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ORIGINAL ARTICLE

Wealth, Health, and the Moderating Role of Implicit Social Class Bias

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Abstract
Background Subjective social status (captured by the MacArthur Scale of Subjective Social Status) is in many cases a stronger predictor of health outcomes than objective socioeconomic status (SES).
Purpose The study aims to test whether implicit beliefs about social class moderate the relationship between subjective social status and inflammation.
Methods We measured implicit social class bias, subjective social status, SES, and baseline levels of interleukin-6 (IL-6), a marker of inflammation, in 209 healthy adults.
Results Implicit social class bias significantly moderated the relationship between subjective social status and levels of IL-6, with a stronger implicit association between the concepts "lower class" and "bad" predicting greater levels of IL-6.
Conclusions Implicit social class bias moderates the relationship between subjective social status and health outcomes via regulation of levels of the inflammatory cytokine IL-6. High implicit social class bias, particularly when one perceives oneself as having low social standing, may increase vulnerability to inflammatory processes.

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Wealth, Health, and the Moderating Role of Implicit Social Class Bias

Socioeconomic status (SES) is one of the most powerful and pervasive predictors of health and disease in human populations. An inverse relationship between SES and health has been documented for a striking variety of mental and physical health outcomes, quality of life measures, and life expectancy. These relationships are observed across the full range of SES, irrespective of industrialization: the wealthiest at the upper ends of SES distributions generally fare best while those at the lower ends fare worst [1, 2]. A variety of traditional indicators including individual income, education, and occupation has been used to assess SES. Recently, however, there has been a growing interest in understanding and assessing how the perception of one's relative status within a social hierarchy (subjective social status) may help account for the effects of social status on health. Towards this purpose, the MacArthur Scale of Subjective Social Status [3] was designed to capture a person's "sense of their place" in the social ladder; that is, their personal and subjective assessment of their status relative to others.

Adler and colleagues [3] demonstrate that subjective social status is related to indicators of both physiological and psychological function while controlling for objective SES. Similar subjective social status effects, over and above those of SES, have also been reported for self-rated health [4], mental health [5], and cortisol levels [6]. These findings suggest that the inverse relationship between SES and health may have as much to do with the psychosocial experience of "feeling poor" as it does with the economic experience of "being poor" [7]. These findings focus on psychosocial

determinants of health, in contrast to the historical focus on economic determinants of health. Subjective social status is in many cases a more powerful predictor of negative health outcomes than traditional objective measures [2, 7, 8].

Inflammation is a critical component of the immune system's defense against infection and injury; however, chronic activation of inflammatory pathways can eventually lead to deleterious health outcomes [9]. Over-activation of inflammation pathways is one proposed mechanism by which SES shapes health [10]. The products of these pathways, pro-inflammatory cytokines, increase in response to acute psychosocial stress and are elevated under conditions of chronic stress, such as low SES [11, 12].

Excessive inflammation is implicated as a key pathway for numerous illnesses including cardiovascular disease, depression, and obesity [13–16]. Psychosocial factors are also associated with markers of inflammation. For example, optimism predicts lower levels of the pro-inflammatory cytokine interleukin-6 (IL-6), while pessimism predicts decreased levels [17]. Furthermore, while challenging psychosocial experiences predict higher levels of IL-6 [12], positive psychosocial experiences, such as maternal warmth, can moderate the relationship between SES and production of IL-6 [18].

A parallel body of work from social psychology on implicit bias—the tendency to automatically evaluate a given social category (e.g., race, gender) as good or bad—suggests that automatic, negative self-evaluations predict psychological distress [19]. Here, we used a novel application of the widely used Implicit Association Test (IAT) to assess unconscious attitudes about social class [20]. The IAT is a computerized reaction time program that measures the ease with which people categorize a target concept (e.g., "flowers" or "Latinos") with evaluative terms such as "good" or "bad." The difference in average matching speed for opposite pairings determines the IAT effect size *D*, a measure of the strength of association between the concept and the evaluative term (for further discussion of the IAT, see [20]). By assessing implicit associations, the IAT can reveal biases that people might not explicitly divulge or be conscious of. Implicit attitude measurement is particularly relevant in areas where self-presentation concerns are high, such as with prejudice and stereotyping [21]. Although critics have questioned the relevance of implicit associations for real life events [22], a recent meta-analysis directly counters this criticism with a large body of predictive validity findings for a host of behavioral consequences [21]. In this study, we utilized the methodology of the IAT to examine the implications of implicit biases on immune function.

