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RACE AND ETHNICITY (M ALBERT, SECTION EDITOR)

Self-Reported Experiences of Discrimination and Cardiovascular Disease

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Abstract Researchers have long speculated that exposure to discrimination may increase cardiovascular disease (CVD) risk but compared to other psychosocial risk factors, large-scale epidemiologic and community based studies examining associations between reports of discrimination and CVD risk have only emerged fairly recently. This review summarizes findings from studies of self-reported experiences of discrimination and CVD risk published between 2011–2013. We document the innovative advances in recent work, the notable heterogeneity in these studies, and the considerable need for additional work with objective clinical endpoints other than blood pressure. Implications for the study of racial disparities in CVD and clinical practice are also discussed.

Keywords Racial · Ethnic · Discrimination · Cardiovascular disease

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Introduction

Although overall rates of cardiovascular disease (CVD) have declined over the past decade, the burden of CVD in the United States remains high [1]. An estimated 83.6 million adults in the United States (greater than 1 in 3) has at least one form of CVD and CVD (including coronary heart disease, stroke, and hypertension) costs the United States $312.6 billion each year [1]. Traditional risk factors (smoking, high cholesterol and obesity) do not completely account for total CVD risk. Thus, it is important to identify additional, potentially modifiable, risk factors for CVD.

Discrimination, defined as the "the unjust or prejudicial treatment of different categories of people … especially on the grounds of race, age, or sex" [2], has long been considered an important determinant of CVD [3]. However, in contrast to the literature on other psychosocial factors (e.g. depression, type A behavior, social support) [4–10], large-scale epidemiologic and community-based investigations of the association between self-reported experiences of discrimination and objective indices of CVD have only emerged recently [11–14, 15•]. The bulk of this research has focused on documenting associations between self-reported experiences of discrimination and indices of CVD among African-American populations [14, 15•, 16–18]. However, more recent work has found that reports of discrimination impact CVD risk among other racial/ethnic groups (including Whites) [19–21, 22••], suggesting that discriminatory experiences may have implications for the cardiovascular health of multiple groups.

The goal of the current review is to highlight recent findings, identify gaps in our current knowledge, and outline important avenues for intervention in the growing field of discrimination and CVD.

Identification of Relevant Studies

We conducted a comprehensive review of articles published between 2011 and 2013. In accordance with procedures followed by Pascoe and Richman [12], we conducted a literature search within several major electronic databases, including MEDLINE, PsychINFO and Sociological Abstracts. Keywords that included both discrimination-related terms (e.g., perceived discrimination, everyday discrimination) and CVD-related terms (e.g., coronary heart disease, blood pressure, smoking) were utilized. An initial search retrieved 412 articles, dissertations and book chapters. From these, titles and abstracts were reviewed and only those containing data relevant to the review were retained. After excluding duplicates, 43 articles were selected for further analysis. Of these 43 articles, we excluded those that relied on self-report measures for objective outcomes (e.g., self-reported CVD [23], self-reported adiposity [21], and/or self-reported hypertension [24]), resulting in a total of 38 studies (see Table 1).

Studies of Self-reported Experiences of Discrimination Across the Continuum of CVD risk

Smoking, Physical Activity and other Lifestyle Factors

The American Heart Association (AHA) recently adopted the concept of "cardiovascular health" [1], that includes non-smoking, physical activity, a healthy dietary intake and appropriate energy intake. Of these, smoking was most commonly studied in relation to self-reported discrimination [25–37]. Recent data examine associations in both US and international populations. Though the majority of studies reported positive associations between self-reported discrimination and smoking (see Krieger et al. [38] for an exception to this), these associations were heavily influenced by sex, cultural context, and measurement strategies.

Among these, Purnell et al. found evidence for associations between smoking and discrimination using data from the 2004–2008 Behavioral Risk Factor Surveillance System cohorts of non-Hispanic white, non-Hispanic black, and Hispanic adults in the US [37]. The study used the Reactions to Race modules to capture self-reported experiences of discrimination in health care and workplace settings, and was unique in using survey questions to try to measure emotional and physical reactions to self-reported experiences of discrimination as potential correlates of smoking behavior. The study found that self-reported experiences of discrimination were associated with smoking, but there were no associations between emotional and physical reactions to discrimination and smoking behavior.

Among youth, Alderete et al. found ethnic-specific susceptibility to smoking behavior associated with racial insults. The study followed youth in Argentina as they progressed from the 8^{th} to 10^{th} grade, and found that ethnic Amazonian and other indigenous groups exposed to racial insults were more likely to become smokers than those who were not exposed to insults [26]. However, European and Andean youths who reported such insults did not have increased risks. Harris et al. observed similar findings in the New Zealand Health Survey, where associations were more pronounced in indigenous ethnic subgroups [29].

