SSM - Population Health 8 (2019) 100418

Contents lists available at ScienceDirect

SSM - Population Health

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

Article

Differential associations between state-level educational quality and cardiovascular health by race: Early-life exposures and late-life health

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ARTICLE INFO

Keywords:
Education
Race
Heart disease
Stroke
Hypertension
Health disparities
Obesity
Smoking

ABSTRACT

Cardiovascular diseases (CVD) are patterned by educational attainment but educational quality is rarely examined. Educational quality differences may help explain racial disparities. Health and Retirement Study respondent data (1992–2014; born 1900–1951) were linked to state- and year-specific educational quality measures when the respondent was 6 years old. State-level educational quality was a composite of state-level school term length, student-to-teacher ratio, and per-pupil expenditure. CVD-related outcomes were self-reported (N = 24,339) obesity, heart disease, stroke, ever-smoking, high blood pressure, diabetes and objectively measured (N = 10,704) uncontrolled blood pressure, uncontrolled blood sugar, total cholesterol, high-density lipoprotein cholesterol (HDL), and C-reactive protein. Race/ethnicity was classified as White, Black, or Latino. Cox models fit for dichotomous time-to-event outcomes and generalized estimating equations for continuous outcomes were adjusted for individual and state-level confounders. Heterogeneities by race were evaluated using state-level educational quality by race interaction terms; race-pooled, race by educational quality interaction, and race-specific estimates were calculated. In race-pooled analyses, higher state-level educational quality was protective for obesity (HR = 0.92; 95%CI(0.87,0.98)). In race-specific estimates for White Americans, state-level educational quality was protective for high blood pressure (HR = 0.95; 95%CI(0.91,0.99). Differential relationships among Black compared to White Americans were observed for obesity, heart disease, stroke, smoking, high blood pressure, and HDL cholesterol. In race-specific estimates for Black Americans, higher state-level educational quality was protective for obesity (HR = 0.88; 95%CI(0.84,0.93)), but predictive of heart disease (HR = 1.07; 95%CI(1.01,1.12)), stroke (HR = 1.20; 95%CI(1.08,1.32)), and smoking (HR = 1.05; 95%CI(1.02,1.08)). Race-specific hazard ratios for Latino and Black Americans were similar for obesity, stroke, and smoking. Better state-level educational quality had differential associations with CVD by race. Among minorities, better state-level educational quality was predominately associated with poorer CVD outcomes. Results evaluate the 1900–1951 birth cohorts; secular changes in the racial integration of schools since the 1950s, means results may not generalize to younger cohorts.

Introduction

Cardiovascular disease (CVD) is a leading cause of morbidity and mortality in the United States, with minorities disproportionately affected (Egan, Zhao, & Axon, 2010; Wong, Shapiro, Boscardin, & Ettner, 2002). While extensive work characterizes these racial disparities (Egan et al., 2010; Wong et al., 2002), evidence on root causes is limited; as such, scalable, population-level solutions to racial disparities in CVD have not been identified (Sampson et al., 2016).

A promising mechanism to reduce disparities in CVD is through educational interventions. For example, eligibility for the college education subsidies provided by the Korean War and Vietnam War GI Bills are associated with smaller socioeconomic disparities in mental (Vable et al., 2016), physical (Vable, Kiang et al., 2018), and cognitive (Vable,

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https://doi.org/10.1016/j.ssmph.2019.100418
Received 5 February 2019; Received in revised form 20 May 2019; Accepted 24 May 2019

