SSM - Population Health 19 (2022) 101224

Contents lists available at ScienceDirect

SSM - Population Health

journal homepage: www.elsevier.com/locate/ssmph

Education in the Jim Crow South and Black-White inequities in allostatic load among older adults

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ARTICLE INFO

Keywords:
Systemic structural racism
School term
Historical context
Measurement

ABSTRACT

In the U.S., Black adults consistently have higher allostatic load – an indicator of physiological dysregulation – than White adults. Education is considered a likely mechanism given racial differences in attainment, but evidence is mixed. This may be due, in part, to data limitations that have made it difficult for scholars to account for the structurally rooted systemic racism that shaped the U.S. education system and led to large racial inequities in school term length and school attendance among older adults who grew up in the Jim Crow South. Our study addresses this limitation by linking historical data on Black and White segregated school systems in the U.S. South from 1919 to 1954 to the Health and Retirement Study (HRS) to determine if a new measure of educational attainment that accounts for structural racism that led to differences in the number of school days attended by Black and White students across years and states better explains Black-White inequities in allostatic load among older adults who attended school during Jim Crow. We restrict our sample to HRS respondents racialized as White or Black, who resided in the South when they were school-aged, completed primary/secondary school between 1919 and 1954, and provided a measure of allostatic load (n = 1932). We find that our new measure of schooling – duration in school – reduced the Black-White inequity in allostatic load more so than self-reported years of schooling whether we measured allostatic load continuously (34% vs 16%) or categorically (45% vs 20%). Our findings highlight the importance of identifying and using historically informed measures of schooling that account for structurally rooted systemic racism when trying to understand how education shapes the health of individuals racialized as Black in the United States.

1. Introduction

In the United States, large, long-standing, and reliably patterned Black-White inequities in health, morbidity, and mortality are well documented (Churchwell et al., 2020; Hummer & Hamilton, 2019; Williams & Mohammed, 2009). Research on these phenomena demonstrates that – net of differences in conventional health predictors such as socioeconomic status, individual behaviors, healthcare access, and health care utilization – the experiential and psychosocial burdens associated with minoritized status in a structurally racist society manifest as persistent and pervasive health disadvantage for Black Americans compared to their White peers (Hummer & Hamilton, 2019; Krieger, 2021). Distress from racially minoritized lived experience increases disease susceptibility and subsequent poor health. Allostatic load, which reflects wear and tear on body systems, is a measure of this distress (Seeman et al., 2004).

Racialized differences in allostatic load are increasingly documented (Duru et al., 2012; Thomas et al., 2019). Because Black adults, on average, complete fewer years of school than their White counterparts, educational attainment is a common explanation for these racialized differences (Howard & Sparks, 2015), even though it often does not explain them (Mitchell et al., 2020; Moore et al., 2021; Richardson et al., 2021). Moreover, the educational gradient in allostatic load is not always similar in size or direction for White and Black adults. These findings and inconsistencies may be due, in part, to the use of an education measure – years of schooling – that assumes a year of schooling is equivalent across race, time, and place. The use of this measure ignores how systemic structural racism – defined as the macro-level social processes that serve to construct and define race, the racial hierarchy, and racial bias in the U.S. (Bonilla-Silva, 1997; Gee & Hicken, 2021) – shaped the U.S. education system and led to large race inequities in school term length and days attended among older cohorts of adults,

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https://doi.org/10.1016/j.ssmph.2022.101224
Received 4 May 2022; Received in revised form 6 July 2022; Accepted 30 August 2022
Available online 6 September 2022
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particularly those who grew up in the Jim Crow South. The purpose of our study is to determine if using a historically informed measure of education that accounts for state and racial variation in school term length and days attended better explains Black-White inequities in allostatic load – a measure of physiological dysregulation that is linked to the development or progression of a range of preclinical and clinical health outcomes (Geronimus et al., 2010; Khansari et al., 2009; Seeman et al., 2004) – than a traditional measure of education among older adults who attended school in the U.S. South during Jim Crow.

1.1. Background

Humans respond to stressors through the cooperative effects of the primary stress response systems – the sympathetic nervous system (SNS) and hypothalamic-pituitary-adrenal (HPA) axis (Sapolsky et al., 2000). Repeated activation and over stimulation of these systems compromises homeostasis and efficient functioning, resulting in an allostatic load on the body's systems (McEwen, 1998). Allostatic load, therefore, represents the repeated psychological and physical insults to healthy hormonal, metabolic, immunological, and cardiovascular systemic functioning over time that degrades physical health for multiple stress responsive indicators (McEwen, 1998; Seeman et al., 2004) and may lead to accelerated aging (Geronimus et al., 2010; Khansari et al., 2009; Seeman et al., 2004).