Using longitudinal data from the CARDIA study, Borrell et al. analyzed examined associations between reports of discrimination and smoking, alcohol use and physical activity [25]. The authors found that African Americans who reported the highest levels of discrimination were more likely to smoke and use alcohol, but conversely, were also more likely to be physically active than African-Americans who reported less discrimination. Whites reporting high discrimination were more likely to smoke than those less exposed to discrimination, and whites reporting limited discrimination were more physically active than those with greater reports of self-reported experiences of discrimination. Corral et al. report similar findings among African-Americans--that reports of discrimination are associated with *increased* physical activity among African-American adults [40]. Borrell et al. speculate that this finding suggests that physical activity is a potential coping mechanism against experiences of discrimination among African-Americans, but the inverse relationship between discrimination and physical activity among whites is not explained by this reasoning.

We located only two studies that examined associations between reports of discrimination and eating behaviors [39, 40], one finding significant associations between self-reported experiences of discrimination and emotional eating [39], and the second reporting no association between reports of discrimination and fruit and vegetable intake [40].

Finally, although not included as one of the AHA-identified components of cardiovascular health, we also examined sleep as a potential lifestyle factor that could be impacted by self-reported experiences of discrimination, given the growing evidence that sleep that contributes to cardiovascular risk factors [41–44], as well as clinical CVD events [45, 46]. Of the five studies that we located that examined the relationship between self-reported experiences of discrimination and sleep [47, 48, 49•, 50], two relied on self-reported sleep only [47, 51], while the other three examined both self-reported sleep and objectively measured sleep by actigraphy [50] or polysomnography [48, 49•, 50]. All five studies found associations between reports of discrimination and subjective reports of sleep as well as objectively measured aspects of sleep (either architecture [48] or continuity [49•, 50]).

Table 1 Summary of research linking racism with CVD-associated risk factors/outcomes

Study	Sample	Design	Measure of discrimination	Outcome variable	Covariates	Findings
Alderete et al., Mar 2012 [26]	Indigenous Amazonian, unspecified Indigenous groups, Indigenous Andean and European School aged children (13-15 years old at baseline in 2004) in Jujuy, Argentina (N= 3,122)	prospective	Racial discrimination measured through assessment of racial insult exposure (found through interviews)	• self-reported smoking	• sex • date of birth • age • religion • SES • ethnic self-identification • positive expectations for the future • respect for parents • religiosity • ideas of role models • body image ideas	• conditional association: -positive association for Indigenous Amazonians and unspecified Indigenous groups -no association for European and Indigenous Andean groups
Copeland-Linder et al., Feb 2011 [27]	500 urban African American students assessed beginning in first grade and followed until middle school	longitudinal	7 items drawn from Racism and Life Experiences Scale	• self reported tobacco use • self-reported marijuana use • self-reported alcohol use	• gender • SES (measured by proportion of sample receiving free or reduced lunches) • age • self worth - measured by Harter Self Perception Scale (potential protective factor) • academic competence - measured by Harter Self Perception Scale (potential protective factor) • parental monitoring - measured by Structured Interview of Parent Management Skills and Practices-Youth Version (potential protective factor)	• conditional association: -self worth: Among *boys* but not girls with low self worth, *contextual stress* (discrimination, neighborhood disorder, exposure to community violence) *positively associated* with substance abuse -academic competence: Among *boys* but not girls with low academic competence, *contexual stress* positively associated with substance abuse.
Crengle et al., Jan 2012 [28]	Maori, Pacific, Asian, Other, or NZ European secondary school students in New Zealand (N= 9,080)	cross-sectional	Ethnic discrimination in three domains: by police, by health professionals, and ethnicity-related bullying	• self-reported cigarette smoking at least weekly, • self-reported binge alcohol,	• age • area deprivation • food security • housing mobility	• positive association • positive association
Harris et al., Feb 2012 [29]	Maori, Pacific, Asian or European New Zealand Health survey participants 15 years or older (n=24,988)	cross-sectional	Overall discrimination measured by 5-item survey questionnaire assessing experiences of ethnically motivated physical or verbal attacks and unfair treatment due to ethnicity by health professional, in work, or when gaining housing	• self-reported smoking	• education • equalized household income • area deprivation	• positive association
Krieger et al., Nov 2011 [38]	Black and White adults (35-64 years old) from roster of 4 community health centers in Boston (N=1005)	cross-sectional	Experiences of Discrimination scale and short form Everyday Discrimination Scale. Implicit racial discrimination	• self-reported smoking	• childhood and adult social class • household income • household poverty • public assistance • housing tenure • debt and wealth	• no association

Table 1 (continued)

