ann. behav. med. (2021) 55:266–279
DOI: 10.1093/abm/kaaa050

REGULAR ARTICLE

Experiences of Discrimination Are Associated With Worse Metabolic Syndrome Severity Among African Americans in the Jackson Heart Study

Michelle I. Cardel, PhD, MS, RD[1] · Xiaofei Chi, MS[1] · Yuan-I Min, PhD[2] · Mario Sims, PhD, MS[2] · Solomon K. Musani, PhD[2] · Akilah Dulin, PhD[3] · Clarence C. Gravlee, PhD[4] · Steven M. Smith, PharmD, MPH[5] · Mark D. DeBoer, MD[6] · Matthew J. Gurka, PhD[1]

Published online: 20 July 2020

Abstract

Background Metabolic syndrome (MetS) is a risk factor for the development of cardiovascular disease and type 2 diabetes. Although the development of MetS is attributed to known lifestyle factors, perceived discrimination may also contribute to MetS development and severity.

Purpose We examined the associations of perceived discrimination with MetS severity among African American adults at baseline and 8-year follow-up.

Methods Three thousand eight hundred and seventy participants (mean age 53.8 ± 13.0; 63.1% female) without diabetes and no missing MetS severity scores at baseline were included. Each self-reported measure of discrimination at baseline (everyday, lifetime, and burden of lifetime) was classified into tertiles (low, medium, high). After adjustment for demographics and MetS risk factors, associations of discrimination were examined with a sex- and race/ethnicity-specific MetS severity *Z*-score. We employed a mixed model approach that allowed for the assessment of an overall association between reported discrimination at baseline and MetS severity, and for the possible change over time.

Results Sex and age differences were observed in experiences with discrimination, such that men reported higher levels of all aspects of discrimination relative to women. Everyday discrimination decreased with age, whereas lifetime discrimination increased with age ($p < .05$). Independent of lifestyle and demographic factors, everyday and lifetime discrimination were significantly associated with MetS severity ($p = .003$ and $p = .017$, respectively) and the associations remained constant over the 8 years (i.e., no interaction with time).

Conclusions Our results suggest that, in a large community-based sample of African Americans, discrimination is a salient psychosocial risk factor for severity of MetS.

Keywords: Discrimination · African Americans · Metabolic syndrome · Adults · Psychosocial

✉ Michelle I. Cardel
mcardel@ufl.edu

1 Department of Health Outcomes and Biomedical Informatics, University of Florida, PO Box 100177, Gainesville, FL 32610-0177, USA

2 Department of Medicine, University of Mississippi Medical Center, 2500 N. State St., Jackson, MS 39216, USA

3 Department of Behavioral and Social Sciences, Brown University School of Public Health, Box G-S121-4, 121 S. Main St., Providence, RI 02912, USA

4 Department of Anthropology, University of Florida, Turlington Hall, Room B370, Gainesville, FL 32610, USA

5 Department of Pharmacotherapy and Translational Research, University of Florida, PO Box 100495, Gainesville, FL 32610-0495, USA

6 Department of Pediatrics, University of Virginia Health System, PO Box 800386, Charlottesville, VA 22908-0386, USA

Introduction

Metabolic syndrome (MetS), a clustering of cardiometabolic risk factors that includes abdominal adiposity, hypertension, hyperglycemia, and dyslipidemia [1], is a risk factor for the development of type 2 diabetes and cardiovascular disease (CVD). Individuals with MetS are five times more likely to develop type 2 diabetes

[2] and twice as likely to develop CVD [3]. African Americans (AA) have slightly higher rates of MetS than the general population [4], and in the largest prospective study of CVD among AA, approximately one in three participants was classified as having MetS [5]. Although the development of MetS is partly explained by known risk factors (e.g., poor diet, physical inactivity, smoking, low education) [6, 7], evidence suggests that psychosocial factors are also associated with MetS development and severity.

Perceived discrimination is a psychosocial factor associated with worse health outcomes, particularly among AA adults [8–14]. For example, previously published work has indicated that discrimination is associated with prevalent hypertension, chronic stress, decreased ability to control anger, and greater allostatic load [8, 14–17]. This work demonstrates that both incidents of unfair treatment and the magnitude of burden those incidents caused are associated with poor health outcomes that increase cardiometabolic risk. People who report experiencing discrimination are also more likely to engage in adverse health behaviors that negatively affect cardiometabolic risk (e.g., increased smoking, overeating, higher fat consumption, physical inactivity) [18–20]. Furthermore, self-reported everyday discrimination has been correlated with indicators of weight status including higher body mass index and higher waist circumference [9]. Moreover, two recently conducted studies, one of women's health using longitudinal cohort data from a diverse U.S. sample and the other using data from a sample of AA adults, found that one measure of discrimination, everyday discrimination, contributed to greater incidence of MetS among racially/ethnically diverse middle-aged women and higher allostatic load among AA adults [12, 14]. Thus, with potential contributors including unhealthy coping mechanisms often used as a response to experiences of discrimination [9], perceived discrimination is a potential risk factor for increased weight status and related risk factors for CVD and may differ by sex. Additionally, previous work demonstrates that individuals report less everyday discrimination as they age [21–23]. Though age is consistently cited as an important predictor of MetS [24, 25], we are not aware of any studies that have stratified the relationship between discrimination and cardiovascular markers by age.

Most studies investigating the role of discrimination in health outcomes have only used a single measure [12, 26]. However, discrimination is a multifactorial construct and multiple measures are likely needed to better capture the relationships between discrimination and health [27]. The mechanisms underlying the relationship between perceived discrimination and MetS are likely multifactorial. Despite AA adults experiencing significant discrimination [27], limited research has been conducted on the influence of self-reported discrimination on MetS outcomes in large samples of AA. Additionally, most research has been cross-sectional and has focused on the incidence of CVD risk factors resulting from discrimination, rather than MetS outcomes, including MetS severity [8, 28, 29]. Thus, the objective of this study was to examine the associations of three separate constructs of discrimination (lifetime, everyday, and lifetime burden), better informing the multifactorial construct of discrimination [27], with severity of MetS among a large sample of AA adults of varying ages. We hypothesized that AA adults who report higher levels of discrimination will demonstrate increased MetS severity at baseline and a worsening of MetS severity over a median of 8-year follow-up.

Methods

Study Population

Data were utilized from a large, community-based cohort study investigating cardiovascular health among AA adults 21–95 years of age in a metropolitan area in the southern United States. 5,306 total participants (63.3% female) were recruited between 2000 and 2004. Further details of recruitment and study design have previously been published elsewhere [30–32]. Institutional Review Board (IRB) approval was granted and all participants consented to participate in the study. Data were gathered at three visits with visit 1 (baseline) occurring between 2000 and 2004, visit 2 occurring between 2005 and 2008, and visit 3 occurring between 2009 and 2013. Data collected on 3,870 nondiabetic participants with MetS severity *Z*-scores at visit 1 were utilized to evaluate the cross-sectional association between discrimination and MetS severity. Data collected on 2,711 participants who had no diabetes at visit 1 and with MetS severity *Z*-scores from both visit 1 and visit 3 were utilized to evaluate the change in MetS severity over time. Sample sizes for each analysis may vary due to missing data.

Discrimination Measures

During visit 1, home and clinic interviews were conducted to gather baseline information from participants. During this process, trained AA interviewers administered questionnaires to collect demographic and behavioral information including physical activity, smoking status, alcohol consumption, and dietary intake [32]. The questionnaires included an instrument to assess reactions to and experiences with self-reported discrimination [33].

