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Socioeconomic status trajectories across the life course, daily discrimination, and inflammation among Black and white adults

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ABSTRACT

Objective: This study replicates and expands Surachman et al.'s (2020) findings documenting socioeconomic status (SES) trajectories across the life course in an independent sample of Black (majority recruited from Milwaukee, WI) and white adults in the United States. We extend this work by examining whether SES trajectories and daily discrimination are independently associated with markers of inflammation.

Method: Data were from 215 Black adults (188 recruited from Milwaukee, WI; 27 recruited from across the continental US) and 985 white adults (7 recruited from Milwaukee, WI; 978 recruited from across the continental US) who completed the baseline interview and biomarker assessment during the second wave of the Midlife in the United States (MIDUS) Study (ages = 34–84). SES life course trajectories were examined using latent class analysis based on objective (e.g., income and education) and subjective (e.g., social status and financial strain) indicators of SES. The association between life course SES trajectories and daily discrimination with markers of inflammation (IL-6, CRP, fibrinogen) were examined using multiple linear regression analyses, controlling for demographic, psychological, behavioral, and health-related covariates.

Results: Black and white participants showed different patterns of life course SES trajectories. Among Black participants, the trajectories were Objectively Stable Low (45.16%), Downwardly Mobile (18.05%), and Upwardly Mobile (36.79%). Compared to the Upwardly Mobile, the Objectively Stable Low class showed elevated IL-6 after controlling for all covariates. Further, daily discrimination, but not SES trajectories, was significantly associated with CRP and fibrinogen after controlling for demographic, psychological, and behavioral covariates. White participants' experiences of life course SES trajectories were characterized as Objectively Stable Low (7.02%), Subjectively Downward (12.48%), Upwardly Mobile (39.99%), and Stable High (40.51%). Among white participants, SES trajectories, but not daily discrimination, were associated with all markers of inflammation (controlling for age and sex).

Discussion: Consistent with the fundamental cause theory, multiple independent pathways link SES trajectories across the life course and daily discrimination to racial disparities in IL-6, CRP, and fibrinogen.

Over the past two decades, there has been a growing interest in examining the impact of life course SES on disparities in adult inflammation (Loucks et al., 2010; Pollitt et al., 2008). According to the biological embedding model, childhood is a sensitive period in which the experience of socioeconomic hardship can increase the probability of chronic diseases in adulthood through an exaggerated inflammatory response (Miller et al., 2011). Moreover, exposure to socioeconomic hardship during childhood can lead to a higher probability of exposure to socioeconomic hardship later in life, including lower levels of education and lower levels of income, creating a trajectory of continuous socioeconomic adversity across the life course (Surachman et al., 2019). Similarly, early life socioeconomic privilege can accumulate over time, leading to high SES across the life course. Some individuals experience socioeconomic mobility, however, either gaining or losing socioeconomic position throughout their lives (Surachman et al., 2020).

Growing research has demonstrated that SES trajectories across the life course are associated with inflammation in adulthood. Stable low SES across the life course was associated with elevated C-reactive protein (CRP), while downward mobility was associated with higher interleukin-6 (IL-6) relative to stable high SES across the life course

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(Loucks et al., 2010). Another study showed the beneficial effects of life course upward mobility on circulating inflammatory markers (Castagné et al., 2016). The present study adds to the emerging body of scholarship that examines the associations between SES trajectories across the life course and inflammation in adulthood.

1. Race, socioeconomic trajectories, and inflammation

Numerous studies have also documented racial disparities in inflammation, particularly between Black and white American adults (Boylan et al., 2020; Stepanikova et al., 2017). However, it is unclear whether racial disparities in inflammation between Black and white adults are related to racial differences in trajectories of SES across the life course (Loucks et al., 2010). It is important to incorporate both the objective indicators of SES (e.g., income and education) with subjective SES (i.e., appraisal of one's social status and ability to access resources) when examining the role of SES trajectories in health disparities between Black and white adults (Surachman et al., 2020). Despite having lower levels of education and income compared to white adults, Black adults tend to perceive higher subjective SES, especially when proximal references are used as a comparison (Wolff et al., 2010). Subjective SES, whether measured at the community- (Murray et al., 2019), neighborhood- (Weden et al., 2008), or nation-level (Derry et al., 2013), is significantly correlated with multiple health outcomes, including inflammation, independent of levels of education and income. This approach presents a more comprehensive representation of socioeconomic hardships and privileges across the life course among Black and white adults (Surachman et al., 2020).

Combining both objective and subjective measures of SES across the life course, Surachman et al. (2020) conducted a within-race examination of the association between SES trajectories and inflammation among Black and white adults. Using latent class analysis, they found unique patterns of SES trajectories among Black and white adults, with Black Americans' trajectories characterized by the lack of upward mobility and a higher proportion of low SES across the life course and white adults' trajectories marked by constant high SES across the life course and a lack of downward mobility. Further, Surachman et al. (2020) found that SES trajectories were significantly associated with inflammation, including CRP and IL-6, only among white adults but not Black adults. The authors posited the lack of effect of SES on