Study	Sample	Design	Measure of discrimination	Outcome variable	Covariates	Findings
			measured using Implicit Association Test (IAT) methodology		• educational level • response to unfair treatment, • racial/ethnic centrality, • social desirability, • hostility	
Lorenzo-Blanco et al., Nov 2011 [31]	Hispanic/Latino youth from Southern California (N=1,124)	cross-sectional	10-item Everyday Discrimination Scale	• self-reported smoking	• age • gender	• conditional association: -Positive association for girls but not boys
Lorenzo-Blanco et al., May 2013 [32]	Hispanic students participating in three wave study RED in South California (N=1,436)	longitudinal	10-item Everyday Discrimination Scale	• self-reported smoking in the past 30 days	• age • gender • SES (mother and father's education as indicator of SES)	• positive association
Nguyen et al., Apr 2012 [35]	Urban Black and Hispanic women 18-44 years (N=677)	prospective	Experiences of Discrimination (EOD) index	• self-reported smoking	• ethnic identity • maternal education • marital status • parity • nativity • maternal age	• positive association
Ornelas et al., Jun 2011 [36]	Latino men in central North Carolina already enrolled in another study called HoMBReS (N=291)	cross-sectional	Perceived Barriers to Opportunity (such as discrimination) measured with one question: "In what ways if any do you differ from those with the greatest opportunity for success in this country?" provided options of race, ethnicity, language, legal status	• self-reported binge drinking • self-reported smoking status,	• age • marital status • education • income • Country of Birth • Years in US • acculturation	• no association • no association
Purnell et al., May 2012 [37]	Nationally representative sample of 85,130 individuals from Behavioral Risk Factor Surveillance System (BRFSS)	cross-sectional	Perceived discrimination assessed in 2 domains (workplace and while seeking healthcare) using Reactions to Race module by the BRFSS	• self-reported current smoking	• age • gender • self-identified race • marital status • income • education • health insurance coverage • state of residence • psychological distress (potential mediator) • self-rated general health status	• positive association (psychological distress mediated relationship - accounting for between 8 %-21 % of association)
Shin et al., Feb 2013 [33]	Rural-to-urban Chinese migrant women in China (restaurant hotel workers (RHWs) and female sex workers (FSWs)) (N=2,228)	cross-sectional	Questionnaire asking: "How often do people treat you unfairly because you are a migrant?"	• self-reported smoking	• age • ethnicity • monthly income • education • marital status • city smoking prevalence level • age at first migration • month since first migration • satisfaction with life and job	• positive association
Zuckerman et al.,		cross-sectional			• age	• no association

Table 1 (continued)

Study	Sample	Design	Measure of discrimination	Outcome variable	Covariates	Findings
Autumn 2012 [34]	Nationally representative sample (White non-Hispanic, Black non-Hispanic, Hispanic) of 8,266 respondents to Reactions to Race module in 2006 and 2008 BRFSS study		Racism assessed via two questions about race-based treatment: "Within the past 12 months at work, do you feel you were treated worse than other races, the same as other races, better than other races, or worse than some races but better than others?" and 'Within the past 12 months, when seeking health care, do you feel your experiences were worse than other races, the same as other races, better than other races, or worse than some races but better than others?"	• self-reported binge/heavy drinking • self-reported smoking	• sex • education • marital status	• no association
Borrell et al., Aug 2013 [25]	African-American and White adults from the CARDIA cohort (N=2,491)	cross-sectional	Experiences of Discrimination Scale	• self-reported smoking status • Self-reported alcohol consumption • self-reported physical activity	• age • sex • marital status • educational attainment • Annual family income • coping with unfair treatment	• positive association • positive association in African-Americans but not Whites • positive association
Corral & Landrine, Nov 2012 [40]	African-American adults (N= 2,118)	cross-sectional	Single item question inquiring about personal experiences with racism in the past year	• physical activity (PA) • smoking • >5 servings of fruits and vegetables daily	• age • gender • education • income	• positive association • positive association
Johnson et al., Jul 2012 [39]	Obese African American women, participating in a weight control study	cross-sectional	Experiences of Discrimination Scale	• weight status, • stress levels • emotional eating behaviors,		• positive association
Beatty et al., May 2011 [50]	African American and White adults participating in larger prospective study (HeartSCORE) (N=127)	cross-sectional	10-item Everyday Discrimination Scale	• self-reported sleep disturbance • Actigraphy and Polysomnography (PSG)-assessed sleep	• age • gender • race • education • Annual Income • resting blood pressure, • measured self-reported history of hypertension, • anger, • anxiety, • hostility • depressive symptoms	• positive association • positive association
Grandner et al., Oct 2012 [47]	Nationally representative sample of Michigan and Wisconsin adult participants of 2006 Behavioral Risk Factor Surveillance System (BRFSS) (N=7,148).	cross-sectional	Single-item question inquiring about racism in healthcare settings	• self-reported sleep disturbance • daytime fatigue	• age • gender • race/ethnicity • education • income • marital status • employment	• positive association
Hicken et al., Jun 2013 [51]	White, Black and Hispanic participants from the Chicago Community Adult Health Study	cross-sectional	3-item scale assessing Racism-related vigilance	• Self-reported sleep difficulty	• age • gender • education • income	• positive association mediating effect of discrimination: ***partial mediator*** *of racial differences*

