BMJ Public Health

Racial disparities in hypertension subtype prevalence over the lifecourse: evidence of accelerated arterial ageing in a population representative cross-sectional study

Alexis N. Reeves [1], Michelle C Odden [2]

To cite: Reeves AN, Odden MC. Racial disparities in hypertension subtype prevalence over the lifecourse: evidence of accelerated arterial ageing in a population representative cross-sectional study. *BMJ Public Health* 2025;**3**:e001993. doi:10.1136/bmjph-2024-001993

► Additional supplemental material is published online only. To view, please visit the journal online (https://doi.org/10.1136/bmjph-2024-001993).

Received 3 September 2024
Accepted 14 March 2025

[1]Epidemiology and Population Health, Stanford University, Stanford, California, USA
[2]Epidemiology and Population Health, Stanford University, Palo Alto, California, USA

Correspondence to
Dr Alexis N. Reeves;
alexisnr@stanford.edu

ABSTRACT

Introduction Racially minoritised populations, particularly Black individuals, have been shown to have an earlier average age of onset of hypertension (elevated systolic and/or diastolic blood pressure) compared with White individuals potentially due to 'weathering' or accelerated health declines due to the cumulative impact of marginalisation over the lifecourse. Systolic blood pressure is more reactive to stress, increases linearly with age indicative of arterial ageing and is more highly associated with cardiovascular morbidity and mortality versus diastolic blood pressure. However, little research has examined racial differences in isolated systolic hypertension. This study examines the race/gender differences in the prevalence of two mutually exclusive manifestations of hypertension: diastolic hypertension (ie, elevated diastolic with or without elevated systolic blood pressure) and isolated systolic hypertension (increased systolic only) over the lifecourse.

Methods The National Health and Nutrition Examination Survey from 2016 to 2020, a US-based population representative cross-sectional study, was used in weighted multinomial logistic regression models to estimate age-specific prevalence of hypertension subtypes by race/gender subgroups controlling for socioeconomic status and anti-hypertensive use. Outcomes were diastolic (diastolic ≥90 mm Hg with/without systolic ≥140 mm Hg) and isolated systolic (systolic ≥140 mm Hg and diastolic <90 mm Hg) hypertension.

Results The prevalence of diastolic hypertension increased until midlife and then decreased with increasing age, while the prevalence of isolated systolic hypertension increased throughout the lifecourse. Black women had nearly triple the prevalence of diastolic hypertension from 20 to 45 years where the disparity lessens to double the prevalence and continues to lessen with increasing age and 2–3 times the prevalence of isolated systolic hypertension as early as 35 years with continued disparity at older ages. Black men had nearly double the prevalence of diastolic hypertension from 35 to 65 years and at least double the prevalence of isolated systolic hypertension throughout the lifecourse with the widest disparities at 40 years. Disparities attenuated but remained statistically significant with adjustment for socioeconomic status.

Conclusions Results suggest that isolated systolic hypertension is a dominant and important form of hypertension starting in midlife (~50–60 years); however, indicative of potential earlier arterial ageing, Black men and women's increased prevalence may start as early as 35 and 45 years, respectively.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Black adults have been shown to have increased prevalence of general hypertension (elevated systolic or diastolic) at earlier ages compared with White adults in the USA. Systolic blood pressure is more reactive to stress, increases linearly with age indicative of arterial ageing and is more strongly associated with cardiovascular morbidity and mortality versus diastolic blood pressure.

WHAT THIS STUDY ADDS

⇒ This study examines the race/gender differences in the prevalence of two mutually exclusive manifestations of hypertension: diastolic hypertension (ie, elevated diastolic with or without elevated systolic blood pressure) and isolated systolic hypertension (increased systolic only) over the lifecourse.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The prevalence of isolated systolic hypertension was greater than diastolic hypertension by midlife and later, and Black men and women had earlier increased prevalence (35 and 45 years, respectively) versus White individuals. Results highlight the importance of measuring differing manifestations of hypertension, especially isolated systolic hypertension as a marker of arterial ageing, over the lifecourse and calls for further research on the potential structural and social determinants of accelerated arterial ageing in minoritised groups.

INTRODUCTION

Life expectancy for Black Americans is approximately 5.6 years lower than White individuals[1 2]—and the Black-White gap in life expectancy tends to be slightly wider for men than for women. Although COVID-19 contributed to an increase in the life expectancy gap starting in 2021, higher rates of cardiometabolic diseases such as heart disease, stroke and diabetes[1] have been a lasting contributor to these disparities with the largest disparity, particularly for women, occurring at midlife and early old age.[3–7] Literature to date supports the hypothesis that earlier ageing and earlier onset of disease leading to decreased life expectancy may be due to 'weathering' or 'early health deterioration due to the cumulative impact of repeated experience with social or economic adversity and political marginalisation'.[8] In support of this theory, Geronimus *et al* used data from the National Health and Nutrition Examination Survey (NHANES) 1999–2002 to show that there was an increased prevalence of hypertension at earlier ages for Black men and women compared with their White counterparts.[9] Disparities in the prevalence of hypertension were robust to control for socioeconomic status and obesity. Further research in other US samples has corroborated this phenomenon, showing that Black men and women have an increased risk of hypertension at earlier ages than White men and women.[3–7]