Within the U.S., research on allostatic load remains limited; however, this small body of work reliably documents higher levels of allostatic load for those racialized as Black (Crimmins et al., 2009; Howard & Sparks, 2015; Langellier et al., 2021; Nelson et al., 2007; Seeman et al., 2010). For example, using a nationally representative sample of U.S. adults aged 18–64 years, Geronimus et al. (2010) found higher allostatic load scores among Black versus White adults. This race disadvantage was also found among mid-life adults (Van Dyke et al., 2020) as well as among a community sample of Black and White women living in Nashville (Thomas et al., 2019).

On balance, efforts to reduce racialized health inequity remain largely unsuccessful. This lack of success is arguably attributable to the focus in the field of public health on individual and interpersonal explanations rather than on the structurally rooted, unequal social arrangements, relationships, and experiences that operate simultaneously and synergistically across multiple dimensions of society to disadvantage individuals racialized as Black (Geronimus, 2000; Williams et al., 2019). Yet, there is growing recognition that Structurally Rooted Systemic Racism (SSR) is a primary contributor to racialized health inequity (Gee & Hicken, 2021; Phelan & Link, 2015) and pervades virtually every major institution comprising U.S. society (Feagin, 2006), including the U.S. education system.

It is quite difficult to measure how SSR operates within the U.S. education system and ultimately shapes the health of Black and White Americans, however. Health researchers often rely on educational attainment to explain Black-White inequities in allostatic load given that Black adults have completed, on average, fewer years of schooling than White adults coupled with the persistent finding that lower education is associated with the accumulation of social and economic disadvantages that increase risk of prolonged exposure to stressors and accelerated aging of biological systems (Ding et al., 2019; Howard & Sparks, 2015). Yet, educational attainment often does not fully explain Black-White inequities in physiological dysregulation and allostatic load (Boen, 2020; Howard & Sparks, 2015) and the relationship sometimes varies by race (Howard & Sparks, 2015; Sims & Coley, 2019). For example, educational attainment has shown both negative and positive associations with allostatic load as well as diminished health returns for Black adults. Using the National Health and Nutrition Survey (NHANES), Howard and Sparks (2015) found no Black-White differences in allostatic load among individuals with low education, but a 24% higher rate of allostatic load among Black college educated compared to White college educated adults. Sims and Coley (2019) likewise found an inverse association between education and allostatic load among White young adults, but a positive association among Black young adults (Sims & Coley, 2019). Alternatively, educational attainment was significantly and inversely associated with allostatic load scores of Black Mississippians (Hickson et al., 2012).

Educational attainment may not adequately capture the SSR operating within the education system at the time individuals attended school and may be one reason why formal education does not always explain Black-White inequities in allostatic load or why the educational gradient sometimes varies by race. Indeed, educational attainment – measured as years of schooling – assumes that one year of completed school reflects the same *quantity of school* across race, time, and place. And while the reliance on years of schooling is most likely driven by data limitations that make it challenging to accurately measure quantity of schooling attained, the measure is ahistorical and imprecise, particularly for older cohorts of Black Americans who were subjected to explicit state sanctioned segregated schooling in the Jim Crow South – a period lasting from the 1870s through the 1960s. This period saw the U.S. South and several border states enact laws mandating the separation of races in public spaces, including schools (Krieger, 2012). Prior to *Brown v. Board of Education (1954)* – the U.S. Supreme Court decision that ruled racial segregation in public schools unconstitutional – all states in the U.S. South *and* Missouri legally mandated separate schools based on race (Campbell et al., 1967). This *de jure* school segregation led to large race inequities in the allocation of educational resources to Black and White segregated school systems, which resulted in significant inequities in school term length and how many days of instruction students received across racially segregated school systems. Annual school terms were, on average, 50–100% shorter for Black students than for White students (Walsemann et al., 2022) and Black students consistently attended fewer days of schooling than their White peers. Importantly, almost 80% of Black older adults who completed school prior to *Brown v. Board of Education* were educated in the U.S. South (Ruggles et al., 2020).

Our study addresses this gap in the literature by using historical data from Black and White segregated school systems in the U.S. South (including the District of Columbia) to create a modified measure of self-reported years of schooling – duration in school – that accounts for the structural racism within the Jim Crow education system that led to Black students spending significantly fewer days in school than their White peers. We examine if this historically informed measure of education explains more of the Black-White inequity in allostatic load than reported years of schooling.

2. Methods

2.1. Data

Individual-level data come from the Health and Retirement Study (HRS), a nationally representative, longitudinal study of U.S. adults over age 50 (Sonnega & Weir, 2014). Since 1992, the HRS has conducted core interviews with age-eligible respondents and their spouses approximately every two years with data collection ongoing. The HRS is a multi-stage area probability sample of age-eligible households selected from primary sampling units chosen from U.S. Metropolitan Statistical Areas (MSAs) and non-MSA counties, with an oversampling of minorities and the oldest-old. Using a steady-state design, the HRS sample is replenished with younger cohorts about every 6 years.

