BLACK-WHITE DIFFERENCES IN AGE TRAJECTORIES OF HYPERTENSION PREVALENCE AMONG ADULT WOMEN AND MEN, 1999–2002

Arline T. Geronimus, ScD; John Bound, PhD;
Danya Keene, MAT; Margaret Hicken, MPH

Objectives: To describe age patterns of hypertension prevalence in young through middle-aged adults and to test the hypothesis that hypertension prevalence rises more rapidly with age among Blacks than Whites in the United States.

Design, Setting, and Participants: Using multiple logistics regression, we predicted probability of being hypertensive for participants ages 15–65 years in the National Health and Nutrition Examination Survey (NHANES) IV, 1999–2002. We estimated age-specific Black-to-White odds ratios of hypertension overall, by sex, and adjusted for body mass index (BMI) and poverty income ratio. We also followed NHANES cohorts to test whether differential age patterns of hypertension prevalence by race or gender represented cohort effects.

Main Outcome Measure: Hypertension: systolic blood pressure ≥140 mm Hg, diastolic blood pressure ≥90 mm Hg, or current antihypertensive medication use.

Results: Black/White odds of hypertension increased from 1.71 to 3.12 between ages 15 and 65. Odds for women increased faster, from 2.11 to 4.04. By age 40, Black women had the highest hypertension rates and steepest age-gradient of race/sex groups. Adjustment for poverty income ratio did not affect results. Adjustment for BMI reduced Black women's hypertension risk somewhat but not men's. Cohort analysis confirmed a more rapid increase in hypertension prevalence among Blacks and women.

Conclusions: Hypertension screening of Blacks should begin at young ages. Early diagnosis and vigilant management are critical to addressing racial and sex differences and their effect on cardiovascular disease, life expectancy, and maternal and infant health. Psychosocial stressors merit consideration as candidates for primary prevention. Addressing fundamental causes is needed. Understanding the growing age-gradient increase among US Black women is pressing. (*Ethn Dis*. 2007;17:40–48)

From the Department of Health Behavior and Health Education, School of Public Health, and Population Studies Center (ATG, DK, MH); Department of Economics and Population Studies Center (JB), University of Michigan, Ann Arbor, Michigan.

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INTRODUCTION

Excess hypertension prevalence among US Blacks compared to US Whites is well documented and contributes to racial disparities in adult mortality.[1–3] Further, adult age trajectories of hypertension prevalence may follow a steeper gradient for Blacks than Whites. In an analysis of a national sample of women ages 15–44 years, we observed that at age 15, Blacks faced 1.5 times the odds of being hypertensive than Whites, but at age 44 Blacks were more than three times as likely to be hypertensive than Whites.[4]

Such an age dimension to racial differences in hypertension is consistent with the "weathering" hypothesis[5–6] that African Americans experience early health deterioration as a consequence of repeated experience with social or economic adversity and with related psychosocial stressors. These negative health impacts can be cumulative, producing a steeper age-gradient increase in poor health among Blacks compared to Whites. According to this interpretation, in addition to identifying hypertension risk factors to treat or modify at the individual level, addressing fundamental causes[7] is necessary to eliminate excess hypertension prevalence among Blacks.

Address correspondence and reprint requests to Arline T. Geronimus, ScD; Professor; Department of Health Behavior and Health Education; School of Public Health; University of Michigan; Ann Arbor, MI 48109-2029; 734-936-0929; 734-763-1428 (fax); arline@umich.edu

However, our earlier work was based on a single cross-section, leaving the interpretation that hypertension prevalence rises more steeply with age for Blacks than Whites subject to the assumption that observed age patterns approximated life-course trajectories. An alternative possibility is that observed patterns represented cohort effects; for example, smaller racial disparities among younger than older women might reflect improved health among Black women born in the 1960s relative to those born in the 1930s.

The current study updates and extends our earlier work by analyzing recent data, studying women and men through middle age (15–65 years), and testing the alternative hypothesis that cohort effects explain age/race patterns of hypertension prevalence. We also examine the extent to which poverty status confounds or body mass index (BMI) mediates Black/White differences in age patterns of hypertension prevalence.

