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ORIGINAL RESEARCH ARTICLE

Cumulative Psychosocial Stress and Ideal Cardiovascular Health in Older Women

Data by Race/Ethnicity

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BACKGROUND: Research implicates acute and chronic stressors in racial/ethnic health disparities, but the joint impact of multiple stressors on racial/ethnic disparities in cardiovascular health is unknown.

METHODS: In 25 062 women (24 053 white; 256 Hispanic; 440 black; 313 Asian) articipating in the Women's Health Study follow-up cohort, we examined the relationship between cumulative psychosocial stress (CPS) and ideal cardiovascular health (ICH), as defined by the American Heart Association's 2020 strategic Impact Goals. This health metric includes smoking, body mass index, physical activity, diet, blood pressure, total cholesterol, and glucose, with higher levels indicating more ICH and less cardiovascular risk (score range, 0–7). We created a CPS score that summarized acute stressors (eg, negative life events) and chronic stressors (eg, work, work-family spillover, financial, discrimination, relationship, and neighborhood) and traumatic life event stress reported on a stress questionnaire administered in 2012 to 2013 (score range, 16–385, with higher scores indicating higher levels of stress).

RESULTS: White women had the lowest mean CPS scores (white: 161.7±50.4; Hispanic: 171.2±51.7; black: 172.5±54.9; Asian: 170.8±50.6; $P_{overall}<0.01$). Mean CPS scores remained higher in Hispanic, black, and Asian women than in white women after adjustment for age, socioeconomic status (income and education), and psychological status (depression and anxiety) ($P<0.01$ for each). Mean ICH scores varied by race/ethnicity ($P<0.01$) and were significantly lower in black women and higher in Asian women compared with white women (β-coefficient [95% CI]: Hispanics, −0.02 [−0.13 to −0.09]; blacks, −0.34 [−0.43 to −0.25]; Asians, 0.34 [0.24 to 0.45]); control for socioeconomic status and CPS did not change these results. Interactions between CPS and race/ethnicity in ICH models were not significant.

CONCLUSIONS: Both CPS and ICH varied by race/ethnicity. ICH remained worse in blacks and better in Asians compared with whites, despite taking into account socioeconomic factors and CPS.

Key Words: ethnicity ■ ideal cardiovascular health ■ psychosocial stress ■ risk factors ■ women's health

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Clinical Perspective

What Is New?

- Cumulative psychological stress and socioeconomic status were evaluated as potential explanations for racial/ethnic differences in ideal cardiovascular health among older women.
- Our results show that these factors did not explain the racial/ethnic differences noted in ideal cardiovascular health among older female health professionals.
- Stressors were jointly evaluated and included both acute (eg, life events) and chronic (eg, job, financial, work-family conflict, neighborhood) sources of stress.

What Are the Clinical Applications?

- Psychosocial stressors are social determinants of health that likely have different prevalence according to race/ethnicity.
- Clinicians should incorporate psychosocial stressors in their assessment of patients because they might help to better target cardiovascular care, particularly since different patients will have wide variability in socioeconomic status, a potential source of stress.
- This analysis used a psychosocial stress questionnaire with potential clinical utility in part because of its succinct but comprehensive components.

Cardiovascular disease (CVD) is a leading cause of death for every racial/ethnic group in the United States and accounts for much of the excess premature mortality among blacks compared with whites.[1] Several decades of research have sought to unpack the mechanisms through which race/ethnicity impacts traditional modifiable risk factors for CVD, such as hypertension, elevated cholesterol, poor diet, and low physical activity, with the aim of targeting cardiovascular prevention programs to reduce differences in CVD outcomes.[2] Although it is a known risk factor for CVD, including myocardial infarction,[3,4] much of the work related to psychosocial stress in different racial/ethnic groups is limited to single domains of stress, such as discrimination, or to general perceived stress. Thus, almost no data exist pertaining to the relationship of a combination of acute and chronic stressors (cumulative psychosocial stress [CPS]) to race/ethnicity or to CVD health, resulting in significant gaps in the literature in these regards. Indeed, individuals typically experience a combination of stressors, and the examination of single domains of stress likely does not accurately capture the impact of cumulative stress over time. Moreover, whether the association between CPS and CVD varies based on race/ethnicity is unknown.