The instrument was completed by 96% of participants in the study and was given during visit 1. It measures both self-reported everyday and lifetime discrimination through a series of questions. Everyday discrimination was determined using an adapted version of the Williams scale [34] with inquiries assessing daily experiences of being treated with less respect and less courtesy than others, as well as frequency of others acting as if you are dishonest or threatening. Scores for each of the nine responses ranged from 1 (never) to 7 (several times per day), and the mean of all nine items was calculated as the everyday discrimination score. Instrument consistency and validity were established through Cronbach α calculations of internal consistency and confirmatory factor analysis. The instrument overall α = .78, .84, and .77 for the everyday and lifetime subscales.

Lifetime discrimination was assessed by asking participants about incidents of unfair treatment in their lifetime across nine different areas of interest using an adaptation from Krieger and Sidney (α = .78) [35, 36]. Areas assessed for experiences of unfair treatment included at school, getting a job, at work, getting housing, getting resources or money, getting medical care, on the street or at another public place, and getting services (scored 0 or 1). The count of unfair treatment across all domains (0–9) was reported as the lifetime discrimination score. If participants reported experiencing lifetime discrimination in at least one area, burden of lifetime discrimination was then measured using the following questions: "When you had experiences like these over your lifetime, have they been—very stressful, moderately stressful, or not stressful?", "Overall, how much has discrimination interfered with you having a full and productive life?", and "Overall, how much harder has your life been because of discrimination?" Each response was coded using a continuous 1 (low burden) to 4 (greater burden) score. The mean score of the responses to these three questions was calculated to represent the burden of lifetime discrimination. Moderate internal consistency was demonstrated (α = .63).

Covariates Measured

Socioeconomic status was measured by education and income level of each participant. Educational attainment was classified into three categories including: less than high school (<HS), high school graduate or GED equivalency through 1 to 3 years of college (HS4-C1–3), and college graduate or more (C4+ years). Income was divided into four categories based on family size, U.S. Census poverty levels, and year of baseline clinic visit (2000–2004): poor (less than federal poverty level), lower-middle (1–1.5 times the federal poverty level), upper-middle (more than 1.5, but less than 3.5 times the federal poverty level), and affluent (3.5 or more times the federal poverty level). Additional covariates included sex, age (continuous), smoking status, alcohol consumption, physical activity, and dietary intake.

Smoking status was categorized based on American Heart Association (AHA) classifications as never smoked or quit ≥12 months ago, quit <12 months ago, or current smoker. Alcohol consumption was defined as a binary response as to whether or not alcohol was consumed in the past 12 months. If respondents indicated alcohol was consumed in the past 12 months, the average number of drinks per week was assessed and recorded as a continuous variable. Physical activity and dietary intake of each participant were also categorized according to AHA using the Life's Simple 7 cardiovascular health status metrics [37]. Levels of nutritional health were split into ideal, intermediate, or poor as measured by the AHA recommended [38] components in a participant's diet. The five components of the recommendations are consumption of ≥4.5 cups/day of fruits and vegetables, ≥2 servings/week of fish, ≥3 servings/day of whole grains, no more than 36 oz/week of sugar-sweetened beverages, and no more than 1,500 mg/day of sodium. The presence of four to five recommended dietary components indicates ideal nutritional health, whereas the presence of two to three recommended dietary components indicates intermediate and zero to one indicate poor nutritional health. Physical activity was measured as ideal when participants completed ≥150 min/week of moderate physical activity or ≥75 min/week of vigorous activity or a combined ≥150 min/week of moderate and vigorous activity. Intermediate physical activity was indicated if 1–149 min/week of moderate or 1–74 min/week of vigorous activity or 1–149 min/week of combined moderate and vigorous activity [39]. Furthermore, participants were characterized as having poor physical activity if no physical activity was reported. These covariates may confound the association between discrimination and MetS; thus, results are displayed using linear modeling with and without covariate adjustment in three different models.

MetS Classification and *Z*-Score

Adult ATP-III criteria was used to define traditional MetS [1]. Those with three or more of the following five criteria were classified as having MetS: triglyceride concentration ≥ 1.69 mmol/L (150 mg/dL), high-density lipoprotein cholesterol < 1.04 mmol/L (40 mg/dL) for males and < 1.3 mmol/L (50 mg/dL) for females, waist circumference ≥ 102 cm for males and ≥ 88 cm for females, concentration of glucose ≥ 5.55 mmol/L (100 mg/dL), and systolic blood pressure ≥ 130 mm Hg or diastolic blood pressure ≥ 85 mm Hg [1].

MetS severity *Z*-score was calculated with previously published formulas using confirmatory factor analysis [24, 25]. Weighted contribution to a latent MetS "factor" of each of the standard components previously mentioned [1] was determined on a sex- and race/ethnicity-specific basis. Data from the National Health and Nutrition Examination Survey (NHANES) were utilized to conduct the confirmatory factor analysis of adults ages 20–64 [25] and divided into six subgroups based on sex and self-identified race/ethnicity including: non-Hispanic white, non-Hispanic black, and Hispanic. Loading coefficients for each MetS component were determined toward a single MetS factor for each of the six subgroups. These were then used to calculate equations of a standardized MetS severity score for each population subgroup (http://mets.health-outcomes-policy.ufl.edu/calculator/). The *Z*-scores (with 99.75% of values between the range of −3 to 3) indicate relativity of MetS severity based on sex and race/ethnicity specifications with higher scores designating greater severity of MetS. Changes in MetS severity were calculated as the difference of MetS *Z*-scores at visit 1 minus MetS *Z*-scores at visit 3. A positive change indicates a decrease in MetS severity over time.

Statistical Analysis

Baseline characteristics assessed during visit 1 were examined by age (21–44, 45–64, and ≥ 65) and sex. Categorical and continuous variables were analyzed across sexes and age categories using chi-square or analysis of variance, respectively. Due to the previously published limitations of using Likert-scale variables to assess discrimination and the challenges associated with using discrimination as a continuous variable [10, 40], measures of discrimination were stratified into tertiles indicating low, medium, and high discrimination. Because the three discrimination measures were not all on the same ordinal scale, this tertile approach also allowed for comparisons of MetS associations across the three discrimination measures. Linear mixed models were used to directly model mean MetS *Z*-scores at the two visits (visit 1 and visit 3), while also modeling the correlation between the two visits. These models were fit separately for each of the three discrimination measures. For each discrimination measure, three models were fit to investigate the effects of covariates on the association between discrimination and MetS severity. Model 1 adjusted for age and sex; model 2 adjusted for model 1 covariates plus education (<HS/HS4-C1–3/C4+); and model 3 adjusted for model 2 covariates + nutrition (poor heath/other), physical activity (poor/intermediate/ideal health), smoking status (current smoker/other), and alcohol consumption (number of drinks per week). Interactions between sex and age were also explored with additional models, using the "model 3" covariate framework. The above modeling approach used all 3,870 individuals with complete data at baseline; many of the individuals did not have visit 3 MetS *Z* data. Mixed models are valid if data are missing at random, which we find to be plausible here. However, as a sensitivity analysis, we repeated our models described above for only those who had complete data at both visits 1 and 3 to allow for comparisons. An additional analysis of prevalence of ATP-III MetS was analyzed and compared across discrimination tertiles at visit 1. All analyses were conducted with SAS 9.4 (SAS Institute Inc., Cary, NC).