METHODS

For our primary analyses we used data from the National Health and Nutrition Examination Survey (NHANES) IV, 1999–2002. To test the cohort effects hypothesis, we added data from the first phase of NHANES III, 1988–1991. The NHANES are stratified, multistage probability samples, designed to provide national estimates of health and nutritional status for the civilian, non-institutionalized population of the United States.[8] Initially administered on a periodic basis, beginning in 1999 NHANES became a continuous survey, and data are released in two-year cycles.[9] We combined data from the first two

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cycles of NHANES IV (1999–2000 and 2001–2002) collected in the adult household interview and the medical examination.

Our NHANES IV sample included non-Hispanic men and women, ages 15–65 years, who self-identified as Black or White. We focused on 15- to 65-year-olds because of our interest in the possibility of early health deterioration or "weathering" during the reproductive and working ages, ages that are thought of as low risk and where hypertension has implications for pregnancy outcome and work disability.

Because pregnancy affects blood pressure, we excluded pregnant women, which reduced the sample by 14% of White women and 8% of Black. We also excluded individuals who were missing data on current blood pressure readings or health history, further reducing the sample by 2% for White men, 3% for White women, 4% for Black men, and 6% for Black women. The final sample size was 5,501: 1,803 White men, 1,681 White women, 1,047 Black men, and 970 Black women.

In NHANES III and IV, blood pressure was measured by using procedures recommended by the American Heart Association. Three blood pressure measurements were taken during the household interview and three during the medical exam. Large adult and thigh blood pressure cuffs allowed reliable blood pressure readings among the obese. Blood pressure was reported as an average of the six measurements. In NHANES IV, reported averages excluded the first reading and also any readings of zero for diastolic blood pressure, assuming other non-zero readings existed.[10] We considered individuals with a systolic blood pressure $\geq$140 or a diastolic blood pressure $\geq$90 or who reported the current use of antihypertensive medications to be hypertensive.

STATISTICS

We fit logistic regression models to the data to estimate the relationship between age and hypertension prevalence within each race/sex group, measuring age as a continuous variable from 15 to 65 years. We used results from this model to calculate the predicted probability of hypertension by age. We also estimated Black-to-White odds ratios of hypertension by using this model. In all analyses, we followed statistical procedures recommended by the National Center for Health Statistics to account for the complex sample design.[8]

To ensure that study findings were not driven by functional form, we reanalyzed the data by using alternative functional forms, including introducing age-squared, age-cubed, and age-to-the-fourth variables and then splines in our estimating equations. All approaches yielded similar results. We report results from models where age is entered linearly.

We adjusted estimated odds ratios by the poverty income ratio (PIR) and by body mass index (BMI). The PIR is an income-to-needs variable that measures the ratio of household income to the US poverty threshold, which varies by family size and composition. Extensive sensitivity analyses included entering PIR and BMI into equations as categories, then linearly, then with higher order terms, including fourth order polynomials. Results were insensitive to these choices. We report results based on measuring PIR as continuous and BMI as categorical. Body mass index (BMI) categories are lean ($<$24.9), overweight (25–29.9), and obese ($>$30), according to National Institutes of Health standards. Being overweight or obese is associated with hypertension. Underweight, while linked to excess mortality for other reasons is not a hypertension risk factor.[11–13] We included it with normal BMI in the lean category.

To test the cohort effects hypothesis, first, we analyzed the initial phase of NHANES III (1988–1991) and compared results to those from the NHANES IV analysis. Shifts in age-specific hypertension rates between these two datasets would suggest cohort effects. In addition, we used the two datasets to follow cohorts over time as they aged. In the absence of longitudinal data, and under the assumption that NHANES III and NHANES IV are each representative of the same population, we used repeated cross-sections to draw inferences about population means.[14–15] Using reported age at exam to estimate birth year, we followed individuals born between 1935 and 1975. These cohorts aged from 13–53 to 24–67 between NHANES III and IV, respectively.

RESULTS

Sample Statistics

Table 1 describes sample characteristics. On average, Whites were five years older than Blacks and had a higher PIR (income relative to needs). Approximately half of Blacks in the sample were poor, almost twice the rate for Whites. (Poverty was defined as a PIR $\leq$1.85, on the basis of the eligibility cut-point for US Department of Agriculture food assistance programs.[16])

