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Accumulating burden: Exposure to interpersonal discrimination based on multiple attributes and allostatic load

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ABSTRACT

Exposure to interpersonal discrimination is an acute type of social stressor. Extant evidence suggests a positive association exists between experiencing interpersonal discrimination and physiological dysregulation measured by allostatic load. However, research to date has overlooked the role of exposure to interpersonal discrimination based on multiple attributes. This is an important oversight because individuals who confront discrimination often accredit the experiences to more than one attribute, which may be associated with increased stress and adverse physiological functioning. Using data from the Wave V biomarker subsample of the National Longitudinal Study of Adolescent to Adult Health (Add Health), I investigate the relationship between reports of interpersonal discrimination based on multiple attributes and allostatic load among adults ages 33–44. I also consider the roles of frequency of exposure to discrimination and perceived stress in this relationship through moderation and mediation analyses. Results reveal a positive association between the number of forms of discrimination that individuals report and allostatic load. However, frequency of exposure to discrimination does not moderate this association. Moreover, frequency of discrimination did not mediate the association between the number of forms of discrimination and perceived stress only marginally mediated it. This study offers novel and important insight into the role of exposure to more than one form of discrimination and allostatic load. Given that heightened allostatic load is a precursor to the development of chronic conditions and a strong risk factor for mortality, efforts to reduce discrimination among Americans adults will work to improve physical health.

1. Introduction

Discrimination is pervasive in the United States (U.S.) and disproportionately targeted toward individuals in marginalized social groups. Exposure to discrimination has adverse consequences for innumerable facets of life, including physical health (Lewis et al., 2015; Pascoe & Richman, 2009). Accordingly, advancing our understanding of how discrimination influences physical health is critical in addressing issues of health inequities in the U.S. (Williams, Lawrence, Davis, et al., 2019).

The relationship between interpersonal discrimination and allostatic load has garnered increasing attention in the discrimination and health literature. Interpersonal discrimination comprises interactional demonstrations of unjust or prejudicial mistreatment toward individual members of a social group (Richman et al., 2018) and operates as a type of social stressor (Goosby et al., 2018; Williams, Lawrence, Davis, et al., 2019). Allostatic load is an established physiological measure of the cumulative burden of exposure to chronic stress on the dysregulation of bodily systems (Goosby et al., 2018), including within the

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cardiovascular, immunology, and metabolic systems (Miller et al., 2021). Subsequently, increased allostatic load is a critical marker of poor overall physical health and functioning through its association with chronic conditions and all-cause mortality (Beckie, 2012).

Unsurprisingly, research has documented a positive association between interpersonal discrimination and allostatic load (see Miller et al., 2021 for a review of existing studies). However, this body of literature has concentrated on interpersonal discrimination based solely on one social attribute (e.g., race/ethnicity or body weight) or not specified to any social attribute (Miller et al., 2021), overlooking the role of exposure to discrimination based on multiple social attributes. This in an important unobserved line of investigation because individuals who experience discrimination often accredit the experiences to more than one attribute (Grollman, 2012, 2014) which is associated with increased perceived stress (Grollman, 2014) and self-reported adverse physical health and functioning (Grollman, 2012, 2014; Ridgeway & Denney, 2023; Udo & Grilo, 2017). Thus, restricting the focus to discrimination based on one attribute in isolation of others may underestimate the impact of discrimination on allostatic load for individuals who experience it in more than one domain.

Using 2016–2018 data from the Wave V biomarker sample of the National Longitudinal Study of Adolescent to Adult Health (Add Health), I consider this possibility by investigating the relationship between perceived interpersonal discrimination based on multiple social attributes and allostatic load among a nationally representative sample of U. S. adults ages 33–44. This study has three overarching research aims. First, I investigate the association between the number of attributes accredited to interpersonal discriminatory experiences and allostatic load. Then, I consider how the number of forms of discrimination operates in tandem with frequency of exposure to discrimination to influence allostatic load. Finally, I test the extent perceived stress and frequency of discrimination operate as pathways underlying the relationship between multiple forms of discrimination and allostatic load.

2. Background

2.1. Social stress theory, discrimination, and physical health

Social stress theory underscores the role social sources of stress play in contributing to adverse health that especially impact groups in disadvantaged social positions (Anderson, 2013). Stressful life experiences arise due to an individual's location within social structures and the systems of stratification within them that cut across socially constructed class, race, ethnicity, and gender lines, among others (Pearlin, 1989). Pearlin et al. (2005) describe discrimination as an especially pernicious form of psychosocial stress for several reasons. First, most socially assigned statuses, such as race and sex, span from birth to death, and discrimination based on these statuses are likely experienced chronically across the life course. Second, exposure to discrimination is regularly faced in multiple realms including within interpersonal interactions and institutional settings such as education, housing, employment, and medical care. Finally, individuals who routinely encounter discrimination often fall into a state of vigilant anticipation of future exposure (Pearlin et al., 2005) which can cultivate anticipatory stress and exacerbate the harmful effects of discrimination on health (Williams, Lawrence, & Davis, 2019).

Expectedly, the literature on discrimination and health implicates stress associated with discrimination as one of the fundamental links to adverse physical health outcomes (e.g., Pascoe et al., 2022; Williams, Lawrence, Davis, et al., 2019), and interpersonal discrimination as a discrete source of psychosocial stress that impacts health (Pascoe et al., 2022). Over time, heightened physiological responses associated with stress from habitual encounters with interpersonal discrimination can have downstream effects on health through "wear and tear" on the body, including the erosion of protective resources that decrease vulnerability to physical illness (Pascoe & Richman, 2009; Richman et al., 2018).