Results

Sample Characteristics

Characteristics of participants are displayed in Table 1 and include overall sample characteristics, as well as those stratified by sex and by age. Participants' mean age was 53.8 (± 13.0) years with 63.1% of participants being female. At 49.8%, the category including those who completed high school and up to 3 years of college was the most common level of education among participants, whereas 15.4% of participants had less than a high school education and 34.8% identified as completing 4 years of college or more. Affluence was most common among participants (32.9%), whereas 29.9% of participants were identified in the upper-middle-income level, 23.3% of participants in the lower-middle-income level, and 14.0% were categorized in the poor-income level.

Eighty-five percent of this cohort has never smoked or quit smoking ≥12 months ago and 13.3% were current smokers. Poor nutritional health status (60.3%) and poor physical activity status (46.2%) were the most common categorizations of JHS participants based on AHA criteria [39], while only 0.8% of the cohort had ideal nutritional status and 21.0% had ideal physical activity status.

Discrimination scores for the total sample indicated means of 2.09 (± 1.01) for everyday discrimination, 3.00 (± 2.13) for lifetime discrimination, and 2.33 (± 0.77) for burden of lifetime discrimination. When stratifying by sex, males reported significantly more discrimination when compared with females at all levels of discrimination including everyday (2.17 vs. 2.04, $p = .0003$), lifetime (3.24 vs. 2.86, $p < .0001$), and burden of lifetime discrimination (2.36 vs. 2.31, $p = .0488$). Incidences of everyday discrimination consistently decreased as age increased, with those aged 21–44 reporting 2.33 (± 1.05), aged 45–64 reporting 2.12 (± 1.01), and 65+ reporting 1.70 (± 0.80). Lifetime discrimination differed by age ($p < .0001$), with those aged 21–44 reporting 3.16 (± 2.08),

Table 1. Participant characteristics

	Overall	By sex			By age			
		Females	Males	*p*-value[a]	21–44	45–64	65+	*p*-value[b]
N	3,870	2,441	1,429		1,087	1,965	818	
Demographics								
Age, mean (*SD*)	53.8 (13.0)	54.2 (13.0)	53.1 (13.0)	**.0136**	38.2 (5.7)	55.0 (5.9)	71.6 (5.1)	**<.0001**
Sex (%female)	63.1	-	-	-	61.7	62.8	65.5	.2211
SES/lifestyle factors								
Education (%)								
<High school	15.4	14.9	16.2	.5026	3.7	11.7	39.8	**<.0001**
High school 4–college 3	49.8	50.4	48.8		60.7	49.3	36.4	
College 4+	34.8	34.7	35.0		35.6	39.0	23.8	
Income (%)								
Poor	14.0	16.6	9.6	**<.0001**	16.4	10.3	19.5	**<.0001**
Lower-middle	23.3	24.9	20.6		19.3	19.7	37.0	
Upper-middle	29.9	30.8	28.2		36.4	29.5	21.9	
Affluent	32.9	27.7	41.7		27.9	40.5	21.6	
Cigarette smoking (AHA categorization) (%)								
Never smoked/ quit ≥ 12 month ago	85.5	88.4	80.6	**<.0001**	84.6	84.0	90.4	**<.0001**
Quit < 12 month ago	1.2	1.2	1.2		1.9	1.0	0.8	
Current smoker	13.3	10.5	18.2		13.6	15.0	8.8	
Alcohol consumption								
Alcohol drinking in the past 12 months (%)	49.1	41.9	61.5	**<.0001**	63.7	49.4	29.3	**<.0001**
Average number of drinks per week, mean (*SD*)	1.8 (5.8)	0.7 (3.4)	3.5 (8.2)	**<.0001**	2.4 (7.1)	1.8 (5.7)	0.8 (3.4)	**<.0001**
Nutrition (AHA categorization) (%)								
Ideal health	0.8	0.9	0.6	**.0051**	0.2	0.8	1.5	**<.0001**
Intermediate health	38.9	40.8	35.5		28.8	40.9	46.6	
Poor health	60.3	58.3	63.8		71.0	58.2	51.9	
Physical activity (AHA categorization) (%)								
Ideal health	21.0	18.2	25.8	**<.0001**	26.2	20.8	14.6	**<.0001**
Intermediate health	32.8	34.3	30.1		38.2	32.3	26.7	
Poor health	46.2	47.5	44.1		35.6	46.9	58.8	
Discrimination, mean (*SD*)								
Everyday discrimination	2.09 (1.01)	2.04 (1.00)	2.17 (1.06)	**.0003**	2.33 (1.05)	2.12 (1.01)	1.70 (0.80)	**<.0001**
Median (IQR)	1.89 (1.33, 2.67)	1.78 (1.33, 2.56)	2.00 (1.33, 2.76)		2.11 (1.56, 2.89)	1.89 (1.33, 2.67)	1.44 (1.00, 2.00)	

Table 1. Continued

	Overall	By sex			By age			
		Females	Males	*p*-value[a]	21–44	45–64	65+	*p*-value[b]
Lifetime discrimination	3.00 (2.13)	2.86 (2.09)	3.24 (2.16)	**<.0001**	3.16 (2.08)	3.20 (2.15)	2.33 (2.00)	**<.0001**
Median (IQR)	3 (1, 4)	3 (1, 4)	3 (2, 5)		3 (2, 5)	3 (2, 5)	2 (1, 4)	
Discrimination burden	2.33 (0.77)	2.31 (0.77)	2.36 (0.76)	**.0488**	2.21 (0.75)	2.39 (0.77)	2.34 (0.80)	**<.0001**
Median (IQR)	2.17 (1.67, 2.83)	2.17 (1.67, 2.83)	2.33 (1.83, 2.83)		2.17 (1.67, 2.83)	2.33 (1.83, 2.83)	2.33 (1.67, 2.83)	
Health measures, mean (*SD*)								
BMI	31.1 (7.1)	32.1 (7.5)	29.3 (6.0)	**<.0001**	31.8 (8.0)	31.2 (6.9)	29.8 (6.1)	**<.0001**
Waist circumference	98.5 (15.6)	98.0 (16.1)	99.4 (14.8)	**.0057**	97.3 (17.2)	98.9 (15.2)	99.0 (14.4)	**.0138**
SBP	126.4 (16.8)	125.7 (17.0)	127.6 (16.3)	**.0006**	118.5 (13.2)	127.3 (15.8)	134.7 (18.6)	**<.0001**
DBP	76.2 (8.7)	74.9 (8.5)	78.5 (8.6)	**<.0001**	75.7 (8.6)	77.5 (8.3)	73.7 (9.0)	**<.0001**
Triglycerides	99.8 (66.4)	94.2 (51.7)	109.4 (85.0)	**<.0001**	89.4 (60.4)	104.3 (74.0)	102.9 (51.4)	**<.0001**
HDL	52.4 (14.8)	55.8 (14.8)	46.5 (12.8)	**<.0001**	49.8 (13.1)	52.5 (14.9)	55.3 (16.0)	**<.0001**
Glucose	90.4 (8.9)	89.8 (9.1)	91.5 (8.6)	**<.0001**	86.9 (7.7)	91.2 (9.0)	93.2 (8.9)	**<.0001**
Cortisol	9.6 (4.1)	8.8 (3.9)	11.0 (4.0)	**<.0001**	9.1 (4.1)	9.6 (4.1)	10.4 (3.8)	**<.0001**
hsCRP	0.48 (0.90)	0.6 (0.8)	0.3 (1.1)	**<.0001**	0.4 (0.7)	0.5 (1.0)	0.5 (0.8)	.2997[c]
ATP-III MetS status (%)	21.5	22.7	19.5	**.0222**	13.2	23.7	27.4	**<.0001**
MetS severity score *Z*-score	−0.070 (0.72)	−0.073 (0.73)	−0.064 (0.70)	.7292	−0.253 (0.76)	−0.016 (0.70)	0.046 (0.67)	**<.0001**

AHA American Heart Association; *BMI* body mass index; *DBP* diastolic blood pressure; *IQR* interquartile range; *HDL* high-density lipoproteins; *hsCRP* high-sensitivity C-reactive protein; *SBP* systolic blood pressure; *SES* socioeconomic status.