Psychosocial stress can result from multiple sources, including trauma, interpersonal relationships, employment, and neighborhood environment, potentially resulting in physiological consequences, including dysregulation of the inflammatory, neurohormonal, and autonomic nervous systems.[5,6] Psychosocial stress associated with social inequalities is arguably disproportionately experienced by racial/ethnic minorities living in the United States.[7,8] For example, job instability and financial strain are associated with increased serum C-reactive protein concentration in Mexicans living in the United States.[9] Additionally, everyday discrimination is associated with increased serum biomarkers of endothelial dysfunction and blood pressure.[6,10] These aforementioned forms of psychosocial stress in turn may be potential mechanisms by which racial/ethnic disparities in CVD risk occur.[7–11]

Ideal cardiovascular health (ICH) is a metric supported by the American Heart Association 2020 Impact Goals to improve the cardiovascular health of all Americans by 20%; in this metric, a higher score is associated with a more favorable cardiovascular profile.[12] More than a mere tally of the absence of 7 lifestyle-related risk factors for CVD (tobacco use, blood pressure, cholesterol, fasting glucose, weight, physical activity, and diet), ICH was created to take into account both behavioral and clinical risk factors to be used both in research and in clinical practice as a pragmatic tool to empower patients to reduce their CVD risk. To date, emerging data indicate an inverse association of ICH with incident myocardial infarction, heart failure, stroke, and cardiovascular mortality in men and women.[13,14] Although women live longer than men, black women in particular do not achieve as much of the cardiovascular benefit associated with sex as women of other races/ethnicities.[15,16] Although lower socioeconomic status (SES) regardless of race/ethnicity is associated with poor cardiovascular health, differences in cardiovascular health outcomes by race/ethnicity are not fully explained by SES differences.[17] Given that psychosocial stress is as important a risk factor for CVD as traditional risk factors such as smoking and dyslipidemia, and that psychosocial stressors might be differentially associated with heightened cardiovascular risk based on race/ethnicity and culture,[3,18] we sought to assess the relationship between CPS and race/ethnicity and to evaluate the impact of CPS on any observed ICH-race/ethnicity relationship in women participating in the WHS (Women's Health Study).[13,19,20]

METHODS

Data Availability

The data will not be made available to other researchers for purposes of reproducing results; however, we highly encourage collaboration and contacting the corresponding author regarding sharing of methods and other information.

Study Population

We used participants from the follow-up cohort of the WHS, a completed randomized clinical trial of the effect of low-dose aspirin, vitamin E, and beta carotene in the primary prevention of cancer and CVD.[21] Female health professionals ≥45 years of age in the United States were invited to participate in the trial (N=39 876). Study randomization began in April 1993, and follow-up for the clinical trial ended in March 2004. After trial conclusion, consenting participants from the trial were recruited into an observational cohort starting in 2005 (N=33 796). Follow-up questionnaires were conducted every 6 months during the first year and every year starting in year 2 to assess self-reported sociodemographic information and health outcomes. In 2012 to 2013, participants in the WHS observational cohort with no history of CVD were invited to participate in this stress cohort. A total of 25 335 participants were willing and eligible and provided informed consent for the stress study. Women with complete data on race/ethnicity, CPS, and ICH metrics were included in this analysis (N=25 062); 193 women without complete race/ethnicity, stress, and ICH data were excluded. Because of the small sample size of American Indian women (n=49) and women who reported their race/ethnicity as other (n=31), we do not present these data. Therefore, 273 women were excluded, representing 1.1% of this stress cohort. The distributions of available baseline characteristics were similar in the excluded group compared with women in this analysis (data not shown). This study was approved by the institutional review boards of Brigham and Women's Hospital and the University of California, San Francisco.

Assessment of CPS

Details of the WHS stress follow-up study have been detailed previously.[22] A mailed written questionnaire to evaluate acute and chronic psychosocial stressors was completed by each participant. Acute stress domains (reported as yes or no) included items regarding negative events in the past 5 years (eg, fired from a job, moving to a worse neighborhood, unemployment) and traumatic life events (eg, life-threatening illness or death of child/spouse, physical attack/assault victim). Chronic stress domains included work stress (eg, unable to express work creativity, lack of decision authority, monotony or excessive work, conflicting demands, job insecurity), work-family conflict (eg, too stressed out to participate in activities with family/others), financial stress (eg, inadequate funds, difficulty paying bills), intimate partner stress (eg, relationship happiness, partner demands, conflict resolution), neighborhood stress (eg, safety, community member trust/support), and everyday discrimination (eg, less respect, poor service, treated as unintelligent/dangerous). These chronic stress domains were assessed using 4 or 5 option Likert-style responses depending on the domain.[22] Weights were assigned to each of the 8 domains that constituted the cumulative stress score based on the reciprocal of the SD of the scores for questions in each domain. The 8 domain-specific weighted scores were then added to create the cumulative stress score (CPS; range, 16–385), with higher values representing higher stress.

Assessment of ICH

We created an ICH score using the American Heart Association Strategic 2020 Impact Goals, which captures an index of ICH consisting of 7 health behaviors and factors. ICH is defined as body mass index (BMI) <25 kg/m^2; ≥150 min/wk of moderate physical activity; a healthy diet pattern that includes sufficient amounts of fruits and vegetables; optimal blood pressure (<120/<80 mm Hg); fasting glucose <100 mg/dL; total cholesterol <200 mg/dL; and never smoking or smoking cessation for >12 months.[12] ICH was determined for each participant in WHS using self-reported data collected within 1 year of stress study baseline in 2011 to 2012 because of the WHS follow-up data collection schedule. The accuracy of self-reported health conditions in WHS, including blood pressure, diabetes mellitus, and weight, is >90%.[23–26] Diet information was collected in a self-administered food frequency questionnaire administered in 2004. Missing values for total cholesterol were imputed using the value from the data collection period immediately preceding the 2011 to 2012 follow-up assessment (ie, 2010–2011).

