

**The association between perceived discrimination and allostatic load among Puerto Ricans:**

**Results from the Boston Puerto Rican Health Study**

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**The association between perceived discrimination and allostatic load among Puerto Ricans:  
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**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 and everyday perceived discrimination and allostatic load (AL), a pre-clinical indicator of disease. We examine the association between two measures of discrimination and AL among Puerto Rican adults.

**Method:** Using primarily Wave 3 data from the Boston Puerto Rican Health Study, we examined the association between major and everyday perceived discrimination and AL among Puerto Ricans residing in the Boston metro area (n=882). Five models were tested using multivariable regression. The final model adjusted for demographic factors (age, sex, marital status), socioeconomic status (education, income, and employment status) and work history, health behaviors/risk factors (alcohol, tobacco, exercise, diet, and sleep) and depressive symptomatology.

**Results:** Respondents had a mean AL score of 4.86 (SD=0.21). They had an average score of 0.28 (0.49) for major perceived discrimination and 0.29 for everyday perceived discrimination. In a fully adjusted model, major perceived discrimination was associated with greater AL (b = 0.56; 95% CI: 0.19, 0.92), whereas greater everyday perceived discrimination was marginally associated with lower AL (b = -0.42; 95% CI: -0.87, 0.04).

**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 and everyday perceived discrimination operate to affect physiological systems among Puerto Ricans.

Keywords: Discrimination, dysregulation, allostatic load, Puerto Rican

## Introduction

Chronic experience of psychosocial 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 cortisol 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), renders physiological systems from producing hormones that promote homeostasis (5). This process leads to tissue and organ failure that depletes the body's immune system to fight disease (5). 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 (SNS), and the hypothalamic pituitary–adrenal (HPA) axis (6–9). Therefore, AL represents the “wear and tear on the body” that accumulates by repeated exposure to chronic stress (10).

Perceived discrimination operates as other stressors, in that they can be acute and observable or subtle, yet chronic. Acute forms of discrimination is commonly referred to as major perceived discrimination, whereas more subtle, chronic experiences of perceived discrimination is referred to as everyday perceived discrimination (11,12). Life-long and cumulative experiences of major and everyday perceived discrimination have been implicated as risk factors for poor health (11). Perceived discrimination has been found to be associated with a variety of poor health outcomes, such as diabetes, heart disease, and hypertension (11,13–15). Growing research is now illuminating the biological underpinnings that may link perceived discrimination to health outcomes. For instance, greater perceived discrimination has been associated with inflammation (interleukin-6 and c-reactive protein)(16), higher circulating E-

selectin (indication of endothelial dysfunction) (17), increased oxidative stress (18), and steeper cortisol awakening response (19).

Because psychosocial stress affects multiple physiological systems, research focusing on one system or pre-clinical indicator may not comprehensively capture the effects of perceived discrimination (5,20). Therefore, a multisystem concept like allostatic load (AL) can effectively establish associations between perceived discrimination and health-related outcomes (1). Studies that have taken a multisystem approach, have shown evidence of an association between greater perceived discrimination and greater multisystem dysregulation among African Americans (20,21).

Despite empirical evidence for the associations between discrimination and health outcomes, research has mostly focused on non-Hispanic blacks and whites. Puerto Ricans suffer a disproportionate burden of a variety of chronic diseases relative to other Hispanics/Latinos (22–25). For example, prevalence of self-reported cancer and heart disease among Puerto Ricans are almost twice that of Mexican Americans (22). Puerto Ricans without high school education, in particular, have significantly higher prevalence of diabetes than similarly educated Cuban or Mexican Americans (23). Among Puerto Ricans, women suffer a disproportionate burden of disease, typically reporting more medical conditions than Puerto Rican men (26,27).

Emerging research is beginning to implicate exposure to discrimination as a risk factor for poor health for Puerto Ricans (28,29). Research using data from the Boston Puerto Rican Health Study 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) (29). 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. The current study examined the association between perceived everyday discrimination and AL in a sample of Puerto Rican men and women residing in the Boston metro area of Massachusetts. We hypothesized that there would be evidence of an association between perceived discrimination-- major and everyday--and allostatic load.

## **Methods**

### ***Sample Description and Study Design***

We mostly used cross-sectional data from the Boston Puerto Rican Health Study (BPRHS) conducted between 2009 and 2013 (Wave 3). The BPRHS was designed to examine the interplay among psychosocial stress, health behaviors, and sociocultural factors and the onset and progression of disease among 1,500 U.S.-mainland Puerto Rican adults. Participants in this study self-identified as Puerto Ricans, were between 45-75 years of age, 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 (30). A battery of questionnaires and tests were completed by participants, including blood, urine, and salivary tests.