Women were more likely to be obese than men, and Black women were sub-

Table 1. Sample characteristics

Characteristic	White Men	White Women	Black Men	Black Women
Mean age (SE)	38 (.38)	38 (.40)	33 (.53)	33 (.55)
Mean systolic pressure (mm Hg)	120 (.34)	116 (.43)	123 (.54)	120 (.65)
Mean diastolic pressure (mm Hg)	73 (.31)	71 (.27)	71 (.51)	71 (.46)
Mean PIR	3.31 (.04)	3.21 (.04)	2.25 (.05)	2.04 (.05)
Mean BMI (kg/m^2)	27 (.14)	27 (.17)	26 (.20)	29 (.29)
% Poor	27%	28%	49%	54%
% Lean	39%	48%	50%	36%
% Obese	26%	28%	22%	41%
% Hypertensive	20%	18%	23%	26%

Table 2. Observed hypertension prevalence by age (%), with 95% confidence intervals*

Age (years)	White Men	White Women	Black Men	Black Women
15–24	4 (2–8)	1 (0–5)	8 (5–13)	1 (0–5)
25–34	10 (7–15)	2 (0–5)	15 (10–21)	8 (3–21)
35–44	15 (11–20)	13 (9–17)	29 (22–38)	3 (27–39)
45–54	31 (25–36)	28 (23–34)	43 (33–54)	50 (43–58)
55–65	44 (39–48)	49 (43–54)	62 (52–71)	74 (66–81)

* Standard errors are adjusted for complex survey design per National Health and Nutrition Examination Survey IV guidelines.

stantially more likely to be obese than either Black men or White women and men. Black men were the least likely to be obese and the most likely to be lean. Despite being younger, Blacks had higher hypertension prevalence than Whites.

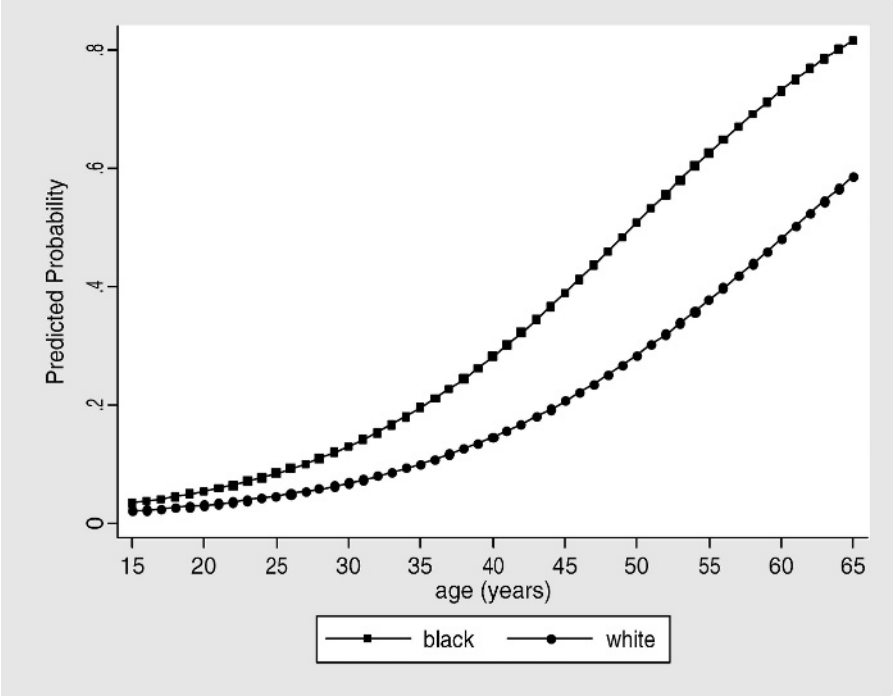

Figure 1. Predicted probability of hypertension by age and race, NHANES IV

Table 2 lists observed hypertension prevalence by age. Hypertension rates increased with age for Blacks and Whites of both sexes. However, beginning with the 25- to 34-year age group, the probability of being hypertensive was consistently higher for Blacks than Whites. Between ages 35 and 65, this disparity was greater for women than men.

Odds Ratios

The results of fitting the logistic regression models are shown in Figures 1 and 2. The size of the Black-White difference in hypertension prevalence increased with age from 15 to 65 (Figure 1). Blacks reached a probability of being hypertensive at age 50 that Whites did not reach until approximately age 64. These patterns were more pronounced among women than men. Beginning at age 30, Black women had a higher probability of being hypertensive than did White men or women (Figure 2), and by age 40 they surpassed Black men as well. White women did not surpass White men until age 55; however, by age 65 their probability of hypertension was well above that of White men and appeared to be converging with that of Black men.