Isolated systolic hypertension, or elevated systolic pressure in the absence of elevated diastolic pressure, has been thought to increase with age and occur mostly in older adults.[10–12] This is due to the differing dynamics of systolic and diastolic blood pressure over the lifecourse.[6 10 11 13–17] Although increases in blood pressure with ageing are not inevitable in all populations,[18–20] decades of hypertension research in Western societies have established that systolic blood pressure tends to linearly increase with age while diastolic blood pressure increases until about midlife (50–60 years) and then starts to decrease (upside down U).[6 10 11 13–17] Therefore, later in the lifecourse, isolated systolic hypertension becomes more prevalent, and increased systolic blood pressure becomes an important indicator for cardiovascular risk.[10–12] Increases in systolic blood pressure are a marker of arterial ageing and rigidity, and isolated systolic blood pressure is highly associated with an increased risk of stroke, left ventricular hypertrophy, increased ventricular-arterial stiffness and a tendency for diastolic dysfunction and heart failure.[21–24] Additionally, prior research suggests that systolic blood pressure is more highly associated with stress exposure and, in recent work, racial discrimination stress in Black women,[25] compared with diastolic blood pressure.[26–28]

Given that systolic blood pressure is more reactive to stress,[25–28] increases linearly with age indicative of arterial ageing,[6 10 11 13–17] and is more highly associated with cardiovascular morbidity and mortality vs diastolic blood pressure,[21–24 29–31] isolated systolic hypertension could be a marker of arterial ageing that occurs at earlier ages for minoritised or 'weathered' groups. However, little research has examined racial differences in isolated systolic hypertension over the lifecourse, for example, two studies conducted in the 1980s/1990s relied on non-representative community samples and found evidence of racial differences in isolated systolic hypertension prevalence.[32–34] Further work in representative samples of the current US population is needed to examine race/gender-specific hypertensive trajectories for different manifestations of hypertension and determine if isolated systolic hypertension is occurring earlier for minoritised populations. Thus, the current study uses data from NHANES 2015–2020 (prepandemic) to examine the race/gender differences in the prevalence of two mutually exclusive manifestations of hypertension: diastolic hypertension (elevated diastolic with or without elevated systolic blood pressure) and isolated systolic (elevated systolic only with normal diastolic) hypertension over the lifecourse controlling for socioeconomic status. Understanding racial/gender differences in different manifestations of hypertension over the lifecourse can potentially guide more precise examination of the causes and consequences of earlier health deterioration and ageing for minoritised or 'weathered' groups.

METHODS

Sample

We used data from non-institutionalised adults aged 20–75 years old from the NHANES 2015–2016 combined with NHANES 2016–2020 (prepandemic) (n=12 991)[35] to evaluate differences in the age-specific prevalence of specific hypertension profiles (systolic/diastolic and isolated systolic hypertension) among eight race/gender subgroups (White, Hispanic, Black and Asian for Males and Females). NHANES is a population representative repeated cross-sectional study conducted approximately every 2 years to gauge the health characteristics of civilian, non-institutionalised persons in the USA. It used a complex, multistage probability sampling design to recruit selected participants to complete a self-conducted questionnaire and in-clinic examination. The in-clinic examination included physiological measurements and interviewer-conducted medical history. Any participants with missing data for any of the analytic variables described below were excluded (analytic n=11 883).

Patient and public involvement

This study used data from a publicly available national survey conducted by the United States National Center for Health Statistics; thus, investigators of the current study were not able to facilitate patient/study participant involvement. More information about NHANES methods and results for study participants can be found here: https://www.cdc.gov/nchs/nhanes/participant.htm

Analytic variables

Participants in the NHANES surveys self-identified their race/ethnicity. Answers to two race/ethnicity questions (Hispanic origin and race) are compiled by NHANES

into the categories: non-Hispanic white, non-Hispanic black, Mexican American, other race (including multiracial) and other Hispanic. Age is calculated by the self-reported date of birth at the study visit. Gender is self-identified as either man or woman. Educational level was self-reported as well. The poverty-income ratio was used to indicate income status; this is a measure calculated from self-reported familial income divided by the US poverty threshold for the year that the survey was collected, taking into account self-reported family size and composition. Waist circumference (cm) was measured to estimate abdominal obesity.

Blood pressure was measured using American Heart Association guidelines; three measures were taken on each participant using a standard mercury sphygmomanometer after 5 min of resting in the clinic. The average of all measures taken on each participant was used to determine resting systolic and diastolic blood pressures. The following definitions were used to categorise participants into one of two profiles of stage two hypertension:[13] (1) diastolic hypertension was defined as diastolic ≥90 mm Hg with or without systolic ≥140 mm Hg and (2) isolated systolic hypertension was defined as systolic ≥140 mm Hg and diastolic <90 mm Hg. The Amercian College of Cardiology/American Heart Association 2017 hypertension guidelines defined hypertension as systolic ≥130 mm Hg and/or diastolic ≥80 mm Hg[18]. However, given that new guidelines can take time to implement, and this study aimed to use one definition throughout the study period (and for all ages) to compare trends by subgroups, the systolic ≥140 mm Hg and/or diastolic ≥90 mm Hg guidelines were used.[13] We evaluated a threshold of systolic ≥130 mm Hg and/or diastolic ≥80 mm Hg in supplemental analyses. Finally, information was collected by an interviewer regarding the current use of any anti-hypertension medication.

Statistical analysis

All analyses were weighted using NHANES provided weights (combined over the necessary survey years) to weight the retained sample to represent the US population. The proportion or mean of selected demographic characteristics including hypertension and medication, abdominal obesity (waist circumference) and socioeconomic status (income poverty ratio and educational level) was calculated for the overall sample and each race/gender subgroup.