Table 1 (continued)

Study	Sample	Design	Measure of discrimination	Outcome variable	Covariates	Findings
					• 5-item Everyday Discrimination Scale • 6-item Lifetime Discrimination Scale • Stressful life events (lifetime) • Stressful life events (recent)	*in self-reported sleep for Blacks only.*
Lewis et al., July 2013 [49•]	African American, White, and Chinese women from Study of Women's Health Across the Nation Sleep Study (N=368)	longitudinal	10-item Everyday Discrimination Scale	• self-reported subjective sleep complaints • objectively measured sleep via Polysomnography (PSG)	• age • race/ethnicity • financial strain • BMI • menopausal status • depressive symptoms (CES-D) • use of medications that impact sleep • education	• positive association • positive association with PSG-assessed WASO • no association with PSG-assessed sleep latency
Tomfohr et al., Jan 2012 [48]	San Diego residents participating in larger study investigating racial vascular health differences (N=164)	cross-sectional	The Scale of Ethnic Experience (32-item questionnaire)	• objectively measured sleep via PSG	• gender • racial identity • years of education • occupation • health practices • age • SES • BMI • smoking	• positive association with PSG-assessed Stage 2 (light sleep) • inverse association with PSG-assessed slow-wave sleep (deep sleep) mediating effect of discrimination: ***partial mediator*** *of ethnic differences in sleep architecture.*
Chae et al., Nov-Dec 2012 [55•]	91 African American men 30-50 years old.	cross-sectional	10-item Everyday Discrimination Scale modified to assess experiences due to race, ethnicity or color	• measured hypertension (rested seated elevated blood pressure - SBP≥ 140 mmHg, DBP≥ 90 mmHg)	• age • ratio of household income to poverty threshold • social desirability response bias • relationship status • education • employment status • health insurance	• conditional association - positive relationship among those with implicit *antiblack bias* - inverse relationship among those with *implicit problack bias*.
Eliezer et al., Jun 2011 [56]	Study 1: White women 18-24 years old (N=89); Study 2: White woman 18-23 years old (N=52)	laboratory experiment	Perceived personal discrimination due to gender using three item questionnaire: "I experience discrimination because of my gender," "Gender discrimination will affect many areas of my life," and "Gender discrimination will have a severe impact on my life,"	• measured systolic blood pressure • measured diastolic blood pressure	• age • general anxiety • distance from heart to blood pressure cuff • system-justifying belief (the extent to which people believe success determined by hard work (possible moderator)	• conditional association: - positive association between perceived personal discrimination and DBP and SBP among women who strongly endorsed system-justifying beliefs (belief that success is due to hard work)
Gregoski et al., Feb 2013 [57]	White and African American participants from Georgia and South Carolina (N=352)	cross-sectional	Everyday Discrimination Scale	• measured ambulatory BP • measured nocturnal BP dipping	• gender • age • BMI	• conditional association: Interaction Ethnicity x ET-1 x EDS ONLY significant for nighttime DBP such that among African-Americans with the ET-1 T-allelle, everyday discrimination led to decreases in noncturnal DBP dipping

Table 1 (continued)