Beginning in 2006, the HRS switched to a mixed mode design in which a random one-half of the sample completed an enhanced face-to-face interview (EFTF) that included the collection of physical and biological measures while the other one-half of the sample completed the interview via the telephone. The HRS used dried blood spots to assay five biomarkers during the EFTF – total cholesterol, high-density lipoprotein, glycosylated hemoglobin (HbA1c), C-reactive protein, and cystatin C (Crimmins et al., 2013). Interviewers also measured arterial blood pressure three times using an automated blood pressure monitor

and waist circumference using a tape measure during the EFTF (Crimmins et al., 2008).

State-level data on school attendance and school term length come from the 1919/20 to 1953/54 Biennial Surveys of Education (BSE) of the United States compiled by the U.S. Department of Health, Education, and Welfare. Data were reported separately for White and Black-segregated school systems. We linked BSE data to HRS via a single measure that asked respondents the state they lived in most of the time they were in primary/secondary school or, for respondents who did not attend school, around age 10. The BSE reported data for the 18 states/territories that legally mandated segregated schools (Campbell et al., 1967): Alabama, Arkansas, Delaware, the District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia. We excluded Missouri because our restricted data agreement prevents us from reporting HRS data at a geographic level below census division, and Missouri is the only state that is in the West North Central census division.

2.2. Sample

We restricted our sample to Black and White HRS respondents who resided in the U.S. South when they were school-aged, began primary school during or after 1919, and completed their primary/secondary schooling by 1954 (n = 4727). Supplemental Table S1 shows selected examples of who is included/excluded given these restrictions. We then excluded respondents who did not provide at least one measure of allostatic load from 2006 to 2016. Our final analytic sample included 1354 White adults and 578 Black adults. Our sample reflects those members of the cohort that survived until at least 2006/8 when they were between 60 and 95 years old and is therefore representative of this population.

2.3. Measures

Allostatic Load. To calculate allostatic load, we used eight biomarkers available in the HRS – systolic and diastolic blood pressure, hemoglobin A1c, high-density lipoprotein (reverse coded), total cholesterol, waist circumference, cystatin C, and C-reactive protein – collected during the respondent's first EFTF. Over 86% of respondents provided biomarker data in 2006 or 2008. We assessed allostatic load cross-sectionally because 71% of our sample only provided 1 or 2 observations on allostatic load given the timing of first assessment. Next, following prior work, we standardized each biomarker so that each measure had a mean of zero and a standard deviation of one (Tampubolon & Maharani, 2018). Finally, we averaged respondents' standardized z-scores across the 8 measures, resulting in a summated score ranging from −1.2 to 2.1. We calculated allostatic load for respondents who had data on at least 4 of the 8 biomarkers. Higher values on the summated measure represent higher physiological dysregulation. To account for possible threshold effects, we also categorized allostatic load into tertiles to represent low, average, and high risk.

Independent Variable. Respondents self-reported their *race* as non-Hispanic Black or non-Hispanic White.

Mediators. We used several measures on schooling to construct the *education* variables we include as mediators in our models. First, HRS respondents were asked how many years of schooling they had completed (range 0–17) as well as their highest degree attained. We top-coded years of schooling at 12 years since the BSE provided data on days attended and school term length for primary and secondary schools only. This indicator reflects *self-reported years of schooling.* To account for respondents who completed post-secondary school but were top-coded at 12, we included an indicator of postsecondary degree completion. To examine the implications of top-coding years of schooling, we re-estimated models using the original variable. These results provided similar inferences to those we report.

Next, we created a *duration in school* measure for each respondent, which we calculated as:

$$x_i = \frac{\sum b_{rst}}{\sum z_t} \times c_i \qquad \text{(Eq 1)}$$

where x_i is duration in school for respondent i, $\sum b_{rst}$ is the sum of school days attended for students in racially-segregated school system r in state s over time t, t is the years that respondent i attended primary and/or secondary school, $\sum z_t$ is the sum of the maximum number of school days a student in the U.S. South could have attended school during time t derived from school term length, and c_i is the years of schooling respondent i reported completing which was top-coded at 12.

To calculate b_{rst}, we used state-level BSE data on school days attended and individual-level HRS data on birth year, self-reported years of schooling, and state of residence. We assumed respondents started primary school 6 years after birth and attended school for the number of days students of their race, on average, attended school in their state of residence for each year they attended school. For selected examples based on BSE data, see Supplemental Table S2.

Because school term length varied significantly across states, racially segregated school systems, and over time (Supplemental Fig. S1), we used the longest-term length across all Southern states reported in the BSE (regardless of whether the longest term length occurred in White or Black-segregated school systems) for each year a respondent attended school to calculate $\sum z_t$. Doing so normalized the measure and facilitated Black-White comparisons. For example, the total maximum number of school days White or Black students who attended school in the U.S. South *could* have attended if they were born in 1914 and completed 8 years of school was 1676 (See Supplemental Table S2).