The definition of each component of ICH is consistent with the American Heart Association definition, with the following modifications to accommodate the methodology of the WHS (Table 1):

1. Physical activity: Ideal, moderate physical activity ≥150 min/wk; intermediate, 1 to 150 min/wk; poor, <1 min/wk.
2. Diet: The diet metric is composed of 5 components consistent with a DASH (Dietary Approaches to Stop Hypertension) diet: fruits and vegetables, fish, fiber-rich whole grains, sodium, and sugar-sweetened beverages. In this analysis, each component of the DASH diet was assessed by 25th or 75th percentiles for the WHS cohort. Participants were classified as ideal if they reported fruit and vegetable consumption above the 75th percentile, fish intake above the 75th percentile, sodium intake below the 25th percentile, and sugar-sweetened beverage intake below the 25th percentile. Fiber-rich whole grains consumption was divided into whole grains intake and fiber intake, and each received a score of 0.5 above the 75th percentile. Diet was rated according to the number of dietary components that met the criteria for ideal (ideal, 4 to 5; intermediate, 2 to 3; or poor, 0 to 1) and presence or absence of glycemia (ideal, no self-report of type 2 diabetes mellitus; or poor, self-report of diabetes mellitus), consistent with the definitions used in the American Heart Association 2020 goals.[12]

For each component of ICH, participants were given a score of 1 for ideal classification, 0.5 for intermediate, and 0 for poor. The scores for the 7 metrics were summed to give a total ICH score ranging between 0 and 7, with 7 indicating an ideal risk factor category for all components. This continuous ICH score was categorized into 3 groups: low (scores 0–3), intermediate (scores 3.5–5.5), and high (scores 6–7).

Covariates

Age, race/ethnicity, education level, and annual household income (income) were self-reported. Other conditions included in the analyses were obesity/overweight (normal, <25.0 kg/m^2; overweight, 25.0 to <30.0 kg/m^2; and obese,

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Table 1. Definition of Poor, Intermediate, and Ideal Cardiovascular Health in the Women's Health Study

	Ideal Cardiovascular Health		
	Poor	Intermediate	Ideal
Health behaviors			
Smoking	Current	Former	Never
Weight/BMI	≥30 kg/m²	25 to <30 kg/m²	<25 kg/m²
Physical activity	Moderate physical activity <1 min/wk	Moderate physical activity between 1 and 149 min/wk	Moderate physical activity ≥150 min/wk
Diet	0–1 Components	2–3 Components	4–5Components
Fruits and vegetables (>75th percentile) Fish (>75th percentile) Sodium (<25th percentile) Sugar-sweetened beverages (<25th percentile) Fiber-rich whole grains: fiber (>75th percentile); whole grains (>75th percentile)			
Health factors			
Blood pressure	SBP ≥140 mm Hg or DBP ≥90 mm Hg	SBP 120–139 mm Hg or DBP 80–89 mm Hg	<120/80 mm Hg
Total cholesterol	≥240 mg/dL	200–239 mg/dL	<200 mg/dL
Glycemia/fasting plasma glucose	Positive T2DM diagnosis	N/A	No history of T2DM

BMI indicates body mass index; DBP, diastolic blood pressure; N/A, not applicable; SBP, systolic blood pressure; and T2DM, type 2 diabetes mellitus.

≥30.0 kg/m²; for Asians: normal, <23.0 kg/m²; overweight, 23.0 to <27.0 kg/m²; and obese, ≥27.0 kg/m²), hypertension history, hypercholesterolemia, and alcohol use (<1 glass/d versus ≥1 glass/d).[27,28]

Physical activity was evaluated by self-report at initiation of the WHS and was updated every 2 to 3 years with questions based on the College Alumni Health Study, for which reliability and validity have been investigated extensively.[29,30] Ascertained data include information about usual pattern of stair climbing and walking and average time spent weekly doing leisure-time activities (eg, walking/jogging, aerobic exercise, dance, swimming). Blood pressure was self-reported using the following criteria from the annual WHS follow-up questionnaire: (1) physician diagnosis of hypertension; (2) initiation of blood pressure–lowering medication; and (3) systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg. Validation of self-report of hypertension in WHS is 96%.[24]