We sought to integrate the social epidemiology and social psychology literatures by examining the extent to which a person's implicit attitude about social class, coupled with their subjective perception of their social status, impacts an indicator of immune health. The current study is the first to test whether low subjective social status individuals who also possess a strong negative class bias (i.e., associate lower class with bad at an automatic level) are at the greatest risk for poor health outcomes. We predicted that baseline levels of inflammatory cytokines would be highest in those individuals who explicitly place themselves low in social status yet simultaneously harbor the strongest implicit belief that lower class is bad.

We selected circulating levels of the pro-inflammatory cytokine interleukin-6 (IL-6) as a biomarker of immune function, as elevated levels of IL-6 are implicated in a broad spectrum of diseases including type II diabetes [23], cardiovascular disease, and obesity [14, 16]. The Macarthur Scale of Subjective Social Status [1] was used to measure subjective social status; we collected an explicit measure of social class bias and used an Implicit Association Test [24] to measure implicit social class bias. We also measured SES for use as a covariate in the analyses.

Method

To test for the replicability of our findings, we collected data from two cohorts at two separate times drawn from the same population. The study was advertised on the UC Berkeley Campus; subjects were undergraduate students recruited through the Psychology department's Research Participation Program and received partial course credit for participation. All participants who signed up for participation completed the entire experiment. Cohort 1 consisted of 113 participants (71 females), sampled from the undergraduate student population at the University of California, Berkeley. The age of participants ranged from 18–33 (mean=19.6). The sample was 24 % Caucasian, 47 % Hispanic, 25 % Asian, and 4 % African American. Hispanic students were overrepresented in cohort 1 because participants from another study focusing on Hispanic students were invited to participate in this study. This overrepresentation was addressed in cohort 2, with the percentage of Hispanic students in the sample being similar to the percentage of students of other races. Cohort 2 consisted of undergraduate students from UC Berkeley, recruited in the same manner, and included 96 participants (46 female), ages 18–29 (mean=19.7). Participants were 27 % Caucasian, 24 % Asian, 25 % Hispanic, and 24 % African American. The analyses reported below were not moderated by cohort; thus all data presented is combined from both cohorts, and this variable is not discussed further. Participants were asked to refrain from eating and drinking 1 h prior to the beginning of the experiment and inclusion criteria included being free of chronic and acute health conditions. Consent for all procedures was obtained, and all procedures were carried out in accordance with the standards and practices of the UC Berkeley Committee for the Protection of Human Subjects.

Measures

Socioeconomic Status Measures

Demographic information included age, sex, and race. Participants provided parental occupation and highest level of education; these scores were averaged to index SES [3]. As a measure of subjective social status, we used the Macarthur Scale of subjective social status for which participants are asked to place an "*x*", indicating where they place themselves on a 10-rung ladder relative to others in the United States [1]. This measure correlates with, but is not equivalent to, objective measures of SES such as income, education, or occupation [3].

Explicit Social Class Bias

Participants completed an existing measure of explicit bias for social class [25]. A 10-point thermometer assessed the coldness or warmth of their feelings towards upper class and lower class individuals. The difference score was used as a measure of explicit social class bias. Larger values indicate that the participant self reported that they felt more warmth towards upper class individuals than lower class individuals.

Implicit Social Class Bias

A "social class" implicit association test (IAT) was used here to measure the strength of participants' automatic associations between the target concepts "upper class" and "lower class" with the evaluative terms "good" and "bad". This social class IAT is a modified version of an IAT that has previously been used to measure differences in implicit attitudes about rich people and poor people [26]. The concept categories were changed from "rich" and poor" to "upper class" and "lower class". The stimulus items used for "upper class" and "lower class" were identical to the stimulus items used in the "rich" and "poor" IAT, with the addition of the terms upper class and lower class. Upper class items included *rich*, *wealthy*, *affluent*, *prosperous*, *well off*, *loaded*, *fortune*, and *upper class*. Lower class items included *poor*, *poverty*, *impoverished*, *needy*, *broke*, *penniless*, *bankrupt*, and *lower class*. The stimulus items used for the "good" evaluative terms were *marvelous*, *superb*, *pleasure*, *beautiful*, *joyful*, *glorious*, *lovely*, and *wonderful*. The "bad" evaluative terms were *tragic*, *horrible*, *agony*, *painful*, *terrible*, *awful*, *humiliate*, and *nasty.* The IAT effect size *D* is the standardized difference in response latencies between the association pairs and was computed for each session [24]. Raw *D* scores were both positive and negative, and in this study, smaller raw values reflect a stronger implicit association between lower class and poor. The raw *D* scores were transformed in order to make all values positive, by adding 10 to the raw value. After this transformation, larger *D* scores are indicative of a weaker implicit association between the concepts of "lower class" and "bad".