Weighted multivariable multinomial logistic regression models, accounting for the complex sampling design of the NHANES study, were used to examine the age-specific hypertension prevalence (diastolic or isolated systolic hypertension) by race/gender subgroups. Then, a weighted linear regression model was used to examine the mean level of systolic and diastolic blood pressure with increasing age for each race/gender subgroup. All models controlled for survey wave and anti-hypertensive medication use, and then an additional model subsequently controlled for socioeconomic status (poverty-to-income ratio). All models included an interaction between age and each race/gender subgroup to examine the extent to which the risk of each hypertension subtype or systolic/diastolic blood pressure level increases with a 1-unit increase in calendar age, in years, for each race/gender subgroup. Age was tested as a polynomial (age^2, age,[3] age^4 etc) to allow for non-linearity in the risk of hypertension types or blood pressure level with increasing age; the best fit was determined using Wald and likelihood ratio tests at alpha level 0.05. Age^2 was the best fit for all models other than systolic blood pressure which was linear. The predicted probability of each hypertension subtype (multinomial model) or blood pressure level (linear regression models) with increasing age for each race/gender subgroup was calculated from each model. Pseudo maximum likelihood estimation and Taylor series linearisation were used to calculate estimates, predicted probability and blood pressure level along with accompanying variances. All analyses were conducted using STATA V.16.[36]

RESULTS

Among the NHANES sample weighted to represent the non-institutionalised US population ages 20–75 years old from 2015 to 2020 (prepandemic), the average level of abdominal obesity was 100.5 cm (SE=0.42 cm); White men (103.8 cm, SE=0.59 cm), Hispanic men (102.3 cm, SE=0.46 cm) and Black women (102.4 cm, SE=0.60 cm) all had the highest levels of abdominal obesity compared with other race/gender subgroups (average 95.8 cm, SE=0.53 cm). The population had an average 3.1 income-to-poverty ratio (SE=0.05). Hispanic and Black men and women had the lowest poverty-to-income ratios compared with other race/gender subgroups. Most of the population had some college, an associate degree or greater levels of education (64.4%). The race/gender subgroups with the lowest levels of individuals with some college or greater levels of education were Hispanic men (38.6%) and women (45.4%) followed by Black men (52.1%) and Black women (62.0%) compared with an average of 72.1% of individuals in the four other race/gender subgroups. Overall, 21.1% of the population were on anti-hypertensive medication. Black women had the highest proportion on anti-hypertensive medication (31.0%) followed by Black men (25.0%), White women (22.1%) and then White men (21.8%). (table 1).

Table 2 and figure 1 show the predicted prevalence of diastolic and isolated systolic hypertension with increasing age for each race/gender subgroup. Generally, for all groups, the prevalence of diastolic hypertension increases with age and then starts to decrease in middle age (40–55 years) eventually reducing to a prevalence of around 3% (range 0.4% (SE=0.30) to 2.9% (SE=1.45)) of the population at age 75. The prevalence of isolated systolic hypertension also increases with age but continues to increase throughout the life-course ending at around a 30% (range 20.1% (SE=4.41) to

Table 1 Demographic characteristics of NHANES 2015–2020 (prepandemic) sample of selected race/gender subgroups at 20–75 years old, weighted to represent the US population (n=12 991)

		Male		Female	
	% or mean (SE*)	48.8		51.2	
		White	Black	White	Black
	Overall	31.7	5.5	32.6	6.7
Waist circumference	100.5 (0.42)	103.8 (0.59)	99.3 (0.75)	98.6 (0.62)	102.4 (0.60)
Income poverty ratio	3.1 (0.05)	3.6 (0.06)	2.5 (0.07)	3.4 (0.06)	2.2 (0.08)
Education level					
<9th grade	4.0	1.4	1.5	1.1	2.5
9th–11th grade	7.2	5.8	12.1	4.3	9.7
HS graduate/GED	24.3	25.4	34.3	21.6	25.8
Some college/associates degree	31.2	30.8	33.8	34.5	37.4
>College graduate	33.1	36.5	18.3	38.6	24.6
Currently on hypertension medication	21.1	21.8	25.0	22.1	31.0
Prevalent hypertension overall					
General hypertension (elevated diastolic)	6.6	6.8	13.0	4.5	11.0
Isolated systolic hypertension	7.8	7.2	11.4	7.8	11.1

See online supplemental table 1 for all (Hispanic and Asian) racial groups.
*Linearised SE.
GED, General Educational Development; HS, highschool; NHANES, National Health and Nutrition Examination Survey.

46.3% (8.46)) prevalence in the population by age 75. The patterns were similar when we used a threshold of 130/80 mm Hg, although the prevalence of diastolic and isolated systolic hypertension were increased at all ages (online supplemental table 1)

Black men have nearly two times the prevalence of diastolic hypertension at every age compared with White men, and the gap is statistically significant as early as 35 until 65 years old. Black men also have at least two times the prevalence of isolated systolic hypertension compared with White men at every age, and the gap widens further around age 40 and on. Black women have nearly three times the prevalence of diastolic hypertension at every age compared with White women. The higher prevalence of diastolic hypertension for Black women peaks around 45–50 years, whereas White women have their highest prevalence of diastolic hypertension at 50–55 years the gap that becomes non-significant around 60 years old. Black women have 2–3 times the prevalence of isolated systolic hypertension at every age compared with White women, and the gap continues to widen with age (figure 1). Black and White men and women are the most disparate race/gender subgroups, but Hispanic and Asian men and women follow similar trends, to a lesser degree, of higher prevalence of hypertension compared with White men and women at most ages (table 2 and online supplemental figure 1). All race/gender differences remain with control for poverty-income ratio differences (online supplemental table 2) and attenuate but remain with lower blood pressure guidelines (online supplemental table 3).