2.2. Multiple forms of discrimination, stress, and allostatic load

First introduced by McEwen and Stellar (1993), allostatic load is an indicator of how chronic exposure to social, behavioral, and environmental stressors accumulates to negatively affect multiple physiological systems (McEwen & Gianaros, 2010). Encountering chronic stressors modulates allostatic regulation which over time strains bodily systems and depletes their ability to function adequately, as reflected by higher allostatic load (Goosby et al., 2018). The existing literature on the relationship between interpersonal discrimination and allostatic load consistently shows a positive association among disparate populations of adults in cross-sectional and longitudinal analyses, alike (Miller et al., 2021). However, as previously stated, research has yet to consider the relationship between interpersonal discrimination based on multiple attributes and allostatic load.

Within a social stress framework, there are reasons to anticipate this relationship exists, meriting consideration. First, scholars have theorized that experiencing multiple forms of prejudice or discrimination could result in compounding stress due to the distinct nature of each type (Grollman, 2012; Meyer et al., 2008; Vargas et al., 2020). Furthermore, it is plausible that routine experiences with multiple types of discrimination could increase heightened vigilance and anticipation of future exposure. Discrimination-related vigilance is a coping mechanism that includes monitoring and responding to environments, including modifying one's behavior, to protect oneself from discriminatory threats—all of which can lead to increased stress and physiological arousal (Himmelstein et al., 2015; Williams, 2018). Individuals who face multiple forms of discrimination may be especially susceptible to discrimination-related vigilance if they anticipate exposure for more than one attribute and/or in multiple different contexts, including having to adapt their behavior depending on the attribute(s) they anticipate being discriminated against for. Finally, evidence suggests that individuals who experience discrimination based on multiple attributes experience it more frequently (Grollman, 2014), which likely increases the frequency of exposure to stress.

Substantiating these suppositions, several studies have documented that experiencing discrimination based on multiple attributes is associated with poorer self-rated health (Grollman, 2012, 2014; Ridgeway & Denney, 2023), functional limitations (Grollman, 2014), and cardiovascular disease (Udo & Grilo, 2017). While these studies provide a critical foundation for understanding the relationship between discrimination based on multiple attributes and aspects of physical health, advantages exist to using more objective health indicators, including measurements of allostatic load, that can help to advance our knowledge of this relationship. Foremost, measures of physiological dysregulation capture the impact of stress on bodily systems. If stress is the driving force between discrimination and health, allostatic load can better highlight the amassed effect of stress on the body due to exposure to multiple forms of discrimination. Moreover, employing biological measures in examining this relationship helps to address concerns of reverse causality (Goosby et al., 2018).

2.3. Current study

Motivated by this, the overarching purpose of the present study is to extend the literature by investigating the relationship between interpersonal discrimination based on multiple attributes and allostatic load among a nationally representative sample of adults ages 33 to 44. Proceeding, I provide further detail on each research aim.

First, I examine the association between the number of attributes an individual accredits to discrimination and allostatic load. I incorporate a range of social stressors in these analyses, including from earlier in the life course. As scholars continue to advocate, research should consider other psychosocial stressors that are associated with disadvantage, and intrinsically discrimination, including within earlier in the life course, to discern whether discrimination is associated with health independent of

them (Williams, Lawrence, Davis, et al., 2019; Williams, Lawrence, & Davis, 2019).

Second, I assess how frequency of exposure to discrimination works *in conjunction* with the number of forms of discrimination to influence allostatic load. One study to date has investigated how the number of forms of discrimination and frequency of discrimination work together to impact physical health (Ridgeway & Denney, 2023). The authors found that perceiving discrimination more frequently and for three or more reasons was associated with higher odds of fair/poor self-rated health. Grounded in social stress theory and these findings, it is plausible that individuals who experience discrimination based on multiple attributes and more frequently could be at increased risk of higher allostatic load.

Finally, I determine the extent to which perceived stress and frequency of discrimination mediate the association between discrimination based on multiple attributes and allostatic load. Despite the ubiquity of applying social stress theory to the contextualization of the relationship between discrimination and health, studies formally assessing the latent nature of perceived stress in this relationship are relatively scarce (Schwartz & Meyer, 2010). Moreover, given individuals who experience discrimination based on multiple attributes experience it more frequently (Grollman, 2014), it is possible that frequency of discrimination may also explain part of the association. Taken together, applying a mediation analysis to gauge the extent to which perceived stress and frequency of discrimination underlie the relationship between discrimination based on multiple attributes and allostatic load will yield insight into the potential nature of it.

3. Data and methods

3.1. Data and sample

Data were drawn from the National Longitudinal Study of Adolescent to Adult Health (Add Health), a longitudinal nationally representative study of adolescents in 7th-12th grades in 1994–1995. The first wave of data (Wave I) was collected from 20,745 adolescents; a parent or guardian of these adolescents also completed a survey. The most recent wave of data (Wave V) was collected in 2016–2018 and included 12,300 respondents ages 33 to 44. Additionally, an in-home health examination was conducted for a subsample of 5,381 respondents from this sample (Wave V biomarker sample) including the collection of anthropometric and cardiovascular measurements, as well as venous blood via phlebotomy.