Inflammation Measures

Baseline samples of oral mucosal transudate were collected for IL-6 measurement. While not a proxy for plasma levels, oral mucosal transudate has been shown to reflect immune system activity [27], and correlate with psychosocial variables [28]. An Orasure collective device (Epitope, Beaverton, OR.) was placed between the lower cheek and gum for 2 min. The sample was frozen and stored at −80 °C. IL-6 concentrations were determined by an enzyme linked immunosorbent assay using commercially available kits (R&D systems, Minneapolis, MN). Samples from each individual were run in duplicate on the same plate. Protein levels in oral fluids was quantified using the BCA protein assay with bovine serum albumin as the standard (Thermo Scientific, Rockford, IL), with HEPES as the diluent, and all samples were run in triplicate on the same plate according to kit instructions. Total protein was measured to control for individual differences in salivary flow rate [29].

Physical Health and Current Depressive Symptoms

Body Mass Index (defined as weight in kilograms/height in meters squared) and current depressive symptoms (with the Beck Depression Inventory) were measured [30]. Participants completed the following measure of self-rated health: in general would you say your health is: excellent/very good/good/fair/poor [31].

Statistical Analyses

Only four participants (.02 % of sample) demonstrated an implicit association between lower class and good, while all other participants demonstrated an implicit association between lower class and bad to varying degrees. The raw IL-6 and implicit class bias distributions were positively skewed (skewness 2.07, SE=0.17, kurtosis 5.00, SE=0.34; skewness 0.96, SE=.17, kurtosis 0.95, SE=0.17, respectively) and did not meet the diagnostic criteria for linear regression according to the IQR and Shapiro-Wilk test [32]. Thus, these values were normalized by log-transformation [33, 34]. IL-6 levels, implicit social class bias, and subjective social status values were converted to *z* scores (see Table 1 for descriptive statistics of non-transformed variables).

Associations among all variables were examined initially with bivariate analyses using Pearson's correlation analysis. Hierarchical multiple regression analyses were then used to examine the independent and interactive relationships among

Table 1 Descriptive characteristics of study population

IL-6 (pg/mL) (mean (SD))	2.81 (3.43)
Age (mean (SD))	19.62 (2.11)
Gender (% male)	44 %
Beck Depression Inventory (mean (SD))	7.71 (6.10)
Body Mass Index (mean (SD))	24.51 (3.27)
Implicit Social Class Bias (mean (SD))	−.88 (.36)
Subjective Social Status (mean (SD))	5.45 (2.01)

subjective social status, implicit social class bias, and IL-6 levels. Control variables included age, gender, Beck Depression Inventory, and Body Mass Index. These variables were not significantly related to IL-6 levels (see Table 2), and the model was still significant while controlling for these variables. Thus, these variables were dropped from subsequent analyses to preserve degrees of freedom. The relationship between the time of collection of the oral mucosal transudate sample and baseline levels of IL-6 was non-significant, which suggested that differences in IL-6 levels were not driven by diurnal variations in inflammatory activity. An alpha level of 0.05 was used to determine statistically significant associations.

Results

All variables were measured and analyzed as continuous variables. Measures of central tendency and variability for the primary variables of interest are listed in Table 1. Bivariate relationships between study variables are shown in Table 2. Figure 1 displays the relationship between implicit social class bias and the central dependent variable, baseline levels of IL-6. Self-rated health was significantly related to explicit social class bias (b=0.21, p<0.01) and current depressive symptoms (b=−0.18, p<0.01) but had no significant relationship with implicit social class bias.