Figure 2 shows the predicted level of systolic and diastolic blood pressure with increasing age for Black and White men and women. Overall, systolic blood pressure increases linearly from age 20 (range 104–121 mm Hg) to 75 years (range 125–144). Diastolic blood pressure increases with age, reaching its peak levels between ages 40 and 50 years (range 73–84 mm Hg) and then decreasing until age 75 years (range 63–72 mm Hg).

Black men's average level of systolic blood pressure increases more rapidly than White men. The gap for Black versus White men starts as early as age 30 (122.8 mm Hg (SE=1.44) vs 120.0 mm Hg (SE=0.95)) and widens over the rest of the lifecourse to age 75 years (139.2 mm Hg (SE=2.10) vs 127.9 mm Hg (SE=1.92)). Average level of diastolic blood pressure increases at a similar rate with increasing age for Black and White men (range 61–81 mm Hg), until age 55 where levels decrease thereafter, and Black men have higher levels compared with White men (79.4 mm Hg (SE=1.27) vs 76.8 mm Hg (SE=1.08)). Black women's average level of systolic blood pressure also increases at a quicker rate than White women. The gap for Black women starts at 30 years old (114.4 mm Hg (SE=1.15) vs 111.7 mm Hg (SE=1.31)) and widens until 75 years old (140.4 mm Hg (SE=2.75) vs 129.9 mm Hg (SE=1.89)). Black women's average level of diastolic blood pressure also increases at a quicker rate than White women. The gap starts to widen in the late 20s (at age 27, 70.8 mm Hg (SE=0.92) vs 68.9 mm Hg (SE=0.97)) and peaks in early midlife (at age 48, 78.2 mm Hg (SE=1.04) vs 74.6 mm Hg (SE=0.92)) ending with similar levels post age 65 (range at age 65, 71.3–73.9 mm Hg) (figure 2).

Table 2 Predicted probability of diastolic and isolated systolic hypertension (HTN) with increasing age by race/gender subgroup, weighted to represent the US population

		Male		Female	
	Age	White	Black	White	Black
Diastolic HTN	20	1.4 (0.57)	1.6 (0.70)	0.8 (0.47)	3.2 (0.99)
	25	2.8 (0.84)	3.9 (1.13)	1.5 (0.53)	5.5 (1.13)
	30	5.0 (1.06)	7.8 (1.43)	2.4 (0.53)	8.4 (1.19)
	35	7.5 (1.24)	12.9 (1.59)	3.5 (0.59)	11.5 (1.37)
	40	9.8 (1.44)	17.8 (1.88)	4.6 (0.83)	14.0 (1.62)
	45	11.1 (1.62)	21.1 (2.19)	5.6 (1.10)	15.3 (1.68)
	50	11.1 (1.63)	21.6 (2.20)	6.2 (1.22)	15.1 (1.45)
	55	9.8 (1.45)	19.3 (1.88)	6.3 (1.13)	13.5 (1.08)
	60	7.5 (1.16)	14.9 (1.53)	5.7 (0.98)	10.7 (1.01)
	65	4.9 (0.89)	9.8 (1.46)	4.9 (1.02)	7.6 (1.19)
	70	2.8 (0.66)	5.4 (1.32)	3.8 (1.25)	4.8 (1.22)
	75	1.4 (0.45)	2.4 (0.95)	2.9 (1.45)	2.8 (1.05)
Isolated Systolic HTN	20	0.8 (0.54)	2.0 (0.89)	0.0 (0.01)	0.1 (0.13)
	25	1.2 (0.56)	3.0 (0.98)	0.0 (0.02)	0.3 (0.25)
	30	1.8 (0.54)	4.4 (0.99)	0.1 (0.06)	0.7 (0.43)
	35	2.5 (0.51)	6.0 (0.97)	0.3 (0.15)	1.5 (0.64)
	40	3.4 (0.56)	7.8 (1.01)	1.0 (0.29)	3.1 (0.83)
	45	4.7 (0.76)	9.9 (1.19)	2.3 (0.52)	5.6 (1.03)
	50	6.2 (1.06)	12.6 (1.48)	4.9 (0.90)	9.6 (1.34)
	55	8.2 (1.35)	15.9 (1.76)	8.7 (1.44)	15.0 (1.84)
	60	10.7 (1.55)	19.8 (1.99)	13.3 (1.86)	21.7 (2.29)
	65	13.6 (1.76)	24.1 (2.38)	17.6 (1.88)	28.9 (2.61)
	70	16.8 (2.52)	28.0 (3.38)	20.5 (1.90)	35.6 (3.60)
	75	20.1 (4.41)	31.1 (5.26)	21.3 (3.13)	40.9 (6.15)

Probability and (linearised SE).
Results from multinomial logistic regression models all adjusted for survey wave and hypertension medication use.
See online supplemental table 2) for all (Hispanic and Asian) racial groups and results adjusted for socioeconomic status.

Black and White men and women are the most disparate race/gender subgroups, but Hispanic and Asian men and women follow similar trends, to a lesser degree, of higher prevalence levels of systolic and diastolic blood pressure compared with White men and women at most ages (online supplemental figure 2).

DISCUSSION

Our findings illustrate striking differences in the prevalence of hypertension subtypes between Black and White women and men. Black women had at least three times the prevalence of diastolic hypertension compared with White women from ages 20 to 45 years and triple the prevalence of isolated systolic hypertension starting as early as 35 years with continued disparity at older ages. Black men had at nearly double the prevalence of diastolic hypertension compared with White men as early as 45 years and at least double the prevalence of isolated systolic hypertension throughout the lifecourse from 35 to 55 years with continued disparity at older ages. Moreover, our findings support the 'weathering' hypothesis by suggesting that racial disparities in isolated systolic hypertension onset for Black men and women may appear as early as ages 35 and 45 years, respectively.

