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The Association Between Perceived Discrimination and Allostatic Load in the Boston Puerto Rican Health Study

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Abstract

Objective: Perceived discrimination is a risk factor for poor health among ethnic and racial minority groups. However, few studies have examined the association between major lifetime and everyday perceived discrimination and allostatic load (AL), a preclinical indicator of disease. We examine the association between two measures of discrimination and AL among Puerto Rican adults.

Methods: Using primarily wave 3 data from the longitudinal Boston Puerto Rican Health Study, we examined the association between major lifetime and everyday perceived discrimination and AL (multisystem dysregulation of 11 physiological components) among Puerto Rican adults residing in the Boston metro area ($N = 882$). Five models were tested using multivariable regression. The final model adjusted for demographic factors, migration factors, socioeconomic status and work history, health behaviors/risk factors, and depressive symptom.

Results: Respondents had a M (SD) AL score of 5.11 (1.76; range = 0–11). They had an average score of 0.21 (0.42) for major lifetime perceived discrimination (0–3) and 0.29 (0.49) for everyday perceived discrimination (0–3). In a fully adjusted model, major lifetime perceived discrimination was associated with greater AL ($b = 0.56$; 95% CI = 0.19 to 0.92), whereas greater everyday perceived discrimination was marginally, but not significantly, associated with lower AL ($b = -0.42$; 95% CI = −0.87 to 0.04).

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Conclusions: Perceived discrimination remains a common stressor and may be a determinant of AL for Puerto Ricans, although the type of perceived discrimination may have differing effects. Further research is needed to better understand the ways in which major lifetime and everyday perceived discrimination operate to effect physiological systems among Puerto Ricans.

Keywords

allostatic load; discrimination; dysregulation; Puerto Ricans

INTRODUCTION

Chronic experience of stress can directly influence health through dysregulation of interrelated physiological systems (1,2). Stress evokes an emotional response that triggers physiological arousal through the release of cortical hormones in an effort to maintain physiological functioning, such as control of metabolic processes (3,4). The continual release of these hormonal chemicals (e.g., corticosteroids) disrupts physiological systems from producing hormones that promote homeostasis (5). This process affects tissues and organs and depletes the body's immune system to fight disease (5,6). Such dysregulation due to chronic stress, often referred to as allostatic load (AL), is characterized by elevated (or reduced) physiological activity across multiple regulatory systems, including cardiovascular and metabolic processes, immune system, sympathetic nervous system, and the hypothalamic-pituitary-adrenal (HPA) axis (7-10). Therefore, AL represents the "wear and tear on the body" that accumulates by repeated exposure to chronic stress (11).

AL has been shown to increase between ages 20 and 60 years and to generally remain constant in later life (12). The increase in AL by age is indicative of the cumulative challenge imposed on various physiological systems across the life course. Crimmins and colleagues (12) suggest that in the course of a normal lifespan, physiological responses should occur within an optimal range. However, when the body receives significant challenges across a lifespan, physiological systems may begin to operate outside this optimal range, which is AL (12). Black and Hispanic middle-aged and older adults have higher AL compared with their non-Hispanic white counterparts (8,13). It is presumed that the disproportionate burden of adversities that racial/ethnic minorities experience relative to non-Hispanic whites may be contributing to racial/ethnic differences in AL (14,15).

Life-long and cumulative experiences of unfair treatment, often referred to as perceived discrimination, have been implicated as risk factors for poor health (16). Perceived discrimination is associated with a variety of poor health outcomes, such as type 2 diabetes, heart disease, and hypertension (16-19). A growing body of research is now illuminating the biological underpinnings that may link perceived discrimination to health outcomes. For instance, greater perceived discrimination is associated with inflammation (interleukin 6 and c-reactive protein [CRP]) (20), higher circulating E-selectin (indication of endothelial dysfunction) (21), increased oxidative stress (22), and steeper cortisol awakening response (23). However, research focusing on one system or preclinical indicator may not comprehensively capture the effects of perceived discrimination (5,24). Therefore, a

multisystem concept, such as AL, can effectively establish associations between perceived discrimination and health-related outcomes (1).

Studies that have taken a multisystem approach have shown evidence that greater perceived discrimination, irrespective of whether it was attributed to race or other social reasons, was associated with greater multisystem dysregulation among middle-aged and older adults (24). For example, in a community-based sample of middle-aged African American women, researchers found that chronic exposure to everyday perceived discrimination predicted higher AL over time (9). Other researchers found that this association was also present among black (24) and white adults in their midlife (25).