### ***Measures***

*Allostatic load.* An AL score is a summation of dysregulation across multiple physiological systems. Following previous work using BPRHS data (31), high allostatic load was defined by the following 11 biomarkers that represent parameters of biological functioning across a range of regulatory systems. These scores were previously validated by Mattei and colleagues (31) in this Puerto Rican population, using cutoff values for each parameter based on

clinical recommendations and when these were not available, on population-based cutoffs. A point was assigned to account for relevant medication use (e.g., individuals having hypertension, diabetes or lipid-lowering) when the respective parameter was within the established cutoff (31).:

- 1) systolic blood pressure and 2) diastolic blood pressure (cardiovascular system); 3) waist circumference (adipose tissue deposition); 4) total cholesterol concentrations and 5) serum high-density lipoprotein (long-term atherosclerotic risk indicator and lipid metabolism); 6) serum DHEA-S and 7) urine cortisol (HPA axis); 8) plasma concentration of total glycosylated hemoglobin (glucose metabolism); 9) urinary norepinephrine and 10) epinephrine (sympathetic nervous system); and 11) C-reactive protein (CRP; inflammation). Final AL scores ranged from 0 to 11.

*Major perceived discrimination.* Major perceived discrimination was measured with a modified version of the Major Experiences of Discrimination scale (32), which tries 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 employs 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 discrimination. The scores were averaged across items. The scale demonstrates an internal consistency of 0.65.

*Everyday discrimination.* Everyday discrimination was measured with a modified version of the Everyday Experiences of Discrimination Scale (32). This adapted version asked participants about times and places where they were treated unfairly in the past 12 months. The scale employs eight items with 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?”, with higher scores indicating greater reports of perceived everyday discrimination. The scores were averaged across items. The scale demonstrates high internal consistency (Cronbach’s  $\alpha = 0.87$ ).

### *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, marital status, language-based acculturation, years lived in the U.S., 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 sleep quality. Following previous research (30), we categorized alcohol consumption as non-drinker vs. moderate drinker vs. heavy drinker. Moderate drinker was defined as  $\leq 1$  drink/day in females or  $\leq 2$  drinks/day in males. Heavy drinker defined as  $\geq 6$  drinks during one day of drinking, or  $\geq 1$  drink/day in females or  $> 2$  drinks/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 (33). A physical activity score was calculated as the sum of hours spent on typical 24-hour activities (heavy, moderate, light, or sedentary activity as well as sleeping) multiplied by weighing factors that parallel the rate of oxygen consumption associated with each category. 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, and total energy intake. Further details of the Mediterranean diet for this population can be found elsewhere (34). The diet scores ranged from 0–9, 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 (CES-D) Scale was used to measure symptoms of depression (35). Scores range from 0 to 60, with higher scores indicating high severity of depression symptoms.

### *Statistical Analysis*

To address missing values, we used multivariate imputation for all the variables in the study (36). Given that the distribution of AL was normally distributed, multivariable regression analyses were used to examine the association between everyday discrimination and AL, following a series of multivariate-adjusted models. Five models were tested. All models included both major and everyday measures of discrimination to examine their independent association with AL. Model 1 tested the association between major and everyday perceived discrimination with AL scores, adjusting for demographic factors (age, sex, marital status); Model 2 tested the association between major and everyday perceived discrimination with AL scores, adjusting for demographic factors and migration factors (language acculturation, years in US); Model 3 added socioeconomic status (SES; education, income, and employment status) and work history; Model 4 included health behaviors/risk factors (alcohol, tobacco, exercise, diet, and sleep); and, lastly, Model 5 included depression. All parameters from the multivariable regression were estimated based on five sets of imputed data using Stata 15 (36).

## **Results**

### *Descriptive statistics*

The final study sample consisted of 882 Puerto Rican adult participants, including 645 women and 237 men. The average age of the sample was 63.2y (SD=7.7). Just over half of the respondents had a high school education (or GED) or more (52.1%). The mean allostatic load score for the whole sample was 4.86 (SD=0.21). The mean major perceived discrimination score was 0.28 (0.49), and the mean everyday perceived discrimination score was 0.29 (0.49; see Table 1).

### ***Major perceived discrimination and allostatic load***

Major perceived discrimination was positively associated with AL in the simple model that included age, sex, and marital status ( $b = 0.49$ ; 95% CI: 0.14, 0.85). The association became significant when were included in the model ( $b = 0.43$ ; 95% CI: 0.06, 0.81). The association remained significant even after including migration factors, SES and work history, health behaviors, and depressive symptoms ( $b = 0.56$ ; 95% CI: 0.19, 0.92).