Covariates. Our models included several variables that may confound the relationship between race and allostatic load. Demographic covariates included gender (female or male), education cohort (completed primary/secondary school by 1939, 1940–1948, or 1949–1954), the highest level of education completed by either parent (<8 years, ≥ 8 years of schooling) and census division where the respondent resided when school aged.

2.4. Missing data

From 1919/20 to 1953/54, 5 of the 17 Southern states did not report data on the average number of school days attended and school term length in some years: Kentucky (1919/20–1927/28), Mississippi (1919/20, 1931/32, 1941/42), Oklahoma and Texas (1919/20–1921/22), Tennessee (1919/20–1925/26), and West Virginia (1921/22, 1927/28, and 1931/32). To assess patterns of item non-response, we visually inspected the data for each state by year. Next, we estimated predicted values for days attended or school term length separately for each state using linear regression. In these models, we used reported data on each variable, respectively, to predict estimates for the missing years, and modeled time as either linear or quadratic based on model fit. We considered using multiple imputation but given the low levels of non-response and small sample size (n = 17 states), these models would not converge.

In addition to item non-response, BSE reports data biennially; thus, we did not have data in school years that ended in an odd number (e.g., 1920/21). Visual inspection of the data indicated a linear or quadratic pattern for each state with little variation over time. We therefore chose to interpolate data for the odd years using data from the two adjacent years in each respective state.

Complete data were available on HRS measures utilized in this analysis except for parents' level of education, which had 12% item non-response. HRS respondents with missing data on parental education have similar economic and health profiles as those whose parents completed less than 8 years of schooling (Montez & Hayward, 2014). We therefore coded those with missing values on parental education as less

than 8 years of schooling. Models that used case-wise deletion to address missing data yielded similar inferences.

2.5. Analytic approach

We used linear regression and multinominal logistic regression to estimate race differences in the z-score and categorical allostatic load measures, respectively. We applied person-level weights to account for selection into the HRS biomarker data collection and the complex survey design. All analyses were estimated using Stata, version 17 (StataCorp LP).

We estimated 3 models. Our first model adjusted for demographics, education cohort, parent's education, and Census division of residence when respondents were school aged. Model 2 included self-reported years of schooling (top-coded at 12) and post-secondary degree attainment. Model 3 replaced self-reported years of schooling with the duration in school measure. We used the khb command in Stata (Karlson et al., 2012) to examine the relative contribution of each measure of schooling in explaining the association between race and allostatic load. This method compares the estimated coefficients of nested linear and nonlinear probability models, and hence, decomposes the total effect of the independent variable (i.e., race) into direct and indirect effects. We report the total percentage of the race coefficient that is explained uniquely by years of schooling and degree attainment (i.e., Model 2 to Model 1) and that is explained uniquely by duration in school and degree attainment (Model 3 to Model 1).

3. Results

3.1. State-level description

Prior to linking the BSE data to HRS, we examined state and annual variation in the proportion of the school term attended for students in Black and White-segregated school systems from 1919/20 to 1953/54 in the Jim Crow South. We show this variation in Fig. 1 to provide an overview of the level of inequity in the amount of time Black and White students spent in school *due to de jure* school segregation. Several patterns emerge. First, Black students, on average, attended less of the school term than White students across all states during this period, except for the District of Columbia. These inequities narrowed in later years, but were still quite large in Mississippi, South Carolina, and Georgia. Second, students attended less of the school term in the 1920s than they did in the 1950s regardless of race; however, students attended much less of the school term in the 1920s in states such as Alabama, South Carolina, and Mississippi, than in Delaware, the District of Columbia, and Maryland. These patterns highlight why it is critical to account for how structural racism – in the form of *de jure* school segregation – led to race inequities in time spent in school and determined the *quantity* of education White and Black older adults ultimately received given *when* and *where* they attended school.

3.2. Sample characteristics

Table 1 presents sample characteristics. White adults reported an average standardized allostatic load score (mean = 0.04, SE = 0.01) that was about one-third of a standard deviation lower than Black adults (mean = 0.14, SE = 0.02; $p < 0.001$).

Fig. 2 shows that this difference occurred across the distribution of allostatic load. White and Black adults were, on average, around 77 years old and women comprised about 60% of the sample, regardless of race. Most Black adults attended school in the South Atlantic division (49.7%), whereas White adults were a bit more evenly split across divisions.[1] Less than one-third of White adults had a parent who completed fewer than 8 years of school, compared to 60.4% of Black adults.