Participants completed a validated, reproducible 131-item semiquantitative food frequency questionnaire before WHS randomization and in 2004 to assess dietary intake.[31] Women responded to questions that inquired about frequency of consumption of the following foods: fruits and vegetables (includes fruit juices and excludes potatoes), fish (eg, canned tuna, shrimp/lobster, dark meat fish, breaded fish), fiber (eg, dark bread, brown rice, oatmeal, grains), sugar-sweetened beverages (eg, carbonated beverage with caffeine and sugar, punch, lemonade), and sodium. Responses were on a 9-point scale ranging from never/less than once monthly to ≥6 times/d. Because of skewedness related to food consumption distribution, food intake was treated as both continuous and dichotomous variables (ie, cut points were for fruits and vegetables ≥4.5 cups/d, fish ≥2 3.5-oz servings/wk, fiber-rich whole grains ≥3 1-oz equivalent servings/d, sugar-sweetened beverages ≤450 kcal (36 oz)/wk, sodium <1500 mg/d). Total caloric intake (kcal/d) was a continuous variable.[32]

Lipid levels were initially obtained via blood from WHS participants before randomization and by self-report. Thereafter, history of hypercholesterolemia was self-reported on annual follow-up questionnaires. The reliability of self-report is extremely high and correlates well with CVD risk.[33] Self-reported type 2 diabetes mellitus is also collected on the annual WHS follow-up questionnaire and validated using American Diabetes Association criteria (positive predictive value for validation is 91%).[23] Finally, self-reported weight correlates strongly (r=0.96) with directly measured weight.[26] Psychological status including depressed mood (eg, feeling downhearted/blue/in the dumps) and anxiety (eg, nervousness, feeling calm/peaceful) was assessed by the stress questionnaire.

Statistical Analysis

Baseline characteristics are reported by race/ethnicity as means and medians; significance testing was performed with ANOVA or Kruskal-Wallis and χ^2 tests. CPS is reported as median and associated 25th and 75th interquartile range based on race/ethnicity. To compare CPS by race/ethnicity, we used linear regression analyses and report the β-coefficients (reference group, whites). Linear regression models assessed the relationship between race/ethnicity as follows: model 1, unadjusted; model 2, age-adjusted; model 3, model 2 + SES (income and education); model 4, model 3 + psychological status (depression and anxiety symptoms); and model 5, model 4 + hypertension, BMI, smoking, alcohol use, and physical activity.

The relationship between race/ethnicity and ICH (continuous variable) was examined by linear regression: model 1, unadjusted; model 2, age-adjusted; model 3, age + CPS; model 4, model 3 + SES (education, income); and model 5, model 4 + psychological status. We also performed mediation analyses using the CAUSALMED procedure in SAS (SAS

Table 2. Sociodemographic Characteristics and Cardiometabolic Risk Factors of Participants in the Women's Health Study by Race/Ethnicity

	White (n=24 053)	Hispanic (n=256)	Black (n=440)	Asian (n=313)	*P* Overall
Age, y	70.9 (67.3–75.8)	70.4 (67.2–75.1)	71.5 (68.0–75.4)	71.1 (67.8–74.6)	0.56
Education					<0.001
Less than college (<bachelor's degree)	50.8	55.5	50.6	20.9	
College or more (≥bachelor's degree)	45.1	44.5	49.4	79.1	
Household income					<0.001
Less than $50 000	40.3	46.4	45.6	15.6	
$50 000 or more	57.2	53.6	54.4	84.4	
Type 2 diabetes mellitus	9.8	19.5	23.0	19.5	<0.001
Current hypertension	69.8	70.3	88.4	70.9	<0.001
Current hypercholesterolemia (>240 mg/dL)	73.6	79.3	73.3	79.2	0.02
Current BMI, kg/m^2	25.8 (23.0–29.7)	26.5 (23.4–30.1)	28.3 (25.7–32.1)	23.0 (21.1–25.6)	<0.001
Current BMI					<0.001
<25.0 kg/m^2	42.7	38.0	19.3	71.3	
25.0 to <30.0 kg/m^2	34.0	35.7	43.4	21.7	
≥30.0 kg/m^2	23.3	26.3	37.3	7.0	
Smoking					<0.001
Never	49.2	62.5	51.9	77.3	
Past	46.1	34.0	42.4	20.8	
Current	4.8	3.5	5.7	1.9	
Alcohol					<0.001
<1 glass/d ≥1glass/d	84.6 15.5	93.4 6.6	95.0 5.0	94.9 5.1	
Current METs (h/wk)	17.5±16.5	16.3±18.1	16.1±17.5	21.7±17.5	<0.001
Depression score	5.5±2.1	5.7±2.6	5.3±2.0	5.7±2.0	0.01
Anxiety score	4.4±1.6	4.4±1.8	4.0±1.5	4.4±1.6	<0.001

Data are mean±SD, median (interquartile range), or %. BMI indicates body mass index; and MET, metabolic equivalent.

Institute Inc, Cary, NC) to understand the effect of cumulative stress on racial/ethnic differences in ICH. In addition, we examined the individual components of the ICH and CPS scores by race/ethnicity. Pearson correlation coefficients between CPS and ICH were also calculated. The proportional odds assumption and models of unequal slopes for race/ethnicity were performed. A 2-tailed *P* value <0.05 indicated statistical significance. Analyses used SAS 9.4 (SAS Institute Inc).