Data were used from Wave I and Wave V. Because the outcome variable (allostatic load) is constructed from data collected during the in-home health examination from the Wave V biomarker sample, the analytic sample is drawn from the pool of these participants.[2] Respondents who were pregnant at the time of the in-home health data collection (n = 76) are excluded because pregnancy can impact some of the biomarkers used to construct the allostatic load measure and bias results (Richardson et al., 2021; Touma & Hummer, 2022). Wave V biomarker survey weights are used in the analyses to account for Add Health's complex sampling design (Chen & Harris, 2020) and respondents that are missing region information needed to incorporate survey weights are also excluded (n = 106). Multiple imputation was used to address cases with missing values on any of the independent and/or dependent variables, resulting in a final analytic sample size of 5195 respondents ages 33 to 44. Using the *mi* function in Stata 18.0 (StataCorp, College Station, Texas) imputations were executed using "chained" equations (MICE) over 20 iterations.

[2] Although Wave IV (2008) of Add Health also has biomarker data, the interpersonal discrimination questions were not asked in Wave IV which limits the ability to look at trajectories of allostatic load in relation to interpersonal discrimination.

3.2. Measures

The outcome of interest is Wave V *allostatic load* (range: 0–12). It consists of a summed measure of 12 biomarkers that are each dichotomized (0 or 1) at high-risk cut-points at the 75th or 25th (depending on the biomarker) percentile of the sample's distribution of values for the biomarker (e.g., McLoughlin et al., 2020); respondents that have values at or above (75th percentile) or below (25th percentile) the high-risk threshold are assigned a point (1). Individuals that are not categorized as high risk for some of the biomarkers (detailed below) but report the use of biomarker regulating medication or having been diagnosed with a health-condition related to the biomarker are also assigned a point (Richardson et al., 2021; Touma & Hummer, 2022).

The Wave V biomarker data was collected by trained field examiners through measurements of weight, height, waist circumference, blood pressure, pulse, and a venous blood sample from each participant which provided data for 12 biomarkers within six bodily systems (see Table 1). A point is assigned for each of the following biomarkers if an individual had values at or above the 75th percentile of the sample's distribution: body mass index (BMI, kg/m^2), waist circumference (cm), systolic blood pressure (SBP, mmHg), diastolic blood pressure (DBP, mmHg), pulse rate (/minute), glucose (mg/dL), hemoglobin A1C (HbA1c, %), total cholesterol (TC, mg/dL), triglycerides (TG, mg/dL), and c-reactive protein (hsCRP, mg/L). Then, individuals are assigned a point if they had high-density lipoprotein (HDL-C, mg/dL) and estimated glomerular filtration rate (based on creatinine and cystatin C)[3] (eGFR, ml/min/1.73 m^2) values at or below the 25th percentile of the sample distribution.

Finally, for SBP, DBP, glucose, HbA1c, TC, HDL-C, TG, and eGFR, individuals received a point, respectively, if they did not have values at or above or below the high-risk thresholds but took a biomarker regulating medication and/or reported a health condition related to the biomarker: SBP and DBP if they took medication to manage hypertension and/or reported a history of hypertension, heart attack, stroke, and/or clogged artery; glucose and HbA1c if they took diabetes medication and/or reported a diagnosis of diabetes; TC, HDL-C, and TG if they took medication for high cholesterol and/or reported ever having been diagnosed with high cholesterol; and eGFR if they reported ever having been diagnosed with chronic kidney disease or failure. After summing all 12 biomarkers, each individual has an allostatic load score within a range of 0–12.

The focal independent variable is *number of forms of discrimination* (range: 0–11). The Wave V survey asks questions from an abridged (5-item) version of the Everyday Discrimination Scale (EDS) (Williams et al., 1997) that include: "In your day-to-day life, how often have any of the following things happened to you?" 1) You are treated with less courtesy or respect than other people; 2) You receive poorer service than other people at restaurants or stores; 3) People act as if they think you are not smart; 4) People act as if they are afraid of you; and 5) You are threatened or harassed. Respondents who answered affirmatively ("rarely", "sometimes", or "often") to at least one of the five questions were asked a follow-up question: "What do you think were the reasons why these experiences happened to you?" They were prompted to select "no" (0) or "yes" (1) for each of the following attributes: ancestry or national origin, biological sex, gender identity or gender expression, race, age, religion, weight, a physical disability, an aspect of your physical appearance, sexual orientation, financial status, and "other". Respondents could answer positively to as many attributes as necessary. I create a dummy variable for each attribute (e.g., *weight discrimination* (0 = no, 1 = yes)) and include respondents who answered "never" to all five EDS questions (n = 1927) in the "no" category. I combine race and ancestry or national origin into a single racial/ethnic discrimination category due the high correlation (0.66) between the measures (e.g., Shariff-Marco et al., 2011). Finally, the 11 attributes are summed to

[3] Calculated based on the 2021 NIDDK CKD-EPI guidelines.

Table 1
Descriptive statistics of the 12 biomarkers used to construct allostatic load.