Despite empirical evidence for the associations between discrimination and health outcomes, research has mostly focused on non-Hispanic blacks and whites. Puerto Ricans have a disproportionate burden of a variety of chronic diseases relative to other Hispanics/Latinos (26-29). For example, prevalence of self-reported cancer and heart disease among Puerto Ricans are almost twice that of Mexican Americans (26). Puerto Ricans without high school education, in particular, have significantly higher prevalence of diabetes than Cuban or Mexican Americans with the same educational attainment (27). Among Puerto Ricans, women have a disproportionate burden of disease, typically reporting more medical conditions than Puerto Rican men (30,31).

Emerging research is beginning to implicate exposure to discrimination as a risk factor for poor health for Puerto Ricans (32,33). Researchers using data from the Boston Puerto Rican Health Study, an ongoing longitudinal cohort study of mostly middle-aged and older Puerto Rican adults, previously found that perceived discrimination was a significant predictor of a variety of medical conditions (e.g., diabetes, hypertension, heart disease, stroke, and kidney disease) (33). There is a need to understand the biological underpinnings linking perceived discrimination to chronic disease for Puerto Ricans. Improving the understanding of the mechanisms underlying the discrimination-health association among Puerto Ricans would be valuable for informing prevention and intervention efforts to reduce health disparities in populations at high risk for discrimination.

Building from previous research (9,24,25), the current study examines the association between perceived discrimination and AL in a sample of middle-aged and older Puerto Rican men and women residing in the Boston metro area of Massachusetts. Previous work has mainly focused on the association between everyday perceived discrimination and AL. Everyday perceived discrimination refers to minor daily hassles of mistreatment, such as being treated with less respect than other people or receiving poorer service than other people at restaurants or stores (34). Perceived discrimination can also include major and observable events, such as being denied a bank loan or prevented from buying a home (34). This form of discrimination is known as major lifetime perceived discrimination. Not only does major lifetime perceived discrimination differ in magnitude compared with everyday perceived discrimination, it also differs in timeframe (35). Measures capturing major lifetime perceived discrimination are concerned with major events that may have happened earlier in life, whereas measures capturing everyday perceived discrimination are concerned with more recent minor events (e.g., within the last 12 months). Given these distinctions, it is

important to examine the extent to which each form of perceived discrimination is independently associated with AL. Therefore, we hypothesized that there would be evidence of an association between perceived discrimination—major lifetime perceived discrimination and everyday perceived discrimination—and AL.

METHODS

Sample Description and Study Design

We used cross-sectional data from wave 3 of the longitudinal Boston Puerto Rican Health Study (BPRHS), collected between 2009 and 2013, because this wave was the first to include measures of major lifetime perceived discrimination. The BPRHS was designed to examine the interplay among psychosocial stress, health behaviors, and sociocultural factors and the onset and progression of disease among 1500 US-mainland Puerto Rican adults at wave 1 (i.e., baseline). Participants in this study self-identified as Puerto Rican were between 45 and 75 years old and resided in the Boston, MA metro area. Participants were recruited through door-to-door enumeration and community approaches to obtain a true community-based sample (36). A battery of questionnaires and tests were completed by participants, including blood, urine, and salivary tests. All participants provided written informed consent. Approval was provided by the institutional review boards at Tufts Medical Center and Northeastern University for the original study and by Tufts University for the secondary analysis.

Measures

Allostatic Load—Following previous work using BPRHS data (37), an AL score was defined based on dysregulation in 11 biomarkers that represent parameters of biological functioning across a range of regulatory systems (Table 1). The score was previously validated by Mattei and colleagues (37) in this Puerto Rican population by assigning a point to parameters outside of normal values using cutoff values based on clinical recommendations and, when these were not available, on population-based cutoffs; parameters within normal values were assigned a zero. Also consistent with previous work (37-43), a point was assigned to account for relevant medication use (e.g., medication for hypertension, medication for diabetes, lipid-lowering drugs, or testosterone) when the respective parameter was within the established cutoff. The 11 parameters and corresponding systems were as follows: (*a*) systolic blood pressure and (*b*) diastolic blood pressure (cardiovascular system); (*c*) waist circumference (adipose tissue deposition); (*d*) total cholesterol concentration and (*e*) serum high-density lipoprotein cholesterol concentration (HDL, lipid metabolism); (*f*) serum dehydroepiandrosterone sulfate (DHEA-S); (*g*) urine cortisol (HPA axis); (*h*) plasma glycosylated hemoglobin concentration (glucose metabolism); (*i*) urinary norepinephrine and (*j*) epinephrine (sympathetic nervous system); and (*k*) CRP (inflammation). The AL score reflected the summation of dysregulated parameters (i.e., points) across the multiple physiological systems. Final AL scores ranged from 0 to 11.