RESULTS

Among the 25 062 participating women (24 053 white; 256 Hispanic; 440 black; 313 Asian), overall mean age at the time of the stress questionnaire was 72.2±6.0 years. Compared with white women, Hispanic women had lower educational attainment and income, higher prevalent diabetes mellitus and hypercholesterolemia, higher BMI, and less current smoking; black women had lower income, more diabetes mellitus and hypertension, higher BMI, and more current smoking (Table 2). Asian women had higher educational attainment and income, more diabetes mellitus, and lower BMI and current smoking. White women had more prevalent alcohol use than women of other racial/ethnic groups.

Figure 1 displays CPS scores (mean, median, and interquartile range) by race/ethnicity. Overall, nonwhites had higher CPS scores than whites. Specifically, mean CPS scores were lowest for white women (161.7±50.4). Black women had the highest mean CPS score (172.5±54.9), followed by Hispanic women (171.2±51.7) and then Asian women (170.8±50.6). Table 3 shows the results of linear regression analyses of CPS by race/ethnicity (white women=referent). After adjustment for potential confounders, black (β=0.08; 95% CI, 0.06–0.10), Hispanic (β=0.05; 95% CI, 0.03–0.08), and Asian (β=0.04; 95% CI, 0.02–0.07) women reported higher CPS than white women (all *P*<0.001). Table 4 shows the relationship between the individual stressors and ICH by race/ethnicity. These results revealed that the impact of each stress domain on ICH was relatively similar in magnitude in blacks and Asians. The effect of individual stressor domains in Hispanics was negligible and not statistically significant.

As shown in Figure 2, mean ICH score was the highest in Asian women (5.0±0.9), followed by white (4.6±0.9),

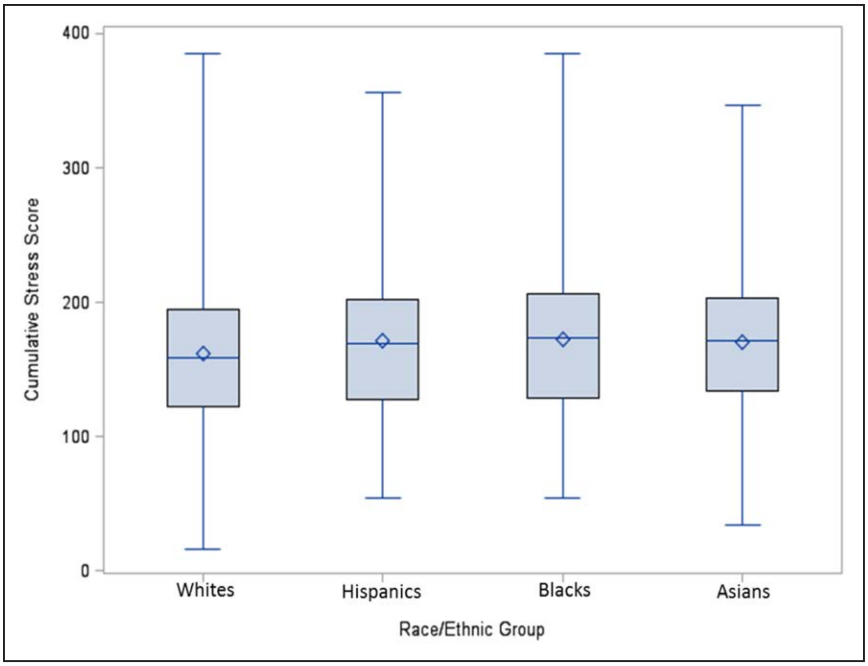

Figure 1. Cumulative psychosocial stress score by race/ethnicity in the Women's Health Study stress study.
Mean (◊) and median cumulative stress scores and associated interquartile range according to race/ethnic group among participants in the Women's Health Study stress study. *P* value across race/ethnicity groups <0.001.

Hispanic (4.5±1.0), and black (4.1±1.0) women. Black women had the highest proportion of participants with low ICH scores (19.1%), that is, lowest cardiovascular health, and the lowest percentage of participants with high ICH scores (3.9%) (Table I in the online-only Data Supplement). Asian women had the lowest percentage of participants with low ICH scores (4.8%) and the highest percentage of participants with high ICH scores (19.2%), that is, with ICH. The odds of having ideal ICH classification (ICH score=6–7) versus poor ICH classification (ICH score=0–3) were significantly decreased for black women compared with white women (odds ratio [OR], 0.46; 95% CI, 0.28–0.75) after adjustment for age, CPS, and SES (Table I in the online-only Data Supplement). Asian women were 2 times more likely than white women to have ideal versus poor ICH (OR, 2.21; 95% CI, 1.65–2.98).