System	Biomarker	Range	Mean (SE)[a]	High risk threshold	% in high-risk category
Anthropometrics	BMI (kg/m^2)	16.4–79.6	30.92 (0.22)	≥ 34.7	26.26
	Waist Circumference (cm)-men	52–185	101.78 (0.61)	≥ 110	27.56
	Waist Circumference (cm)-women	47–181	96.10 (0.75)	≥ 107	27.56
Cardiovascular	BP -Systolic (mmHg)	80.5–215	124.14 (0.36)	≥ 131	41.10[b]
	BP -Diastolic (mmHg)	45–133	80.50 (0.27)	≥ 86.5	38.87[b]
	Pulse (/min)	40–139	75.29 (0.30)	≥ 82.5	26.84[b]
Glucose homeostasis	Glucose (mg/dL)-fasting	41–552	94.23 (0.61)	≥ 96	28.63[b]
	Glucose (mg/dL)-non fasting	43–618	97.86 (0.99)	≥ 101	28.63[b]
	Hemoglobin A1C (%)	4.1–14	5.40 (0.03)	≥ 5.4	34.61[b]
Lipids	Total Cholesterol (TC, mg/dL)	62–424	180.76 (0.75)	≥ 201	34.42[b]
	High-density Lipoprotein (HDL-C, mg/dL)	17–156	48.21 (0.33)	≤ 39	38.22[b]
	Triglycerides (TG, mg/dL)	22–1604	134.08 (2.20)	≥ 155	35.49[b]
Renal function	Estimated Glomerular Filtration Rate (based on creatinine and cystatin C) (eGFR, ml/min/1.73 m^2)	3.98–157.54	109.25 (0.41)	≤ 102.01	26.96[b]
Inflammation and immune function	C-reactive protein (hsCRP, mg/L)	0.15–88.2	3.79 (0.13)	≥ 4.6	23.53

[a] Based on imputed values.
[b] Includes medication use and/or diagnosis of condition related to the biomarker.
Source: National Longitudinal Study of Adolescent to Adult Health

create the continuous measure.

Frequency of discrimination (range: 0–15) is included as both a moderator and mediator of the relationship between the number of forms of discrimination and allostatic load in analyses. This measure is created from the five EDS questions listed above; each question's response options are coded as 0 = never, 1 = rarely, 2 = sometimes, and 3 = often, and then responses to the five questions are summed (Cronbach's alpha = 0.74) (e.g., Grollman, 2012, 2014).

Perceived stress (range: 0–16) is also included as a mediator. The measure is constructed from the four available Wave V questions from the Perceived Stress Scale (Cohen et al., 1983). These include, "in the past 30 days, how often have you felt that" 1) you were unable to control the important things in your life; 2) confident in your ability to handle your personal problems; 3) things were going your way; and 4) difficulties were piling up so high that you could not overcome them? Responses include 0 = never, 1 = almost never, 2 = sometimes, 3 = fairly often, and 4 = very often. Questions two and three are reverse coded and then responses to the four questions are summed (Cronbach's alpha = 0.80).

A range of control variables are incorporated in analyses from both Wave V and Wave I. Exposure to other types of discrimination include whether a respondent had ever perceived being *treated unfairly by the police* (0 = no, 1 = yes), *adolescent in-school peer prejudice* (range: 1–5), and *adolescent in-school teacher fairness* (range: 1–5). Unfair police treatment is based on the Wave V question: "Have you ever been unfairly stopped, searched, or questioned by the police?" This question captures a "major" discriminatory experience (Williams et al., 1997). The adolescent in-school perceived discrimination measures are from Wave I survey questions that asked adolescent respondents how strongly they agree or disagree with the following statements: "The students at this school are prejudiced" and "The teachers at this school treat students fairly". Responses options range from "strongly agree" (1) to "strongly disagree" (5); "students are prejudiced" is reverse coded so that higher scores indicate greater perceived prejudice.

Earlier life course stressors include measures of adolescent family socioeconomic status and self-reported adverse childhood experiences (ACEs). A socially disadvantaged background in adolescence and ACEs are sources of early life social stress that have been found to have far-reaching deleterious effects on adult health status (Nurius et al., 2013). The adolescent family socioeconomic status (*social origins* (continuous)) measure was created by Belsky et al. (2018) using information from the Wave I parent/guardian survey including parental education, parental occupation, household income, and household receipt of public assistance. It is a composite index with Z-transformed values; higher scores indicate a more advantaged social background. Each type of ACE is constructed from Wave I or Wave V questions that addressed: whether a respondent had a parent(s) that was incarcerated during their childhood or adolescence (0 = no, 1 = yes), a parent(s) that died during childhood or adolescence (0 = no, 1 = yes), a parent(s) with alcoholism in adolescence (parent reported) (0 = no, 1 = yes), and a family member(s) that had attempted suicide in adolescence (0 = no, 1 = yes). Responses are summed for an *ACEs* (range: 0–4) measure.

Finally, health behaviors that impact allostatic load are controlled for in analyses including *smoking status* (0 = non-smoker, 1 = smoker) and frequency of *binge drinking* (range: 1–7) (e.g., Lawrence et al., 2022), and a variety of Wave I and Wave V sociodemographic indicators. These include a Wave I measure of *adolescent household structure* ("two biological parents" (reference), "two parents", "single parent", and "other") and Wave V measures of respondents' *marital status* (1 = married), highest level of *educational attainment* ("less than high school degree", "high school degree of equivalent", "some college", and "four-year degree or more"), *sex assigned at birth* (1 = female),[4] self-identified *race/-ethnicity* ("non-Hispanic, White (reference)", "non-Hispanic, Black", "Hispanic", "non-Hispanic, Asian/Pacific Islander", and "non-Hispanic, Other"), *age* (range: 33–44) at Wave V, and *nativity* (1 = non-U.S.-born).