Major Lifetime Perceived Discrimination—Major lifetime perceived discrimination was measured with a modified version of the Major Experiences of Discrimination Scale

(34), which is designed to capture acute and observable discriminatory experiences. This adapted version asked participants about times and places where they were treated unfairly during their lifetime. The scale uses five items with four frequency response codes (0 = never, 1 = rarely, 2 = sometimes, 3 = often). The scale includes items, such as “Over your entire lifetime, how often have you been treated unfairly or been discriminated against by the police and the courts?”, with higher scores indicating greater reports of major lifetime perceived discrimination. The scores were averaged across items. The scale demonstrates an internal consistency of 0.65 (Cronbach’s α). Approximately 28% of the study participants attributed the way they spoke English as the main reason for experiencing major lifetime perceived discrimination. This was followed by “other reasons” (25%) and ancestry or national origin (18%). “Other reasons” included physical disability and low socioeconomic position.

Everyday Perceived Discrimination—Everyday perceived discrimination was measured with a modified version of the Everyday Experiences of Discrimination Scale (34). Although the original scale does not specify the timeframe (34), this adapted version asks study participants how often they have experienced discriminatory event in their day-to-day lives within the past 12 months. This version has been used in prior research (9,44,45). Similar to the original 9-item scale, this scale uses four frequency response codes (0 = never, 1 = rarely, 2 = sometimes, 3 = often). The scale includes items, such as “In the past 12 months, how often have you been threatened or harassed?” and “In the past 12 months, have you been treated unfairly because of the way you speak English?”, with higher scores indicating greater reports of everyday perceived discrimination. The scores were averaged across items. The scale demonstrates high internal consistency (Cronbach’s $\alpha = 0.87$). Similarly, approximately 33% of the study participants attributed the way they spoke English as the main reason for experiencing everyday discrimination, followed by “other reasons” (25%) and ancestry or national origin (14%). Similar to major lifetime perceived discrimination, “other reasons” included physical disability and low socioeconomic position.

Covariates—Given the known associations between perceived discrimination and health outcomes, analyses were adjusted for sets of factors, including sociodemographic factors, health behaviors, and depressive symptoms. Sociodemographic factors included age, educational attainment, income-to-poverty ratio, marital status, language-based acculturation, years living in the mainland United States, work history (i.e., having ever worked a job for more than 3 months), and current employment status. Health behaviors included alcohol consumption, smoking status, physical activity, diet quality, and insomnia symptoms. Following previous research (36), we categorized alcohol consumption as nondrinker versus moderate drinker versus heavy drinker. Moderate drinker was defined as one drink per day or less in females or less than two drinks per day in males. Heavy drinker defined as six drinks or less during one day of drinking or more than one drink per day in females or more than two drinks per day in males. Smoking status was categorized as never (<100 cigarettes in entire life), former, or current smoker. Physical activity was assessed with a modified Paffenbarger questionnaire (46). A physical activity score was calculated as the sum of hours spent during a typical 24-hour period on various activities (heavy, moderate, light, or sedentary activity as well as sleeping) multiplied by weighting factors

that parallel the rate of oxygen consumption associated with each category. Higher scores are indicative of greater physical activity. Diet quality was assessed using the Mediterranean diet score, which captures intake of a variety of food groups (e.g., vegetables, legumes, fruits and nuts, dairy products) in grams per day, adjusted for total energy intake. Further details of the Mediterranean diet for this population can be found elsewhere (47). The Mediterranean diet score ranged from 0 to 9, with higher values indicating greater adherence to a Mediterranean style diet. Participants were asked questions to assess levels of sleep insomnia, such as "How frequently do you have difficulty falling asleep?" and "How frequently do you have trouble with waking up at night?" The final score was categorized as having insomnia most of the time versus sometimes or rarely/never. The Center for Epidemiologic Studies Depression Scale was used to measure symptoms of depression (48). Scores range from 0 to 60, with higher scores indicating higher symptom.

Statistical Analysis

Given that AL was normally distributed, multivariable regression analyses were used to examine the association between everyday discrimination and AL, following a series of multivariable-adjusted models. Five models were tested. All models included both major lifetime and everyday measures of discrimination to examine their independent association with AL. Model 1 tested the association between major lifetime and everyday perceived discrimination with AL scores, adjusting for demographic factors (age, sex, marital status); model 2 tested the association between major lifetime and everyday perceived discrimination with AL scores, adjusting for demographic factors and migration factors (language acculturation, years living in mainland United States); model 3 added socioeconomic status (SES; i.e., educational attainment, income-to-poverty ratio, and employment status) and work history; model 4 included health behaviors/risk factors (alcohol, tobacco, physical activity, diet quality, and sleep quality); and model 5 included depressive symptoms.