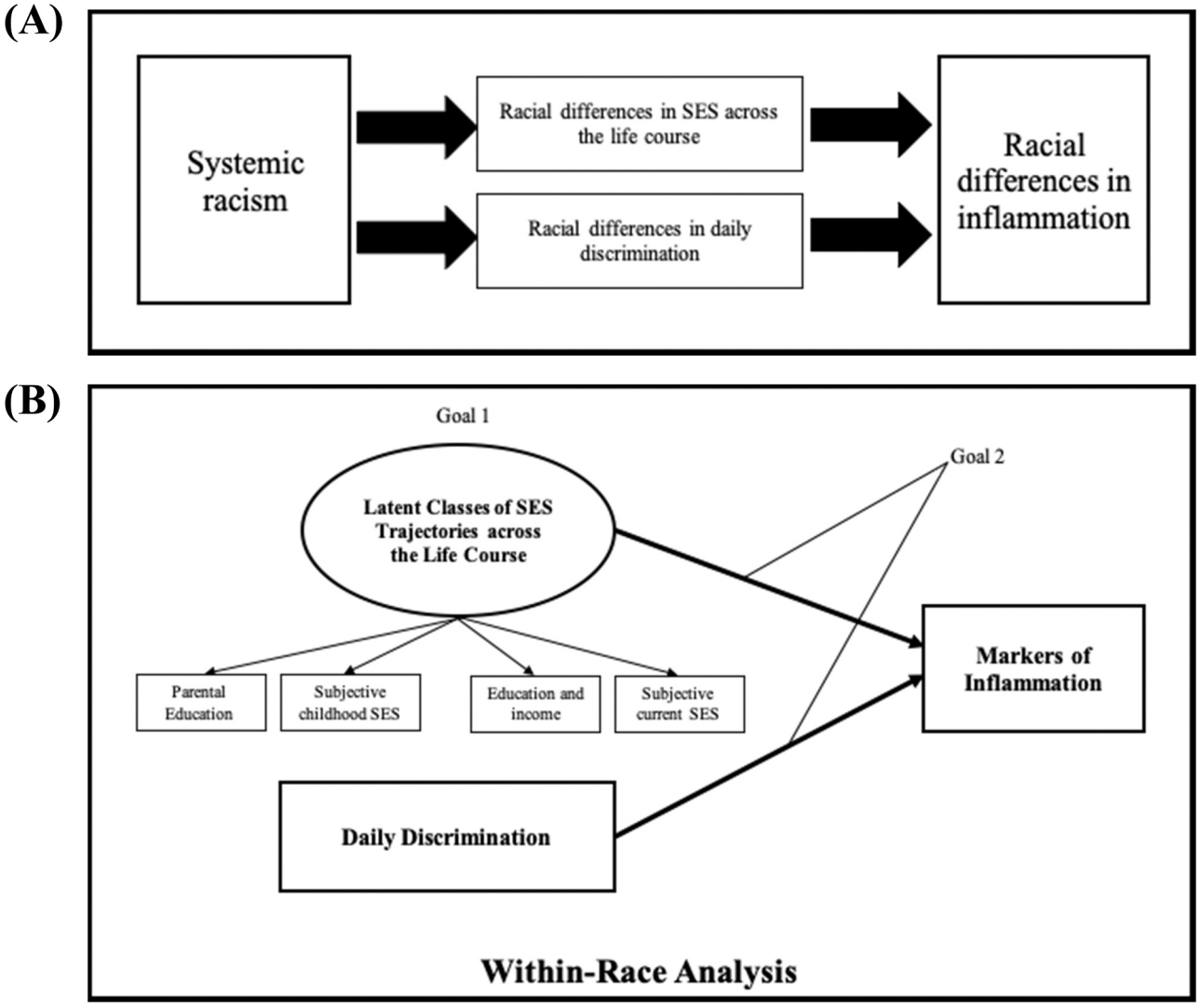

Fig. 1. (A) According to the fundamental cause theory (Phelan and Link, 2015), systemic racism is the fundamental cause of racial differences in adult health, including inflammatory biomarkers. Systemic racism is manifested in socioeconomic inequity across the life course that disadvantage Black adults. In addition, Black adults also experience more frequent daily discrimination, which is independent of SES level. (B) The goal of the current study was two-fold: 1) to identify latent classes of SES trajectories based on both objective and subjective indicators of SES separately for Black and white adults, and 2) to examine whether latent classes of SES trajectories and daily discrimination were significantly associated with multiple markers of inflammation, including IL-6, CRP, and fibrinogen.

inflammation among Black adults supported the *diminishing return hypothesis* (Surachman et al., 2020), in which the most affluent Black individuals receive fewer health benefits compared to their white counterparts. The authors speculated that the diminishing return of SES on inflammatory biomarkers among Black adults is due to lower levels of SES (even for the most affluent group of Black adults) and the pervasive experience of daily discrimination (Surachman et al., 2020). However, the study by Surachman et al. (2020) did not examine the association between daily discrimination and inflammation.

According to the fundamental cause theory (Phelan and Link, 2015), investigation of the role of SES in health disparities between Black and white adults must explicitly examine the impact of systemic racism as a fundamental cause. Specifically, systemic racism manifests via two main pathways (Fig. 1A). The first pathway entails the social, economic, and educational exclusion and marginalization of racial minorities that routinely results in lower social standing for Black adults (Phelan and Link, 2015; Williams and Mohammed, 2009). Compared to white adults, Black adults have a higher chance of being unemployed even with a college education and they have less wealth across every level of income (Williams and Mohammed, 2009). As a result, there is inequality between Black and white adults' ability to accumulate socioeconomic resources across the life course (Oliver et al., 2006), which may result in compromised physical health, as evidenced by higher levels of inflammation in adulthood (Loucks et al., 2010).

The second pathway linking systemic racism to health disparities is through factors independent of SES, including pervasive experiences of discrimination (Phelan and Link, 2015). Day-to-day experiences of discrimination are associated with increased levels of inflammation among Black adults, even after controlling for SES (Beatty et al., 2014; Kershaw et al., 2016). Thus, the disparities in inflammation between Black and white adults are not only a consequence of the accumulation of inequitable socioeconomic experiences over the life course between Black and white adults but also the chronic experiences of daily discrimination that directly affect Black adults' physiological health. Thus, building upon prior research linking SES trajectories to inflammation, the current study examined both the independent effects of life course SES and daily discrimination on inflammation among Black and white adults.

The Surachman et al. (2020) study examined SES trajectories using latent class analysis – a data-driven approach that examines the heterogeneity of the grouping of SES characteristics across the life course using categorical SES indicators (Lanza et al., 2007). Because LCA is a data-driven approach, identification of specific latent classes can be idiosyncratic and differences in sample characteristics across studies (e.g., birth cohort differences) can influence the number or nature of the identified latent classes of SES life course trajectories (Glei et al., 2018). The current study attempted to replicate the latent classes of life course SES trajectories found in the previous study by Surachman et al. (2020) using a different sample of Black and white adults to examine the robustness of these latent classes of SES trajectories based on both objective and subjective indicators of SES (Fig. 1B). Furthermore, we sought to extend the previous findings by Surachman et al. (2020) to investigate the unique effects of daily discrimination, along with SES trajectories, on inflammation among Black and white adults.

2. Methods

2.1. Participants and procedures

Data for the current analysis are from the Midlife in the United States (MIDUS) study (Brim et al., 2004). Relevant information for the current study is provided below and additional information regarding the MIDUS study can be found elsewhere (Kirsch et al., 2019; Radler, 2014). The MIDUS study started in 1995–1996 (MIDUS 1) with 7108 adults (ages 25–74; 79.5% white and 4.7% Black participants) recruited through random digit dialing (RDD). In 2004–2006, a longitudinal follow-up of the MIDUS study (MIDUS 2) was conducted with 4963 longitudinal participants (mortality-adjusted retention rate = 75%) who completed the initial baseline phone interview. Among them, 81% also completed self-administered questionnaires (SAQs). The MIDUS study sample is not representative of the US population, especially due to the low number of participants who identified as racial minorities (MIDUS 2 racial composition: 90.1% white and 4.6% Black; US population in 2000: 75.1% white and 12.3% Black). To increase the racial diversity of the MIDUS sample, a supplemental sample consisting of mostly Black adults was recruited from Milwaukee County, WI at MIDUS 2. This sample included 592 adults (response rate = 70.7%; 553 [93.4%] self-identified as Black and 19 [3.2%] self-identified as white) who completed the initial baseline phone interview and most of whom (67.2%) also completed SAQs.