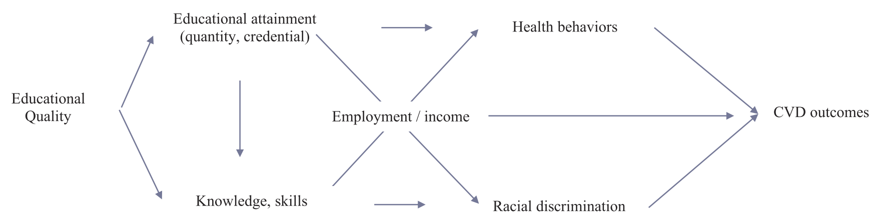

Fig. 1. Conceptual model of hypothesized pathways through which educational quality may effect CVD outcomes among minorities.
Better education quality can result in both higher educational attainment and more knowledge and skills. Both educational attainment and knowledge and skills can result in better jobs, higher income, and more wealth, which, in turn, can contribute to behaviors that promote CVD health for outcomes on health behavior pathways. Conversely, both higher educational attainment and knowledge and skills may put minorities in a social world where they are more unique, resulting in more experiences of discrimination, which, in turn, can contribute to higher rates of CVD outcomes on stress/discrimination related pathways.

Eng et al., 2018) health among veterans compared to non-veterans. Similarly, a randomized high-quality early childhood education intervention resulted in better cardiovascular and metabolic outcomes in adulthood (Campbell et al., 2014).

There are several pathways through which education may influence health overall and CVD in particular (Fig. 1). Those with higher educational attainment have better access to health-promoting resources including better neighborhoods, healthy food (Kushi et al., 2018, pp. 1–2), medication, and healthcare, and more salubrious behaviors and social norms around exercise (He & Baker, 2005) and smoking, benefitting cardiovascular health (Fagard, 2009). For racial/ethnic minorities, however, the relationships between education and health may be different (Liu, Manly, Capistrant, & Glymour, 2015; Vable, Cohen et al., 2018). For example, Black Americans with more education report more racial discrimination than Black Americans with less education (Krieger et al., 2011). Stress and discrimination are associated with poorer outcomes in a variety of cardiometabolic risk factors (Winning, Glymour, McCormick, Gilsanz, & Kubzansky, 2015), suggesting there may be heterogeneities in the relationship between education and CVD by race.

The literature on education and CVD to date has focused almost exclusively on years of schooling; for example, a recent meta-analysis suggests that compulsory schooling laws, which mandate additional years of K-12 schooling, resulted in improved CVD outcomes and risk factors in multiple countries (Hamad, Elser, Tran, Rehkopf, & Goodman, 2018). Although a relatively small literature examines educational quality and CVD, prior work suggests educational quality may be an important target for intervention in efforts to reduce disparities (Campbell et al., 2014; Liu et al., 2015).

Several educational quality measures, including student-to-teacher ratio, school term length (days of the year when school is open to students), and per-pupil expenditure, have been associated with higher educational attainment (Jackson, Johnson, & Persico, 2016) and earnings (Card and Krueger, 1990, 1991), with low-income and minority students benefitting more (Jackson, 2016). School term length is thought to reflect better quality as states that prioritize educational quality have longer term length; term length is also correlated with self-reported educational quality (Manly et al., 2018). In terms of health outcomes, longer term length (better quality) has been associated with lower hypertension (Liu et al., 2015) and mortality (Sansani, 2011), and better cognitive function (Crowe et al., 2013), while lower student-to-teacher ratio (better quality) is associated with better cognitive function (Crowe et al., 2013), and higher teacher pay (better quality) is associated with lower mortality (Sansani, 2011). There is evidence of heterogeneities by race: for example, longer term length is associated with reduced hypertension for Black women, but not for White women or men (Liu et al., 2015). However, other work found that lower student-to-teacher ratios (better quality) led to higher mortality through age 29, indicating the potential for unintended negative consequences (Muennig, Johnson, & Wilde, 2011).

The literature suggests educational quality may be an important target for interventions to reduce racial disparities in CVD, however, given the potential for differential effects by race and unintended consequences, it is important to test these relationships, specifically. Improving educational quality is an active area of state and federal policymaking in the U.S.; examining the relationship between educational quality and CVD outcomes will aid in understanding the long-term health consequences of both state and federal policies. In these analyses, we examine the association between state-level educational quality and selected CVD outcomes and risk-factors using a large sample of U.S. older adults, and test for differential relationships by race. The state is an appropriate and relevant level to evaluate educational quality as quality improvement programs and policies around class size (Muennig et al., 2011) and teacher tenure (Arnold, Cowen, Angeles, & Orleans, 2016) have been enacted by state legislatures.