Analysis of missing values showed that missing data were not completely at random in this study. Specifically, everyday perceived discrimination, education, and heavy drinking were associated with lower odds of being excluded from the analytical sample, whereas age was associated with greater odds of being excluded from the analytic sample because of missing data. To address potential biases caused by data missing, but not completely at random, we used multiple imputation for all the variables in the study (49). We used the variance inflation factor to test for potential multicollinearity among the predictor variables. All parameters from the multivariable regression were estimated based on five sets of imputed data using Stata 15 (49).

RESULTS

Descriptive statistics

The final study sample consisted of 882 Puerto Rican adult participants, including 645 women and 237 men. The M (SD) age of the sample was 63.2 (7.7) years. Just more than half of the respondents had a high school education (or General Education Development) or more (52.1%). The M (SD) AL score for the whole sample was 5.11 (1.76). The M (SD)

major lifetime perceived discrimination score was 0.21 (0.42), and the M (SD) everyday perceived discrimination score was 0.29 (0.49). Even with imputed data, the average point estimates remained relatively the same (Table 2). The pairwise correlation between everyday and lifetime perceived discrimination was moderate ($r = 0.49$). Everyday perceived discrimination was negatively correlated with AL ($r = -0.02$), whereas lifetime perceived discrimination was positively correlated with AL ($r = 0.03$). The variance inflation factor was 1.42, which suggests that there was no multicollinearity issue present in the model (50).

Major Lifetime Perceived Discrimination and AL

Major lifetime perceived discrimination was positively associated with AL in the first model that included age, sex, and marital status ($b = 0.50$; 95% CI = 0.14 to 0.85) (Table 3). The association remained significant after further adjusting for migrant factors in the model ($b = 0.55$; 95% CI = 0.18 to 0.93) and again remained significant after including SES and work history ($b = 0.54$; 95% CI = 0.17 to 0.92). The relationship between major lifetime perceived discrimination and AL became slightly stronger when health behaviors were included in the model ($b = 0.57$; 95% CI = 0.20 to 0.94) and remained relatively unchanged when depressive symptoms was included in the final model ($b = 0.56$; 95% CI = 0.19 to 0.92).

Everyday Perceived Discrimination and AL

Everyday perceived discrimination was inversely associated with AL ($b = -0.42$; 95% CI = −0.81 to −0.03) in the first model and remained significant when migration factors were added to the model ($b = -0.43$; 95% CI = −0.82 to −0.03). However, the significant association disappeared when SES and work history were included in the model ($b = -0.39$; 95% CI = −0.80 to 0.02) and was further attenuated when health behaviors were included in the model ($b = -0.30$; 95% CI = −0.74 to 0.14). Although the inclusion of depressive symptoms in the model strengthened the relationship between everyday perceived discrimination and AL, the association was not statistically significant ($b = -0.42$; 95% CI = −0.87 to 0.04).

Supplemental Analyses

We also examined the associations between both discrimination measures and AL primary and secondary regulatory system scores. Consistent with prior work (51), the primary AL system included serum DHEA-S and urinary cortisol (HPA axis), urinary epinephrine and norepinephrine (sympathetic nervous system), and serum CRP (inflammation). The secondary system included waist circumference and glycated hemoglobin (metabolic), blood pressure, HDL-C, and total cholesterol (cardiovascular). Greater everyday perceived discrimination tended to be associated with lower primary system score ($b = -0.37$; 95% CI = −0.60 to −0.15), although this was not statistically significant, whereas greater major lifetime discrimination was associated with higher primary system scores ($b = 0.31$; 95% CI = 0.08 to 0.55), in the fully adjusted models. No associations were observed between everyday and major lifetime discrimination and secondary system score.

We examined the association between everyday and major lifetime perceived discrimination with the individual AL indicators, using logistic regression. Neither major lifetime nor everyday perceived discrimination was associated with the individual AL indicators, with

the exception of CRP and epinephrine. Greater everyday perceived discrimination was associated with lower odds of having high CRP (OR = 0.48; 95% CI = 0.08 to 0.89) and lower odds of having high epinephrine (OR = 0.39; 95% CI = 0.03 to 0.75), after adjusting for all covariates. Greater major lifetime perceived discrimination was associated with higher odds of having high CRP (OR = 1.48; 95% CI = 1.05 to 1.91), in the fully adjusted model.