A new protocol of biomarker assessment was also introduced in MIDUS 2, known as the MIDUS 2 Biomarker Project (2004–2009) (Weinstein et al., 2018). Biological indicators of physiology and health were assessed in the MIDUS 2 Biomarker Project, with the ultimate goal of investigating the long-term consequences of behavioral and psychosocial factors for health and well-being (Ryff et al., 2017). Both the longitudinal MIDUS participants and Milwaukee oversample participants who completed the baseline interview and SAQs were eligible to participate in the MIDUS 2 Biomarker Project. The total number of participants in the MIDUS 2 Biomarker Project was 1255, of which 16% of them were from the Milwaukee oversample. The final analytic sample consisted of 1200 adults (215 Black and 985 white participants) who participated in the MIDUS 2 Biomarker Project and self-identified as either Black or white. The majority of the Black participants in this study ($n = 188$; 87.4%) were from the MIDUS Milwaukee oversample, recruited from Milwaukee County, WI. The majority of the white participants ($n = 978$; 99.3%) were part of the MIDUS national sample recruited from across the continental US. The analytic sample of the current study was independent of the analytic sample used in the Surachman et al. (2020) study, which used data from the MIDUS Refresher. Participants in the current study were born between 1920 and 1970 (i.e., most participants were from the Silent Generation or Baby Boomers birth cohort); the MIDUS Refresher used in the Surachman et al. (2020) study included participants born between 1940 and 1989 (i.e., most participants were from the Baby Boomers or Gen X birth cohort).

2.2. Biomarker assessment protocol

Participants in the MIDUS 2 Biomarker Projects were invited to stay overnight at one of the three clinical research units (CRUs) located in the East Coast, Midwest, and West Coast. The selection of the CRU for each participant was based on the one that imposed the least travel burden. Blood and urine samples were collected during the stay at the CRU. Overnight, each participant was instructed to collect 12 h urine samples from 7 PM to 7 AM the next morning. In the morning before participants had their breakfast, fasting blood samples were also collected. To ensure consistency, blood samples were collected using standardized procedures (Weinstein et al., 2018). In addition to providing urine and blood samples, participants also completed physical exams, psychophysiology experimental protocol, and SAQs related to psychosocial assessments.

2.3. Measures

2.3.1. Socioeconomic trajectories

SES trajectories were assessed using seven indicators of SES across the life course: 1) parent's highest level of education (1 = less than high school; 2 = high school and above), 2) perception of family of origin's financial level (1 = a lot/ somewhat/ a little worse off than the average family, 2 = same/ a little/ somewhat/ a lot better off than the average family); 3) participant's level of education (1 = high school/ GED or less, 2 = some college and above); 4) participant's household-size adjusted income-to-poverty ratio (1 = less than 150%, 2 = equal or

more than 150%); 5) perception of current financial level (1 = low, 2 = medium or high); 6) perception of the availability of money to fulfill basic needs (1 = not enough money, 2 = enough money or more than you need); and 7) perception of hardship paying monthly bills (1 = very/somewhat difficult, 2 = not very difficult/ not at all difficult). This scale has been used in previous studies and is predictive of multiple health outcomes, including inflammation (Surachman et al., 2020), allostatic load (Gruenewald et al., 2012), chronic health conditions (Ferraro et al., 2016), and diabetes (Tsenkova et al., 2014).

2.3.2. Daily discrimination

Discrimination was measured using the Daily Discrimination scale (Williams et al., 1997), a nine-item measure of the frequency (1 = never, 2 = rarely, 3 = sometimes, 4 = often) of everyday discriminatory experiences including: 1) treated with less courtesy, 2) treated with less respect, 3) received poorer service, 4) perceived as not smart, 5) others acted as afraid of you, 6) perceived as being dishonest, 7) perceived as not as good as others, 8) called names or insulted, and 9) threatened or harassed. All items were summed, with higher score reflecting more discrimination (Cronbach's alpha = 0.92).

2.3.3. Markers of inflammation

We included three inflammatory biomarkers as the main outcome of this analysis, C-reactive protein (CRP), interleukin-6 (IL-6), and fibrinogen. Blood serum CRP was measured using a particle enhanced immunonephelometric assay (BNII nephelometer, Dade Behring Inc., Deerfield, IL). The assay range was 0.156–10 pg/mL, intra-assay coefficient of variability (CV) was 3.25% and inter-assay CV was 12.31%. Blood serum IL-6 was measured using ultra-sensitive ELISA (R&D Systems, Minneapolis, MN). The assay range was 0.156–10 pg/mL, intra-assay CV was 3.25%, and the inter-assay CV was 12.31%. Finally, fibrinogen was assayed using the BNII nephelometer (N Antiserum to Human Fibrinogen; Dade Behring Inc., Deerfield, IL). The assay range was 60–1200 mg/dL, intra-assay CV was 2.7%, and the inter-assay CV was 2.6%. Natural log-transformed data for CRP and IL-6 were used for the analysis.

2.3.4. Covariates

Multiple covariates covering demographic, psychological, behavioral, and health-related correlates of inflammation were included in the analysis, following recommendations from Stepanikova et al. (2017) and Loucks et al. (2010). Demographic covariates were age (years) and sex (0 = female, 1 = male). Psychological covariates were depressive symptoms (Center for Epidemiological Studies Depression Scale/ CES-D; score) and perceived stress (Perceived Stress Scale/ PSS; score). CES-D (Radloff, 1977) is a widely used self-reported scale for depressive symptoms in which participants responded to the frequency of experiencing 20 symptoms of depression in the past week (e.g., I feel sad, my sleep was restless, and I felt depressed; Cronbach's alpha = 0.89). PSS (Cohen et al., 1983) includes 10 items of perceived stress (e.g., felt nervous and stressed, felt difficulties were piling up so high that you couldn't overcome them) in which participants reported the frequency of them in the past month (Cronbach's alpha = 0.86). Behavioral covariates included lifetime smoking status (0 = never, 1 = ever), current smoking status (0 = no, 1 = yes), and regular exercise status (20 mins, 3 times/week; 0 = no, 1 = yes). Finally, health-related covariates were body mass index (BMI; kg/m^2), total/HDL cholesterol ratio, elevated blood pressure (blood pressure $\geq$ 140/90 mmHg or diagnosed by physician; 0 = no, 1 = yes), and insulin resistance (HbA1c $\geq$ 6.5% or blood fasting glucose $\geq$ 126 mg/dL or diagnosed by physician; 0 = no, 1 = yes).