Table 3 lists Black-White relative odds of being hypertensive, overall and by age group and sex, under different models. Unadjusted Black-White odds (column 1) rose from 1.71 at age 15 to 3.12 at age 65.

Black men and Black women had higher estimated odds relative to their White counterparts at all ages, and these relative odds increased in size with age. For men, the Black-White odds increased from 1.61 at age 15 to 2.30 at age 65. For women, they increased from 2.11 at age 15 to 4.04 at age 65.

Estimated male-female relative odds of being hypertensive favored women at younger ages, but by age 35 for Blacks and age 55 for Whites they converged, crossing over by age 55 for Blacks and

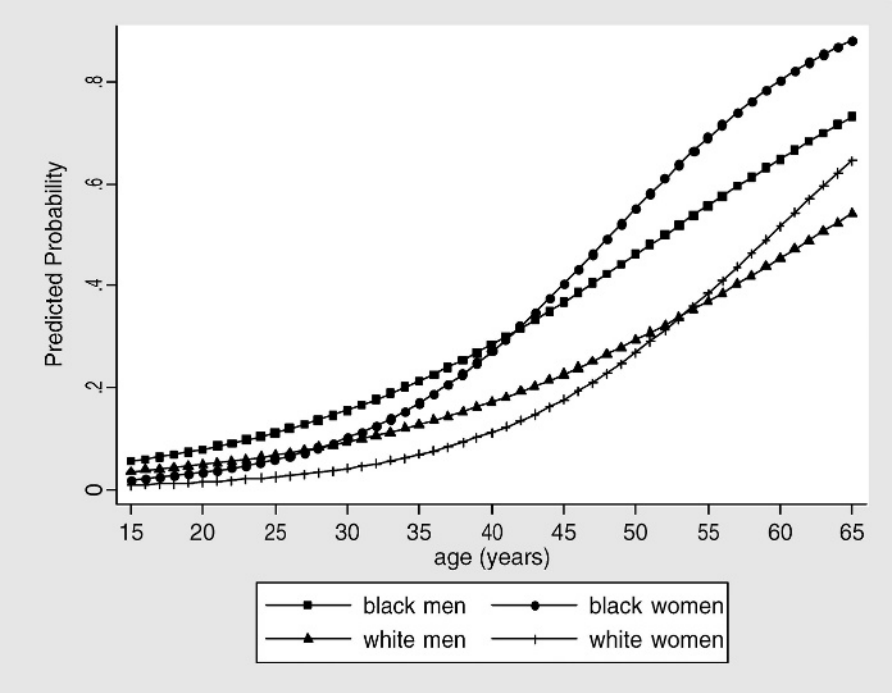

Figure 2. Predicted probability of hypertension by age, race, and gender, NHANES IV

age 65 for Whites. At age 65, White women were ≈50% more likely to be hypertensive than White men; Black women fared worse than Black men; they exhibited three times the odds of being hypertensive.

Poverty and Obesity

In the full sample, being poor or obese was associated with excess hypertension risk (Table 4). Obese sample members had 4.2 times the odds of being hypertensive than did the lean. Poor sample members had 1.5 times the odds of being hypertensive as did the nonpoor. However, when Black-White relative odds of hypertension were adjusted for PIR (Table 3, column 2), point estimates were slightly smaller, overall and by sex, but they remained strong and were not qualitatively different from the unadjusted estimates (column 1).

When we added BMI categories to the PIR adjusted model (Table 3, column 5), Black-White odds ratios were only slightly reduced for the full sample. The Black-White odds ratios were unchanged for men, reflecting the fact that Black and White men had similar obesity rates. Consistent with the greater percentage of Black compared to White women who were obese, the point estimates for women were reduced, but the reduction was not dramatic. Adjusted Black-White odds ratios were not significantly different from the unadjusted odds ratios, and the age pattern was unchanged.

Among Whites, adjusting for PIR left female-to-male odds unaffected, reflecting their similar rates of poverty and odds of being hypertensive, if poor. This finding held true for Blacks until age 45. Then, Black female-to-male odds ratios appeared to increase somewhat when adjusted for PIR, although insufficiently to qualitatively alter the age pattern of odds ratios. After adjusting for BMI as well, the estimated disadvantage of the oldest White women compared to the oldest White men increased slightly, but no change in estimates at younger ages or in the general age patterns were apparent. Black women's greater propensity to be obese than Black men resulted in a larger advantage for Black women under age 45 and a smaller disadvantage for Black women over age 45, once BMI was included in the model. However, even taking BMI and PIR into account, 55-year-old Black women had >1.5 times the risk of being hypertensive than Black men; by age 65, they had >2.5 times the odds of being hypertensive as Black men.