Exploratory Analyses

We tested for interaction effects between perceived discrimination and sex, on AL. No significant interaction was observed between sex and major lifetime perceived discrimination on AL ($b = -0.41$; 95% CI = −1.02 to 0.20) or between sex and everyday perceived discrimination on AL ($b = -0.45$; 95% CI = −0.97 to 0.08).

DISCUSSION

As Ong and colleagues (24) suggest, midlife is a critical period in the life course, because it is marked by high risk of acute and chronic illness. Perceived discrimination can heighten these risks by dysregulating physiological systems. We examined the association between perceived discrimination—major lifetime and everyday—and AL, among middle-aged and older Puerto Rican adults living in the Boston metro area. We found that greater major lifetime perceived discrimination was associated with greater AL, even after adjusting for covariates. Seeman and colleagues (7) proposed that AL occurs as a result of constant exposure to major acute traumatic events. The frequent activation of multiple physiological systems to respond to acute internal or external challenges alters the balance and responsiveness of physiological systems, producing a wear and tear on the regulatory systems in the brain and body (7,52). The marginally significant association observed between everyday perceived discrimination and AL, after adjustment for major lifetime perceived discrimination, was contrary to our expectations. Albeit insignificant in the full model, the initial association suggested greater everyday perceived discrimination being associated with lower AL. There are three possible explanations for our finding. First, it may be that those who have experienced major lifetime discriminatory events in their lives are more likely to become resilient later in life when facing newer, more minor experiences of discrimination. Romero and colleagues (53) suggest that prior exposure to stressors can alter the threshold of homeostasis over time. This alteration can give an individual greater ability to counteract threatening and unpredictable stimuli (53). Prior acute challenges may help prepare individuals to effectively respond to less severe chronic challenges. Another possibility is that appraising ambiguous stressful events to discrimination allows negative outcomes to be attributed to faults in others, rather than one’s own shortcomings (54-56). It allows individuals to make meaning of and cope with the stressful events (e.g., seeking social support) (57,58). Respondents in our study who reported lower everyday discrimination may have had difficulty appraising negative events, which may cause health-damaging effects (54,55). The third possible explanation is that participants who reported lower everyday discrimination may be actively suppressing actual discriminatory experiences (59,60). In experiencing unfair treatment, these individuals may have internalized the stigmatization and reasoned with the unfair treatment by finding it to be

expected (59). Therefore, individuals who internalize discrimination may underreport discriminatory experiences but experience its health-damaging effects. Given that SES and work history attenuated the association between everyday perceived discrimination and AL, they may play key roles. Being employed and having higher SES may expose Puerto Ricans to more discriminatory experiences. A recent study finds that upwardly mobile African Americans and Hispanics report more instances of discrimination than their stable counterparts (61). Despite having potentially more health-related resources and access to care, Puerto Ricans with higher SES and work history may interact with more non-Puerto Ricans and, therefore, increase their exposure to discriminatory experiences. Further examination is needed to clarify this phenomenon and better understand the biological consequences of discrimination.

We also found that greater major lifetime discrimination was associated with higher primary system score, whereas greater everyday discrimination tended to be associated with lower primary system score, although the latter was not statistically significant. Primary regulatory systems are typically activated in intensely threatening events, which, in turn, affect the activities of secondary regulatory systems to meet internal or external demands (62,63). Our findings suggest that major lifetime perceived discrimination may lead to primary (e.g., inflammation) physiological disturbances. The negative association between everyday perceived discrimination and primary systems, on the other hand, may be indicative of physiological adaptation to more minor forms of discrimination. Assessing the association between perceived discrimination and the individual parameters of AL give us insight into the previously mentioned findings. Greater major lifetime perceived discrimination was associated with higher odds of having high CRP concentration, which suggests that inflammation may be a potential pathway by which acute forms of discrimination increase the risk of disease for Puerto Ricans. Nevertheless, our findings for everyday perceived discrimination contradicts previous studies. We found that greater everyday perceived discrimination was associated with lower odds of having high CRP and epinephrine concentrations. Previous research reported a positive association between everyday discrimination and CRP among low-income African American youth (64). Moreover, Ong and colleagues (24) found a positive association between everyday discrimination and CRP and epinephrine concentrations in African American adults. It is possible that cultural differences in responses to stress exist in differing ethnic groups. Our findings suggest that major lifetime and everyday perceived discrimination may operate differently among Puerto Ricans and have varying physiological effects on individuals. However, our findings need to be replicated to better understand the saliency of perceived discrimination as a risk factor for the different physiological systems.