[4] The Wave V question asking about a respondent's sex assigned at birth has response options of either male or female; intersex is not a response option.

3.3. Analytic strategy

Weighted descriptive statistics for each study variable are first estimated. Then, to address the first aim of the study, the association between the number of attributes accredited to discrimination (number of forms of discrimination) and allostatic load are estimated through a series of negative binomial regression models. Model 1 examines the bivariate association between the number of attributes and allostatic load and Model 2 adjusts for all control variables.

To address the second aim of the study, an interaction term between the number of forms of discrimination and frequency of discrimination is added to the fully adjusted Model (Model 3). Because current methodological recommendations for examining interactions in nonlinear models suggest that the coefficient from the interaction term in nonlinear models should not be used to draw conclusions about the significance of the interaction, from Model 3, the average marginal effects (AMEs) and second differences (test of interaction) are estimated (Mize, 2019).

Finally, to address the third aim of the study, a generalized structural equation modeling approach (GSEM) is employed to assess the extent to which the frequency of discrimination and perceived stress mediate the association between the number of forms of discrimination and allostatic load. GSEM is flexible because it allows for count modeling as well as adjustment for complex survey design. Using the *gsem* command (with *nbreg* for each path to account for over dispersion in the outcome, primary independent, and mediator variables) in Stata version 18.0 (StataCorp, College Station, Texas), the preliminary association between the number of forms of discrimination and allostatic load is first estimated, adjusted for control variables. Then, the frequency of discrimination and perceived stress are added to the model; this model is fitted to simultaneously test the direct effect of the number of forms of discrimination and indirect effects through frequency of discrimination and perceived stress on allostatic load. The direct and indirect effects are formally assessed using a bootstrapping approach with 500 replications to compute the standard errors and 95% confidence intervals (Preacher & Hayes, 2008). Finally, the proportion of the effect that is mediated (PME) is determined by dividing the total indirect effect by the total effect (PME = $a_1b_1 + a_2b_2/c$).

4. Results

4.1. Descriptive statistics

Table 2 displays the descriptive statistics for the sample. As shown, the mean allostatic load score is 3.8 out of a range of 0–12. Regarding the primary predictor, the mean number of forms of discrimination is 1.5 out of a range of 0–11 forms. The mean frequency of discrimination is 3.5 out of a range of 0–15 and the mean level of perceived stress is 5.1 out of a range of 0–16. The majority of respondents in the sample are married (56.5%), self-identify their race and ethnicity as non-Hispanic, White (63.3%), were born in the U.S. (94.6%), and/or have a highest educational attainment of some college (40.8%) or a bachelor's degree or more (40.9%).

Table 2
Weighted descriptive statistics of variables for total sample (n = 5195).

	Percent	Mean	SE	Min.	Max.
Allostatic load score		3.82	0.08	0	12
Number of forms of discrimination		1.46	0.05	0	11
Frequency of discrimination		3.51	0.06	0	15
Perceived stress		5.10	0.06	0	16
Treated unfairly by the police (ref = no)	22.76				
Adolescent in-school peer prejudice		3.18	0.05	1	5
Adolescent in-school teacher fairness		2.51	0.03	1	5
Social origins		0.10	0.07	−4.67	3.51
ACEs		0.39	0.02	0	4
Smoker (ref = non-smoker)	26.05				
Frequency of binge drinking		2.12	0.03	1	7
Adolescent household structure					
Two biological parents (reference)	56.60				
Two parents	15.65				
Single parent	22.53				
Other	5.22				
Married (ref = not married)	56.52				
Educational attainment					
Less than high school degree (reference)	4.82				
High school degree or equivalent	13.46				
Some college	40.83				
Bachelor's degree or more	40.89				
Female (ref = male)	49.91				
Race/ethnicity					
Non-Hispanic, White (reference)	63.34				
Non-Hispanic, Black	15.54				
Hispanic	11.68				
Non-Hispanic, Asian/Pacific Islander	3.37				
Non-Hispanic, Other	6.07				
Age		37.91	0.13	33	44
Non-U.S.-born (ref = U.S.-born)	5.41				

Source: National Longitudinal Study of Adolescent to Adult Health

4.2. Negative binomial regression results

Table 3 displays models estimating the association between the number of forms of discrimination and allostatic load. In the bivariate Model (Model 1), the number of forms of discrimination is positively and significantly associated with allostatic load (IRR = 1.03, 95% CI: 1.01–1.05). Model 2 adjusts for all control variables and indicates that the number of forms of discrimination remains positively and significantly associated with allostatic load net of covariates. For each additional form of discrimination, the allostatic load rate increases, on average, by 2%.

Model 3 includes an interaction term between the number of forms of discrimination and the frequency of discrimination. To determine whether this interaction effect is significant, the AME of the predicted count of allostatic load for the frequency of discrimination was estimated across the number of forms of discrimination and then the second differences; no significant differences in the AMEs between any of the levels of the frequency of discrimination was found (results available upon request). Contrary to expectation, this indicates the frequency of discrimination does not significantly moderate the association between the number of forms of discrimination and allostatic load.