[a]*t*-test for continuous variables, chi-square tests for categorical variables.

[b]ANOVA for continuous variables, chi-square tests for categorical variables.

[c]$p = .0002$ by Kruskal–Wallis test.

aged 45–64 reporting 3.20 (± 2.15), and 65+ reporting 2.33 (± 2.00). Burden of lifetime discrimination significantly differed by age ($p < .0001$), with younger groups (ages 21–44) reporting significantly more discrimination than their older counterparts (45–64 and 65+).

In the total sample, MetS prevalence as defined by ATP-III was 21.5%, with significant differences in the sample by sex ($p = .0222$) and by age ($p < .0001$). The greatest prevalence of ATP-III MetS in JHS participants was seen in those ages 65+ (27.4%) and in females (22.7%). MetS severity *Z*-scores were shown to significantly increase by age ($p < .0001$), but did not differ by sex ($p = .7292$).

Cross-sectional and Longitudinal Relationships Between Self-reported Discrimination, ATP-III MetS Status, and MetS Severity

Table 2 includes all models of MetS severity association with reported levels of discrimination at visit 1. After adjustment for age, sex, education, nutrition, physical activity, smoking status, and alcohol consumption (model 3), an overall association between everyday discrimination and MetS severity was observed ($p = .0026$); this association did not vary over time (interaction $p = .1644$). Consistent across both visits, higher MetS severity to some degree was observed with increasing levels of everyday discrimination. Similar results were observed for lifetime discrimination (Model 3 main effect $p = .0169$). Low levels of lifetime discrimination were associated with lower levels of MetS severity, whereas medium and high levels of lifetime discrimination were associated with worse MetS severity at both visits. There was no significant association between burden of lifetime discrimination and MetS severity in any model.

Table 3 includes associations between self-reported discrimination and severity of MetS at baseline and over 8-year follow-up stratified by age categories, including covariates that were included in "model 3" described earlier. For all three measures, age × discrimination interactions were significant ($p < .0001$), justifying the stratification. In the middle-aged group (45–64 years), overall associations between everyday discrimination and lifetime discrimination and MetS severity were observed; these associations did not vary

Table 2. Linear mixed models on MetS severity (overall)

	Model 1				Model 2				Model 3			
	Mean *Z*-score (95% CI)		*p*-value		Mean *Z*-score (95% CI)		*p*-value		Mean *Z*-score (95% CI)		*p*-value	
	Visit 1	Visit 3	Disc main effect	Disc × visit interaction	Visit 1	Visit 3	Disc main effect	Disc × visit interaction	Visit 1	Visit 3	Disc main effect	Disc × visit interaction
Everyday discrimination tertile *n*, mean ± *SD*			.0603	.2162			**.0388**	.2449			**.0026**	.1644
Low *n* = 1,275 1.15 ± 0.17	−0.10 (−0.14, −0.06)	0.10 (0.04, 0.15)			−0.10 (−0.14, −0.06)	0.09 (0.04, 0.15)			−0.16 (−0.21, −0.11)	0.03 (−0.03, 0.09)		
Median *n* = 1,336 1.91 ± 0.24	−0.06 (−0.10, −0.02)	0.14 (0.09, 0.19)			−0.05 (−0.10, −0.01)	0.15 (0.09, 0.20)			−0.09 (−0.14, −0.04)	0.11 (0.05, 0.17)		
High *n* = 1,182 3.32 ± 0.82	−0.05 (−0.09, 0.00)	0.19 (0.14, 0.25)			−0.04 (−0.09, 0.00)	0.19 (0.14, 0.25)			−0.08 (−0.13, −0.02)	0.17 (0.10, 0.23)		
Lifetime discrimination tertile			**.0493**	.0782			**.0093**	.0909			**.0169**	.1167
Low *n* = 1,640 1.04 ± 0.83	−−0.09 (−0.12, −0.05)	0.10 (0.06, 0.15)			−0.10 (−0.13, −0.06)	0.10 (0.05, 0.14)			−0.13 (−0.18, −0.08)	0.06 (0.00, 0.11)		
Median *n* = 1,167 3.46 ± 0.50	−0.05 (−0.09, −0.01)	0.20 (0.15, 0.25)			−0.04 (−0.09, 0.00)	0.20 (0.15, 0.26)			−0.08 (−0.14, −0.03)	0.16 (0.10, 0.23)		
High *n* = 921 5.93 ± 1.02	−0.04 (−0.09, 0.00)	0.15 (0.09, 0.21)			−0.02 (−0.07, 0.03)	0.17 (0.10, 0.23)			−0.07 (−0.13, −0.01)	0.13 (0.06, 0.20)		
Discrimination burden tertile			.3052	.4892			.3584	.4932			.4602	.5496
Low *n* = 1,115 1.50 ± 0.34	−0.05 (−0.09, −0.01)	0.19 (0.13, 0.24)			−0.05 (−0.09, 0.00)	0.19 (0.13, 0.24)			−0.09 (−0.14, −0.03)	0.15 (0.08, 0.22)		
Median *n* = 1,005 2.34 ± 0.19	−0.07 (−0.12, −0.03)	0.12 (0.07, 0.18)			−0.06 (−0.11, −0.02)	0.13 (0.07, 0.19)			−0.10 (−0.16, −0.04)	0.10 (0.03, 0.17)		
High *n* = 1,048 3.20 ± 0.39	−0.03 (−0.08, 0.01)	0.17 (0.12, 0.23)			−0.03 (−0.07, 0.02)	0.18 (0.12, 0.24)			−0.06 (−0.12, 0.00)	0.15 (0.08, 0.18)		

Low first tertile; *median* second tertile; *high* third tertile; *CI* confidence interval; *disc* discrimination. Model 1 covariates: Individual discrimination score (by tertile), age, sex; Model 2 covariates: Model 1 covariates + education (<HS/HS–some college/college graduate); Model 3 covariates: Model 2 covariates + nutrition (poor heath/other), physical activity (poor/intermediate/ideal health), smoking status (current smoker/other), alcohol consumption (number of drinks per week).