Limitations

The present study was cross-sectional, which precludes the assumption of causality. It is possible that those who have multisystem dysregulations are more likely to report more major lifetime perceived discrimination. Having high AL may be marked by physical disability, and these individuals may be more prone to major lifetime forms of discrimination based on their disability (e.g., being denied a promotion) (65). It may also be that those with diabetes or multiple conditions that require care may face discrimination

when looking for jobs or being at clinical settings (66). Prospective studies are needed to better understand the directionality of these relationships. Longitudinal designs may also reveal potential mediators (e.g., smoking, alcohol consumption, and other health behaviors) that may help explain our findings. Moreover, future research should examine potential moderators that may be pertinent to Puerto Ricans, such as familism and social support, because they may provide insight into the inverse relationship between everyday perceived discrimination and AL. Another limitation is that the adapted version of the Major Experiences of Discrimination Scale had relatively low Cronbach α. Future studies should replicate the current study using the complete Major Experiences of Discrimination Scale (34). Participants in this study had a higher mean AL score, more normally distributed AL score, and lower mean everyday perceived discrimination score, compared with participants in similar studies (9,24,45). It is important to acknowledge that the operational definition of AL differs across studies (1). For instance, Tomfohr and colleagues (45) did not include DHEA-S, whereas, in our study, DHEA-S is included in the operationalization of AL. Upchurch and colleagues (9) did not include medication use as a point in their AL index nor did they adjust for medication use in the model. Therefore, it is difficult to accurately compare AL scores and distributions across similar studies. Likewise, we used adapted versions of the perceived discrimination scales, which prevents us from directly comparing our study scores with scores from other studies (9,24,45). Research looking to replicate these findings should be cognizant of the measures used in this study.

Perceived discrimination may not be the predominant stressor in this study sample. Significantly higher average experiences of other stressors are common among Puerto Ricans, (51,67) and we may be underestimating the effects of stress on AL (68). Further research is needed to understand how discrimination and other stressors individually and cumulatively affect AL. Lastly, future research should consider intraindividual factors, such as personality traits, in the relationship between perceived discrimination and AL. Individuals who score high on neuroticism and low in conscientiousness may be more likely to appraise negative events as discriminatory (69). Sutin and colleagues (69) found that perceived discrimination can also increase neuroticism and decrease agreeableness and conscientiousness overtime among middle-aged and older adults, increasing their risk of poor health.

To our knowledge, this is the first study to examine the association between perceived discrimination and AL among Puerto Ricans. Despite the previously mentioned limitations, the current study is strengthened by a large sample of Puerto Rican adults, assessment of a variety of preclinical indicators related to disease and illness, and statistical control of important covariates. We further examined sex as an effect modifier but did not find evidence that the association between perceived discrimination and AL differed by sex. Nevertheless, future studies may benefit from examining whether similar results will be obtained, especially when taking the attribution to the discriminatory events into account. Although a strength of this study was the focus on general perceived discrimination, regardless of whether the events were attributed to race or other social categories, future research should explore the health effects of discrimination because of race, sex, sexuality, or other attributes.

CONCLUSIONS

In our study, major lifetime perceived discrimination was associated with greater AL among a representative sample of Puerto Ricans in Boston, MA. However, greater everyday perceived discrimination was marginally associated with lower AL. More research is needed to determine causal relationship between both measures of discrimination and AL. Moreover, consideration of sociocultural factors may help elucidate the relationship between discrimination and AL. Nevertheless, psychosocial interventions aimed at reducing discrimination-related stress might help reduce the health consequences of discrimination in Puerto Ricans.

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Glossary

AL	allostatic load
BPRHS	Boston Puerto Rican Health Study
CRP	C-reactive protein
DBP	diastolic blood pressure
DHEA-S	dehydroepiandrosterone sulfate
HbA1c	glycosylated hemoglobin
HDL-C	high-density lipoprotein cholesterol
HPA	hypothalamic-pituitary-adrenal
SBP	systolic blood pressure
SES	socioeconomic status
TC	total cholesterol

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TABLE 1.