2.4. Statistical analysis

Consistent with the goals of the study (Fig. 1B), analyses were conducted in two parts. First, we utilized a person-centered framework—latent class analysis (LCA)— to describe trajectories of SES across the life course utilizing both objective (income and education) and subjective indicators (subjective social status and subjective financial strain) of SES for Black and white adults. This data-driven approach examines SES trajectories based on multiple categorical indicators of SES across the life course and provides a parsimonious and interpretable categorization of SES trajectories (Lanza et al., 2007; Surachman et al., 2020). Second, we conducted multivariate regression analyses to examine the effect of SES trajectories and daily discrimination on markers of inflammation, including CRP, IL-6, and fibrinogen, controlling for demographic, psychological, behavioral, and health-related covariates.

2.4.1. Identification of latent classes of SES trajectories

For each racial group, we identified the best-fitting LCA model and described latent classes of SES trajectories for each racial group. We conducted separate analyses for Black and white adults based on a previous study by Surachman et al. (2020) showing different latent class structures of SES trajectories among Black and white adults. Selection of the optimally fitting model was based on model fit statistics and selection criteria, parsimony principle, and theoretical interpretability (Lanza et al., 2007). To select the best fitting model for each racial group, latent class models ranging from 1-class to 5-class solutions were tested. Model fit statistics and selection criteria from each solution, including the Akaike information criterion (AIC), Bayesian information criterion (BIC), sample-size adjusted BIC (a-BIC), Bozdogan's consistent AIC (CAIC), entropy, and bootstrapped likelihood ratio test (BLRT), were compared. Better model fit is indicated by lower values of AIC, BIC, a-BIC and CAIC; higher values of entropy, which indicates higher classification utility; and a significant *p*-value of BLRT, indicated an improvement in model fit compared to a model with one fewer class. Model identification was conducted by utilizing 1000 sets of random starting values. When no consensus was provided across model fit statistics, latent class solutions with fewer classes but still theoretically interpretable were preferred (i.e., parsimony principle). Following the selection of the best fitting model, two parameters were then examined. First, the latent class membership probabilities indicated the distribution of the classes in the sample or the size of each latent class. Second, the item-response probabilities indicated the likelihood of providing certain responses to the observed variables, conditional on class membership, and were used to label the classes. Item-response probabilities of.60 or higher indicated greater likelihood of endorsing certain SES characteristics. Identification of the best fitting model was conducted using PROC LCA in SAS (Lanza et al., 2007).

2.4.2. Regression of inflammation on SES trajectories and daily discrimination

To examine whether SES trajectories and daily discrimination were independently associated with markers of inflammation, we conducted a series of multiple linear regressions. Prior to the regression analyses, each participant was classified to an SES trajectory class from the best-fitting model selected in the previous step that best represented their trajectory characteristics based on posterior probabilities using the maximum-probability assignment method (Bray et al., 2015). We conducted ANOVA and chi-squared tests to investigate whether the means or the proportions of the outcome and the covariates were differentiated based on groupings of SES trajectories. Finally, binary variables that represent SES trajectories were created using dummy coding, in which the most affluent SES trajectory group (e.g., Stable High group) was used as a reference group for the multiple linear regression analysis. SES trajectories and daily discrimination were simultaneously entered as predictors of the three markers of inflammation in separate linear regression models. Following Stepanikova et al. (2017), for each inflammation marker, age and sex were initially included as covariates in the model. Then, psychological and behavioral covariates were added, and finally, health-related covariates (BMI, cholesterol, elevated

BP status, and insulin resistance status) were entered into the model.

3. Results

The descriptive statistics for demographic characteristics, indicators for SES trajectories, daily discrimination, inflammatory biomarkers, and other covariates are presented in Table 1. Compared to white participants, Black participants reported generally lower levels of SES across the life course ($p < .001$), higher levels of daily discrimination ($p < .001$), higher levels of depressive symptoms and perceived stress ($p < .001$), worse behavioral and health factors ($p < .001$), and showed higher levels of all inflammatory biomarkers ($p < .001$). (Table 2).

3.1. SES trajectories, daily discrimination, and inflammation among Black participants

3.1.1. Latent classes of SES trajectories

Based on model fit information, the 3-class model of SES trajectories showed the most optimal solution for latent classes of SES trajectories among Black participants ($n = 215$). Table 3 presents information regarding latent class membership probabilities and item-response probabilities for this three-class model of SES trajectories among Black participants. Class 1 was identified as Objectively Stable Low (class prevalence = 45.16%), characterized by low objective SES across the life course and low subjective adult SES, but medium to high financial status growing up. Class 2 was labeled as Downwardly Mobile (18.05%), as this class showed higher levels of childhood SES and education but lower levels of current income and financial strain. Finally, class 3 was labeled Upwardly Mobile (36.79%), as they exhibited lower levels of parental education but higher levels of participant's education level and current levels of objective and subjective SES.

Table 4 provides information on ANOVA and chi-squared tests for the differences in daily discrimination, covariates, and inflammatory biomarkers based on class membership. Among Black participants, SES trajectories were associated with depressive symptoms ($p < .01$), perceived stress ($p < .01$), and current smoking behavior ($p < .001$). However, all health-related covariates among Black adults were not differentiated by SES trajectories. In terms of inflammatory biomarkers, only IL-6 was associated with SES trajectories among Black adult ($p < .01$). Results from the multiple linear regression analysis are presented in Table 5 (see Supplementary Table 1 for the full regression results).

3.1.2. IL-6

SES trajectories, but not daily discrimination, significantly predicted IL-6 when controlling for age and sex (Model 1). Compared to the Upwardly Mobile group, the Objectively Stable Low ($b = 0.35$, $SE = 0.11$, 95%$CI = 0.13–0.57$) and Downwardly Mobile ($b = 0.29$, $SE = 0.14$, 95%$CI = 0.02–0.56$) groups showed elevated levels of IL-6, and this effect remained significant (although slightly attenuated) after controlling for psychological and behavioral covariates (Model 2). However, after adding health-related covariates (Model 3), only the Objectively Stable Low group ($b = 0.24$, $SE = 0.12$, 95%$CI = 0.01–0.46$) was associated with higher IL-6 than the Upwardly Mobile group.

3.1.3. CRP

Daily discrimination, but not SES trajectories, was significantly associated with CRP ($b = 0.04$, $SE = 0.01$, 95%$CI = 0.01–0.06$) when accounting for age and sex. After adding psychological and behavioral covariates into the model (Model 2), daily discrimination remained significantly associated with CRP ($b = 0.04$, $SE = 0.01$, 95% $CI = 0.01–0.06$). The association between daily discrimination and CRP was not significant ($b = 0.02$, $SE = 0.01$, 95%$CI = -0.01$ to 0.04) after adding health-related covariates into the model (Model 3).

3.1.4. Fibrinogen

Similarly, daily discrimination, but not SES trajectories, was significantly associated with fibrinogen ($b = 2.81$, $SE = 1.03$, 95% $CI = 0.77–4.85$) when accounting for age and sex. After adding psychological and behavioral covariates into the model (Model 2), daily discrimination remained significantly associated with fibrinogen ($b = 2.85$, $SE = 1.06$, 95%$CI = 0.76–4.93$). However, the addition of health-related covariates (Model 3) fully accounted for the association between daily discrimination and fibrinogen ($b = 1.54$, $SE = 1.02$, 95% $CI = -0.48$ to 3.56).