4.3. Generalized structural equation models

Finally, generalized structural equation models were estimated to determine whether the frequency of discrimination and perceived stress mediate the relationship between the number of forms of discrimination and allostatic load. The correlation matrix in Table 4 shows that each of the correlations between allostatic load, the number of forms of discrimination, the frequency of discrimination, and perceived stress are weak (<0.5). Figs. 1 and 2 show the results from the GSEM models. Fig. 1 shows the adjusted structural equation model of the preliminary association between the number of forms of discrimination and allostatic load without the proposed mediators. The significant path coefficient demonstrates a positive and significant association exists between the number of forms of discrimination and allostatic load (β = 0.027, 95% CI: 0.011–0.043). As shown in Path *c*' of Fig. 2, with the addition of the frequency of discrimination and perceived stress to the model, the magnitude of this association is attenuated but remains statistically significant (β = 0.022, 95% CI: 0.0052–0.040). Moreover, Paths a_1 and a_2 in Fig. 2 indicate the number of forms of discrimination is positively and significantly associated with both the frequency of

Table 3
Weighted estimates (incident rate ratios) from negative binomial models predicting allostatic load (n = 5195).

	Model 1		Model 2		Model 3	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
Number of forms of discrimination (continuous)	1.03**	(1.01, 1.05)	1.02*	(1.01, 1.04)	1.03*	(1.00, 1.06)
Frequency of discrimination			1.00	(0.99, 1.01)	1.00	(0.99, 1.02)
Number of forms x frequency of discrimination					1.00	(0.99, 1.00)
Perceived stress			1.02**	(1.01, 1.03)	1.02**	(1.01, 1.03)
Treated unfairly by the police (ref = no)			0.96	(0.89, 1.04)	0.96	(0.89, 1.04)
Adolescent in-school peer prejudice			1.00	(0.97, 1.02)	1.00	(0.97, 1.02)
Adolescent in-school teacher fairness			1.02	(0.99, 1.05)	1.02	(0.99, 1.04)
Social origins			0.96**	(0.94, 0.99)	0.96**	(0.94, 0.99)
ACEs			1.01	(0.96, 1.07)	1.01	(0.96, 1.07)
Smoker (ref = no)			1.07	(0.99, 1.15)	1.07	(0.99, 1.15)
Frequency of binge drinking			0.98*	(0.96, 0.99)	0.98*	(0.96, 0.99)
Adolescent household structure (ref = two biological parents)						
Two parents			0.98	(0.90, 1.06)	0.98	(0.90, 1.06)
Single parent			1.04	(0.97, 1.11)	1.04	(0.97, 1.11)
Other			0.98	(0.86, 1.12)	0.98	(0.86, 1.12)
Married (ref = unmarried)			0.92**	(0.86, 0.98)	0.91**	(0.86, 0.97)
Educational attainment (ref = less than high school degree)						
High school degree or equivalent			0.91	(0.80, 1.03)	0.90	(0.80, 1.03)
Some college			0.85**	(0.75, 0.96)	0.85**	(0.75, 0.96)
Bachelor's degree or more			0.69***	(0.60, 0.79)	0.69***	(0.60, 0.79)
Female (ref = male)			0.82***	(0.75, 0.89)	0.82***	(0.75, 0.89)
Race/ethnicity (ref = non-Hispanic, White)						
Non-Hispanic, Black			1.12**	(1.03, 1.21)	1.12**	(1.04, 1.21)
Hispanic			0.96	(0.85, 1.08)	0.96	(0.85, 1.09)
Non-Hispanic, Asian/Pacific Islander			1.01	(0.83, 1.23)	1.01	(0.83, 1.23)
Non-Hispanic, Other			1.21**	(1.07, 1.37)	1.21**	(1.06, 1.37)
Age			1.04***	(1.02, 1.05)	1.04***	(1.02, 1.05)
Non-U.S.-born (ref = U.S.-born)			0.90	(0.78, 1.05)	0.90	(0.78, 1.05)
***p < 0.001 **p < 0.01 *p < 0.05						

Source: National Longitudinal Study of Adolescent to Adult Health

discrimination (β = 0.16, 95% CI: 0.14–0.17) and perceived stress (β = 0.051, 95% CI: 0.041–0.062). However, Path b_1 indicates the frequency of discrimination is not significantly associated with allostatic load (β = 0.00060, 95% CI: −0.012-0.014) but Path b_2 indicates perceived stress is significantly associated with allostatic load (β = 0.015, 95% CI: 0.0055–0.025).

Finally, Table 5 shows the indirect effect of each mediator, the combined (total) indirect effect, and the total effect as well as the bootstrapped standard errors, the bias-corrected 95% confidence intervals, and the proportion of the effect mediated (PME). As shown, while the indirect effect of perceived stress is significant, it only mediates 3.4% of the total effect. The combined indirect (or the total indirect effect) is not significant.

4.4. Robustness check

Although using the 75th/25th percentile of the sample distribution is the established gold standard of measuring allostatic load (McLoughlin et al., 2020), there are alternative ways researchers have constructed measures of allostatic load. To determine if the results are robust to other established measurements of allostatic load, all analyses were estimated using clinically defined high risk threshold measures for each biomarker (e.g., McLoughlin et al., 2020; Santos-Lozada & Daw, 2018). Results from these analyses were substantively identical to results using the 75th/25th percentile measurement (results available upon request). This helped to determine that my findings are not conditional on how allostatic load is measured.