Table 3. Linear mixed models on MetS severity by age (model 3)

	21–44 years					45–64 years					65+ years					
		Mean *Z*-score (95% CI)		*p*-value			Mean *Z*-score (95% CI)		*p*-value			Mean *Z*-score (95% CI)		*p*-value		*p*-value
	N	Visit 1	Visit 3	Disc main effect	Disc × visit interaction	*N*	Visit 1	Visit 3	Disc main effect	Disc × visit interaction	*N*	Visit 1	Visit 3	Disc main effect	Disc × visit interaction	Age × disc interaction
Everyday discrimination tertile				.6713	.5624				**.0235**	.6292				**0.0233**	0.2688	**<.0001**
Low	428	−0.21 (−0.36, −0.07)	0.19 (0.02, 0.35)			1,074	−0.07 (−0.14, 0.01)	0.11 (0.02, 0.20)			621	−0.14 (−0.25, −0.03)	−0.10 (−0.23, 0.02)			
Median	647	−0.19 (−0.33, −0.05)	0.17 (0.02, 0.32)			1,200	0.02 (−0.05, 0.09)	0.21 (0.13, 0.30)			436	−0.13 (−0.25, −0.01)	−0.17 (−0.31, −0.03)			
High	742	−0.23 (−0.36, −0.07)	0.11 (−0.03, 0.26)			1,097	0.02 (−0.05, 0.10)	0.24 (0.15, 0.33)			213	0.02 (−0.13, 0.17)	0.10 (−0.08, 0.27)			
Lifetime discrimination tertile				.9104	.4100				**.0151**	.5052				0.6042	0.6494	**<.0001**
Low	734	−0.22 (−0.36, −0.09)	0.14 (−0.01, 0.28)			1,524	−0.05 (−0.12, 0.02)	0.13 (0.04, 0.21)			703	−0.11 (−0.22, 0.00)	−0.11 (−0.24, 0.01)			
Median	575	−0.22 (−0.36, −0.07)	0.18 (0.03, 0.34)			1,228	0.04 (−0.03, 0.11)	0.27 (0.18, 0.36)			340	−0.09 (−0.21, 0.04)	−0.04 (−0.19, 0.11)			
High	483	−0.20 (−0.34, −0.05)	0.12 (−0.04, 0.28)			1,032	0.03 (−0.05, 0.11)	0.22 (0.12, 0.32)			200	−0.07 (−0.22, 0.09)	−0.03 (−0.21, 0.16)			
Discrimination burden tertile				.7373	.5339				.3694	.3597				0.2799	0.0520	**<.0001**
Low	662	−0.19 (−0.34, −0.04)	0.17 (0.01, 0.33)			904	0.00 (−0.08, 0.07)	0.25 (0.15, 0.34)			418	0.00 (−0.14, 0.14)	−0.09 (−0.25, 0.07)			
Median	492	−0.16 (−0.32, 0.00)	0.16 (−0.01, 0.34)			948	0.00 (−0.08, 0.07)	0.19 (0.09, 0.28)			374	−0.11 (−0.24, 0.03)	−0.08 (-0.23, 0.07)			
High	428	−0.25 (−0.40, −0.10)	0.15 (−0.03, 0.32)			1,043	0.06 (−0.01, 0.14)	0.25 (0.16, 0.34)			400	−0.01 (−0.15, 0.14)	0.05 (−0.11, 0.21)			

Low first tertile; *median* second tertile; *high* third tertile; *CI* confidence interval; *disc* discrimination. Model 3 covariates: Individual discrimination score (by tertile), sex, education (<HS/HS–some college/college graduate), nutrition (poor heath/other), physical activity (poor/intermediate/ideal health), smoking status (current smoker/other), and alcohol consumption (number of drinks per week).

by visit. Similar trends described above for the overall sample were observed in the middle-aged group, with higher levels of discrimination associated with worse MetS severity. In the oldest age group (65+ years), only everyday discrimination was associated with MetS severity. Reported levels of high everyday discrimination had higher levels of MetS severity related to low and medium everyday discrimination across both visits. No associations between any of the discrimination measures and MetS severity were observed for the younger age group (21–44 years).

Table 4 includes associations between self-reported discrimination and severity of MetS at baseline stratified by sex. Among females, both everyday and lifetime discrimination were associated with MetS severity overall, and these associations did not vary over the two visits. No associations between self-reported levels of discrimination and MetS severity were observed among males. However, interactions between sex and the self-reported discrimination measures were not significant; thus, no definitive conclusions can be made regarding sex differences in this context.

Table 5 shows the unadjusted prevalence of ATP-III MetS by levels of discrimination at baseline. Everyday, lifetime, and burden of lifetime discrimination were not associated with prevalence of ATP-III MetS at baseline. No significant associations with self-reported discrimination of any kind were found when stratified by sex or by age at baseline (data not shown).

The above results arise from those individuals who have complete data at least at visit 1 (n = 3,870), but who may be missing visit 3 MetS severity. A sensitivity analysis was performed to replicate all of the above analyses with only those individuals with complete covariate data at visit 1 as well as complete MetS data at both visits 1 and 3 (n = 2,711); these results are provided in Supplementary Tables 1b–4b. Results were consistent between the overall sample and the completers-only sample for the lifetime discrimination main effect. After adjustment for age, sex, education, nutrition, physical activity, smoking status, and alcohol consumption (model 3) in the completers-only overall sample represented in Supplementary Table 2b, lifetime discrimination main effect was associated with significantly worse (p = .0105) MetS severity over time. Consistency was demonstrated between the overall sample and the completers-only sample stratified by age (Supplementary Tables 3 and 3b) and by sex (Supplementary Tables 4 and 4b). Associations with everyday discrimination and MetS severity were similar in this completers-only sample, although the main effect from Model 3 was no longer significant (p = .0621).

Discussion

This study assessed multiple measures of discrimination to better capture the complexity of discrimination and investigated its relationship with severity of MetS among AA adults at baseline and over an 8-year period. To our knowledge, this is the first study to examine the influence of discrimination on MetS severity over time in a large sample of AA adults. We found that everyday and lifetime discrimination were significantly associated with MetS severity; these associations did not change over the 8-year span of the study. We also observed that these associations varied by age, with middle-aged adults exhibiting the strongest associations between everyday and lifetime discrimination and MetS severity. Though males reported significantly greater discrimination for all measures of discrimination, the interactions between sex × discrimination on MetS severity were not significant.

Independent of demographic and lifestyle factors known to contribute to MetS [6, 7], everyday and lifetime measures of discrimination main effects were significantly associated with MetS severity. However, burden of lifetime discrimination was not associated with MetS severity. This suggests that both the level and occurrence of discrimination (everyday vs. lifetime) are important for predicting MetS severity among AA adults. This is consistent with the evidence suggesting that discrimination can lead to worse health outcomes for AA adults [8, 9, 12, 18, 41, 42]. Specifically, perceived discrimination has an adverse association with markers of cardiovascular health among AA adults including hypertension [8], weight status [9], coronary artery calcification [43], subclinical carotid artery disease [10, 44], and allostatic load [17]. Findings in this study parallel the existing literature regarding the relationship between discrimination and allostatic load, a health outcome designed to assess cumulative physiological dysregulation similar to MetS severity [16, 17]. However, the relationship between self-reported discrimination and MetS is not limited to AA adults. A positive association between self-reported discrimination and MetS has also been observed in other racial/ethnic minority populations including South-Asian Surinamese, African Surinamese, and Moroccans while living in the Netherlands [26]. Moreover, incidences of racial discrimination are associated with reduced trust in physicians, as well as reduced adherence to medications among AA adults living with chronic disease [40, 45]. Physiological factors also play a role, with self-reported discrimination activating stress-related hypothalamus, pituitary, and adrenal glands' axis pathways [46], releasing high levels of stress-related hormones which can lead to wear and tear on the body and increased risk for CVD [46]. Additionally, researchers have observed a gene-by-environment interaction on vicarious racism on

Table 4. Linear mixed models on MetS severity by sex (model 3)