To test for main effects of subjective social status and implicit bias on log-transformed IL-6 levels, SES and total protein were entered in step 1 of a multivariate regression analyses as control variables, and subjective social status and log-transformed implicit bias were entered in step 2. Both subjective social status and the degree of implicit social class bias were significant independent predictors of IL-6 (b=−0.31, t (203)=−4.65, p<0.001; b=0.53, t (203)=8.90, p<0.001). These relationships were in the directions predicted with low subjective social status and high implicit social class bias predicting higher baseline levels of IL-6. The overall model was significant, F (2,204)=48.27, p<0.001 and explained 32.4 % of the total variance in IL-6 levels (adjusted R^2=0.32).

To explore interactive effects, we first entered SES and implicit social class bias into the following regression model followed by the interaction term: log IL-6=(constant+b_1 (log implicit bias)+b_2 (SES)+b_3 (implicit bias*SES)+b_4 (total protein)). The interaction was not significant (b=−0.11, t (203)=−1.75, p>0.05). To examine the predicted moderating influences on IL-6 levels, subjective social status and implicit social class bias were entered into the following regression model followed by the interaction term: log IL-6=(constant+b_1 (log implicit bias)+b_2 (subjective social status)+b_3 (subjective social status*implicit bias)+

Table 2 Bivariate correlations among study variables

	Implicit social class bias	Explicit social class bias health	Log IL-6[a]	SSS[b]	SES[c]	BMI[d]	Self-rated health	BDI[e]	Age
Implicit social class bias	1.00	0.06	0.53**	−0.13	0.12	−0.03	−0.13	−0.05	0.01
Explicit social class bias	–	1.00	0.02	−0.01	0.53**	0.03	0.21**	0.04	0.09
Log IL-6[a]	–	–	1.00	−0.31**	−0.09	−0.06	−0.33**	−0.06	−0.03
SSS[b]	–	–	–	1.00	0.53**	−0.10	0.09	−0.04	−0.03
SES[c]	–	–	–	–	1.00	0.04	0.08	−0.15	−0.10
BMI[d]	–	–	–	–	–	1.00	−0.12	0.08	−0.09
Self-rated health	–	–	–	–	–	–	1.00	−0.18**	0.06
BDI[e]	–	–	–	–	–	–	–	1.00	−0.06
Age	–	–	–	–	–	–	–	–	1.00

