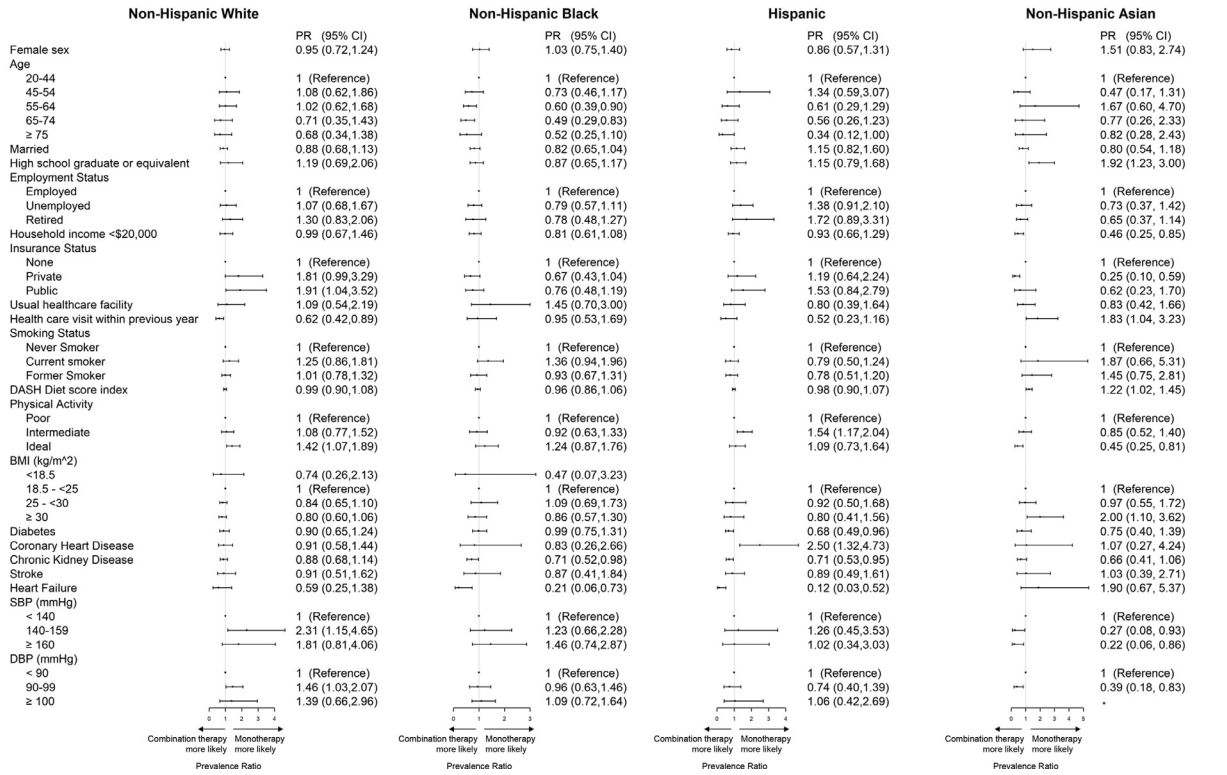
Figure 3



Factors associated with antihypertensive monotherapy vs combination therapy among US adults with hypertension taking antihypertesnive medication and uncontrolled BP (≥140 mmHg or ≥90 mmHg) by race/ethnicity, NHANES 2013-2018. *Sample size was too small to show the point estimate and associated 95% confidence interval on the same scale as the other factors (PR 9.84, 95% CI 2.53-38.29). To the left of one (ie, less than one) represents a lower likelihood to receive monotherapy, to the right of one (ie, greater than one) represents a higher likelihood to receive monotherapy. All models are adjusted for sex, age, marriage status, education, household income, health insurance, usual health care facility, healthcare visit within previous year, smoking status, BMI, individual comorbidities (diabetes mellitus, coronary heart disease, chronic kidney disease, stroke, heart failure), SBP, and DBP. No *P*-values for interaction were statistically significant (Supplemental Table SII). Abbreviations: *BMI*, body mass index; *CI*, confidence interval; *DBP*, diastolic blood pressure; *NHANES*, National Health and Nutrition Examination Surveys; *PR*, prevalence ratio; *SBP*, systolic blood pressure.

to SBP < 140 mmHg. This may be related to clinicians being less likely to intensify when patients are closer to goal owing to clinical uncertainty around the BP measurement. Identifying patients at risk of not escalating appropriately from antihypertensive monotherapy is an important step in designing interventions to increase combination therapy use.