Descriptive Characteristics Among Participants of Wave 3 of the Boston Puerto Rican Health Study (N = 882)

Characteristic	Mean (SD)/%	Obs.	Average Point Estimates With Imputed Data
AL score (0–11)	5.11 (1.76)	636	5.14 (0.08)
Major perceived discrimination score (0–3)	0.21 (0.42)	866	0.21 (0.01)
Everyday perceived discrimination score (0–3)	0.29 (0.49)	870	0.29 (0.02)
Age, y	63.2 (7.7)	882	63.2 (7.7)
Sex, %		882	
Female	73.1		73.1
Male	26.9		26.9
Marital status, %		873	
Married/living as married, spouse in household	25.5		25.6
Married, spouse not in household	4.8		4.76
Divorced/separated	34.0		34.1
Widowed	18.0		17.8
Never married	17.7		17.7
Language acculturation score (0–100)	20.8 (22.8)	875	20.8 (0.77)
Years living in the mainland US, y	40.1 (11.9)	865	40.1 (0.40)
Income-to-poverty ratio	147 (422)	753	160 (18.8)
High school/GED or above, %	52.1	880	52.0
Currently employed, %	11.8	881	11.9
Ever worked, %	88.6	882	88.5
Smoking status, %		871	
Never smoked	47.0		46.8
Formerly smoked	35.3		35.3
Currently smoke	17.8		17.8
Alcohol use, %		875	
Nondrinker	77.6		77.7
Moderate drinker	7.49		7.48
Heavy drinker	14.9		14.9
Physical activity score	31.0 (5.8)	877	31.0 (0.19)

Characteristic	Mean (SD)/%	Obs.	Average Point Estimates With Imputed Data
Mediterranean diet score (0–9)	4.40 (1.70)	882	4.40 (1.70)
Insomnia symptoms, %		875	
Most of the time	20.3		20.3
Sometimes or rarely/never	79.9		79.7
Depressive symptom score (0–60)	18.9 (9.6)	867	18.9 (0.33)

M (SD) = mean (standard deviation); Obs. = observations; AL = allostatic load; GED = General Education Development.

The numbers of observations vary because of missing values in the column with unimputed data; AL score is a summation of dysregulation across multiple physiological systems; major perceived discrimination derives from modified version of the Major Experiences of Discrimination Scale (32); everyday perceived discrimination derives from a modified version of the Everyday Experiences of Discrimination Scale (32); diet score assesses observance to a Mediterranean diet (34); income-to-poverty ratio reflects the total household income/federal threshold dollar amount of 2011–2014.

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TABLE 2.

Descriptive Statistics and Cut Points of AL Indicators Among Participants of Wave 3 of the Boston Puerto Rican Health Study

Biomarkers by System	Cutoff	% Below Cutoff	% Above Cutoff
Cardiovascular system			
SBP, mm Hg	SBP > 140 or DBP > 90 and/or taking antihypertension medications	24.8	75.2
DBP, mm Hg			
Adipose tissue deposition			
Waist circumference, cm	Men >102; women >88	21.3	78.7
Long-term atherosclerotic risk indicator and lipid metabolism			
Serum HDL-C, mg/dl	HDL-C < 40 or TC ≥ 240 and/or taking antilipemic agents	27.0	73.0
TC, mg/dl			
HPA axis			
Serum DHEA-S, ng/ml	Men ≤ 589.5; women ≤368.5 and/or taking testosterone medication	67.4	32.7
Urinary cortisol, μg/g creatinine Glucose metabolism	Men ≥ 41.5; women ≥ 49.5	73.1	26.8
Plasma HbA1c, %	>7.0 and/or taking and antidiabetic medication	52.6	47.4
Sympathetic nervous system			
Urinary norepinephrine, μg/g creatinine	Men ≥ 30.5; women ≥46.9	58.4	41.6
Urinary epinephrine, μg/g creatinine Inflammation	Men ≥ 2.8; women ≥ 3.6	34.0	66.0
Serum CRP, mg/l	>3	44.4	55.6

SBP = systolic blood pressure; DBP = diastolic blood pressure; HbA1c = glycosylated hemoglobin; HDL-C = high-density lipoprotein cholesterol; DHEA-S = dehydroepiandrosterone sulfate; TC = total cholesterol; CRP = C-reactive protein.

TABLE 3.