	Female					Male					
		Mean *Z*-score (95% CI)		*p*-value			Mean *Z*-score (95% CI)		*p*-value		*p*-value
	N	Visit 1	Visit 3	Disc main effect	Disc × visit interaction	*N*	Visit 1	Visit 3	Disc main effect	Disc × visit interaction	Gender × disc interaction
Everyday discrimination tertile				**.0008**	.2280				.6023	.4754	.5964
Low	1,405	−0.16 (−0.23, −0.09)	0.06 (−0.02, 0.14)			718	−0.11 (−0.20, −0.03)	0.02 (−0.09, 0.12)			
Median	1,474	−0.08 (−0.14, −0.01)	0.14 (0.06, 0.22)			809	−0.08 (−0.16, 0.01)	0.08 (−0.02, 0.18)			
High	1,211	−0.03 (−0.11, 0.04)	0.24 (0.16, 0.33)			841	−0.11 (−0.19, −0.02)	0.09 (−0.01, 0.18)			
Lifetime discrimination tertile				**.0009**	.0726				.6530	.7415	.1742
Low	1851	−0.13 (−0.20, −0.07)	0.07 (0.00, 0.15)			890	−0.10 (−0.17, −0.02)	0.05 (−0.05, 0.14)			
Median	1,262	−0.04 (−0.11, 0.03)	0.25 (0.17, 0.34)			742	−0.10 (−0.19, −0.02)	0.07 (−0.03, 0.17)			
High	908	−0.06 (−0.14, 0.02)	0.16 (0.07, 0.26)			690	−0.07 (−0.16, 0.02)	0.11 (0.00, 0.22)			
Discrimination burden tertile				.4603	.7770				.5729	.7834	.7304
Low	1,231	−0.08 (−0.16, −0.01)	0.17 (0.09, 0.26)			663	−0.06 (−0.15, 0.03)	0.14 (0.02, 0.25)			
Median	1,115	−0.09 (−0.16, −0.01)	0.14 (0.05, 0.23)			637	−0.09 (−0.18, 0.00)	0.06 (−0.05, 0.17)			
High	1,081	−0.04 (−0.12, 0.04)	0.20 (0.11, 0.29)			715	−0.06 (−0.15, 0.03)	0.11 (0.01, 0.22)			

Low first tertile; *median* second tertile; *high* third tertile; *CI* confidence interval; *disc* discrimination. Model 3 covariates: Individual discrimination score (by tertile), age, education (<HS/HS-some college/college graduate), nutrition (poor heath/other), physical activity (poor/intermediate/ideal health), smoking status (current smoker/other), and alcohol consumption (number of drinks per week).

Table 5. Prevalence of ATP-III MetS at visit 1 (overall; unadjusted)

	n	% (95% CI)[a]	*p*-value[b]
Everyday discrimination			.2690
Low (*n* = 1,275, 1.15 ± 0.17)	291	22.8 (20.6, 25.2)	
Median (*n* = 1,336, 1.91 ± 0.24)	287	21.5 (19.3, 23.8)	
High (*n* = 1,182, 3.32 ± 0.82)	238	20.1 (17.9, 22.5)	
Lifetime discrimination			.4431
Low (*n* = 1,640, 1.04 ± 0.83)	371	22.6 (20.6, 24.7)	
Median (*n* = 1,167, 3.46 ± 0.50)	241	20.7 (18.4, 23.1)	
High (*n* = 921, 5.93 ± 1.02)	197	21.4 (18.8, 24.2)	
Discrimination burden			.0736
Low (*n* = 1,115, 1.50 ± 0.34)	241	21.6 (19.2, 24.2)	
Median (*n* = 1,005, 2.34 ± 0.19)	199	19.8 (17.4, 22.4)	
High (*n* = 1,048, 3.20 ± 0.39)	251	24.0 (21.4, 26.7)	

Low first tertile; *median* second tertile; *high* third tertile; *CI* confidence interval.

[a]Clopper–Pearson (exact) confidence limits.

[b]Chi-square test.

blood pressure outcomes, highlighting a potential novel biological pathway for discrimination to affect health outcomes amongst AA [42]. Together, this suggests that experiencing discrimination can lead to worse cardiovascular outcomes for AA, both directly and indirectly, and that measures of everyday discrimination and lifetime discrimination may have prognostic value in identifying individuals at risk for adverse cardiovascular outcomes.

The relationships between perceived discrimination and MetS severity were similar in their consistency and magnitude to that seen for depressive symptoms scores as assessed using the Center for Epidemiologic Survey-Depression (CES-D) scores, which exhibited a similar rise in MetS severity by CES-D tertiles among females [5]. Additionally, U.S. society subjective social status (SSS) using the MacArthur Scale of SSS exhibited an inverse relationship with MetS severity both overall and in particular among females [47]. Together these findings provide a broader picture that AA individuals found in psychosocial evaluations to have a higher self-reported discrimination, more depressive symptoms or lower SSS should be considered for evaluation of MetS severity and associated disease status to provide an opportunity for earlier intervention to reduce future disease risk [48].

Experiences with perceived discrimination significantly differed by age. Incidences of everyday discrimination consistently decreased as people got older, but lifetime discrimination was higher among those aged 45+ when compared to those aged 21–44. Burden of lifetime discrimination significantly differed by age ($p < .0001$), with younger groups (ages 21–44 and 45–64) reporting significantly more discrimination than their older counterparts (65+). Previous work has also demonstrated that age was significantly inversely associated with every domain of everyday discrimination, including experiences with people being afraid of you, followed in stores, poor service, given less courtesy, perceptions that you are not smart, and people thinking they are better than you [21]. Taylor and colleagues found that in each case, younger AA men experience more everyday discrimination than their older counterparts [21]. Similar age-related findings have been reported among the general population [22], as well as among Hispanics/Latinos [23]. In our study, among those who are middle aged (45–64 years), both medium and high everyday discrimination was significantly associated with higher MetS severity. Furthermore, medium lifetime discrimination displayed a significantly higher MetS severity and was nearly significant at high lifetime discrimination among middle-aged AA adults. In individuals aged 65+, high everyday discrimination was associated with higher MetS severity, but not lifetime discrimination. When stratified by age, there were no significant associations between experiences with discrimination and MetS severity among AA young adults aged 21–44. Though age is consistently cited as an important predictor of MetS, we are not aware of any studies that have stratified the relationship between discrimination and cardiovascular markers by age, making these age-related findings novel. This work suggests that experiences with discrimination were not associated with MetS severity in young adults, but that discrimination may increase your risk for worse MetS as one gets older (age 45+). Alternatively, we recognize the possibility that there may be (a) cohort effects associated when describing discrimination (e.g., people in the 65+ group came of age when overt discrimination was more common and in some cases, legally sanctioned), (b) differences in coping, and/or (c) there may be differences in desirability bias across generations. It would be interesting to test these alternative hypotheses in future studies.

Men reported more discrimination than women at all levels of discrimination, including everyday, lifetime, and the lifetime burden of that discrimination. The observed sex differences are in line with previous work demonstrating AA men experience more discrimination when compared with AA women [13, 27, 49]. Though men reported significantly more discrimination, the interaction for the effect of sex and discrimination with MetS severity was not statistically significant. This differs slightly from the work of Assari and colleagues which observed that among AA, racial discrimination was associated with negative health consequences for both sexes, but black males experienced more physiological effects of an increase in racial discrimination over time [13]. However, their analyses simply stratified their models by sex and did not appear to test the interaction between sex and discrimination. When we simply stratified our models by sex, we observed that everyday and lifetime discrimination associations with MetS severity were shown to be significant in females, with no differences in this association observed over time. This is consistent with Moody and colleagues findings that women who experience everyday discrimination were at 33% greater risk for MetS incidence over a 14-year period and that racial/ethnic minorities (AA, Hispanic, and Japanese) were at higher risk than other racial/ethnic groups [12]. However, interactions between sex and the self-reported discrimination measures were not significant in our study; thus, no definitive conclusions can be made via sex differences in this context.