Study	Sample	Design	Measure of discrimination	Outcome variable	Covariates	Findings
Kaholokula et al., Feb 2012 [64]	Adult(>18 years old) Native Hawaiians recruited from previously studied cohort of Kohala Health Research Project in rural Hawaiian community (n=146)	cross-sectional	Attributed and felt racism were assessed with a 10-item shortened version of the Oppression Questionnaire	• measured rested seated systolic blood pressure • measured rested seated diastolic blood pressure	• sex • age • education attainment • marital status • self-reported ethnic identification • Hawaiian and American identity, • measured BMI • global psychological stress	• Felt oppression: positive association Attributed oppression: no association • Felt oppression: no association with DBP; Attributed oppression: no association
Klimentidis et al., Feb 2012 [65]	African American, White and Hispanic children aged 7-12 years old (N=294)	cross-sectional	Everyday Discrimination Scale	• measured systolic blood pressure • measured diastolic blood pressure	• SES • diet • physical activity • ancestry informative markers • pubertal status • height • body composition	• conditional association: -positive association for African Americans • conditional association -negative association for Whites -positive association for African Americans
Mezuk et al., Mar 2011 [53]	Employed older Hispanic, Black and White adults (age ≥50) from the Health and Retirement Study (N=3,794)	prospective cohort	Six-item scale assessing workplace discrimination	• measured hypertension (rested seated elevated blood pressure - SBP≥ 140 mmHg, DBP≥ 90 mmHg)	• age • sex • race/ethnicity • marital status • educational attainment • net worth• occupation • Tenure • self-reported smoking status • self-reported weekly alcohol use • measured BMI	• conditional association: - positive association for women
Neblett & Carter, Jun 2012 [58]	African American students (N= 210)	cross-sectional	Daily Life Experience Scale from the Racism and Life Experience Scales	• measured resting blood pressure	• SES • BMI • Racial Identity • Africentric world view (potential protective factor)	• conditional association: -inverse association between racial discrimination and DBP for those who felt others viewed African-Americans less favorably and who endorsed uniqueness of the African-American experience -racial discrimination positively associated with DBP for those with lower levels of Africentric orientation.
Sims et al., May 2012 [59•]	African American adults aged 35-84 years old from the Jackson Heart Study cohort (N=4,939)	Cross-sectional	9-item Everyday Discrimination Scale Modified 9-item Experiences of Discrimination Scale Burden of Discrimination measured by 3-item questionnaire	• measured hypertension (rested seated elevated blood pressure - SBP≥ 140 mmHg, DBP≥ 90 mmHg)	• education • income • occupation • age • gender • BMI, • physical activity, • cigarette smoking, • alcohol consumption • diet	• positive association for Lifetime discrimination and Burden of discrimination • no association for Everyday discrimination

Table 1 (continued)

Study	Sample	Design	Measure of discrimination	Outcome variable	Covariates	Findings
Trevino & Ernst, May 2012 [54]	Mexican American University students (N=144)	cross-sectional	Schedule of Racist Events instrument	• measured blood pressure	• hostility • locus of control • Skin tone	• no association
Cunningham et al., Sept 2012 [67]	African-American and White adults from the CARDIA cohort (N=3,336)	prospective	Experiences of Discrimination (EOD) index	• measured c-reactive protein (CRP)	• blood pressure • plasma total cholesterol, • triglyceride, • HOMA-IR (homeostatic model assessment for insulin resistance) • current smoking status, • social desirability, • personal control/mastery • age • education • community of study	• conditional association: -curvilinear association for Black women - negative association for Black men -positive association for White women -no association for White men
Hickson et al., Feb 2012 [66]	African American adults aged 21-94 years old from the Jackson Heart Study cohort (N=5,301)	cross-sectional	9-item Everyday Discrimination Scale Modified 9-item Experiences of Discrimination Scale	• Computed Tomography (CT)-assessed subcutaneous fat (SAT) • measured visceral fat (VAT)	• age • self-reported SES • menopausal status • hormone replacement therapy • parity in women • cigarette smoking status • physical activity • alcohol consumption • daily energy and fat intake	• conditional association: -Everyday discrimination: positive association for men (attenuated when adjusted for BMI) -Lifetime non-racial discrimination: positive association for women • conditional association -Everyday discrimination: positive association for women (attenuated when adjusted for BMI) -Lifetime non-racial discrimination: positive association for me
Lewis et al., February 2011 [22••]	African American and White women from the Study of Women's Health Across the Nation Chicago site (N=402)	Cross-sectional	10-item Every Day Discrimination Scale	• CT-assessed Visceral Fat • CT-assessed Subcutaneous Fat	• age • race/ethnicity • education • DEXA-assessed total body fat • Framingham Risk Score • Physical Activity • depressive symptoms (CES-D) • Sex Hormone Binding Globulin	• positive association • no association
Moore-Greene et al., Spring 2012 [60]	African American females (18-50 years old) University of Maryland Medical Center employees (N=90)	cross-sectional	22-item Perceived Ethnic Discrimination Questionnaire	• measured BMI	• age • marital status • education • income • job description • diet	• no association
Mwendwa et al., Jul 2011 [62]	African American women participating in community-based study (N=110)		Behavioral coping responses to Perceived Discrimination measured using Perceived Racism Scale and Perceived Stress Scale	• measured BMI	• age • education • income	• positive association
Subramanyam et al., Apr 2012 [61]		cross-sectional	9-item Everyday Discrimination Scale	• measured waist circumference	• gender • self-rated health	• no association

Table 1 (continued)