White adults also completed more years of primary/secondary schooling – whether measured by self-report or duration in school – than Black adults. On average, White adults completed 10.8 years of

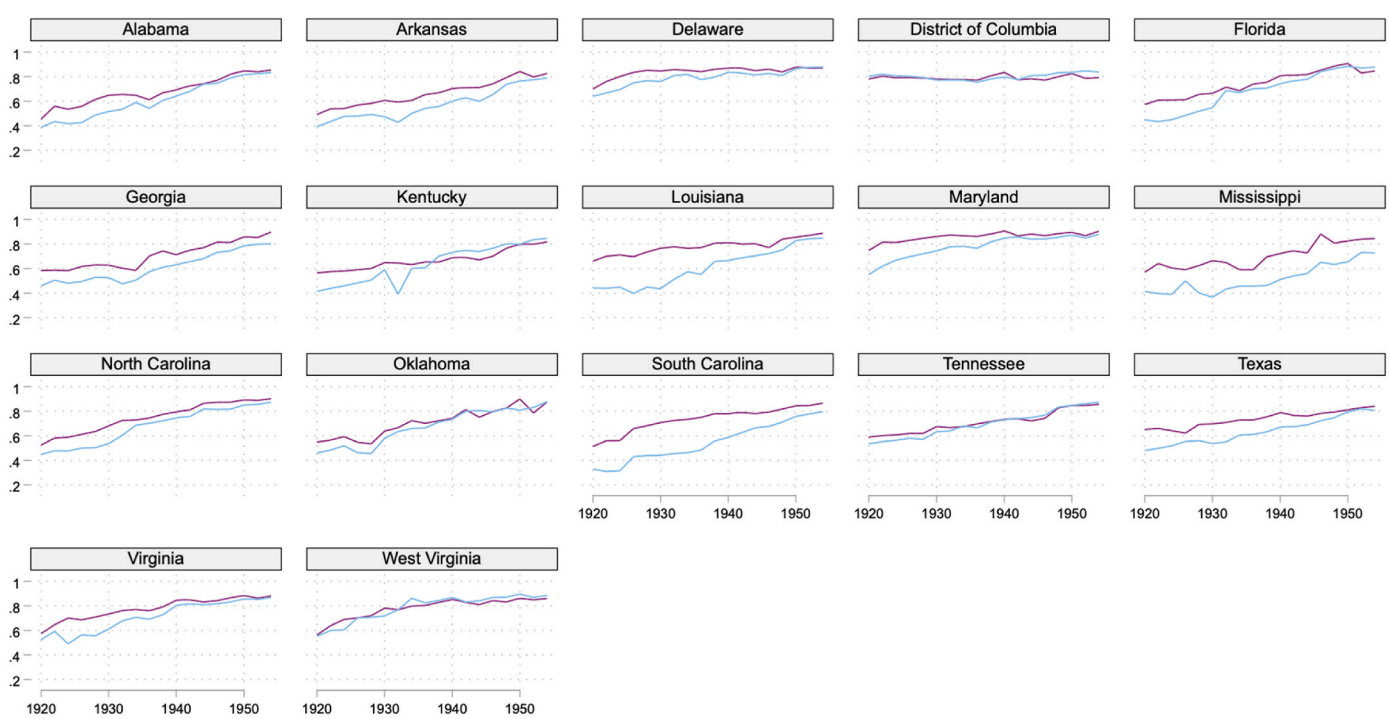

Fig. 1. Proportion of the maximum southern school term attended at White-segregated schools (Purple) and Black-segregated schools (Blue) in the U.S. South by state (n = 17), Biennial Survey of Education, 1919/20 to 1953/54.
Note. Proportion of the school term attended is calculated as the average number of days attended as reported by the state divided by the maximum school term length in the U.S. South in that year. The average number of days attended is reported separately for White-segregated and Black-segregated school systems. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 1
Sample characteristics of Black and White HRS respondents who resided in U.S. South during school (n = 1932).

	White n = 1354	**Black** n = 578	p-value
	Mean (SE) or %	Mean (SE) or %	
Allostatic Load			
z-score	0.04 (0.01)	0.14 (0.02)	<0.001
Low	35.2%	27.9%	0.001
Mid	33.7%	31.8%	
High	31.2%	40.3%	
Age (years)	77.86 (0.19)	77.37 (0.28)	0.15
Women, %	59.9%	60.7%	0.77
Schooling Cohort, %			0.09
≤ 1939	16.6%	21.5%	
1940–1948	41.8%	40.0%	
1949–1954	41.6%	38.6%	
Census Division, %			0.02
South Atlantic	41.9%	49.7%	
East South Central	26.1%	24.3%	
West South Central	31.9%	26.0%	
Parent's Education, %			<0.001
< 8 years of school	32.9%	60.4%	
Respondent's Education			
Self-reported (years)	10.8 (0.07)	9.0 (0.16)	<0.001
Duration in school (years)	8.3 (0.06)	6.2 (0.12)	<0.001
Degree Attainment, %			
Post-secondary degree	22.2%	7.5%	<0.001

Notes: *t*-test for mean differences, chi-sq test for categorical and binary variables.