Cohort Analysis

The four panels of Figure 3 compare age profiles of hypertension for Black and White men and women in the NHANES III and IV data. For men, the profiles are almost identical across survey waves and not statistically significantly different. For women, data from the more recent period show higher hypertension rates; differences were statistically significant starting at age 35 for Blacks and age 45 for Whites. Similarly, estimated survey wave effects were larger for Black than White women. These findings suggest that NHANES IV patterns *understated* the magnitude of the racial difference in the age gradient increase in hypertension prevalence, to a small extent.

Figure 4 shows increases in hypertension prevalence in our cohort of respondents born between the years 1935 and 1975 and followed from 1988 (when they were ages 13–53) through 2002 (when they were age 24–67). In each race/sex category, hypertension prevalence increased as the cohort aged, with a larger increase for women than for men. Moreover, the disparity between Blacks and Whites grew as the cohort aged.

DISCUSSION

Our findings provide evidence that the Black/White disparity in hypertension prevalence in the United States widens over the reproductive and working ages (ages 15–65 years). The largest

Table 3. Relative odds of being hypertensive*

			PIR		BMI&PIR	
Age	Unadjusted	95% CI	Adjusted	95% CI	Adjusted	95%CI
Blacks compared to Whites						
15	1.71‡	1.07–2.73	1.69†	.99–2.88	1.52	.79–2.92
25	1.93§	1.35–2.76	1.84§	1.23–2.76	1.72‡	1.05–2.82
35	2.17§	1.67–2.84	2.01§	1.50–2.70	1.95§	1.38–2.77
45	2.45§	1.98–3.04	2.20§	1.76–2.75	2.22§	1.72–2.86
55	2.76§	2.20–3.47	2.40§	1.90–3.02	2.52§	1.93–3.29
65	3.12§	2.31–4.21	2.60§	1.91–3.58	2.86§	1.96–4.17
Black men compared to White men						
15	1.61‡	1.03–2.52	1.54†	.92–2.58	1.63†	.91–2.92
25	1.74§	1.23–2.43	1.60‡	1.07–2.40	1.74§	1.11–2.73
35	1.86§	1.43–2.40	1.65§	1.20–2.28	1.87§	1.32–2.65
45	1.99§	1.58–2.52	1.71§	1.28–2.29	1.99§	1.45–2.74
55	2.14§	1.62–2.84	1.77§	1.27–2.46	2.13§	1.47–3.08
65	2.30§	1.59–4.34	1.83§	1.21–2.78	2.27	1.41–3.67
Black women compared to White women						
15	2.11‡	1.03–4.55	2.22†	.99–4.96	1.71	.65–4.53
25	2.48§	1.44–4.18	2.45§	1.37–4.36	1.99†	.99–4.00
35	2.78§	1.95–3.97	2.70§	1.86–3.93	2.33§	1.49–3.67
45	3.14§	2.37–4.18	2.98§	2.32–3.85	2.73§	2.02–3.67
55	3.56§	2.44–5.20	3.30§	2.37–4.59	3.19§	2.18–4.66
65	4.04§	2.30–7.07	3.64§	2.15–6.15	3.72§	2.03–6.84
White women compared to White men						
15	.24§	.13–.45	.22§	.11–.43	.21§	.10–.41
25	.35§	.22–.55	.32§	.20–.53	.32§	.19–.53
35	.50§	.38–.68	.48§	.35–.66	.49§	.35–.68
45	.73§	.62–.87	.71§	.59–.85	.74‡	.61–.91
55	1.07	.89–1.28	1.04	.85–1.29	1.14	.92–1.41
65	1.55§	1.13–2.13	1.54‡	1.07–2.21	1.04	1.02–1.06
Black women compared to Black men						
15	.32§	.16–.66	.31§	.16–.62	.23§	.12–.76
25	.49§	.30–.81	.49§	.30–.80	.37§	.22–.63
35	.76†	.55–1.04	.78	.55–1.09	.61§	.43–.86
45	1.16	.88–1.53	1.22	.89–1.67	1.00	.73–1.36
55	1.77‡	1.16–2.70	1.93§	1.25–2.98	1.64‡	1.06–2.53
65	2.72§	1.44–5.13	3.04§	1.63–5.68	2.67‡	1.42–5.06

* Calculated from logistic regression coefficients. See text for details.
† $P \leq .10$; ‡ $P \leq .05$; § $P \leq .01$.
PIR=poverty income ratio; BMI=body mass index.

gap between Blacks and Whites is evident among women, largely because of the rapid increase in hypertension prevalence among Black women as they age from young through middle adulthood.