Study	Sample	Design	Measure of discrimination	Outcome variable	Covariates	Findings
	African American adults aged 21-94 years old from the Jackson Heart Study cohort		Modified 9-item Experiences of Discrimination Scale		• age • income • education • self-esteem social support	
Ayotte et al., Apr 2012 [69••]	Black and White 793 male veterans	cross-sectional	7-item measure of perceived discrimination	• measured coronary artery obstruction	sociodemographic information: • self-reported race • age • education clinical variables: • hypertension • diabetes • current smoking status • prior myocardial infarction psychosocial variables: • negative affect • optimism • social support • religiosity	• conditional association: - positive association among Blacks
Everage et al., Mar 2012 [75]	African American adults aged 33-45 (N=1,362)	cross-sectional (data obtained from a longitudinal study at year 15 follow-up)	Experiences of Discrimination (EOD) index	• measured coronary artery calcification	• education • annual income • anger expression • reactive responding • depressive symptomatology • resting state SBP • total cholesterol • diabetes • BMI	• positive association

Self-reported Experiences of Discrimination as a Psychosocial Correlate of Hypertension and Resting Blood Pressure

Among the traditional CVD risk factors, measures of clinical hypertension based on Joint National Committee (JNC) VII guidelines [52], resting blood pressure as a continuous measure, and ambulatory blood pressure monitoring have been the most frequently studied in recent literature [53, 55•, 56–58, 59•]. Similar to findings from a recent review by Brondolo et al. [63••], we find that current data to date on hypertension and resting blood pressure measures provide mixed evidence for an association with self-reported experiences of discrimination [53, 55•, 56, 58, 59•]. However, these recent studies raise interesting hypotheses suggesting that where any relationship might exist, associations may be sex specific, and may be heavily dependent on psychosocial processes, including the ways in which those who experience discrimination interpret and express their own racial or social identity, as well as the individual's coping style, and the individual's social interpretation of what constitutes fair or unfair treatment in society.

For example, in two large epidemiologic cohort studies that examined self-reported experiences of discrimination among adults in mid-life and older ages, neither found consistent direct associations between clinical hypertension based on JNC VII guidelines, and self-reported experiences of discrimination as measured by the Everyday Discrimination Scale [53, 59•]. However, sex specific associations were observed. In the Health and Retirement Study (HRS), self-reported discrimination was associated with hypertension among women of all races, but no association was seen among men or within racial subgroups [59•]. In the Jackson Heart Study, multiple dimensions of self-reported discrimination were examined, including current self-reports of Everyday Discrimination, self-reported *lifetime* discrimination exposure, and the *burden* of discrimination (whether life has been harder or less productive due to discrimination). No associations were found between hypertension and Everyday Discrimination overall. However, sex differences were seen where women with high exposure to *lifetime* discrimination were more likely to have hypertension than women with low exposure. Instead, the *burden* of discrimination was associated with hypertension among men but not women. The reasons for these differential associations by sex, duration, and burden of discrimination are not known. However, in the HRS, the authors note that self-reported discrimination was exceedingly rare, including low self-reporting among Hispanics and blacks, raising the question of whether additional measures are needed to understand discrimination experiences in older cohorts, beyond those captured by self-reported measures.

To address the issue of self-report bias, Chae and Nuru-Jeter provide early evidence that *implicit racial biases*, defined as subconscious positive or negative ideas about racial identity, may influence the association between self-reported measures of discrimination and clinical diagnoses of hypertension [55•]. In the Bay Area Heart Health Study, implicit biases were measured among a small sample of 91 African-American men using the Black-White Implicit Association Test (IAT). The IAT is an experimental technique that measures the speed and frequency with which the participant matches images of African-American and white faces with positively ("good") and negatively ("bad") charged words. The study found no direct associations between perceived discrimination, implicit racial bias, and hypertension. However, there was a statistically significant interaction effect, where African-American men who were found to hold an implicit anti-black bias had an *increased* risk for hypertension with increasing self-reported experiences of discrimination, while men who had an implicit pro-black bias had a *decreased* risk for hypertension with increasing self-reported discrimination [55•].

Kaholokula et al. [64] provide rare data on racial identity, discrimination and blood pressure among 146 Native Hawaiian men and women in the Kohala Health Research Project. The study found that *felt oppression,* the respondent's subjective experience of feeling oppressed in society, was correlated with systolic blood pressure, but this association was attenuated by covariates, including body mass index (BMI), cortisol, perceived stress, and the participant's degree of Hawaiian ancestry. There are several interpretations of these results, including the possibility that the correlation between felt oppression and blood pressure is spurious, the possibility that BMI, cortisol, and perceived stress are mediators of the relationship, or that the measure of Hawaiian ancestry marks either underlying psychosocial or biologic predispositions to systolic blood pressure sensitivity [64].

Researchers have found fairly robust and consistent associations between reports of discrimination and ambulatory blood pressure in previous studies (see Brondolo review [63••]). Thus, many of the more recent innovations in the study of discrimination and blood pressure noted above (i.e., implicit racial bias, felt oppression) will be important to replicate in future studies with larger cohorts using ambulatory blood pressure outcomes.