3.2. SES trajectories, daily discrimination, and inflammation among white participants

3.2.1. Latent classes of SES trajectories

Among white participants, the 4-class model of SES trajectories showed the most optimal solution ($n = 985$). Detailed information regarding latent class membership probabilities and item-response probabilities for white adults is in Table 3. Class 1 was identified as the Objectively Stable Low (7.02%), characterized by low objective SES across the life course and low subjective adult SES, but medium to high financial status growing up. Class 2 was identified as Subjectively Downward (12.48%), as this class showed higher levels of all the

Table 1
Descriptive statistics for demographic characteristics class indicators, moderators, and outcomes.

	M (*SD*) / %		*t*/ χ^2
	Black ($n = 215$)	White ($n = 985$)	
Age	51.02 (10.62)	55.53 (11.89)	5.13***
Female	67.9	55.6	
Life course socioeconomic status			
Parent's education graduated from high school or higher	44.9	63.9	23.65***
Medium to high subjective financial status during childhood	62.2	68.2	2.83
Participant's education some college or higher	53.5	76.1	44.63***
Household income to poverty ratio higher than 150%	41.9	78.3	115.45***
Medium and high current financial status	40.2	71.2	78.44***
Enough/ more money to meet basic needs	44.2	83.7	153.73***
Not difficult to pay monthly bills	43.3	75.9	89.52***
Daily discrimination	14.79 (6.54)	12.55 (4.16)	4.80***
Psychological factor			
Depressive symptomatology	12.19 (9.65)	7.94 (7.68)	5.99***
Perceived stress	24.85 (6.56)	21.58 (6.14)	6.94***
Health status			
Ever smoking (%)	60.5	44.7	17.66***
Currently smoking (%)	30.2	11.7	47.57***
Exercise regularly (%)	62.3	79.8	30.11***
Body mass index (BMI)	32.81 (8.38)	29.06 (5.95)	6.22***
Total/HDL cholesterol ratio	3.31 (1.12)	3.75 (1.44)	4.91***
Elevated blood pressure	64.2	50.6	13.16***
Insulin resistance	34.9	18.3	29.09***
Inflammatory Markers			
C-reactive protein (CRP; ln)	0.84 (1.21)	0.32 (1.15)	5.88***
Interleukin-6 (IL-6; ln)	1.16 (0.73)	0.73 (0.73)	7.78***
Fibrinogen	388.6 (97.9)	339.5 (83.1)	6.75***

Note: *M* = mean, *SD* = standard deviation, *t* = t score from independent *t*-test (degrees of freedom/ *df* = 1), χ^2 = chi-square value from chi-square tests (*df* = 1);
*** = $p < .001$

Table 2
Model fit information for latent class analysis.

No. of classes	Log-likelihood	No. of parameters estimated	AIC	BIC	a-BIC	Entropy	BLRT
Black ($n = 215$)							
1	-1000.72	7	279.40	302.99	280.81	—	—
2	-929.90	15	153.76	204.32	156.76	.87	$p < .050$
3	**-919.70**	**23**	**149.34**	**226.87**	**153.99**	**.74**	***p* < .050**
4	-911.31	31	148.57	253.06	154.83	.78	$p > .050$
5	-903.68	39	149.31	280.77	157.18	.77	$p > .050$
White ($n = 985$)							
1	-3853.07	7	956.99	991.24	969.01	—	—
2	-3537.83	15	342.51	415.90	368.26	.89	$p < .010$
3	-3468.68	23	220.20	332.74	259.69	.66	$p < .050$
4	**-3448.97**	**31**	**196.80**	**348.47**	**250.02**	**.73**	***p* < .050**
5	-3438.59	39	192.04	382.85	421.85	.78	$p > .050$

Note: Dashes indicate criterion was not applicable; boldface type indicates selected model. AIC = Akaike information criterion; BIC = Bayesian information criterion; a-BIC = sample size adjusted BIC; BLRT = bootstrapped likelihood ratio test.
Measurement invariance based on race indicated that Blacks and white participants showed different patterns of life course SES trajectories (at $p < .05$). Thus, the patterns of life course SES trajectories were examined within each racial group.

objective indicators of SES across the life course, but showed lower levels of current subjective SES. Class 3 was labeled as Upwardly Mobile (39.99%), characterized by lower levels of parental education but higher levels of participant's education and income and subjective measures of current SES. Lastly, class 4 was labeled as Stable High (40.51%), characterized by higher levels of objective and subjective SES across the life course.

For white adults, SES trajectories were associated with all psychological, behavioral, and health-related covariates among white adults (except for insulin resistance status; Table 4). Furthermore, all three markers of inflammation were differentiated based on SES trajectories among white adults ($p < .05$). Results from the multiple linear regression analysis are presented in Table 5 (see Supplementary Table 2 for the full regression results).

3.2.2. IL-6

Controlling for age and sex (Model 1), only the Objectively Stable Low group ($b = 0.27$, $SE = 0.10$, 95%$CI = 0.08$–0.46) was significantly associated with higher levels of IL-6 compared to the Stable High group. However, this association became non-significant ($b = 0.23$, $SE = 0.09$, 95%$CI = 0.07$–0.40) after adjusting for psychological and behavioral covariates (Model 2) and health-related covariates in the model (Model 3). Daily discrimination was not significantly associated with IL-6 in all the regression models.

3.2.3. CRP

Compared to the Stable High group, the Objectively Stable Low ($b = 0.39$, $SE = 0.15$, 95%$CI = 0.09$–0.68), Subjectively Downward ($b = 0.37$, $SE = 0.12$, 95%$CI = 0.14$–0.60), and Upwardly Mobile ($b = 0.23$, $SE = 0.09$, 95%$CI = 0.07$–0.40) groups were associated with higher levels of CRP, controlling for age and sex (Model 1). After adding psychological and behavioral covariates into the model (Model 2), the Subjectively Downward ($b = 0.33$, $SE = 0.12$, 95%$CI = 0.10$–0.55) and the Upwardly Mobile ($b = 0.22$, $SE = 0.08$, 95%$CI = 0.05$–0.38) groups had significantly higher levels of CRP than the Stable High group. Finally, the addition of health-related covariates (Model 3) fully accounted for the relation between SES trajectories and CRP. Daily discrimination was not significantly associated with CRP in all the regression models.