Study findings refute the hypothesis that cohort effects account for this widening. Comparisons of NHANES III and NHANES IV analyses showed that our NHANES IV results underestimated Black/White differences in age trajectory among women and between Black women and men.

At younger ages, women were less likely to be hypertensive than men, but at older ages the reverse was true. By age 40, Black women had the highest hypertension risk, and their age-gradient increase through middle age was steeper than for any other race/sex group.

Calculations based on standard life table methods[17] suggest that differential mortality cannot explain the sex crossover. Instead, Black women appear to experience a faster increase in hypertension as they age from young through middle adulthood. This age dimension to racial differences in hypertension prevalence is consistent with the weathering hypothesis. Most disturbing is evidence that Black women's age-gradient increase has become steeper in recent years.

Although Blacks are more likely to be poor than Whites, and although

Table 4. Relative odds of being hypertensive by poverty income ratio, body mass index, race, and sex

	Both sexes	Men	Women
Full sample			
Poor	1.50 (1.25–1.80)	1.53 (1.15–2.04)	1.51 (1.17–1.95)
Overweight	1.91 (1.44–2.52)	2.16 (1.47–3.17)	1.52 (1.05–2.18)
Obese	4.17 (3.30–5.26)	3.96 (2.77–5.67)	4.60 (3.32–6.38)
Whites			
Poor	1.34 (1.09–1.63)	1.48 (1.05–2.08)	1.22 (.96–1.55)
Overweight	2.03 (1.45–2.84)	2.46 (1.57–3.86)	1.44 (.95–2.17)
Obese	4.48 (3.35–5.99)	4.41 (2.83–6.87)	4.78 (3.29–6.93)
Blacks			
Poor	1.31 (1.02–1.68)	1.27 (.85–1.89)	1.31 (.93–1.85)
Overweight	1.35 (1.01–1.80)	1.60 (1.01–2.51)	1.06 (.57–1.94)
Obese	2.53 (1.85–3.47)	3.43 (2.44–5.24)	1.98 (1.05–3.74)

women, especially Black women, are more likely to be obese than men, neither PIR nor obesity accounted for the differential age gradient in hypertension prevalence between Blacks and Whites or between men and women. Prior evidence on the relationship between socioeconomic position and hypertension is not neatly summarized. In US studies, the relationship is generally inverse, but the magnitude of this association is often small.[18] In their comparison of hypertension rates among several populations of African descent, Cooper et al[19] found US Blacks to have much higher hypertension rates than African or Caribbean populations, despite much deeper and more widespread poverty among the non-US populations. In a study of Jamaicans, Mendez et al[20] found hypertension rates to be highest among the wealthiest women. We found variation in the extent to which the poor faced greater odds of hypertension. Black women,