Genetic Mediators of Associations between Blood Pressure and Reports of Discrimination

Few studies examine genetic factors that may mediate the association between blood pressure and self-reported discrimination. Klimentidis et al. raise the hypotheses that potential associations may begin in early childhood, and that complex relationships exist between blood pressure, genetic admixture and social experiences of discrimination [65]. In their study of school-aged children aged 7 to 12 years, the authors examined the correlation between resting blood pressure, a modified

measure of the Everyday Discrimination scale, and 142 ancestry informative markers among European American, African-American, and Hispanic American children. Among all children, increased systolic blood pressure was associated with markers of African ancestry, but not self-reported discrimination. However, among African-American children, increased systolic blood pressure was associated with perceived discrimination, but not related to markers of African ancestry. The authors did not study specific alleles that may confer risks for elevated blood pressure, and their study raises the interesting methodological challenge of how one should interpret genetic risks that are linked to social experiences. An innovative study by Gregoski et al. [57] addresses this in part by examining the relation between 24 hour ambulatory systolic blood pressure, diastolic blood pressure, nocturnal blood pressure dipping, and Everyday Discrimination among African-American and European American teens and young adults aged 16 to 20 years, who were carriers or non-carriers of the Endothelin-1/ Lys198Asn T-allele, which confers an increased risk of exaggerated blood pressure reactivity to laboratory stressors. The study did not find a main effect of Everyday Discrimination on ambulatory blood pressure overall. However, African-Americans who were Lys198Asn T-allele carriers exposed to high everyday discrimination levels had increases in nighttime DBP and reduced nocturnal SBP and DBP dipping [57]. Additional studies in this vein may begin to untangle the biologic and social underpinnings of susceptibility to risks of elevated blood pressure and hypertension in the face of discriminatory experiences.

Obesity and Other Biomeasures of Cardiovascular Disease Risk

Recent data also examine the association between self-reported discrimination and other cardiovascular risk markers, including obesity, CRP, and coronary artery occlusion.

Among the studies that examined obesity, studies by Lewis and colleagues [22••] and Hickson et al. [66] are unique in using computerized tomography (CT) data to examine visceral (VAT) and subcutaneous (SAT) measures of central adiposity related to reports of discrimination. In 402 middle-aged African-American and White women, Lewis et al. found a significant, dose–response association between reports of everyday discrimination and visceral, but not subcutaneous fat, after controlling for total body fat and various risk factors [22••]. Hickson and colleagues examined similar outcomes and observed sex differences in a sample of adults from the Jackson Heart Study [66]. The authors measured multiple dimensions of self-reported discrimination including everyday and lifetime experiences. Among men, neither SAT nor VAT was associated with lifetime discrimination, though SAT was positively associated with current Everyday Discrimination among men. Among women, self-reported lifetime discrimination attributed to non-racial factors was associated with higher volumes of both VAT and SAT. Among men, passive coping strategies were associated with increased VAT, though coping strategies were not associated with VAT or SAT among women.

A single recent study examined CRP as a correlate of experiences of discrimination among black and white men and women in the Coronary Artery Risk Development in Young Adults (CARDIA) study [67]. In contrast to prior work [68], a reverse association was found, where higher levels of self-reported discrimination were associated with lower levels of CRP among black men, and a curvilinear relationship was observed among black women [67]. The authors describe their findings as potentially explained by the influence of internalized oppression that might lead to high stress among those who deny experiences of discrimination, which suggests that additional data, such as IAT testing, may be needed to further explore this finding.

Data connecting more proximal cardiovascular endpoints to discrimination were rare. We identified a single study measuring coronary artery occlusion in a population of 1025 white and black veterans undergoing cardiac catheterization on the basis of cardiac nuclear imaging results in the Cardiac Decision Making Study [69••]. The study found that among blacks, but not whites, discrimination was associated with more severe coronary artery obstruction found at coronary angiography (at least 70 % occlusion of the left main artery, or three vessel disease), compared to less severe disease (mild or non-obstructing coronary artery disease).

The Role of Depressive Symptoms and Depression

Over recent decades, depression and depressive symptoms have emerged as significant risk factors for heart disease and stroke, with documented associations across a wide variety of studies [70–73]. Reports of discrimination are also strongly linked to depression and depressive symptoms [11, 74]. However, it is noteworthy that only a fraction of the studies reported in Table 1 controlled for depressive symptoms or other forms of negative affect [22••, 50, 69••, 75]. Of these, all found that associations between self-reported discrimination and indices of CVD remained after adjustment for depressive symptoms or negative affect [22••, 49•, 50, 69••, 75].