We also observed that in all race/ethnicity groups, physical activity was the ICH metric with the largest proportion of women categorized as ideal, with a range from 73.8% to 88.6% (Table II in the online-only Data Supplement). The BMI component of the ICH score had the widest range of percentage of participants meeting the criteria for ideal classification, ranging from 19.3% in black women to 71.3% in Asian women. Asian women had the highest percentage of participants meeting the criteria for an ideal rating for the greatest number of individual components of the ICH score. When the individual components of ICH were examined (ie, odds for ideal versus poor component), the odds of absence of diabetes mellitus (ideal) were lower in Hispanics (OR, 0.49; 95% CI, 0.36–0.67), blacks (OR, 0.42; 95% CI, 0.34–0.53), and Asians (OR, 0.45; 95% CI, 0.34–0.60) compared with whites. Additionally in Asians, the odds of other ideal ICH components were significantly higher (eg, never smokers: OR, 3.92; 95% CI, 1.72–8.86) compared with whites, besides total cholesterol. The odds of ideal versus poor blood pressure were significantly lower in blacks (OR, 0.61; 95% CI, 0.44–0.86) compared with whites.

Table 5 shows results of linear regression analyses of ICH according to race/ethnicity. As previously noted, compared with white women, black women and Hispanic women had lower ICH scores and Asian women had higher ICH scores. These racial/ethnic differences persisted and remained statistically significant despite adjustment for CPS (model 3) and additionally for SES (model 4), except among Hispanics. In age-adjusted

Table 3. Comparison of Cumulative Psychosocial Stress (CPS) Scores by Race/Ethnicity in the Women's Health Study

Model	Hispanic (n=256)	Black (n=440)	Asian (n=313)
Model 1: unadjusted	6.7 (3.9 to 9.6) *P*<0.001	7.7 (5.6 to 9.9) *P*<0.001	2.4 (–0.03 to 4.9) *P*=0.05
Model 2	6.4 (3.7 to 9.0) *P*<0.001	7.4 (5.3 to 9.4) *P*<0.001	2.5 (0.007 to 4.8) *P*=0.04
Model 3	6.1 (3.4 to 8.7) *P*<0.001	7.4 (5.3 to 9.5) *P*<0.001	4.8 (2.4 to 7.3) *P*<0.001
Model 4	5.5 (3.1 to 7.8) *P*<0.001	9.5 (7.6 to 11.3) *P*<0.001	4.0 (1.8 to 6.2) *P*<0.001
Model 5: Fully adjusted	5.4 (3.1 to 7.8) *P*<0.001	8.2 (6.1 to 10.1) *P*<0.001	4.3 (2.1 to 6.5) *P*<0.001

Data are percent differences from white women (reference) (95% CI).
Model 1: unadjusted.
Model 2: age.
Model 3: model 2 + income + education.
Model 4: model 3 + depression/anxiety;
Model 5: model 4 + hypertension + smoking + alcohol use + metabolic equivalents + body mass index.

Table 4. Ideal Cardiovascular Health in Relation to Individual Psychosocial Stress Domains by Race/Ethnicity

	White	Hispanic		Black		Asian	
Individual Stressor	β (SE)	β (SE)	*P* Value	β (SE)	*P* Value	β (SE)	*P* Value
Work stress	1.00	−0.08 (0.06)	0.16	−0.41 (0.04)	<0.01	0.41 (0.05)	<0.01
Work-family stress	1.00	−0.08 (0.06)	0.18	−0.43 (0.04)	<0.01	0.43 (0.05)	<0.01
Financial stress	1.00	−0.05 (0.06)	0.38	−0.35 (0.04)	<0.01	0.38 (0.05)	<0.01
Traumatic events	1.00	−0.07 (0.06)	0.24	−0.42 (0.04)	<0.01	0.41 (0.05)	<0.01
Negative life events (past 5 y)	1.00	−0.07 (0.06)	0.24	−0.41 (0.04)	<0.01	0.42 (0.05)	<0.01
Discrimination stress	1.00	−0.07 (0.06)	0.23	−0.39 (0.04)	<0.01	0.44 (0.05)	<0.01
Relationship stress	1.00	−0.06 (0.06)	0.31	−0.36 (0.04)	<0.01	0.44 (0.05)	<0.01
Neighborhood stress	1.00	−0.04 (0.06)	0.47	−0.38 (0.04)	<0.01	0.43 (0.05)	<0.01

White women=reference. β indicates β-coefficient; and SE, standard error.

models, among blacks compared with whites, ≈12.7% of ICH was mediated by CPS (*P*<0.001). No significant associations were noted in Hispanics (*P*=0.27) and Asians (*P*=0.06). The overall correlation between ICH and the CPS score was small (*r*=−0.06, *P*<0.001).