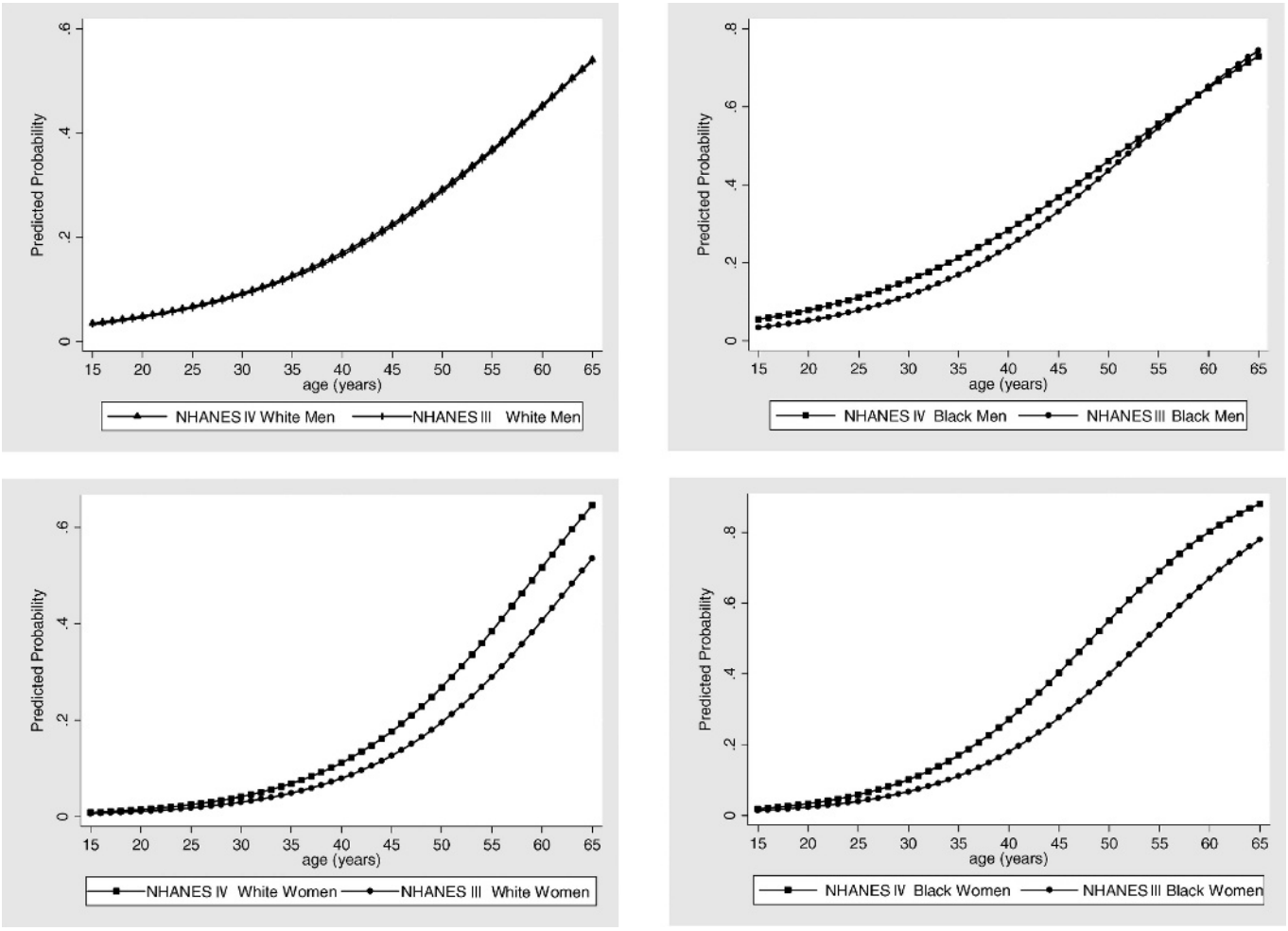

Figure 3. Predicted probability of hypertension by age, race, gender and survey (NHANES III or NHANES IV)