Inadequate healthcare access is major barrier to appropriate BP management.[17] In the current analysis, most participants had at least one healthcare visit in the previous year. However, not having at least one healthcare visit in the previous year was associated with antihypertensive monotherapy. This is consistent with prior studies' findings that found seeing a healthcare provider or having health insurance of any kind is strongly associated with BP control.[18,19] Among NHANES participants in 2017-2018, only 8% of adults who did not report seeing a healthcare provider in the past 12 months achieved BP control (SBP/DBP < 140/90 mmHg), compared to 47% in those who did.[1] Moreover, 22% of those without health insurance had controlled BP compared to BP control of 40% to 46% among those with some form of health insurance.[1] Improving access to and affordability of healthcare through public policy and actively engaging patients with access to care represents a major opportunity to optimize antihypertensive medication use and improve BP control.

Among US adults included in the current analysis, younger adults were less likely to receive combination therapy compared with older adults. This is notable as recent data shows that only 33.4% of US adults who have hypertension and are younger than 45 years old have

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controlled BP.[1] Uncontrolled BP among young adults may be driven by apprehension in prescribing antihypertensive medication and poor perception of cardiovascular risk by both provider and patients.[20] A prior analysis of 10,022 primary care patients found that adults aged 18 to 39 who met criteria for hypertension were initiated on antihypertensive medication in only 34% of clinic visits, which translated into a 44% slower rate of antihypertensive treatment, compared to older patients.[21] Further, after initiation with an antihypertensive medication, young adults were more likely to be nonadherent, which compounds undertreatment risk.[22] Young adults with SBP $\geq$ 140 mmHg or DBP $\geq$ 90 mmHg have a greater risk of CVD events compared to their counterparts with BP below these thresholds (hazard ratio 2.40, 95% CI 2.33-2.47).[23] Concerns about long-term medication exposure and adherence in young adults should be allayed by the fact that drug class combination allow lower doses of the component medications, and that combinations are readily available in single pills. Efforts to increase use of antihypertensive combination therapy among younger adults may translate into significant improvement in BP control and population health benefit.

In the current analysis, only patient-level factors were examined. In addition to individual-level factors, the decision to prescribe antihypertensive mono- vs combination therapy is influenced by provider- and system-level factors. From the clinician perspective, in addition to time constraints, slow adoption of new evidence or guideline recommendations, and BP measurement uncertainty, therapeutic inertia may impact the use of antihypertensive monotherapy.[24] Therapeutic inertia, defined as a clinician's failure to initiate or intensify antihypertensive therapy when a patient's BP remains above goal, has been demonstrated to be the most important barrier to achieving population-wide BP control.[25] Among US adults with hypertension, therapeutic inertia has been estimated to occur in over 20% of primary care visits.[26] Further research to qualitatively understand provider prescribing behaviors and practice patterns may help to reduce the proportion of patients inappropriately treated with antihypertensive monotherapy and consequently improve BP control rates.[27]

There are several strengths and limitations to the current report. NHANES is a nationally representative sample with high-quality medication ascertainment through pill bottle review. Participants included in the current analysis had uncontrolled BP on antihypertensive monotherapy but had hypertension-awareness and contact with the healthcare system as evident by prescription medication. The selection of this population allows for us to describe factors among participants who are already aware of and treated for hypertension. However, antihypertensive prescribing is influenced by patient, provider, and system-level factors, and it is possible that the rationale for prescribing patterns is not sufficiently captured in the current analysis. We do not have the information on medications that were prescribed but not filled by the participant, the appropriateness of monotherapy (ie, white-coat hypertension), medication dose (ie, inappropriately low dose), or the affordability of combination vs monotherapy for participants. As such, we cannot comment on the extent to which monotherapy among participants with uncontrolled BP represents nonadherence vs therapeutic inertia. Data on medication dosing were not available in NHANES so we were unable to further categorize antihypertensive medication regimens according to dosing intensity.

Conclusion

Among US adults with hypertension taking antihypertesnive medication and uncontrolled BP, antihypertensive monotherapy use was most common among non-Hispanic Asian adults and least common among non-Hispanic Black adults. Several clinical and healthcare factors were associated with a lower use of antihypertensive monotherapy among those with uncontrolled BP, including access to healthcare, age, and co-morbid conditions (ie, heart failure), which were similar by race/ethnicity. Improved understanding of specific factors associated with undertreatment may help improve antihypertensive medication regimen use among patients with uncontrolled BP.

Disclosure

None

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ahj.2021.10.184.

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