4.5. Supplementary analyses

As a supplementary analysis, race/ethnicity was examined as a moderator to determine if the association between the number of forms of discrimination and allostatic load varied between racial/ethnic groups. An interaction term of race/ethnicity and the number of forms of discrimination was added to the fully controlled model and then the AMEs of the number of forms of discriminations was estimated and contrasted between each racial/ethnic group. I did not find significant differences in the AMEs between any of the racial/ethnic groups (results available upon request); this suggests there is not significant racial/ethnic variation in the impact of the number of forms of discrimination on allostatic load. Unfortunately, due to the increasingly smaller numbers of respondents within intersectional categories (e.g., race/ethnicity and sex), power limitations made it impossible to examine variations across intersecting identities.

5. Discussion

Growing attention has been given to the relationship between interpersonal discrimination and allostatic load in recent years (Miller et al., 2021). Yet, research to date has not considered the function of perceiving discrimination based on multiple attributes. This is an important overlooked line of investigation because individuals who report experiencing interpersonal discrimination often accredit it to more than one attribute (Grollman, 2012, 2014), which is associated with increased stress (Grollman, 2014) and self-reported aspects of adverse physical health (Grollman, 2012, 2014; Ridgeway & Denney, 2023; Udo & Grilo, 2017). The overarching purpose of the present study was to fill this gap in the literature by investigating the relationship between perceived interpersonal discrimination based on multiple attributes and allostatic load; this includes considering the moderating and mediating role of the frequency of exposure to interpersonal discrimination as well as the mediating role of perceived stress.

The first main finding is that the number of attributes accredited to discrimination is positively and significantly associated with allostatic load net of a wide range of controls, which has several key implications. Foremost, within a social stress framework, it provides further evidence

Table 4
Correlation matrix for dependent, main independent, and mediator variables.

	Allostatic load	Number of forms of discrimination	Frequency of discrimination	Perceived stress
Allostatic load	1.00	0.097***	0.12***	0.13***
Number of forms of discrimination		1.00	0.47***	0.22***
Frequency of discrimination			1.00	0.39***
Perceived stress				1.00

***p < 0.001.
Source: National Longitudinal Study of Adolescent to Adult Health

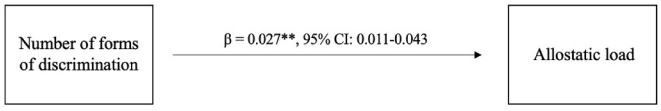

Fig. 1. Structural equation model of the preliminary association between the number of forms of discrimination and allostatic load without mediators† (n = 5195). †Model controls for: unfair police treatment, adolescent in-school peer prejudice, adolescent in-school teacher fairness, social origins, ACEs, smoking status, binge drinking, adolescent household structure, marital status, educational attainment, sex assigned at birth, race/ethnicity, age, and nativity. **p < 0.01. Source: National Longitudinal Study of Adolescent to Adult Health

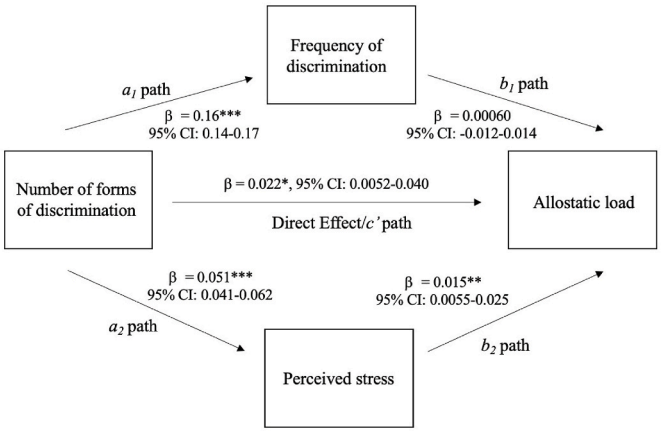

Fig. 2. Structural equation model of the association between the number of forms of discrimination and allostatic load through the frequency of discrimination and perceived stress† (n = 5195). †Model controls for: unfair police treatment, adolescent in-school peer prejudice, adolescent in-school teacher fairness, social origins, ACEs, smoking status, binge drinking, adolescent household structure, marital status, educational attainment, sex assigned at birth, race/ethnicity, age, and nativity. ***p < 0.001 **p < 0.01 *p < 0.05. Source: National Longitudinal Study of Adolescent to Adult Health

that experiencing discrimination based on multiple attributes likely compounds to increase the stress generated by discrimination (Grollman, 2012, 2014). From a physiological standpoint, if the stress associated with exposure to interpersonal discrimination lends to heightened physiological responses (Richman et al., 2018), perceiving discrimination based on more than one attribute takes an increasing toll on physiological dysregulation.

As scholars have posited, this may reflect the distinct and compounding nature of exposure to different forms of discrimination (Grollman, 2012; Meyer et al., 2008; Vargas et al., 2020); however, it also must be acknowledged that exposure to some of these forms are likely not experienced independently but rather interdependently. For example, intersectionality theory argues that different types of inequality, such as racism, sexism, and clasism, *interact* to generate interdependent and mutually reinforcing systems of oppression that structure individuals' lived experiences, opportunities, and the structural constraints they face (Homan et al., 2021). In other words,

Table 5
Total, direct, and indirect effects between the number of forms of discrimination and allostatic load (n = 5195).