3.2.4. Fibrinogen

Similarly, the Objectively Stable Low ($b = 25.8$, $SE = 10.9$, 95% $CI = 4.44$–47.2), Subjectively Downward ($b = 17.9$, $SE = 8.33$, 95% $CI = 1.56$–34.2), and Upwardly Mobile ($b = 13.9$, $SE = 6.09$, 95% $CI = 1.94$–25.8) groups were associated with higher levels of fibrinogen, controlling for age and sex (Model 1). After adding psychological and behavioral covariates into the model (Model 2), only the Upwardly Mobile group ($b = 13.2$, $SE = 6.10$, 95%$CI = 1.26$–25.2) had significantly higher levels of fibrinogen than the Stable High group. After including health-related covariates (Model 3), SES trajectories were not significantly associated with fibrinogen. Daily discrimination was not significantly associated with fibrinogen in all the regression models.

4. Discussion

This study attempted to replicate the previous study by Surachman et al. (2020) by investigating life course trajectories of SES using an independent sample of Black and white adults. Furthermore, guided by the fundamental cause theory (Phelan and Link, 2015), this study expanded the current literature on determinates of racial disparities in inflammation by investigating the independent effects of SES trajectories and experiences of daily discrimination on inflammatory biomarkers. We replicated Surachman et al.'s (2020) findings that Black (mostly recruited from Milwaukee County, WI) and white participants experienced different trajectories of SES across the life course. In the current study, SES trajectories among Black participants were mainly characterized by socioeconomic hardship (e.g., majority of adults belonging to the Objectively Stable Low group, the absence of a Stable High group). SES trajectories among white participants were characterized more by socioeconomic privilege (e.g., majority of adults belonging to the Stable High group). We corroborated the previous findings (Surachman et al., 2020) that Black participants showed higher levels of IL-6, CRP, and fibrinogen compared to white adults. We extend the work by Surachman et al. (2020) by demonstrating that among Black participants, daily discrimination, but not SES trajectories, predicted elevated levels of CRP and fibrinogen inflammation, an effect driven by health-related covariates. Finally, among white adults, SES trajectories were consistently associated with all inflammatory biomarkers, such that individuals who experienced high stable SES over the life course had the lowest levels of inflammation, an effect fully accounted for by health-related covariates, and daily discrimination was not related to any inflammatory markers.

Our findings partially replicate the latent classes of life course SES trajectories among Black participants, compared to Surachman et al. (2020). We found a slightly different structure of SES trajectories across the life course among Black adults including fewer latent classes of SES trajectories (3 classes vs. 4 classes in Surachman et al. (2020)) and the absence of a Stable High SES trajectory class. The absence of a Stable High class among Black participants in this study may have been driven by the fact that relatively few Black participants in the current study had parents that graduated from high school (44.9% in this study vs. 57% in the previous study by Surachman et al., 2020), decreasing the probability of findings a Stable High SES group among the Black participants. Notably, we found that more than one-third of the Black sample in this

Table 3
Latent class membership probabilities and item-response probabilities.

Black ($n = 215$)	Latent Classes of Socioeconomic Trajectories Among Black Adults			
Indicator	Class 1: Objectively Stable Low (45.16%)	Class 2: Downwardly Mobile (18.05%)	Class 3: Upwardly Mobile (36.79%)	
Childhood SES				
Parent graduated from HS/GED or higher	.40	.51	.47	
Medium to high financial level growing up	**.66**	**.71**	.53	
Education				
Some college or higher	.11	**1.00**	**.83**	
Adult SES				
Household income to poverty ratio higher than 150%	.16	.37	**.76**	
Medium to high current financial status	.24	.08	**.75**	
Enough money to fulfill basic needs	.25	.08	**.85**	
Not difficult paying bills	.30	.00	**.81**	
White ($n = 985$)	**Latent Classes of Socioeconomic Trajectories Among White Adults**			
Indicator	Class 1: Objectively Stable Low (7.02%)	Class 2: Subjectively Downward (12.48%)	Class 3: Upwardly Mobile (39.99%)	Class 4: Stable High (40.51%)
Childhood SES				
Parent graduated from HS/GED or higher	.41	**.74**	.37	**.91**
Medium to high financial level growing up	**.81**	.55	**.87**	.52
Education				
Some college or higher	.00	**1.00**	**.60**	**.97**
Adult SES				
Household income to poverty ratio higher than 150%	.58	**.65**	**.72**	**.92**
Medium to high current financial status	.19	.07	**.82**	**.91**
Enough money to fulfill basic needs	.28	.28	**.99**	**.95**
Not difficult paying bills	.17	.03	**.94**	**.90**

Note: Boldface type indicates higher probability for the indicator

study demonstrated a pattern of upward mobility, a class that was absent in the Surachman et al. (2020) study. The Objectively Stable Low group, the most socioeconomically disadvantaged class, represented the largest proportion of Black participants in the study and was characterized by lower levels of objective measures of SES across the life course, although they still reported high levels of subjective childhood SES. In contrast, the most disadvantaged class among the sample of Black adults from the previous study was characterized by low levels of both objective and subjective measures of SES across the life course SES. This difference in perceptions of subjective childhood SES could reflect cohort differences. A previous study by Glei et al. (2018) indicated that, compared to younger birth cohorts (i.e., the Gen X cohort), the older cohorts (i.e., those from the Silent Generation and early Baby Boomers) tend to perceive their childhood SES to be relatively high. Individuals from earlier generations, such as those in the current study, grew up during a period of economic growth following the Great Depression in the 1930 s, which may favorably influence their perceptions of their childhood SES, despite more objective measures indicating low SES across the life course. Despite the differences in the latent classes between the two studies, one consistent finding was the presence of a Downwardly Mobile class, indicating the relative stability in this group across samples of Black adults.

Based on the fundamental cause theory (Phelan and Link, 2015), we extended the work by Surachman et al. (2020) to examine the effect of both SES trajectories and discrimination on inflammation. Our results partially support the fundamental cause theory (Phelan and Link, 2015) as well as the diminishing return hypothesis (Farmer and Ferraro, 2005; Surachman et al., 2020) for Black participants. Black adults did not receive as many health benefits from upward socioeconomic mobility, as the levels of inflammatory biomarkers (CRP and fibrinogen) were not differentiated by SES trajectories. The levels of inflammatory biomarkers among Black participants in the Upwardly Mobile group were not significantly different from those that experienced more socioeconomic hardship (i.e., Objectively Stable Low). In fact, the mean levels of inflammatory biomarkers among the most affluent group of Black adults were only slightly higher than those in the least affluent group of white adults. Interestingly, although SES trajectories often were not associated with inflammation, we found that experiences of daily discrimination were more consistently associated with the inflammation among Black adults, especially CRP and fibrinogen. These results corroborate previous findings (Beatty et al., 2014; Kershaw et al., 2016) demonstrating the unique effect of daily discrimination on inflammatory biomarkers, above and beyond the effect of SES.