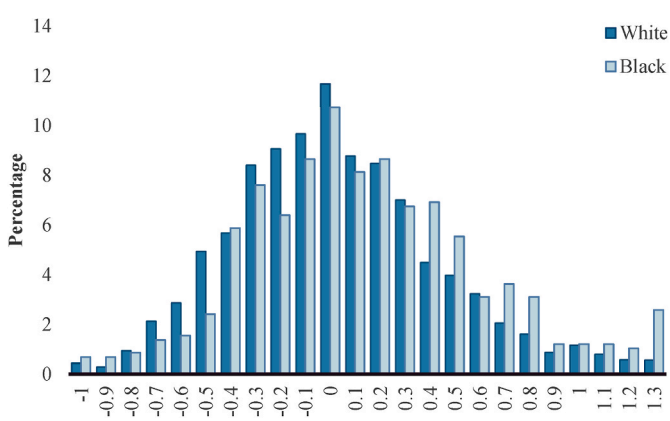

Fig. 2. Histogram of allostatic load (z-scores) by race.

schooling (top-coded at 12) when assessed using the self-reported measure, but 8.3 years in school when assessed using the duration in school measure. Black adults completed 9.0 years (self-reported) and 6.2 years (duration) of schooling, respectively. Approximately 22% of White adults completed at least a post-secondary degree, whereas 7.5% of Black adults did so.

3.3. Linear regression models

Table 2 presents estimates from weighted linear regression models. Black adults had higher allostatic load z-scores (b = 0.09, SE = 0.03; Model 1) than White adults, adjusting for demographics and parent's education; a difference equal to one-fifth of a standard deviation on allostatic load. In Model 2, the race coefficient remained statistically significant (b = 0.07; SE = 0.03, p = 0.02) after adjustment for self-reported years of schooling and post-secondary degree attainment. In Model 3, Black adults no longer had a statistically significantly higher allostatic load score than White adults (b = 0.05, SE = 0.03, p > 0.05) after adjustment for duration in school and post-secondary degree attainment.

Decomposition estimates indicated that years of schooling explained

Table 2
Weighted estimates from linear regression models predicting allostatic load among Black and White HRS respondents who resided in the U.S. South during school (N = 1932).

	Model 1	**Model 2**	**Model 3**
	b (SE)	b (SE)	b (SE)
Black	0.09 (0.03)*	0.07 (0.03)*	0.05 (0.03)
Educational attainment			
Self-reported school years [a]		−0.01 (0.01)*	
Duration in school [a]			−0.02 (0.01)*
Post-secondary degree		−0.09 (0.03)*	−0.09 (0.03)*
% of race coefficient explained by			
Self-reported school years	16.3%*		
Duration in school		33.7%*	
Post-secondary degree	8.7%*	8.7%*	

Notes: All models adjust for age, gender, education cohort, census division in childhood, and parent's education. Decomposition estimates for percent of race coefficient explained by the education variables derived from the khb method developed by Karlson et al., 2012.
[a] top-coded at 12.
*$P < 0.05$, two-tailed.

16.3% of the Black-White difference in allostatic load, whereas duration in school explained 33.7% of this difference and reduced the race coefficient to statistical non-significance. Our results suggest that a modified measure of educational attainment – duration in school – which accounts for inequities in *quantity* of schooling due to structural racism, explains *more* of the Black-White difference in allostatic load than a traditional measure of educational attainment.

3.4. Multinomial logistic regression models

Table 3 presents estimates from weighted multinomial logistic regression models (low allostatic load serves as the baseline category). We found no race difference in the risk of having average versus low allostatic load score in Models 1–3; however, Black older adults had a higher risk of having a high versus low allostatic load score compared to White older adults with adjustment for demographics and parental education (RRR = 1.48, 95% CI: 1.10, 1.98, Model 1). In Model 2, the race coefficient was no longer statistically significant (RRR = 1.32, 95% CI: 0.98, 1.78) after adjusting for self-reported years of schooling and post-secondary degree attainment. Adjustment for duration in school, however, yielded a comparatively smaller Black-White difference in allostatic load (RRR = 1.20, 95% CI: 0.87, 1.65; Model 3) than adjusting for self-reported years of schooling.

Decomposition estimates indicated that years of schooling explained 19.6% of the Black-White difference in high versus low allostatic load, whereas duration in school explained 44.5% of the race difference. Again, our results suggests that the education measure that accounts for inequities in *quantity* of schooling due to structural racism – i.e., duration in school – explained about twice as much of the race difference in high vs. low allostatic load than self-reported years of schooling.