### ***Everyday perceived discrimination and allostatic load***

Everyday perceived discrimination was inversely associated with AL ( $b = -0.42$ ; 95% CI: -0.81, -0.03) in the simple model and remained significant when migration factors were added to the model ( $b = -0.43$ ; 95% CI: -0.83, -0.03). However, the association became marginally significant when SES and work history were included in the model ( $b = -0.39$ ; 95% CI: -0.80, .02). The association remained marginally significant in the fully adjusted model that included health behaviors and depressive symptoms ( $b = -0.42$ ; 95% CI: -0.87, 0.04).

### ***Supplemental Analyses***

We examined the association between everyday and major perceived discrimination with the individual AL indicators. Neither major nor everyday perceived discrimination was associated with any of the AL indicators, with the exception of CRP and epinephrine. Everyday

perceived discrimination was negatively associated with high CRP (OR = -.48; 95% CI: -0.89, -0.08) and negatively associated with high epinephrine (OR = -0.39; 95% CI: -0.75, -0.03), even after adjusting for all covariates. Major perceived discrimination was positively associated with high CRP (OR = .48; 95% CI: 0.05, 0.91), in the fully adjusted model.

### *Exploratory analyses*

We tested for interaction effects between major perceived discrimination and gender, as well as everyday perceived discrimination and gender, on AL. No significant interactions were observed between gender and major perceived discrimination on AL (b = -0.41; 95% CI: -1.02, 0.20) and gender and everyday perceived discrimination on AL (b = -0.45; 95% CI: -0.97, 0.08).

### **Discussion**

We examined the association between perceived discrimination-- major and everyday-- and AL, among Puerto Ricans living in the Boston metro area. We found that greater major perceived discrimination was associated with greater AL, even after adjusting for covariates. Seeman and colleagues (6) propose 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 alter the balance and responsiveness of physiological systems, producing a wear and tear on the regulatory systems in the brain and body (6,37). The marginally significant trend observed between everyday perceived discrimination and AL was contrary to our expectations. Albeit insignificant, the trend was pointing to greater everyday perceived discrimination being associated with lower AL. There are three possible explanations for our finding: It may be that those who have experienced major discriminatory events in their lives are more likely to become resilient when facing newer experiences. Romero and colleagues suggest that prior exposure to stressors can alter the threshold of homeostasis over time (38).

This alteration can give an individual greater ability to counteract threatening and unpredictable stimuli (38). In other words, prior acute challenges may help prepare individuals to effectively respond to less severe challenges long-term. 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 (39–41). It allows individuals to make meaning of and cope with the stressful events (e.g., seeking social support) (42,43). Respondents in our study who reported lower everyday discrimination may have had difficulty appraising negative events which may cause health-damaging effects (39,40). The third possible explanation is that participants who reported lower everyday discrimination may be actively suppressing actual discriminatory experiences (44,45). In experiencing unfair treatment, these individuals may have internalized the stigmatization and reasoned with the unfair treatment by finding it to be warranted (44). Therefore, individuals who internalize racism may also experience the health-damaging effects of discrimination. Further examination is needed to clarify this phenomenon and better understand the biological consequences of discrimination.

Assessing the association between perceived discrimination and the individual parameters of AL give us insight into the above findings. Major perceived discrimination was positively associated with 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 with regards to everyday perceived discrimination contradicts previous studies. We found a negative association between everyday perceived discrimination and high CRP concentration and high epinephrine levels. Previous research have found a positive association between everyday discrimination and CRP among low-income African American youth (46). Moreover, Ong and colleagues (20) found a positive association between everyday

discrimination and CRP and epinephrine levels African American adults. Our findings suggest that major and everyday perceived discrimination operate differently and have varying physiological effects on individuals. Nevertheless, 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 assumptions of causality. It may be that those who have multi-system dysregulations are more likely to report more major perceived discrimination. For example, having high AL may be marked by higher waist circumference, and these individuals may be more prone to major forms of discrimination based on their weight (e.g., being denied a mortgage loan) (47). 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 (48). 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 ethnic identity, as they may provide insight into the inverse relationship between everyday perceived discrimination and AL. Another limitation is that adapted version of the Major Experiences of Discrimination scale had relatively low Cronbach alpha. Future studies should replicate the current study by using the complete Major Experiences of Discrimination scale (32). Lastly, experiences of other stressors are common among Puerto Ricans, (49) we may be underestimating the effects of stress play on AL (50). Further research is needed to understand how discrimination and other stressors individually and cumulatively affect AL.