Measurement Issues in Research on Discrimination

Scientific evidence continues to build suggesting that self-reported experiences of discrimination are a potential risk factor for multiple health outcomes, including at least some indicators of CVD risk [11, 12]. Discrimination is thus

emerging as a psychosocial stressor and a better understanding of its role in CVD disease may be contingent on increased efforts to measure it accurately and comprehensively and to better assess how it combines with other psychosocial risks and resources to affect specific biological pathways by which discrimination can affect health [11]. For example, the assessment of discrimination varies markedly across studies. Some studies use the everyday discrimination scale [76], that captures aspects of interpersonal discrimination that are chronic or episodic and relatively minor (e.g., treated with less courtesy and respect), while others assess discriminatory experiences that are more major and acute (e.g., unfairly fired or abused by the police). More effort is needed to understand and assess discrimination in all its complexity and give more attention to identifying the conditions under which specific aspects of discrimination could adversely affect particular markers of health risk. Discriminatory experiences vary in how emotionally intense, unpredictable, threatening, frequent, ambiguous, negative, uncontrollable and disruptive of individual and family functioning they are – all characteristics that could affect their consequences for health [11].

Implications for Racial Disparities in Cardiovascular Disease

The burden of CVD in the United States is disproportionately high among African-Americans as compared to Whites [1]. Although recent evidence suggests that self-reported experiences of discrimination impact African-Americans as well as Whites [22••], African-Americans consistently report higher levels of these experiences [22••, 25, 48, 69••, 76], suggesting that discrimination may be a more salient stressor for this group. In a recent editorial, Albert and Williams [77] argued for the need for more studies that explicitly examine the role of discrimination in accounting for racial disparities in CVD. However, with limited exceptions [48], very few recent studies have actually done this. Additional research in this area is warranted.

Although our review has focused on discrimination outside of the clinical encounter, future research is needed to better understand how self-reported discrimination combines with racial bias in health care settings to affect racial differences in the severity and course of CVD, and in the use of treatments and technologies used to manage CVD. A 2003 report from the Institute of Medicine (IOM) summarized hundreds of research studies that found that across virtually every therapeutic intervention, ranging from the most basic forms of diagnostic and treatment interventions to high technology procedures, African-Americans and other minorities receive fewer procedures and poorer quality medical care than whites [78]. These differences persisted even after controlling for variations in health insurance coverage, socioeconomic status, stage and severity of disease, co-morbid conditions, and the type of healthcare facility. Instructively, this report found more evidence of bias in the treatment of CVD than in any other area of medicine. Although the IOM report acknowledged that the causes of disparities in the quality of care was multifactorial, it suggested that unconscious bias on the part of providers could be an important determinant of unequal access to high quality medical care.

National data reveal that there are high levels of negative stereotyping of minorities in the U.S., with blacks viewed more negatively than other groups [79]. Healthcare providers are a part of their society and analyses of data from a large sample of persons who took the Implicit Association Test (IAT) reveal that the majority of physicians have an implicit preference for whites over blacks, similar to the pattern in the general population [80]. These data suggest that discrimination is likely to be commonplace in American society with much of it occurring through behaviors that the perpetrator does not experience as intentional. In addition, provider implicit bias is associated with poorer quality of patient provider communication and lower patient evaluation of the quality of the medical encounter including provider nonverbal behavior [81, 82]. Thus, going forward, we need renewed research attention to identifying, developing, and rigorously evaluating effective interventions to reduce the negative effects of interpersonal discrimination on cardiovascular health.

Summary and Conclusions

In summary, there are several important take-home messages from the current studies.

First, currently observed associations between self-reported discrimination and CVD risk appear to be complex, and may relate to underlying psychosocial, genetic, and sex differences in one's susceptibility to exposure to discrimination. However, there is a real need for large-scale, prospective, epidemiologic and community-based studies that control for depressive symptoms and examine the association between self-reported experiences of discrimination and objectively measured, clinically relevant endpoints – with a particular emphasis on clinical CVD outcomes (i.e., myocardial infarction and stroke). Additionally, the role of discriminatory experiences in understanding black-white disparities in CVD needs to be further elucidated. Further, although not covered in great detail in the current review, greater attention should be paid to health care settings. Discrimination may occur commonly in health care settings, and interventions should be developed to counter discriminatory practices that arise in these (as well as other) encounters. Finally, and importantly, more data are needed to better understand the causal mechanisms that may connect discrimination to cardiovascular

disease risk, in order to guide clinical approaches to managing any associated risks.

Compliance with Ethics Guidelines

Conflict of Interest Tené T. Lewis, David R. Williams, Mahader Tamene, and Cheryl R. Clark declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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Recently published papers of particular importance have been highlighted as:
- • Of importance
- •• Of major importance

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