3.5. Sensitivity analysis

We conducted several robustness checks. First, given prior work that found race variation in the relationship between education and allostatic load (Howard & Sparks, 2015; Sims & Coley, 2019), we estimated linear and multinominal models that included interactions between race and our education measures. Our models did not provide evidence for effect modification. Second, we considered if restricting our sample to respondents with valid data on 6 or more biomarkers changed our inferences but found no evidence that it did. Finally, because we calculated duration in school using not only individual-level data on the number of years of schooling completed, but also state-level data on school attendance and term length, we estimated state-fixed effects

Table 3
Relative risk ratios and 95% confidence intervals from weighted multinomial regression models predicting levels of allostatic load among Black and White HRS respondents who resided in the U.S. South during school (N = 1932).

	Average vs Low Allostatic Load			*High vs Low Allostatic Load*		
	Model 1	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
	RRR	RRR	RRR	RRR	RRR	RRR
	[95% CI]	[95% CI]	[95% CI]	[95% CI]	[95% CI]	[95% CI]
Black	1.16	1.12	1.06	1.48*	1.32	1.20
	[0.87,1.54]	[0.83,1.50]	[0.77,1.46]	[1.10,1.98]	[0.98,1.78]	[0.87,1.65]
Educational Attainment						
Self-reported school years [a]		0.98			0.93*	
		[0.91,1.06]			[0.86,1.00]	
Duration in school [a]			0.95			0.89*
			[0.87,1.05]			[0.82,0.98]
Post-secondary degree		0.78	0.79		0.64*	0.65*
		[0.56,1.08]	[0.57,1.09]		[0.45,0.92]	[0.46,0.93]
% of race coefficient explained by						
Self-reported school years					19.6%*	
Duration in school						44.5%*
Post-secondary degree					9.8%*	9.6%*

Notes: All models adjust for age, gender, education cohort, census division in childhood, and parent's education. Decomposition estimates for percent of race coefficient explained by the education variables derived from the khb method developed by Karlson et al., 2012.
[a] top-coded at 12.
*$P < 0.05$, two-tailed.

models. Results provided similar inferences to those we present, but due to small cell sizes in several states, reporting these estimates would violate our restricted data disclosure agreement. Therefore, we present results from models that adjust for census division.

4. Discussion

Our study aimed to determine if a historically-informed measure of education that accounted for one aspect of structurally rooted systemic racism within the Jim Crow education system – race inequity in the proportion of school term attended – explained more of the Black-White inequity in allostatic load, a measure of physiological dysregulation, than a traditional measure of education. We found that our measure of education – duration in school – reduced the Black-White inequity in allostatic load more so than self-reported years of schooling whether we measured allostatic load continuously (34% vs 16%) or categorically (45% vs 20%).

Although education – either measured as years of schooling or duration in school – attenuated Black-White inequities in allostatic load, only duration in school reduced race inequities in allostatic load to statistical non-significance in linear regression models. Studies focused on understanding Black-White inequities in allostatic load often adjust for educational attainment to account for confounding or to estimate mediation; however, educational attainment often explains little of the race inequity in allostatic load (Mitchell et al., 2020; Moore et al., 2021; Richardson et al., 2021). This may be due to the use of an imprecise measure that ignores systemic structural racism in the education system (Walsemann et al., 2013). Because our duration in school measure accounts for institutionalized racial inequity in the amount of time Black and White students spent in school during the Jim Crow era, we can more accurately measure *quantity* of education across race, time, and place. Our findings may, therefore, better explain race inequities in allostatic load that stem from structural racism experienced in early life.

Our study adds to a growing body of literature that documents poorer cardiovascular health (a key component of allostatic load) and increased mortality, including CVD mortality, among Black adults who were born in the U.S. South (Glymour et al., 2013; Kershaw et al., 2010; Patton et al., 2011; Schneider et al., 1997). Early studies identified the highest age-adjusted all-cause mortality (Greenberg & Schneider, 1992) and circulatory-related mortality (Schneider et al., 1997) among Black individuals who were born in the U.S South, and the lowest mortality among those born in the West, even among individuals who subsequently moved to another region. More recent research confirms this earlier finding (Glymour et al., 2013; Kershaw et al., 2010; Patton et al., 2011), with some indication that state of birth has a stronger relationship to cause-specific mortality than current state of residence (Xu et al., 2021). Some posit that these patterns reflect differences in the structural features of the state environment (Rehkopf et al., 2015), including the percentage of residents who are high school graduates, the level of income inequality, or investment in institutional resources (Glymour et al., 2013). Others speculate that state-level differences in exposure to psychosocial stressors early in life may lead to physiological changes and greater allostatic load throughout the life course (Patton et al., 2011). Our sample of Black older adults grew up in a racial regime of White Supremacy that prioritized the motivating interests, experiences, and perspectives of White Americans to the detriment of Black Americans who experienced pernicious racism during childhood – including within the education system (Baker, 2022). Rather than merely controlling for "southern" exposure, our measure of duration in school incorporates the systemic structural racism present in the southern public education system during this historical period. Our findings point to the importance of education policies and practices as one pathway through which structural racism "gets under the skin" to shape the physiology and health of individuals racialized as Black.