When examining MetS prevalence using ATP-III definitions, self-reported everyday, lifetime, and burden of lifetime discrimination were not associated with MetS. This highlights that using the adult ATP-III criteria to classify MetS status only takes into account the five physiological end points that define MetS and does not take into account factors that influence development of MetS including sex, race/ethnicity, and age [6, 7]. We propose that our MetS severity Z-score may be a more relevant measure than using ATP-III criteria alone because it allows for weighted contribution of each of these five clustered components to MetS severity on a sex- and race/ethnicity-specific basis.

This study has many strengths including the assessment of multiple components of discrimination, MetS-related variables, and demographic and lifestyle factors. It also includes data from the largest cohort study of CVD in AA and assesses measures including MetS severity at baseline and changes in MetS severity over an 8-year period. Additionally, not only was everyday and lifetime discrimination assessed, but burden of lifetime discrimination was also collected. Although previous studies assessing the association between perceived discrimination and health outcomes have analyzed the construct dichotomously [16], this research has expanded the measure to three separate variables within the construct of perceived discrimination. However, there are also some limitations that warrant discussion. First, the longitudinal nature of this study resulted in attrition over time and thus, a greater number of results for baseline measures of discrimination (everyday, lifetime, and burden) were obtained when compared with the number of results obtained 8 years later. Additionally, measures of health behaviors in this study were assessed by self-report only. More objective measures of chronic stress (e.g., hair cortisol) could be useful in delineating the underlying etiology relating self-reported discrimination and MetS severity. The study was also conducted in a single metropolitan area in the southern USA, potentially limiting its generalizability to AA adults beyond the southeastern region.

Conclusion

Our results suggest that, in a large community-based sample of AA, discrimination is a salient psychosocial risk factor for MetS severity and worsening of MetS severity over time. Given the high prevalence of both self-reported discrimination and MetS amongst AA adults, addressing discrimination as part of CVD risk interventions may have the potential to decrease MetS severity and thereby, adverse health consequences that result.

Supplementary Material

Supplementary material is available at *Annals of Behavioral Medicine* online.

Acknowledgements: The Jackson Heart Study is supported by contracts HHSN268201300046C, HHSN268201300047C, HHSN268201300048C, HHSN268201300049C, HHSN268201300050C from the National Heart, Lung, and Blood Institute (NHLBI) and the National Institute on Minority Health and Health Disparities (NIMHD). This work was supported by the National Institutes of Health National Heart, Lung, and Blood Institute (R01HL120960) and the National Center For Advancing Translational Sciences of the National Institutes of Health (UL1TR001427). The views expressed in this manuscript are those of the authors and do not necessarily represent the views of the National Heart, Lung, and Blood Institute; the National Institutes of Health; or the U.S. Department of Health and Human Services. Dr. Sims is supported by the grants P60MD002249 and U54MD008176 from the NIMHD. The authors wish to thank the staffs and participants of the JHS.

Compliance with Ethical Standards

Authors' Statement of Conflict of Interest and Adherence to Ethical Standards The authors declare that they have no conflict of interest.

Authors' Contributions Study design: M.I.C., Y.M., M.S., S.K.M., M.D.D., M.J.G.; Data analysis: X.C., Y.M.; Interpretation of study results: All authors; Drafting of manuscript: M.I.C.; All authors provided critical feedback and helped shape the research, analysis, and manuscript.

Ethical Approval Institutional Review Board approval was granted.

Informed Consent All participants were consented prior to participation in the study.

References

1. Grundy SM, Cleeman JI, Daniels SR, et al.; American Heart Association; National Heart, Lung, and Blood Institute. Diagnosis and management of the metabolic syndrome: An American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. *Circulation.* 2005;112:2735–2752.
2. Ford ES, Li C, Sattar N. Metabolic syndrome and incident diabetes: Current state of the evidence. *Diabetes Care.* 2008;31:1898–1904.
3. Mottillo S, Filion KB, Genest J, et al. The metabolic syndrome and cardiovascular risk a systematic review and meta-analysis. *J Am Coll Cardiol.* 2010;56:1113–1132.
4. Aguilar M, Bhuket T, Torres S, Liu B, Wong RJ. Prevalence of the metabolic syndrome in the united states, 2003–2012. *JAMA*. 2015;313(19):1973–1974.
5. Gurka MJ, Vishnu A, Okereke OI, Musani S, Sims M, DeBoer MD. Depressive symptoms are associated with worsened severity of the metabolic syndrome in African American women independent of lifestyle factors: A consideration of mechanistic links from the Jackson Heart Study. *Psychoneuroendocrinology.* 2016;68:82–90.
6. Irwin ML, Ainsworth BE, Mayer-Davis EJ, Addy CL, Pate RR, Durstine JL. Physical activity and the metabolic syndrome in a tri-ethnic sample of women. *Obes Res.* 2002;10:1030–1037.
7. Cameron AJ, Shaw JE, Zimmet PZ. The metabolic syndrome: Prevalence in worldwide populations. *Endocrinol Metab Clin North Am.* 2004;33:351–375, table of contents.
8. Sims M, Diez-Roux AV, Dudley A, et al. Perceived discrimination and hypertension among African Americans in the Jackson Heart Study. *Am J Public Health.* 2012;102(suppl 2):S258–S265.
9. Stepanikova I, Baker EH, Simoni ZR, et al. The role of perceived discrimination in obesity among African Americans. *Am J Prev Med*. 2017;52(1 suppl 1):S77–s85.
10. Okhomina VI, Glover L, Taylor H, Sims M. Dimensions of and responses to perceived discrimination and subclinical disease among African-Americans in the Jackson Heart Study. *J Racial Ethn Health Disparities*. 2018;5(5):1084–1092.
11. Dunlay SM, Lippmann SJ, Greiner MA, et al. Perceived discrimination and cardiovascular outcomes in older African Americans: Insights from the Jackson Heart Study. *Mayo Clin Proc.* 2017;92:699–709.
12. Beatty Moody DL, Chang Y, Brown C, Bromberger JT, Matthews KA. Everyday discrimination and metabolic syndrome incidence in a racially/ethnically diverse sample: Study of women's health across the nation. *Psychosom Med.* 2018;80:114–121.
13. Assari S, Moazen-Zadeh E, Caldwell CH, Zimmerman MA. Racial discrimination during adolescence predicts mental health deterioration in adulthood: Gender differences among blacks. *Front Public Health*. 2017;5:104.
14. Ong AD, Williams DR, Nwizu U, Gruenewald TL. Everyday unfair treatment and multisystem biological dysregulation in African American adults. *Cultur Divers Ethnic Minor Psychol.* 2017;23:27–35.
15. Zilioli S, Imami L, Ong AD, Lumley MA, Gruenewald T. Discrimination and anger control as pathways linking socioeconomic disadvantage to allostatic load in midlife. *J Psychosom Res.* 2017;103:83–90.
16. Vadiveloo M, Mattei J. Perceived weight discrimination and 10-year risk of allostatic load among US adults. *Ann Behav Med.*. 2017;51(1):94–104.
17. Cuevas AG, Wang K, Williams DR, Mattei J, Tucker KL, Falcon LM. The association between perceived discrimination and allostatic load in the Boston Puerto Rican health study. *Psychosom Med.* 2019;81:659–667.
18. Sims M, Diez-Roux AV, Gebreab SY, et al. Perceived discrimination is associated with health behaviours among African-Americans in the Jackson Heart Study. *J Epidemiol Community Health.* 2016;70:187–194.
19. Priest N, Paradies Y, Trenerry B, Truong M, Karlsen S, Kelly Y. A systematic review of studies examining the relationship between reported racism and health and wellbeing for children and young people. *Soc Sci Med*. 2013;95(suppl C):115–127.
20. Johnson P, Risica PM, Gans KM, Kirtania U, Kumanyika SK. Association of perceived racial discrimination with eating behaviors and obesity among participants of the SisterTalk study. *J Natl Black Nurses Assoc.* 2012;23:34–40.
21. Taylor RJ, Miller R, Mouzon D, Keith VM, Chatters LM. Everyday discrimination among African American Men: The impact of criminal justice contact. *Race Justice.* 2018;8:154–177.
22. Kessler RC, Mickelson KD, Williams DR. The prevalence, distribution, and mental health correlates of perceived discrimination in the United States. *J Health Soc Behav.* 1999;40:208–230.
23. Pérez DJ, Fortuna L, Alegria M. Prevalence and correlates of everyday discrimination among U.S. Latinos. *J Community Psychol.* 2008;36:421–433.
24. Gurka MJ, Ice CL, Sun SS, Deboer MD. A confirmatory factor analysis of the metabolic syndrome in adolescents: An examination of sex and racial/ethnic differences. *Cardiovasc Diabetol.* 2012;11:128.
25. Gurka MJ, Lilly CL, Oliver MN, DeBoer MD. An examination of sex and racial/ethnic differences in the metabolic syndrome among adults: A confirmatory factor analysis and a resulting continuous severity score. *Metabolism.* 2014;63:218–225.
26. Ikram UZ, Snijder MB, Agyemang C, et al. Perceived ethnic discrimination and the metabolic syndrome in ethnic minority groups: The healthy life in an urban setting study. *Psychosom Med.* 2017;79:101–111.
27. Sims M, Diez-Roux AV, Dudley A, et al. Perceived discrimination and hypertension among African Americans in the Jackson Heart Study. *Am J Public Health.* 2012;102(suppl 2):S258–S265.
28. Saban KL, Mathews HL, Bryant FB, et al. Perceived discrimination is associated with the inflammatory response to acute laboratory stress in women at risk for cardiovascular disease. *Brain Behav Immun.* 2018;73:625–632.
29. Fox ER, Samdarshi TE, Musani SK, et al. Development and validation of risk prediction models for cardiovascular events in black adults: The Jackson Heart Study cohort. *JAMA Cardiol.* 2016;1:15–25.
30. Fuqua SR, Wyatt SB, Andrew ME, et al. Recruiting African-American research participation in the Jackson Heart Study: Methods, response rates, and sample description. *Ethn Dis.* 2005;15:S6–18.
31. Payne TJ, Wyatt SB, Mosley TH, et al. Sociocultural methods in the Jackson Heart Study: Conceptual and descriptive overview. *Ethn Dis.* 2005;15:S6–38.