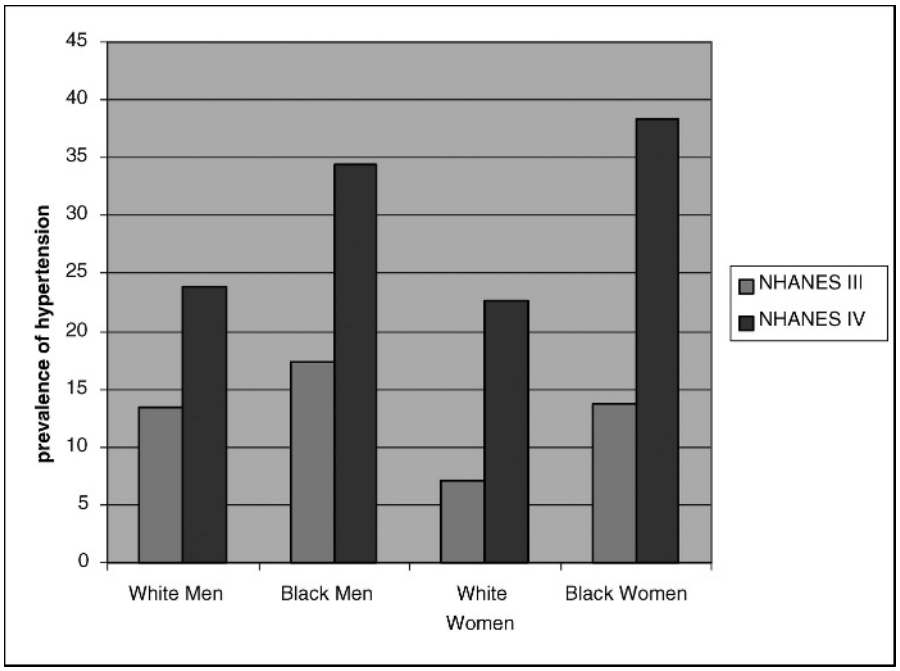

Figure 4. Predicted probability of hypertension by age, race, gender, and cohort

The largest gap between Blacks and Whites is evident among women, largely because of the rapid increase in hypertension prevalence among Black women as they age from young through middle adulthood.

who were most likely of the four race/sex groups to be poor, were least likely to be hypertensive if poor; White men, who were least likely to be poor, were most likely to be hypertensive if poor. Our finding that economically advantaged Blacks faced almost the same excess hypertension risk as poor Blacks is consistent with a growing body of literature that suggests that, for African Americans, higher economic status is more protective against early mortality than against early morbidity.[21–24]

Obesity was associated with elevated risk of hypertension in the sample overall but accounted for none of the difference between Black and White men, and only a small fraction of the differences between Black and White women or between Black women and men. Unlike obese women, Black women who were overweight were not at greater hypertension risk than their leaner counterparts.

The current findings imply the need to consider other factors that may produce or mediate excess Black hypertension risk in the United States, with particular focus on factors whose effects are cumulative and affect Black women. Contributing factors are likely to be multiple and span psychosocial, dietary, activity, and environmental factors, among others. While gene-environment interactions may be important, Cooper et al[19,25–26] caution against inferring a strictly genetic explanation for the excess hypertension rates of Blacks in the United States.

Psychosocial stressors merit further study. Persistent high-effort coping with acute and chronic stressors can have a profound effect on health through stress-related diseases such as hypertension.[27–29] Preliminary studies suggest the benefit of stress reduction for hypertensive Blacks.[30] Its value for primary prevention requires testing. For African Americans, the stress inherent in living in a race-conscious society that stigmatizes and disadvantages Blacks may help explain why they experience hypertension rates typical of Whites who are significantly older.[31] Studies find racial discrimination to be associated with hypertension[32,33] In a sample of Black Caribbean women, Tull et al[33] found evidence that internalized racism was also associated with increased obesity and central adiposity, both of which are hypertension risk factors.

For Black women, the psychosocial effects of racism may be compounded by the "double jeopardy" of being both Black and female or by the stress inherent in fulfilling multiple roles as economic providers and dependent caretakers.[34] African American women play central roles in extended family economies and caretaking systems, fulfilling multiple demands from both older and younger dependents in these multigenerational networks.[34–37] Middle-class Black women may experience token stress, role overload,[38] or psychosocial stress as they maintain a dual identity as autonomous professionals and as responsive and connected members of their families or communities of origin.[39,40] The unique demands on Black women across social class may lead to role strain, caregiver stress, or allostatic overload, all risk factors for stress-related disease.

Recent research by Epel et al[41] suggests that stress is related to accelerated cellular aging in reproductive-age women, through decreased telomerase activity and shortened telomeres. Epel et al found these markers were associated with high perceived stress in their entire sample and with length of caregiving in women caring for a chronically ill child.

Aviv and Aviv found an association between telomere length and hypertension.[42] The current study's findings do not speak directly to mechanistic pathways or to the possible role of stressors. However, Black women's particularly steep age-gradient increase in hypertension suggests psychosocial stressors merit further study.

In the absence of strong direct evidence to inform primary prevention or address fundamental causes, study findings underscore the importance of hypertension screening for Blacks beginning at young ages. Ensuring African Americans access to health services that provide early diagnosis and vigilant medical management of hypertension is critical to reducing its effect on cardiovascular disease, maternal and infant health, active life expectancy, and excess mortality.

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AUTHOR CONTRIBUTIONS

Design concept of study: Geronimusn
Data analysis interpretation: Geronimus, Bound, Keene, Hicken
Manuscript draft: Geronimus, Bound, Keene, Hicken
Statistical expertise: Geronimus, Bound
Acquisition of funding: Geronimus, Bound
Administrative, technical, or material assistance: Bound, Keene, Hicken
Supervision: Geronimus, Bound