*p<0.05, **p<0.01

[a] Interleukin-6

[b] Subjective social status

[c] Socioeconomic status

[d] Body Mass Index

[e] Beck Depression Inventory

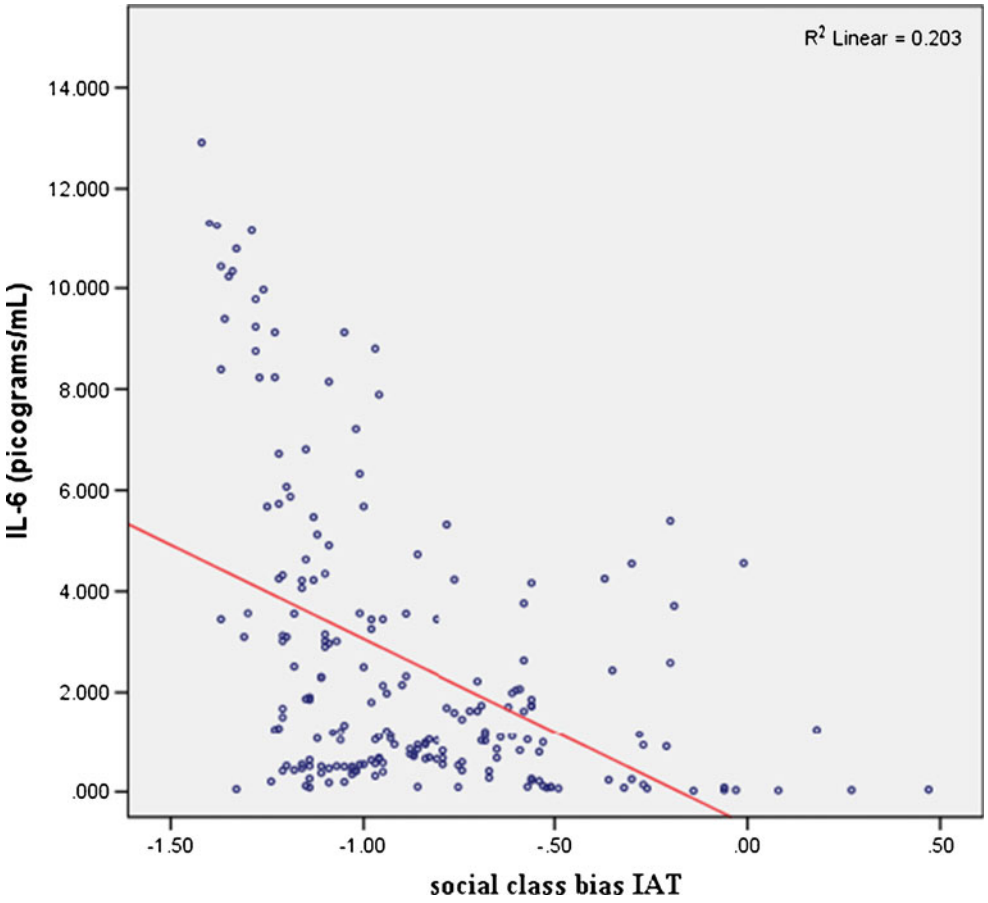

Fig. 1 Scatter plot of untransformed IL-6 levels and implicit social class bias. The *y* axis (IL-6) is measured in picograms per milliliter and the *x* axis reflects the *D* score for each individual. Smaller Implicit Association Test values reflect a stronger implicit association between the concepts poor and bad

b_4 (SES)+b_5 (total protein)). The overall model was significant, F (3,203)=43.76, p<.001, and explained 39.2 % of the total variance in IL-6 levels (adjusted R^2=0.40). The addition of the interaction term significantly improved the model and increased the variance explained in IL-6 levels by 6.8 %. The interaction between subjective social status and implicit social class bias was significant (b=−0.28, t (203)=−4.88, p<0.001), such that low subjective social status participants with high levels of implicit class bias showed significantly elevated levels of IL-6 relative to their peers. This interaction is displayed in Fig. 2; the IL-6 values and implicit bias values used are the *z* scores of the log of the IL-6 and of the transformed *D* scores.

To further illustrate the nature of this interaction, the follow-up simple slope analyses revealed that greater implicit social class bias (i.e., a stronger implicit association between lower class and poor) was significantly associated with increased IL-6 for low subjective social status individuals (b=0.99, t=7.96, p<0.001). In contrast, for high subjective social status individuals, greater implicit social class bias was not significantly associated with increased IL-6 (b=−0.26, t=1.55, p>0.05) [35]. These findings suggest that implicit social class bias moderates the extent to which subjective social status predicts health outcomes.

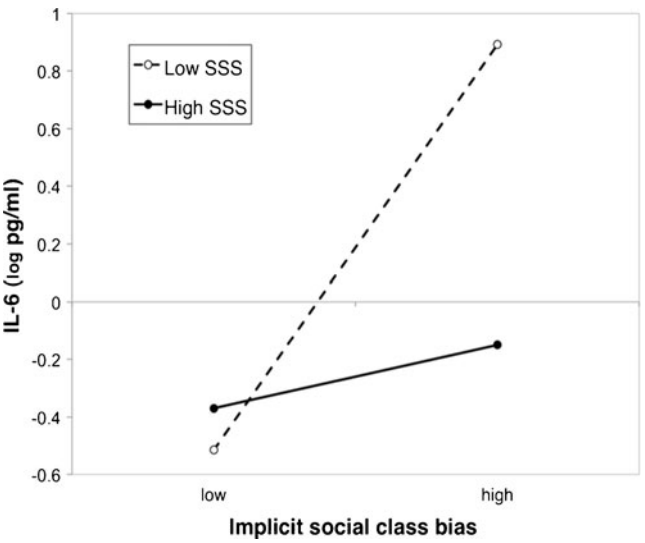

Fig. 2 Implicit social class bias moderated the effect of subjective social status on IL-6 levels (***p<0.001), 95 % CI [−0.417, −0.117], N=209. IL-6 values are reported as a *z* score of log IL-6 (picograms per milliliter). Analyses controlled for objective SES and total oral protein levels. All variables were measured and analyzed as continuous variables. Plotted values represent predicted scores for participants one standard deviation above and below the implicit social class bias and subjective social class distributions

Discussion

To our knowledge, this is the first study to examine the role of implicit beliefs about social class in the SES-health gradient, and more specifically the subjective social status-health gradient. We hypothesized that implicit social class bias could be a powerful factor in the relationship between subjective social status and health as implicit associations revealed by the Implicit Association Test predict health outcomes independent of parallel self-reports. The data demonstrate a subjective social status × implicit social class bias interaction which is significantly associated with IL-6 levels in subjects while the SES × implicit social class bias interaction is not.