32. Taylor HA Jr, Wilson JG, Jones DW, et al. Toward resolution of cardiovascular health disparities in African Americans: Design and methods of the Jackson Heart Study. *Ethn Dis.* 2005;15:S6–S4.
33. Sims M, Wyatt SB, Gutierrez ML, Taylor HA, Williams DR. Development and psychometric testing of a multidimensional instrument of perceived discrimination among African Americans in the Jackson Heart Study. *Ethn Dis.* 2009;19:56–64.
34. Williams DR, Yan Yu, Jackson JS, Anderson NB. Racial differences in physical and mental health: Socio-economic status, stress and discrimination. *J Health Psychol.* 1997;2:335–351.
35. Krieger N, Sidney S. Racial discrimination and blood pressure: The CARDIA Study of young black and white adults. *Am J Public Health.* 1996;86:1370–1378.
36. Krieger N. Racial and gender discrimination: Risk factors for high blood pressure? *Soc Sci Med.* 1990;30:1273–1281.
37. Folsom AR, Yatsuya H, Nettleton JA, Lutsey PL, Cushman M, Rosamond WD; ARIC Study Investigators. Community prevalence of ideal cardiovascular health, by the American Heart Association definition, and relationship with cardiovascular disease incidence. *J Am Coll Cardiol.* 2011;57:1690–1696.
38. Mellen PB, Gao SK, Vitolins MZ, Goff DC, Jr. Deteriorating dietary habits among adults with hypertension: DASH dietary accordance, NHANES 1988–1994 and 1999–2004. *Arch Intern Med*. 2008;168(3):308–14.
39. Lloyd-Jones DM, Hong Y, Labarthe D, et al. Defining and setting national goals for cardiovascular health promotion and disease reduction: The American Heart Association's strategic Impact Goal through 2020 and beyond. *Circulation*. 2010;121(4):586–613.
40. Glover LM, Sims M, Winters K. Perceived discrimination and reported trust and satisfaction with providers in African Americans: The Jackson Heart Study. *Ethn Dis.* 2017;27:209–216.
41. Boulter AC, Quinlan J, Miró-Herrans AT, et al.; HEAT Steering Committee. Interaction of alu polymorphisms and novel measures of discrimination in association with blood pressure in African Americans living in Tallahassee, Florida. *Hum Biol.* 2015;87:295–305.
42. Quinlan J, Pearson LN, Clukay CJ, et al. Genetic loci and novel discrimination measures associated with blood pressure variation in African Americans living in Tallahassee. *PLoS One.* 2016;11:e0167700.
43. Lewis TT, Everson-Rose SA, Powell LH, et al. Chronic exposure to everyday discrimination and coronary artery calcification in African-American women: The SWAN Heart Study. *Psychosom Med.* 2006;68:362–368.
44. Troxel WM, Matthews KA, Bromberger JT, Sutton-Tyrrell K. Chronic stress burden, discrimination, and subclinical carotid artery disease in African American and Caucasian women. *Health Psychol.* 2003;22:300–309.
45. Cuffee YL, Hargraves JL, Rosal M, et al. Reported racial discrimination, trust in physicians, and medication adherence among inner-city African Americans with hypertension. *Am J Public Health.* 2013;103:e55–e62.
46. McEwen CA, McEwen BS. Social structure, adversity, toxic stress, and intergenerational poverty: An early childhood model. *Annu Rev Sociol*. 2017;43(1):445–472.
47. Cardel MI, Guo Y, Sims M, et al. Objective and subjective socioeconomic status associated with metabolic syndrome severity among African American adults in Jackson Heart Study. *Psychoneuroendocrinology.* 2020;117:104686.
48. DeBoer MD, Filipp SL, Gurka MJ. Use of a metabolic syndrome severity *Z* score to track risk during treatment of prediabetes: An analysis of the diabetes prevention program. *Diabetes Care.* 2018;41(11):2421–2430.
49. Sims M, Diez-Roux AV, Gebreab SY, et al. Perceived discrimination is associated with health behaviours among African-Americans in the Jackson Heart Study. *J Epidemiol Community Health.* 2016;70:187–194.