Parameter Estimates of the Association Between Perceived Discrimination and AL: Boston Puerto Rican Health Study

	***b* (95% Confidence Interval)**				
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Major perceived discrimination	0.50 (0.14 to 0.85) **	0.55 (0.18 to 0.93) **	0.54 (0.17 to 0.92) **	0.57 (0.20 to 0.94) **	0.56 (0.19 to 0.92) **
Everyday perceived discrimination	−0.42 (−0.81 to −0.03) *	−0.43 (−0.82 to −0.03) *	−0.39 (−0.80 to 0.02)	−0.30 (−0.74 to 0.14)	−0.42 (−0.87 to 0.04)
Age	0.05 (0.02 to 0.08) **	0.05 (0.02 to 0.07) **	0.05 (0.02 to 0.07) **	0.05 (0.02 to 0.07) **	0.05 (0.02 to 0.08) **
Female (ref: male)	−0.06 (−0.47 to 0.36)	−0.09 (−0.53 to 0.35)	−0.06 (−0.53 to 0.41)	−0.06 (−0.59 to 0.47)	−0.11 (−0.64 to 0.43)
Marital status (ref: married, living as married)					
Married, spouse not in HH	0.27 (−0.44 to 0.99)	0.25 (−0.48 to 0.98)	0.26 (−0.47 to 0.10)	0.12 (−0.59 to 0.84)	0.15 (−0.56 to 0.86)
Divorced/separated	−0.06 (−0.47 to 0.35)	−0.05 (−0.46 to 0.35)	−0.06 (−0.45 to 0.33)	−0.10 (−0.49 to 0.29)	−0.12 (−0.51 to 0.27)
Widowed	−0.04 (−0.52 to 0.44)	−0.04 (−0.52 to 0.45)	−0.07 (−0.57 to 0.43)	−0.15 (−0.66 to 0.36)	−0.20 (−0.72 to 0.31)
Never married	−0.06 (−0.47 to 0.34)	−0.07 (−0.47 to 0.33)	−0.09 (−0.49 to 0.31)	−0.19 (−0.58 to 0.20)	−0.21 (−0.60 to 0.18)
Language acculturation		−0.01 (−0.02 to 0.003)	−0.01 (−0.02 to 0.01)	−0.01 (−0.02 to 0.01)	−0.01 (−0.02 to 0.01)
Years in the mainland US		0.0003 (−0.02 to 0.02)	−0.0002 (−0.02 to 0.02)	−0.0002 (−0.58 to 0.20)	−0.0002 (−0.02 to 0.02)
Income			0.0003 (−0.00006 to 0.0006)	0.02 (−0.01 to 0.05)	0.02 (−0.01 to 0.01)
Education (ref: less than 5th grade)					
5th–8th grade			0.01 (−0.35 to 0.38)	0.05 (−0.31 to 0.42)	0.03 (−0.33 to 0.40)
9th–12th grade or GED			0.23 (−0.20 to 0.66)	0.22 (−0.21 to 0.66)	0.22 (−0.21 to 0.66)
Some college or bachelor’s degree			0.10 (−0.45 to 0.65)	0.08 (−0.47 to 0.62)	0.09 (−0.46 to 0.63)
At least some graduate school			−0.55 (−1.8 to 7.76)	−0.57 (−1.80 to 0.66)	−0.58 (−1.80 to 0.65)
Currently employed			−0.40 (−0.90 to 0.10)	−0.24 (−0.75 to 0.28)	−0.20 (−0.73 to 0.32)
Ever worked			0.14 (−0.31 to 0.59)	0.15 (−0.27 to 0.58)	0.17 (−0.26 to 0.59)
Smoking (ref: never)					
Smoked in the past, but not currently				0.19 (−0.24 to 0.61)	0.16 (−0.27 to 0.59)
Currently smoke				−0.53 (−0.88 to −0.1 7)	0.12 (−0.38 to 0.63)
Alcohol use (ref: never)					
Moderate				−0.35 (−0.24 to 0.61)	−0.37 (−0.86 to 0.12)
Heavy				0.16 (−0.33 to 0.65)	−0.53 (−0.88 to −0.17)
Physical activity				−0.03 (−0.05 to 0.00)	−0.03 (−0.06 to 0.00)
Mediterranean diet				0.05 (−0.03 to 0.13)	0.05 (−0.03 to 0.13)

	b (95% Confidence Interval)				
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Insomnia symptoms				0.09 (−0.24 to 0.43)	0.02 (−0.31 to 0.36)
Depressive symptom					0.02 (−0.00 to 0.03)

HH = household; GED = General Education Development.

Multivariable regression models:

Model 1: everyday perceived discrimination + major perceived discrimination + demographic factors (age, sex, marital status).

Model 2: model 1 + migration factors (acculturation, years living in mainland US).

Model 3: model 2 + SES (education, income, employment) and work history.

Model 4: model 3 + health behaviors/risk factors (alcohol, smoking, physical activity, diet quality, insomnia symptoms).

Model 5: model 4 + depressive symptoms.

* $p < .05$.

** $p < .01$.