Our findings complement prior research on age-related changes in hypertension. In the Framingham Heart Study, 30% of women and 18% of men had isolated systolic hypertension by age 80,[22] while in the present study, isolated systolic hypertension was prevalent in ~20% of White men and women by 75 years and 30% and 40% of Black men and women by 75 years (Hispanic men and women followed a similar pattern of results). Further, given the tendency of diastolic blood pressure to decrease around 50 years of age,[6 10 11 13–17] isolated systolic blood hypertension has been found to become the dominant type of hypertension in mostly White populations around 60 years of age.[21–23] However, the results of this study suggest that onset may be earlier for Black men and

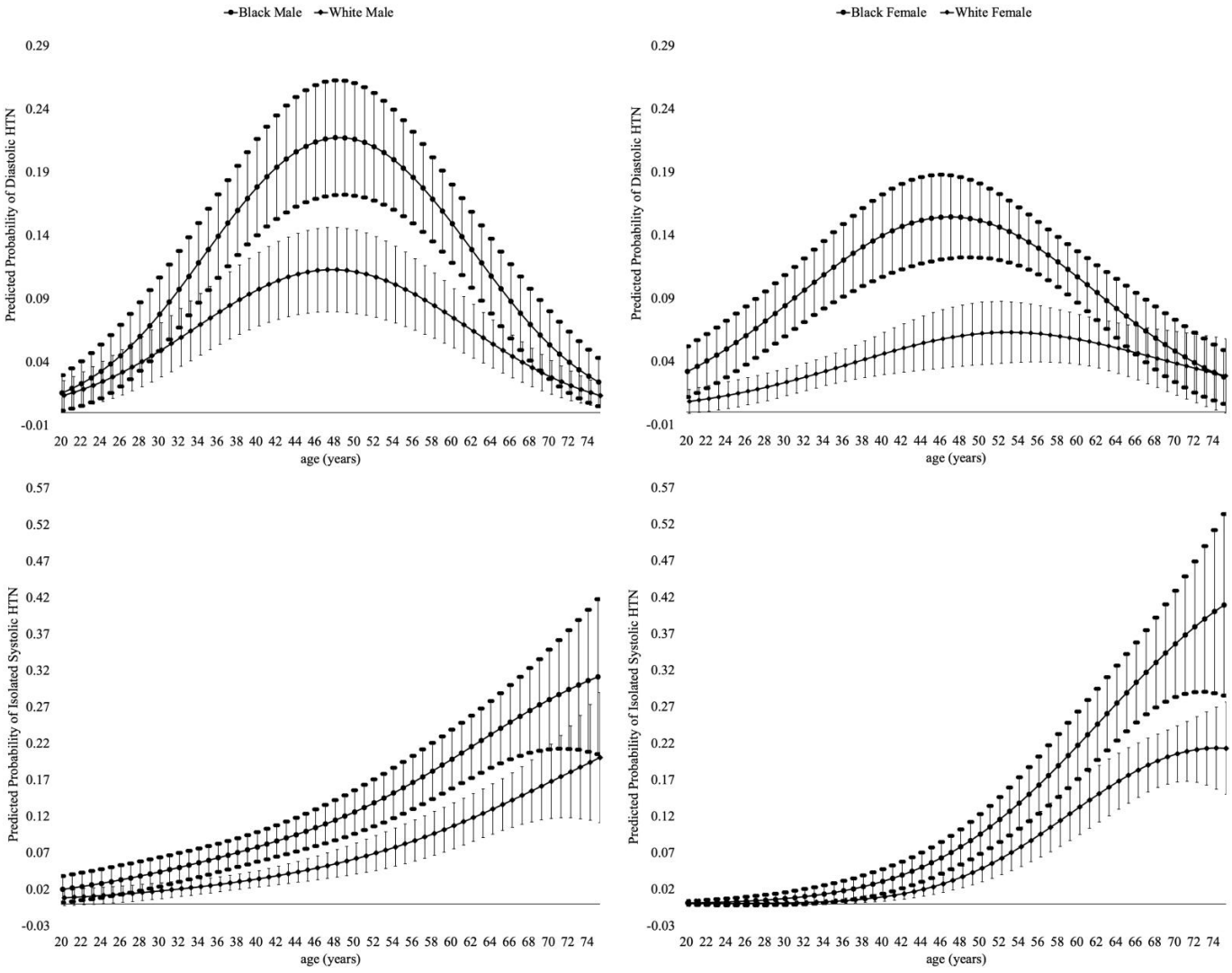

Figure 1 Predicted probability of diastolic and isolated systolic hypertension (HTN) with increasing age for selected race/gender subgroups, weighted to represent the US population. Note: results from multinomial logistic regression models all adjusted for survey wave and hypertension medication use. See online supplemental figure 1) for all (Hispanic and Asian) racial groups.

women, as disparities occurred as early as 35 and 45 years of age, respectively. Although many studies have shown earlier or steeper rises in systolic blood pressure for Black versus White populations in the USA,[6 10 13 37] fewer studies have examined racial differences in isolated systolic hypertension.[32–34] For example, a study in 1981 by Wing *et al* examined the racial/gender subgroup differences in age-specific prevalence of isolated systolic hypertension using data from Evans County in Georgia from 1967 to 1969. The study found that the prevalence of isolated hypertension was up to a two-fold increase in men and 10–30% higher between Black and White individuals.[32] There were also some indications of higher prevalence of isolated systolic hypertension at earlier ages, particularly for Black versus White females.[32] The absence of higher prevalence for Black men in Wing *et al*'s study[32] may be due to sample size limitations, as the disparity for Black men in the current study was less than for Black women (two times the risk vs three times the risk, respectively). Regardless, the current study builds and expands on this early work using a representative sample of the US population, corroborating that Black women *and men* have a three- and two-fold increased prevalence of isolated systolic hypertension at much earlier ages than White men and women.