### **Conclusion**

In our study, major perceived discrimination was associated with greater AL among a representative sample of Puerto Ricans in Boston, MA. 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 to reduce the health consequences of discrimination in Puerto Ricans.

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**Table 1 Descriptive statistics: Boston Puerto Rican Health Study**

Variables	(n = 882)	
	Mean (SD)/%	Obs .
Allostatic load score (range from 0-11)	5.86 (1.76)	636
Major perceived discrimination score (range from 0-3)	0.28 (0.49)	866
Everyday perceived discrimination score (range from 0-3)	0.29 (0.49)	870
Age, y	63.2 (7.7)	882
Sex		882
Female	73.1%	
Male	26.9%	
Marital status		873
Married/Living as married, spouse in household	25.5%	
Married, spouse not in household	4.8%	
Divorced/Separated	34.0%	
Widowed	18.0%	
Never married	17.7%	
Language acculturation score	20.9 (22.8)	875
Years live in the US, y	40.1 (11.9)	865
Income	147 (422)	753
High school/GED or above	52.1%	880
Employed	11.8%	881
Ever worked	88.6%	882
Smoking status		871
Never smoked	47.0%	
Smoked in the past, but not currently	35.3%	
Currently smoke	17.8%	
Alcohol (drinks/d)	0.67 (1.61)	875
Physical activity score	31.0 (5.8)	877
Dietary index (range from 0-9)	4.40 (1.70)	882
Insomnia symptoms		875
Most of the time	20.3%	
Sometimes or rarely/never	79.9	
Depressive symptomatology score	18.9 (9.6)	867

Note: Numbers of observations vary due to missing values; 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 was assessed using the income to poverty ratio (total household income / federal threshold dollar amount of 2011-2014).

**Table 2. Descriptive Statistics and Cut Points of Allostatic Load Indicators**

Biomarkers by system	Cutoff	% below cutoff	% above cutoff
<i>Cardiovascular system</i>			
SBP (mmHg) and DBP (mmHg)	SBP > 140 or DBP > 90 and/or taking anti- hypertension medications	24.8	75.2
<i>Adipose tissue deposition</i>			
Waist Circumference	Men > 102; Women > 88	21.3	78.7
<i>Long-term atherosclerotic risk indicator and lipid metabolism</i>			
HDL-C (mg/dl) and TC (mg/dl)	HDL-C < 40 or TC $\geq$ 240 and/or taking antilipemic agents	27.0	73.0
<i>HPA axis</i>			
D-HEAS (ng/mL)	Men $\leq$ 589.5; Women $\leq$ 368.5 and/or taking testosterone medication	67.4	32.7
Cortisol ( $\mu$ g/g creatinine)	Men $\geq$ 41.5; Women $\geq$ 49.5	73.1	26.8
<i>Glucose metabolism</i>			
HbA1c (%)	> 7.0 and/or taking and anti-diabetic med use	52.6	47.4
<i>Sympathetic nervous system</i>			
Norepinephrine ( $\mu$ g/g creatinine)	Men $\geq$ 30.5; Women $\geq$ 46.9	58.4	41.6
Epinephrine ( $\mu$ g/g creatinine)	Men $\geq$ 2.8; Women $\geq$ 3.6	34.0	66.0
<i>Inflammation</i>			
CRP (mg/L)	> 3	44.4	55.6

Note: SBP=Systolic blood pressure; DBP=Diastolic blood pressure; HbA1c= Blood glyated hemoglobin; HDL-C= High-density lipoprotein cholesterol; TC= Total cholesterol; CRP= Serum C-reactive protein

**Table 3 Parameter Estimates of the Association between Perceived Discrimination and Allostatic Load: 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, 0.85)**	0.55(0.18, 0.93)**	0.54(0.17, 0.92)**	0.57(.20, .94)**	0.56(0.19, 0.92)**
Everyday perceived discrimination	-0.42 (-0.81, -0.03)*	-0.43 (-0.82, -0.03)*	-0.39(-0.80, 0.02)	-0.30(-0.74, 0.14)	-0.42(-0.87, 0.04)

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 in US)

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

Model 4: model 3 + health behaviors/risk factors (alcohol, tobacco, physical activity, diet, sleep)

Model 5: model 4 + depression

<sup>a</sup>: \*:  $p < 0.05$ ; \*\*:  $p < 0.01$ ; \*\*\*:  $p < 0.001$ .