DISCUSSION

In this cross-sectional study of older women participating in the WHS, both CPS and ICH varied by race/ethnicity. White women had lower CPS scores than other women. Black women had the highest CPS and the lowest ICH scores. Asian women had the highest ICH scores and were more likely categorized as having ICH than white women. The observed racial/ethnic differences in ICH persisted after adjustment for CPS or SES. These data suggest that the mechanisms by which racial/ethnic differences in cardiometabolic risk in this cohort likely occur are through multiple pathways beyond SES and measured acute and chronic stressors. Given that racial/ethnic heterogeneity exists in all major groups discussed in this article and is primarily a social construct that serves as a surrogate for other individual and societal variables that might affect health behaviors and health outcomes, our analysis significantly adds to existing literature by additionally examining the impact of cumulative stress on ICH. In future research, it will be important to evaluate whether alternative modes to assess stress can be of additional value for understanding the association between race/ethnicity and cardiovascular health.

Although the prevalence of ICH was higher in our study than in other cohorts, the racial/ethnic differences in ICH were similar to those observed in other cohorts.[19,20,34] NHANES (National Health and Nutrition Examination Survey) 2003 to 2008 data demonstrated a prevalence of ICH in women age ≥65 years of <2%, which is considerably less than what was reported for each of the race/ethnicity groups in our study.[34] However, the participants of WHS were health professionals and thus had a relatively higher educational attainment than other cohorts and likely higher exposure to information on healthy behaviors, which might account for the higher prevalence of ICH. Still, despite the overall

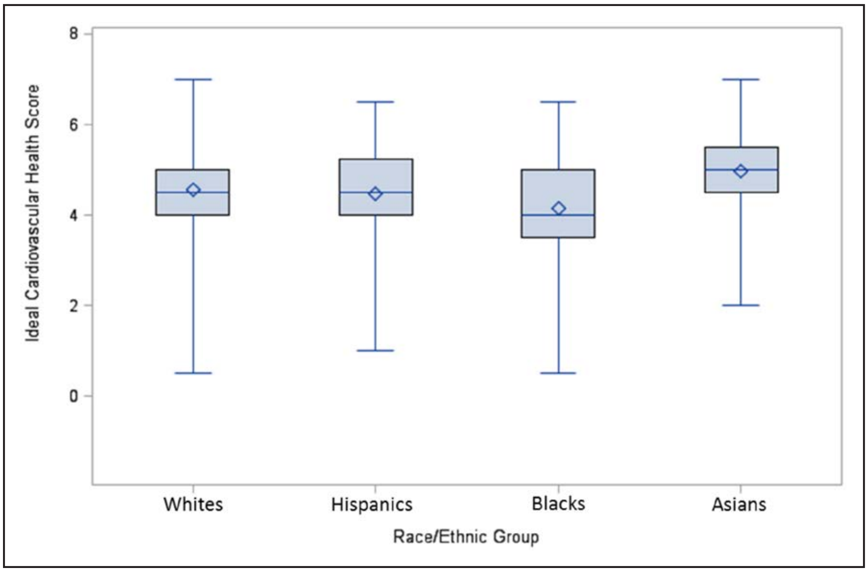

Figure 2. Ideal cardiovascular health score by race/ethnicity in the Women's Health Study.
Mean (◊) and median ideal cardiovascular health scores and associated interquartile range according to race/ethnic group among participants in the Women's Health Study stress study. *P*<0.001.

Table 5. β-Coefficients of Ideal Cardiovascular Health Score by Race/Ethnicity

Model	Hispanic (n=256)	Black (n=440)	Asian (n=313)
Model 1	−0.07 (−0.18 to −0.05) *P*=0.26	−0.37 (−0.45 to −0.28) *P*<0.01	0.42 (0.32 to 0.52) *P*<0.01
Model 2	−0.06 (−0.18 to −0.05) *P*=0.27	−0.37 (−0.45 to −0.28) *P*<0.01	0.42 (0.31 to 0.52) *P*<0.01
Model 3	−0.03 (−0.14 to 0.09) *P*=0.65	−0.32 (−0.40 to −0.23) *P*<0.01	0.43 (0.33 to 0.56) *P*<0.01
Model 4	−0.02 (−0.13 to 0.09) *P*=0.72	−0.33 (−0.42 to −0.24) *P*<0.01	0.35 (0.24 to 0.45) *P*<0.01
Model 5	−0.02 (−0.13 to 0.09) *P*=0.72	−0.34 (−0.43 to −0.25) *P*<0.01	0.34 (0.24 to 0.45) *P*<0.01

Data are β-coefficient (95% CI). Reference=white women. Negative values indicate lower ideal cardiovascular health.

Model 1: unadjusted.

Model 2: age.

Model 3: model 2 + cumulative psychosocial stress.

Model 4: model 3 + education + income.