Higher isolated systolic hypertension prevalence at earlier ages for Black versus White men and women may be an important marker of arterial ageing and 'weathering'. Some research has shown that stress, including race-related stress, is associated with other measures of arterial stiffness particularly among Black women[38–41]—due to overactivation or chronic activation of the stress response system.[8 42–46] In one study, Bromfield *et al* examined the association between discrimination and arterial stiffness among persons with recent myocardial infarctions and found that overall, there was no association between reported discrimination and arterial stiffness, but in subgroup analysis, there was an association

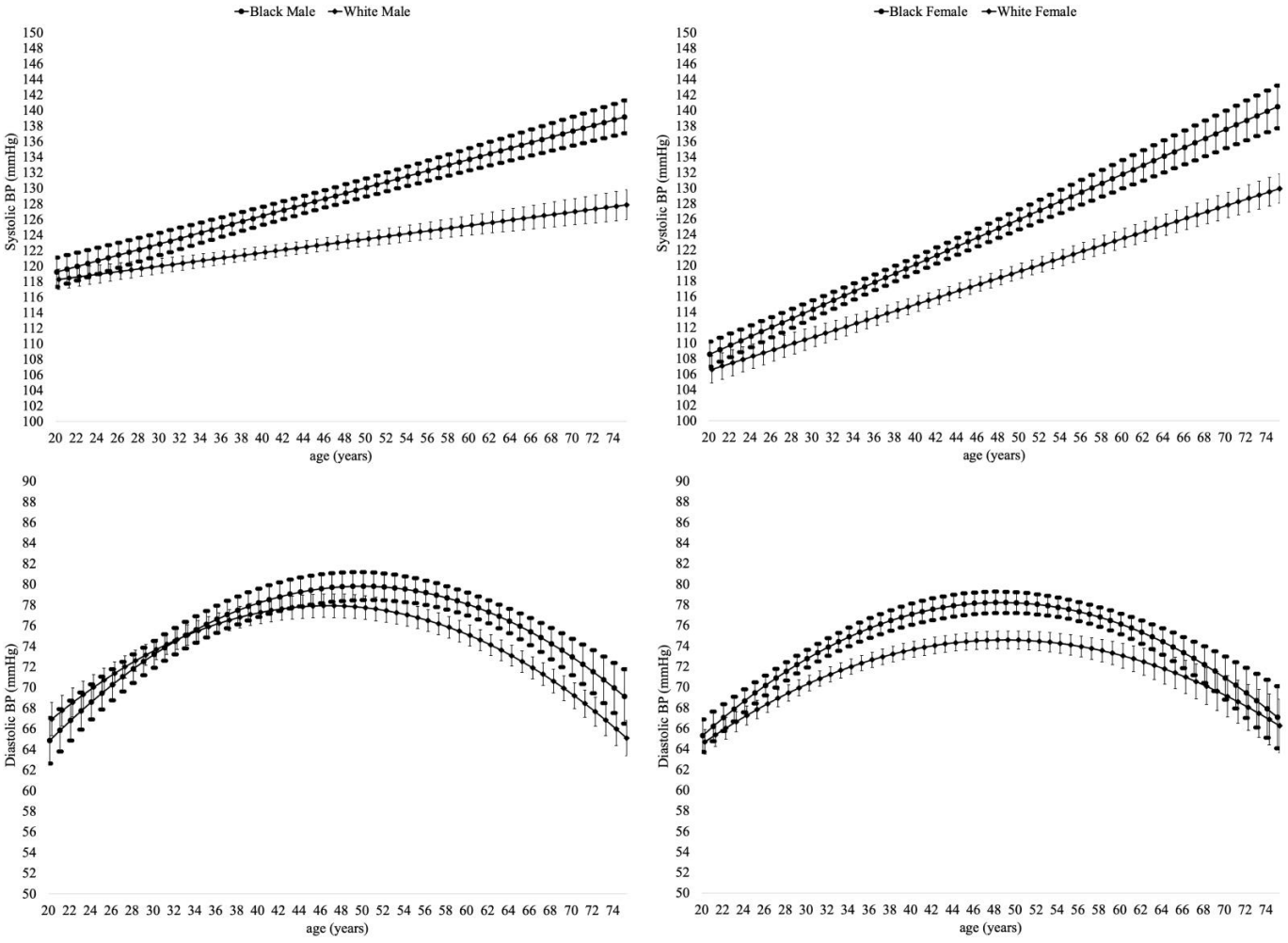

Figure 2 Predicted level of systolic and diastolic blood pressure (BP) by age for selected race/gender subgroups, weighted to represent the US population. Note: results from multinomial logistic regression models are all adjusted for survey wave and hypertension medication use. See online supplemental figure 2) for all (Hispanic and Asian) racial groups.

for Black women.[41] Further, in a study by Kannel *et al* in the Framingham Heart Study, they found that isolated systolic blood hypertension increases with age and was predictive of stroke incidence over and above arterial rigidity measured via the depth of the dicrotic notch from a pulse-wave recording—they suggest that there may be additional risk from elevated systolic blood pressure outside the rigidity captured in the rigidity measure.[21] Taken together, early occurring Black-White disparities in isolated systolic hypertension may be an important marker of 'weathering'[9] via accelerated arterial ageing. And further research is needed to clarify the role of psychosocial stressors, both at the structural and interpersonal level, in producing risk for isolated systolic hypertension in early midlife for minoritised groups.