While the mechanisms through which subjective social status influence health outcomes remain unclear, the most commonly discussed hypothesis suggests that it may be capturing a more "social" dimension to economic status than is typically reflected in more objective measures of SES. This more socially nuanced measure may be influencing health outcomes in a number of ways. Subjective social status may be capturing an individual's assessment of their own SES trajectory over the life course rather than a single moment in time. Another possibility is that it is directly capturing an individual's "relative" social position within the population. In making this assessment, an individual is likely to consider multiple dimensions of social class. Social rank can influence health outcomes in at least two ways: directly influencing processes such as stress reactivity and indirectly through actions that may compromise health [36].

A self-perceived low social status could exert the observed effects on inflammation through feelings of anxiety related to awareness of inequalities [37]. High subjective social status appears to offer protective effects for this important immune biomarker of health; this finding could be explained by feelings of control derived from high subjective social status [38]. Furthermore, low socioeconomic status or self-perceived low social status is often associated with a reduced sense of control over all aspects of life, which leads to increased psychological stress and an increased risk of ill health [39].

The social class IAT measures an individual's automatic evaluative beliefs about social class. Similar to subjective social status, an individual's implicit beliefs about social class are likely based upon consideration of numerous dimensions of social class, not limited to common objective measures such as income, occupation, or education. This similarity between subjective social status and implicit social class bias is one potential explanation for their significant interaction in predicting baseline levels of inflammation. Our findings speak to the importance of the consideration of implicit, automatic beliefs in the study of the SES-health gradient, in addition to both objective and subjective measures of social class.

The biological embedding of childhood adversity model proposes that psychological stress occurring in early life, which is often associated with low SES backgrounds, later gives rise to an immune response associated with a chronic pro-inflammatory state [40]. The model suggests that stressors occurring during early developmental windows, when immune system programming is quite malleable, can result in exaggerated inflammatory responses when exposed to challenges later in life. Unfortunately, our data do not afford us the opportunity to explore whether early-life adversity and psychological stress during childhood are partially responsible for our findings. Future studies should explore early-life measures of adversity and stress as a potential mediator in this relationship.

Our findings are consistent with prior literature documenting an association between IL-6 in oral fluids and psychosocial variables [27]. However, given that IL-6 was measured at one time-point, we could not examine changes in inflammatory responses over time. Future research should extend upon these findings by examining differences in activation of inflammatory responses, as well as differences in the time it takes for individuals to recover from elevated levels of pro-inflammatory cytokines to baseline levels. Individuals with elevated baseline levels of pro-inflammatory cytokines with exaggerated inflammation responses to stressors, who take longer to recover, would be most vulnerable to conditions associated with exaggerated inflammation.

These data are in line with previous findings suggesting that explicit and implicit measures differentially predict health outcomes [15, 16]. While the central dependent variable in this research was baseline IL-6 levels, explicit social class bias was significantly related to both self-rated health and current depressive symptoms, while implicit social class bias was not significantly related to these measures of health. Future research should incorporate both implicit and explicit measures of social class bias and should explore additional domains of health.

Our sample consisted of young, college students; all self reported that they were free from chronic or acute health conditions. As such, caution is needed in generalizing these findings. Nevertheless, given that differences in levels of inflammation exist even within this population, it is possible that in a sample with increased heterogeneity, the size of our effect would be magnified. Future studies utilizing more representative samples will allow us to speak to the generalizability of our findings.

These findings suggest that a low level of implicit social class bias is one psychological variable capable of offsetting inflammation processes, thereby providing a non-medical pathway through which a psychosocial variable can moderate a biological risk factor, particularly in subjects with low subjective social status. Putative interventions that decrease implicit social class bias

(directly or indirectly) may serve to reduce disparities and improve health.

Conflict of Interest The authors have no conflicts of interest to disclose.

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