Our findings may also reflect the historically contingent and cohort dependent nature of education as an explanation for Black-White inequities in allostatic load. Several studies have found that, among Black men and/or women, education has a positive association with allostatic load, such that post-secondary schooling is related to higher allostatic load (Howard & Sparks, 2015; Richardson et al., 2021; Sims & Coley, 2019). Yet, we found no evidence that the education—allostatic load relationship differed by race. Our sample of Black adults completed their primary and secondary schooling in the Jim Crow South prior to *Brown v Board of Education (1954)* and experienced a racial regime that limited their educational, social, and economic opportunities. Indeed, only 7.5% of Black adults in our sample completed *any* post-secondary school compared to 22.2% of White adults in our sample. The samples utilized in studies that found effect modification (Howard & Sparks, 2015; Richardson et al., 2021; Sims & Coley, 2019), however, were either mostly (or solely) comprised of adults who attended school after *Brown*

when access to higher education was greater for Black adults. While more Black adults were able to attend college during the post-*Brown* era, doing so at predominantly White institutions also increases exposure to racial marginalization and discrimination (Feagin et al., 1996; Lewis & Shah, 2021), which has been linked to poorer metabolic health (Colen et al., 2021).

Importantly, racial inequities in school resources and environments continued after *Brown,* but in some respects changed in nature. For example, by the end of this period, term lengths became more standardized across the United States (Office of Vocational and Adult Education, 2003), even in the segregated school system of the Jim Crow South (Fig. 1), but inequities in school funding, teacher quality, and coursework remained (Johnson, 2019; Walsemann et al., 2013). For example, a recent study by Boen (2020) found that greater school toxicity at one's secondary school – measured in terms of school safety and violence, teacher turnover, and low school connectedness – was associated with greater physiological dysregulation in early adulthood. As younger cohorts age and race inequities in health emerge, it will be important to examine how these other aspects of systemic structural racism within the education system shape Black-White inequities in allostatic load, which may help us better understand why educational attainment does not always provide health benefits to Black adults.

4.1. Limitations

There are several limitations to our study. First, when calculating duration in school, we assumed that respondents attended school for the average number of days reported by the state. This may lead to downward bias for those who attended the entire term length and upward bias for those who rarely attended school. Second, we used information on where respondents lived when they were in primary/secondary school or around age 10 to link BSE data to the HRS and, as such, we cannot account for respondents who moved across state lines during childhood. We do not expect that this will substantially impact our results, however, given 92% and 85% of Black and White adults in our sample who were born in the South lived in their state of birth when they were school-aged. Third, other aspects of the Jim Crow racial regime might be related to allostatic load. To account for this possibility, we adjusted for census division of residence in our models, though adjustment for state of residence did not change our results. Fourth, we used 8 biomarkers to calculate allostatic load, rather than 11 or 12 biomarkers (Beckie, 2012), due to data availability. Abbreviated versions of allostatic load are commonly used (Beckie, 2012) and adequately reflect the interactive and synergistic physiobiological impacts associated with racism not reflected in single-item health indicators (Currie et al., 2019). Finally, the HRS biomarker data collection began in 2006 and 2008, when respondents were 60–95 years old. We compared our respondents ($n = 1932$) to those who met our inclusion criteria but did not provide biomarker data ($n = 2706$) to determine the extent of selection bias. Our sample was younger, more educated, and more female, although this was more so the case for White than Black respondents. Thus, our findings likely provide lower bound estimates of Black-White inequities in allostatic load.

5. Conclusion

Our study demonstrated that using a historically informed measure of schooling – duration in school – explained more of the Black-White inequity in allostatic load than self-reported years of schooling. This seems to be due, in part, to the fact that the duration in school measure captures at least one aspect of the structurally rooted systemic racism embedded in the Jim Crow education system, which resulted in Black students spending fewer days in the classroom being educated. Our findings highlight the importance of identifying and using historically informed measures of schooling that account for structurally rooted systemic racism when trying to understand how education shapes the health of individuals racialized as Black in the United States.

Ethical statement

This is an analysis of secondary data that have been de-identified and are publicly available. Ethical approval was not obtained because data was not collected as part of this study.

Credit author statement

Katrina Walsemann: Conceptualization, Methodology, Formal Analysis, Writing – Original Draft, Supervision, Funding acquisition. **Jay Pearson**: Conceptualization, Writing – Original Draft. **Emily Abbruzzi**: Conceptualization, Writing – Original Draft.

Declaration of competing interest

No financial or personal interests to declare.

Acknowledgments

This work was supported with funding from an Alzheimer's Association Grant (AARG-NTF-20-684252) and the National Institute on Aging (R01AG067536). No funding providers played a role in study design/conduct, analysis/interpretation of data, or manuscript preparation.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2022.101224.

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