There are a few limitations to note in this study. First, NHANES is a repeated cross-sectional study; therefore, this study is making inferences about the typical age of onset of hypertension from the prevalence of hypertension at the age of recruitment to the study. In a cohort study among US women, it was estimated that Black women had isolated systolic hypertension onset at a median age of 41.1 years old versus White women at 51.8 years old.[34] It could be that following individuals over time leads to more accurate estimates of the age of onset; thus, further work is needed in cohort studies to further determine the typical age of onset of isolated systolic hypertension in different racial/gender subgroups. Second, there are high rates of hypertension medication use especially for Black individuals in the USA,[9] yet this study controlled for hypertension medication use rather than including it in the outcome definitions in order to meaningfully differentiate hypertension types. This resulted in an estimation of the average blood pressure in each age group for controlled and uncontrolled hypertension (with or without medication use) which can lead to an underestimate of the true blood pressure levels and potentially the disparities in hypertension within the population. Further work in a cohort study following participants' blood pressures before the potential hypertensive medication prescription would further corroborate results. Finally, researchers hypothesise that isolated systolic hypertension may have a different origin in younger adults, such as white coat hypertension rather

than arterial ageing mechanisms for older adults.[47] Further work with the defines isolated systolic hypertension via multiple longitudinal measures of an individual is needed to corroborate the results of the current study; however, the consistency of results across age bands, racial and sex subgroups suggests a stable trend that may be indicative of pathological arterial ageing at younger ages. Overall, this study has the strengths of using a representative sample of the US population, providing strong evidence of the racial disparities in the prevalence of isolated systolic hypertension over the lifecourse.

In conclusion, this study highlights the importance of measuring differing manifestations of hypertension, especially isolated systolic hypertension, over the lifecourse given that isolated systolic hypertension is an important marker of arterial ageing. Further, results suggest that large Black-White disparities exist in the prevalence and likely the age of onset of isolated systolic hypertension indicative of accelerated ageing and 'weathering'.[9] Further research is needed to examine the structural causes and downstream health consequences of accelerated arterial ageing among marginalised and minoritised groups.

Contributors AR contributed the idea for research and analyses, conducted analyses and wrote the manuscript. MO provided guidance and editing at every stage of the analysis and manuscript development. AR is the guarantor of the work.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, conduct, reporting or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval Not applicable.

Provenance and peer review Not commissioned; externally peer-reviewed.

Data availability statement Data are available in a public, open access repository. No data are available.

ORCID iDs
Alexis N. Reeves http://orcid.org/0000-0002-6831-7173
Michelle C Odden http://orcid.org/0000-0002-5974-3648

REFERENCES

1 Kochanek KD, AriasE, AndersonRN. How Did Cause of Death Contribute to Racial Differences in Life Expectancy in the United States in 2010? 2013;125.
2 Arias E, Tejada-Vera B, Kochanek KD, *et al*. Vital Statistics Rapid Release Provisional Life Expectancy Estimates for. 2021.
3 Geronimus AT, Bound J, Waidmann TA, *et al*. Excess mortality among blacks and whites in the United States. *N Engl J Med* 1996;335:1552–8.
4 Geronimus AT, Bound J, Waidmann TA, *et al*. Inequality in life expectancy, functional status, and active life expectancy across selected black and white populations in the United States. *Demography* 2001;38:227–51.
5 Elo IT, Preston SH. Educational differentials in mortality: United States, 1979-85. *Soc Sci Med* 1996;42:47–57.
6 Zeki Al Hazzouri A, Vittinghoff E, Zhang Y, *et al*. Use of a pooled cohort to impute cardiovascular disease risk factors across the adult life course. *Int J Epidemiol* 2019;48:1004–13.
7 Astone NM, Ensminger M, Juon HS. Early adult characteristics and mortality among inner-city African American women. *Am J Public Health* 2002;92:640–5.
8 Geronimus AT, Hicken M, Keene D, *et al*. "Weathering" and age patterns of allostatic load scores among blacks and whites in the United States. *Am J Public Health* 2006;96:826–33.
9 Geronimus AT, Bound J, Keene D, *et al*. Black-white differences in age trajectories of hypertension prevalence among adult women and men, 1999-2002. *Ethn Dis* 2007;17:40–8. Available: http://www.hypnoanalysis.eshonline.ishib.org/ED/journal/17-1/ethn-17-01-40.pdf
10 Chobanian AV. Isolated Systolic Hypertension in the Elderly. *N Engl J Med* 2007;357:789–96.
11 Franklin SS, Gustin W IV, Wong ND, *et al*. Hemodynamic Patterns of Age-Related Changes in Blood Pressure. *Circulation* 1997;96:308–15.
12 Wilking SVB, Belanger A, Kannel WB, *et al*. Determinants of Isolated Systolic Hypertension. *JAMA* 1988;260:3451.
13 Chobanian AV, Bakris GL, Black HR, *et al*. Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Hypertension* 2003;42:1206–52.
14 Burt VL, Whelton P, Roccella EJ, *et al*. Prevalence of Hypertension in the US Adult Population. *Hypertension* 1995;25:305–13.
15 Kannel WB. Blood Pressure as a Cardiovascular Risk Factor. *JAMA* 1996;275:1571.
16 Izzo JL, Levy D, Black HR. Importance of Systolic Blood Pressure in Older Americans. *Hypertension* 2000;35:1021–4.
17 Whelton PK, Carey RM, Aronow WS, *et al*. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *J Am Coll Cardiol* 2018;71:e127–248.
18 Mueller NT, Noya-Alarcon O, Contreras M, *et al*. Association of Age With Blood Pressure Across the Lifespan in Isolated Yanomami and Yekwana Villages. *JAMA Cardiol* 2018;3:1247–9.
19 Gurven M, Blackwell AD, Eid Rodríguez D, *et al*. Epidemiology/population science does blood pressure inevitably rise with age? longitudinal evidence among forager-horticulturalists. 2012.
20 Carvalho JJ, Baruzzi RG, Howard PF, *et al*. Blood pressure in four remote populations in the INTERSALT Study. *Hypertension* 1989;14:238–46.
21 Kannel WB, Wolf PA, McGee DL, *et al*. Systolic Blood Pressure, Arterial Rigidity, and Risk of Stroke. *JAMA* 1981;245:1225.
22 Haider AW, Larson MG, Franklin SS, *et al*. Systolic blood pressure, diastolic blood pressure, and pulse pressure as predictors of risk for congestive heart failure in the Framingham Heart Study. *Ann Intern Med* 2003;138:10–6.
23 Franklin SS. The importance of diastolic blood pressure in predicting cardiovascular risk. *J Am Soc Hypertens* 2007;1:82–93.
24 Sampson RJ, Morenoff JD, Raudenbush S. Social anatomy of racial and ethnic disparities in violence. *Am J Public Health* 2005;95:224–32.
25 Reeves A, Michaels EK, Thomas MD, *et al*. All Stressors Are Not Equal: The Salience of Racial Discrimination and Appraisal for Blood Pressure in African American Women. *Psychosom Med* 2024;86:20–9.
26 Carroll D, Ring C, Hunt K, *et al*. Blood pressure reactions to stress and the prediction of future blood pressure: effects of sex, age, and socioeconomic position. *Psychosom Med* 2003;65:1058–64.
27 Matthews KA, Woodall KL, Allen MT. Cardiovascular reactivity to stress predicts future blood pressure status. *Hypertension* 1993;22:479–85.
28 Markovitz JH, Raczynski JM, Wallace D, *et al*. Cardiovascular reactivity to video game predicts subsequent blood pressure increases in young men: The CARDIA study. *Psychosom Med* 1998;60:186–91.