	Coefficient	Boot-strapped SE	BC 95% CI[a]	PME[b]
Frequency of discrimination	0.000094	0.00090	(-0.0017, 0.0019)	0.0041
Perceived stress	0.00078**	0.00027	(0.00025, 0.0013)	0.034
Combined (total indirect)	0.00088	0.00087	(-0.00083, 0.0026)	0.038
Direct effect	0.022*	0.0087	(0.0052, 0.040)	
Total effect	0.023*	0.0087	(0.0061, 0.040)	

**p < 0.01 *p < 0.05.
[a] Bias-Corrected 95% confidence interval.
[b] Proportion of the effect mediated.
Source: National Longitudinal Study of Adolescent to Adult Health

different forms of interpersonal discrimination may be conditional on one another, rather than mutually exclusive, in shaping health outcomes. While outside the scope of the current study, future research could certainly benefit from exploring the ways in which multiple forms of discrimination exacerbates the risk for increased allostatic load that may not be simply additive but also multiplicative.

Second, I found the relationship between interpersonal discrimination and allostatic load remained net of a wide range of established psychosocial stressors, including other types of discrimination and earlier life course sources of stress, thus demonstrating the robustness of this relationship. In other words, given allostatic load is a physiological marker of the accumulating stress that accompanies life course disadvantage (Goosby et al., 2018), these results emphasize the pernicious effect interpersonal discrimination has on physical health, independent of these stressors.

Finally, these results have important implications for the prediction of the longer-term physical health penalties due to exposure to multiple forms of discrimination earlier in adulthood. Adults between the ages of 30 and 45 are primarily at their peak physical health and functioning out of the adult life span because of their strong immune systems, low vulnerability to infectious diseases, and lower risk of having chronic conditions relative to middle and later adulthood, and better health behavior patterns than earlier adulthood (Mehta et al., 2020). Allostatic load is a key indicator of the risk for developing chronic conditions and mortality (Beckie, 2012); increased allostatic load in earlier adulthood is subsequently a robust predictor of later in life premature physical health deterioration and mortality.

My second major finding is that the frequency of discrimination did not moderate the relationship between the number of forms of discrimination and allostatic load. Moreover, when considered independently in the same model, the number of forms of discrimination was associated with allostatic load whereas the frequency of discrimination was not net of covariates. However, this result should be interpreted with caution and does not necessarily conclude that the frequency of discrimination does not matter to health; it may simply reflect the two-

stage structure of the EDS survey questions, particularly that respondents are foremost asked about unattributed discriminatory experiences and then asked *why* these experiences happened (the social attribute(s) behind them). For example, research assessing different types of survey instruments on discrimination has demonstrated that whether race is directly mentioned in a survey question on discriminatory experiences affects both the frequency and mean scores of reporting racial/ethnic discrimination (Shariff-Marco et al., 2011). Thus, the two-stage nature of the EDS questionnaire may be underestimating the impact of the frequency of exposure to discrimination for some forms of discrimination and/or members of social groups answering them. Future research could certainly benefit from exploring this further.

Along this same vein, my final major finding is that the frequency of discrimination did not mediate the relationship between the number of forms of discrimination and allostatic load, and perceived stress only marginally mediated it. Regarding perceived stress, I speculate that this could indicate that the increasing number of forms of discrimination is generating physiological stress responses regardless of perceived stress, subsequently contributing to increased allostatic load. This possibility is consistent with the notion of an "involuntary response to identity threat" which suggests that despite an individual not necessarily overtly perceiving discriminatory experiences as stressful, they can induce "involuntary" physiological stress responses such as increased blood pressure (Major & O'Brien, 2005).

My study must be considered in the context of limitations. First, I cannot make causal claims. Second, although biomarker data is also available in Wave IV (2008), because the discrimination questions were not asked in prior Waves (Waves I-IV), I cannot determine trajectories of the relationship between interpersonal discrimination and allostatic load. Finally, because of the nature of the EDS questions, it is impossible to know whether an individual is attributing discriminatory experiences to multiple attributes simultaneously or independently, which means I cannot speak to the independence or interdependence of each of the experiences of discrimination. For example, it is possible that individuals may perceive the experiences as being simultaneously due to their race/ethnicity and gender (e.g., gendered racism) or some experiences as due to their race/ethnicity and some experiences due to their gender. In line with intersectionality theory, this discordance could have implications for the effect on health outcomes.

Limitations notwithstanding, my study builds upon and imparts a novel contribution to the extant body of literature on the relationship between interpersonal discrimination and allostatic load by considering discrimination based on multiple attributes. My findings reveal that perceiving discrimination based on multiple attributes is associated with increasing allostatic load, and this is robust to a wide array of other social stressors. Given the pervasiveness of discrimination in the U.S., the exigent need for policies and initiatives to address discrimination in our society to work toward reducing health inequities, and ultimately improving population health, cannot be understated. This could include, as examples, increased and more equitable access to education, which has been shown to have strong influences on reducing prejudice, and implementing laws that prohibit legal forms of discrimination such as weight discrimination. These types of macro level changes would have downstream effects on reducing interpersonal discrimination and its health consequences.

Ethical statement

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CRediT authorship contribution statement

Carlyn Graham: Conceptualization, Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing.

Declaration of competing interest

None.

Data availability

The authors do not have permission to share data.

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