We found an unexpected association related to IL-6 among Black participants, as daily discrimination was not associated with IL-6 but SES trajectories were related to this marker of inflammation. The association between SES trajectories and IL-6 among Black participants may indicate that early and continuous socioeconomic hardship may be a critical factor for IL-6 levels in adulthood for Black adults. The majority of Black participants experienced lower levels of childhood SES which may be linked to the early life programming of the immune system that is critical for adult IL-6 (i.e., the biological embedding hypothesis) (Ehrlich et al., 2016). This explanation is supported by the weaker association between SES trajectories and IL6 among white participants, which could be due to the fact that few white participants experienced early socioeconomic hardship. Other studies that examined other types of early adversity, such as childhood maltreatment, showed a significant association between adversity and adult IL-6 (Ehrlich et al., 2016) and IL-6 reactivity to acute stress (Carpenter et al., 2010). These findings highlight the complex linkages among SES trajectories, inflammation, and race.

Together, the present findings highlight the different factors associated with disparities in inflammatory biomarkers for each racial group. Among Black participants, the limited opportunity for them to accumulate socioeconomic resources across the life course was reflected by the fewer classes of SES trajectories, the relatively large proportion of

Table 4
Result from ANOVA and chi-squared tests on examining the differences in daily discrimination, inflammatory biomarkers, and covariates based on SES trajectories.

Indicator	Black				White				
	Objectively Stable low	Downwardly Mobile	Upwardly Mobile	F/χ^2 ($df = 2$)	Objectively Stable Low	Subjectively Downward	Upwardly Mobile	Stable High	F/χ^2 ($df = 3$)
Age (years)	50.03 (1.10)	48.87 (1.51)	53.35 (1.20)	3.31*	55.22 (1.46)	49.84 (9.46)	60.08 (0.64)	54.57 (11.27)	34.20***
Female (%)	67.8	73.3	65.0	0.92	69.2	60.9	55.8	49.7	12.22**
Daily discrimination (score)	13.69 (0.68)	16.03 (0.98)	15.33 (0.73)	2.38	13.51 (0.61)	14.01 (0.46)	12.50 (3.89)	12.02 (3.79)	9.03***
Psychological factors									
Depressive symptomatology	14.61 (1.02)	12.85 (1.51)	9.18 (0.99)	7.04**	11.83 (1.07)	11.49 (0.92)	7.23 (0.36)	6.90 (0.33)	19.13***
Perceived stress	25.94 (0.65)	26.07 (0.98)	22.95 (0.45)	5.53**	24.33 (0.75)	24.17 (0.64)	21.13 (0.30)	20.79 (0.28)	15.54***
Health Behavior									
Ever smoking (%)	74.4	53.3	48.8	12.9**	67.7	40.6	47.3	40.3	19.14***
Currently smoking (%)	44.4	33.3	12.5	20.8***	27.7	16.4	10.2	9.1	22.42***
Exercise regularly (%)	62.2	71.1	57.5	0.32	70.8	75.0	78.5	83.6	9.44*
Health status									
Body mass index	32.67 (0.88)	33.35 (1.35)	32.65 (0.90)	0.12	30.35 (0.84)	30.36 (0.58)	29.34 (0.31)	28.26 (0.27)	6.06***
Total to HDL cholesterol ratio	3.30 (0.13)	3.57 (0.18)	3.31 (0.10)	1.58	3.98 (0.20)	4.12 (0.15)	3.72 (0.07)	3.64 (0.07)	4.19**
Elevated blood pressure (%)	63.3	64.4	65.0	0.97	55.4	50.0	56.9	44.9	12.05**
Insulin resistance (%)	32.2	35.6	37.5	0.77	26.2	20.3	19.0	15.9	4.77
Inflammatory Markers									
C-reactive protein (CRP; ln)	0.99 (0.14)	0.85 (0.19)	0.67 (0.12)	1.50	0.61 (0.13)	0.53 (0.11)	0.43 (0.06)	0.14 (0.06)	7.65***
Interleukin-6 (IL-6; ln)	1.29 (0.07)	1.24 (0.12)	0.98 (0.08)	4.38*	0.96 (0.09)	0.74 (0.07)	0.80 (0.04)	0.64 (0.03)	5.57**
Fibrinogen	388.7 (10.52)	397.8 (11.83)	383.9 (12.03)	0.27	359.5 (12.71)	343.6 (7.56)	349.6 (4.49)	327.3 (3.71)	6.28***

Note: df = degrees of freedom;
* = $p < .05$,
** = $p < .01$,
*** = $p < .001$.

Black participants who experienced stable socioeconomic hardship across the life course, and the lack of a group that was characterized by constant SES privilege across the life course. As a result, SES trajectories did not differentiate CRP and fibrinogen among this group. Additionally, daily discrimination was a common experience among Black participants and it was not gradually differentiated based on SES trajectories. We found that daily discrimination was a better predictor of CRP and fibrinogen among Black participants than SES trajectories. Taken together, these findings support the notion that racism is a fundamental cause of racial disparities in inflammatory biomarkers (Phelan and Link, 2015). Systemic racism is associated with racial differences in accumulating socioeconomic resources across the life course that disadvantage Black adults. In addition, systemic racism is also manifested in the higher levels of daily discrimination among Black participants that lead to higher levels of inflammation, independent of SES trajectories.

Our results for white adults suggest that their latent classes of SES life course trajectories are largely consistent across studies. Similar to Surachman et al. (2020), we found four classes of SES trajectories across the life course. Furthermore, except for the most disadvantaged class, all the other latent classes had similar characteristics to those in Surachman et al. (2020). In the current study, the most disadvantaged class was labeled as the Objectively Stable Low and was characterized by low SES across the life course, except for the subjective childhood SES. Similar to the case among Black adults, this difference reflects cohort differences in perceptions of childhood SES. Similar to the class among Black adults, this difference possibly reflects cohort differences in perceptions of subjective childhood SES and indicates that favorable views of subjective childhood SES among the older cohort were consistent across both racial groups. There were also slight differences in the proportion of individuals in each class, as in the previous study more than half of the sample were in the Stable High group and only 2% were in the Stable Low group. In the current analysis, 41% of participants were belonged to the Stable High group and 7% belonged to the Objectively Stable Low group. Additionally, the proportion of the Upwardly Mobile group in the current study was doubled and the proportion of those in the Subjectively Downward group was lower compared to the previous study. The Great Recession at the end of the 2000 s happened in between these two studies. The higher proportion of Subjectively Downward class in the previous study among the younger cohort (Surachman et al., 2020) may be associated with the exposure to financial hardship during the recession.

In contrast to the findings among Black participants, SES trajectories, but not daily discrimination, were associated with all markers of inflammation among white participants (controlling for age and sex), such that the Stable High group had lower levels of inflammation than the other three SES trajectory groups. SES trajectories among white adults were characterized by a greater variety of experiences, ranging from individuals experiencing constant socioeconomic hardship to those who enjoyed constant socioeconomic privilege on the other end. Unlike their Black counterparts, white participants in the most affluent group enjoyed the health benefits from being at the top of the SES ladder, which was manifested in their significantly lower levels of inflammatory biomarkers.