29 Morris J, Kagan A, Pattison D, *et al*. Incidence and Prediction of Ischaemic Heart-Disease in London Busmen. *The Lancet* 1996.
30 Lassen NA. Epidemiologic Assessment of the Role of Blood Pressure in Stroke. *JAMA* 1996;276:1279.
31 Kannel WB. Role of blood pressure in cardiovascular morbidity and mortality. *Prog Cardiovasc Dis* 1974;17:5–24.
32 Wing S, Aubert RE, Hansen JP, *et al*. Isolated systolic hypertension in Evans County—I. Prevalence and screening considerations. *J Chronic Dis* 1982;35:735–42.
33 Svetkey LP, George LK, Burchett BM, *et al*. Black/white differences in hypertension in the elderly: an epidemiologic analysis in central North Carolina. *Am J Epidemiol* 1993;137:64–73.
34 Reeves A, Elliott MR, Lewis TT, *et al*. Study Selection Bias and Racial or Ethnic Disparities in Estimated Age at Onset of Cardiometabolic Disease Among Midlife Women in the US. *JAMA Netw Open* 2022;5:e2240665.
35 Centers for Disease Control and Prevention (CDC), National Center for Health Statistics (NCHS). Data from: the national health and nutrition examination survey. US Department of Health and Human Services, Centers for Disease Control and Prevention; 2015. Available: https://www.cdc.gov/nchs/nhanes/index.html
36 StataCorp. Stata statistical software: release 16. 2019.
37 Reges O, Krefman AE, Hardy ST, *et al*. Race- and Sex-Specific Factors Associated With Age-Related Slopes in Systolic Blood Pressure: Findings From the CARDIA Study. *Hypertension* 2023;80:1890–9.
38 Schutte AE, Kruger R, Gafane-Matemane LF, *et al*. Ethnicity and Arterial Stiffness. *Arterioscler Thromb Vasc Biol* 2020;40:1044–54.
39 Midei AJ, Matthews KA. Social Relationships and Negative Emotional Traits are Associated with Central Adiposity and Arterial Stiffness in Healthy Adolescents. *Health Psychol* 2009;28:1–7.
40 Ellins E, Halcox J, Donald A, *et al*. Arterial stiffness and inflammatory response to psychophysiological stress. *Brain Behav Immun* 2008;22:941–8.
41 Bromfield SG, Sullivan S, Saelee R, *et al*. Race and Gender Differences in the Association Between Experiences of Everyday Discrimination and Arterial Stiffness Among Patients With Coronary Heart Disease. *Ann Behav Med* 2020;54:761–70.
42 Juster RP, McEwen BS, Lupien SJ. Allostatic load biomarkers of chronic stress and impact on health and cognition. *Neurosci Biobehav Rev* 2010;35:2–16.
43 Allen AM, Thomas MD, Michaels EK, *et al*. Racial discrimination, educational attainment, and biological dysregulation among midlife African American women. *Psychoneuroendocrinology* 2019;99:225–35.
44 Paradies Y. A systematic review of empirical research on self-reported racism and health. *Int J Epidemiol* 2006;35:888–901.
45 Everson-Rose SA, Lewis TT. Psychosocial factors and cardiovascular diseases. *Annu Rev Public Health* 2005;26:469–500.
46 Krieger N, Sidney S. Racial discrimination and blood pressure: the CARDIA Study of young black and white adults. *Am J Public Health* 1996;86:1370–8.
47 Palatini P, Rosei EA, Avolio A, *et al*. Isolated systolic hypertension in the young: a position paper endorsed by the European Society of Hypertension. *J Hypertens* 2018;36:1222–36.