Model 5: model 4 + depression/anxiety.

increased prevalence of ICH in the WHS, racial/ethnic differences in ICH remain. In other cohorts, despite the considerable heterogeneity in the manner in which the components of ICH have been defined and measured, particularly in diet, the pattern of worse ICH in blacks is a recurrent observation. When the NHANES (2003–2008) data were examined by race/ethnicity, black women aged ≥65 years had the lowest prevalence of ideal classification in the areas of tobacco, BMI, diet, and blood pressure, whereas Mexican American women of the same age group had the lowest prevalence of ideal physical activity and fasting glucose.[34] Of note, Asian American women were not included in many of the studies of ICH with the exception of a study from the BRFSS (Behavioral Risk Factor Surveillance System). In an analysis of BRFSS 2009 data, patterning in overall ICH scores by race/ethnicity was similar to our study, with Asians having the highest prevalence of ICH, followed by whites, Hispanics, and blacks.[19] Importantly, in this analysis, we used recommended cut points for Asian women, who tend to have higher CVD risk at lower BMI.[27,28] ICH in Hispanics differs by national background, as observed in the Northern Manhattan Study, in which Caribbean Hispanics had the lowest prevalence of ICH and the lowest prevalence of ideal classification in the areas of BMI and blood pressure.[13]

In the present data, ICH varied by race/ethnicity despite taking into account CPS and SES. This is surprising, because the CPS scores were statistically different by race/ethnicity, and previous work from this cohort indicates that robust socioeconomic diversity is linked to CVD outcomes even though the WHS participants were female health professionals.[35] Despite this, the overlapping CIs between CPS by race/ethnicity and the likelihood that racial/ethnic differences in ICH in women occur through multiple mechanisms (including genetic but more likely environmental, behavioral, and social factors) may have impacted the findings in this cohort of health professionals.[7,36] For example, characteristics of neighborhood physical and social environment, such as walkability and safety, are associated with hypertension and obesity prevalence.[37] Neighborhood characteristics also influence cardiovascular health behaviors.[36–42] Indeed, the ICH metric comprises both cardiometabolic risk factors and health behaviors, each of which might have different upstream social determinants, including cultural practices that influence food choices and leisure-time physical activity. Although the CPS measurement herein included neighborhood stressors, it is possible that the magnitude of the range in the neighborhood stress score for these female health professionals might be different from that noted in the general population. Despite this, the ability to capture multiple domains of potential stressors in this well-phenotyped cohort is a significant addition to the current literature. Certainly, WHS data about race/ethnicity and inflammation was one of the first published studies about racial/ethnic differences in high-sensitivity C-reactive protein and have remained generalizable over time to other cohorts and to the general population.[43]

Despite the preceding, limitations of this study merit discussion. First, these data are cross-sectional. Stress caused by medical problems was omitted from the CPS assessment for this analysis to help mitigate the potential for reverse causality. Second, participants in WHS are older female healthcare professionals, and thus, similar analyses in other populations, including in men and younger individuals, are needed. Health behaviors of female health professionals might differ from those of other populations. For example, as noted, physical activity levels tend to be greater among participants in the WHS, albeit this would tend to underestimate any observed differences noted in this analysis. Third, the stressors measured in the stress questionnaire are self-reported; however, the perceived experience of psychosocial stress likely represents the actual stress burden of the participant, because it is an individual's perception of a stressor and response to it that influences their physiological response or health outcome via the inflammatory, neurohormonal, and autonomic regulatory systems.[5] Additionally, although the WHS consists of a mailed survey, and other variables such as hypertension and diabetes mellitus are self-reported, the validity of these self-reported variables within the WHS has had >90% accuracy with physician diagnosis.[23–26] Weight as a self-reported variable has been validated in other cohorts.[44] Fourth, ≈42% and 35% of variables related to work and relationship were missing, likely because many of the women were

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older retirees. However, sensitivity analyses revealed that our results without these missing data were similar. Fifth, the dietary questionnaire (2004) was conducted 7 years before the stress questionnaire (2012–2013), and thus, dietary patterns of these women could have changed over time. We are unable to correct for this limitation but note that there have been several published reports from the WHS using these same diet data that accurately predict disease risk.[45–47] Finally, we cannot account for unmeasured confounders.

In conclusion, these data show that although ICH varied by race/ethnicity among female health professionals participating in the WHS, the association between race/ethnicity and ICH was unattenuated by our joint assessment of acute and chronic stressors or by SES as measured by income and education. Our results are intriguing and suggest that other pathways likely contribute to racial/ethnic differences in ICH within the WHS. Additionally, it is uncertain whether our findings are cohort-specific, and thus, similar work in other populations is required. To the best of our knowledge, data regarding this topic remain sparse. Future work must include prospective analyses about the interplay between race/ethnicity, CPS, and CVD risk, because neither behavior at the individual level nor policy interventions intended to reduce CVD risk currently incorporate psychosocial stressors.

CONCLUSIONS

In a cohort of older women, lifetime stress (as defined by acute and chronic stressors) and ICH varied by race/ethnicity. CPS and SES did not account for the racial/ethnic differences in ICH. These data support the need for additional work that addresses the joint impact of multiple social determinants of health, such as psychosocial stress, on CVD in diverse populations.

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Disclosures

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