Table 5
Multiple linear regression models regressing inflammatory biomarkers on life course SES trajectories and daily discrimination.

Variable	CRP (ln)			IL-6 (ln)			Fibrinogen		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Black adults (n = 215)									
SES Trajectories									
Objectively Stable low	0.38 (0.13)	0.37 (0.20)	0.27 (0.18)	**0.35 (0.11)****	**0.30 (0.12)***	**0.24 (0.12)***	12.96 (14.86)	9.19 (16.19)	2.54 (15.25)
Downwardly Mobile	0.13 (0.23)	0.23 (0.23)	0.17 (0.21)	**0.29 (0.14)***	**0.30 (0.14)***	0.24 (0.13)	14.71 (18.30)	17.33 (19.01)	12.43 (17.90)
Upwardly Mobile	—	—	—	—	—	—	—	—	—
Daily Discrimination	**0.04 (0.01)****	**0.04 (0.01)****	0.02 (0.01)	0.00 (0.01)	0.00 (0.01)	-0.01 (0.01)	**2.81 (1.03)****	**2.85 (1.06)****	1.54 (1.02)
Intercept	0.47	1.02	-0.50	0.56	0.52	-0.39	295.2***	291.1***	181.3**
Model F	3.54**	2.58**	6.30***	3.58**	3.16**	4.51***	4.68***	2.52**	4.28***
R^2 (%)	8.1	11.9	32.1	8.0	14.0	24.9	10.4	11.6	24.2
White adults (n = 985)									
SES Trajectories									
Objectively Stable low	**0.39 (0.15)***	0.30 (0.15)	0.11(0.14)	**0.27 (0.10)****	0.19 (0.10)	0.09 (0.09)	**25.80 (10.89)***	19.50 (11.19)	12.13 (10.93)
Subjectively downward	**0.37 (0.12)****	**0.33 (0.12)***	0.17 (0.11)	0.13 (0.07)	0.10 (0.07)	0.03 (0.07)	**17.90 (8.33)***	14.67 (8.45)	6.84 (8.23)
Upwardly mobile	**0.23 (0.09)****	**0.22 (0.08)***	0.11 (0.08)	0.06 (0.05)	0.05 (0.05)	0.00 (0.05)	**13.89 (6.09)***	**13.23 (6.10)***	8.87 (5.92)
Stable high	—	—	—	—	—	—	—	—	—
Daily Discrimination	0.01 (0.01)	0.01 (0.01)	-0.00 (0.01)	0.01 (0.01)	0.01 (0.01)	0.00 (0.01)	0.14 (0.65)	-0.07 (0.68)	-0.54 (0.67)
Intercept	-0.13 (0.23)	0.57 (0.29)	-1.73***	-0.34*	0.05	-0.89 (0.19)***	275.76***	306.5 (21.16)	207.1***
Model F	7.15***	7.06***	19.53***	13.33***	9.89***	16.34***	9.76***	6.17***	9.23***
R^2 (%)	4.3	7.6	23.7	7.7	10.2	20.6	5.8	6.7	12.8

Note: Model 1 = adjusted for age and sex; Model 2 = adjusted for age, sex, depressive symptomology, perceived stress, smoking status, physical activity; Model 3 = adjusted for age, sex, depressive symptomology, perceived stress, smoking status, physical activity, BMI, total: HDL cholesterol ratio, elevated BP status, and insulin resistance status; Upwardly Mobile was a reference group for Black group and Stable High was a reference group for white group.
* = $p < .05$,
** = $p < .01$,
*** = $p < .001$.

4.1. Strengths and limitations

We utilized an innovative, person-centered approach to examined and replicate SES trajectories among Black and white groups from a relatively healthy adult sample. Using LCA, we were able to examine SES trajectories based on both objective and subjective indicators of SES across the life course. Furthermore, we took a theory-based approach to explain the racial disparities in inflammation among Black and white adults by testing the independent influence of SES trajectories and daily discrimination on inflammatory biomarkers, including IL-6, CRP, and fibrinogen. SES trajectories represent the accumulation of exposure to socioeconomic hardship, privilege, and mobility, which are better predictors for inflammation in adulthood. Finally, LCA represents a data-driven approach to examine the heterogeneity of SES trajectories, providing a more objective method to examine patterns of SES accumulation and mobility across the life course in the population.

At the same time, study limitations suggest directions for future research. First, indicators of SES across the life course were based on retrospective data that may have introduced reporting bias. A previous study showed the accuracy of reporting parental education and subjective indicators of childhood SES using sibling dyads in the MIDUS study (Ward, 2011), even though the majority of the siblings were white adults. Future studies should investigate the reliability of retrospective reports of childhood SES among the minority population. Second, although we utilized objective and subjective indicators of SES, all measures were based on self-reporting. In regard to subjective measures, respondents may vary in the referent they use in providing their subjective ratings. Third, the non-significant associations between SES trajectories and inflammation, particularly CRP and fibrinogen, among Black adults may be due to the relatively small number of Black adults in the sample, although studies with larger samples of Black participants showed consistent findings regarding the lack of differentiation of CRP based on SES across the life course (Pollitt et al., 2008). Fourth, there is evidence that inflammatory processes differ by sex (Gruenewald et al., 2009). However, we did not investigate sex differences in this paper. Future examinations related to racial and socioeconomic disparities in inflammation should focus on this topic. Finally, given that the majority of the Black participants in the current study were recruited from Milwaukee County, WI, our results may not be generalizable to the larger Black population in the US. To increase our confidence in our findings, we examined potential differences between the Black population in Wisconsin and the larger Black population in the US (see Supplementary Material 3), analyzing demographic trends, socioeconomic characteristics, and health status. According to the 2000 US Census, 90% of Black individuals in Wisconsin resided in Milwaukee County (WDHS, 2008). Our additional analysis indicated that Black adults in Wisconsin were comparable to the larger US Black population in terms of age and sex composition, employment, and health status. Despite the limitations of this sample coming primarily from one geographic location, these results provide an important advancement for the literature by identifying potential mechanisms underlying racial health disparities. Finally, the longitudinal MIDUS sample was recruited through Random-digit-dialing (RDD), which tends to include participants from higher SES (Wang and Parfrey, 2009).

5. Conclusion

Using LCA, we examined SES trajectories based on objective and subjective indicators of SES among Black and white adults. We found different groups of SES trajectories across the life course for Black and white adults. The majority of Black participants in this study experienced constant socioeconomic hardship across the life course, while

many white participants enjoyed stable socioeconomic privilege. We found that the higher levels of inflammation were associated with daily discrimination among Black adults and socioeconomic trajectories across the life course among white adults.

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Declarations of interest

None.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.psyneuen.2021.105193.

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