Methods

Sample

Data came from the 1992–2014 waves of the U.S. Health and Retirement Study and the 1993 and 1995 cohorts of the Asset and Health Dynamics Among the Oldest Old, longitudinal, biennial samples of adults aged 50 years and older and their spouses. Analyses were restricted U.S.-born individuals as we used birth state to match individuals to state-level educational quality markers. Educational quality data were collected from state and federal educational reports (Nguyen et al., 2015), and were linked to respondents born 1900–1951, yielding an potential eligible sample of 25,129. We included both self-reported (N = 24,339), and objectively measured (N = 10,704) outcome data in these analyses; objectively measured outcome data were collected from 2006 onwards, resulting in smaller sample size for these outcomes (see Appendix Fig. 1 for flowchart of exclusions). Ethics approval was provided by the institutional review board of the University of California, San Francisco.

Exposure

We created a composite educational quality index using data on average state-level term length, student-to-teacher ratio, and inflation-adjusted per-pupil expenditure (adjusted to 1982–1984 dollars). Educational quality measures were assessed when the respondent was 6 years old and matched to the respondent based on his/her state and year of birth; young children rarely moved out of state during this time period, meaning state of birth is a good proxy for state of school attendance (Liu et al., 2015). The state is the smallest level of geographic resolution for place of childhood residence available in HRS data. Data were available from birth years 1900–1951 for term length (N = 25,129; 0% missing), 1901–1949 for student-to-teacher ratio (N = 23,850; 5.1% missing), and 1901–1937 for per-pupil expenditure (N = 15,875; 36.8% missing). All three quality measures were normalized to a mean of zero and a standard deviation of one. One standard deviation corresponds to 13 days of term length (a typical contemporary school year is 180 days), 5 students per teacher, and $270 in inflation-adjusted dollars ($672 in 2016 dollars). We reverse-coded student-to-teacher ratio for consistency with other exposure variables, i.e., higher values indicate higher quality, then averaged the quality measures to create a composite quality index. If data were missing for one or more measures, the available items were averaged; because educational quality measures were correlated (student-to-teacher ratio with per pupil expenditure = 0.58, p < 0.0005; student-to-teacher ratio with term length = 0.63, p < 0.0005; term length with per pupil expenditure = 0.66, p < 0.0005), and missingness patterns were due to variations over time rather than by sociodemographic factors, we do not expect this missingness to impact our overall or race-specific estimates. We normalized the composite index to a mean of zero and standard deviation of one for interpretability. We evaluated validity of the educational quality index by estimating its relationship with hypothesized correlates (DeVellis, 2012); the composite quality index was associated with educational attainment (Card & Krueger, 1996) (standardized education quality β = 1.23, p < 0.0005), and was a stronger predictor of educational attainment than individual quality measures (standardized term length β = 0.96, p < 0.0005; student-to-teacher ratio β = 0.86, p < 0.0005; per-pupil expenditure β = 0.89, p < 0.0005).

Educational policies are often enacted at the state-level, for example, interventions on class size (Muennig et al., 2011) and teacher tenure (Arnold et al., 2016). Partially due to these state-level policies, K-12 educational quality varies substantially across states (Fig. 2); these quality variations are considered a contributing factor to state-level variations in graduation rates (Goldin & Katz, 1910) and variations in test scores (Carnoy, García, & Khavenson, 2015). While there are important and meaningful quality differences within states (Crowe et al., 2013), because funding and quality improvement decisions are also made at the state-level, the state is also an appropriate and relevant level to evaluate educational quality. Prior work demonstrates these state-level measures of educational quality are associated with both economic and health outcomes (Card and Krueger, 1990, 1996; Nguyen et al., 2015), and finds that aggregation of educational-quality data to the state-level, as opposed to measurement at the district- or individual-level, does not bias estimates (Card & Krueger, 1996).

Outcomes

We included self-reported and objective measures of CVD and related risk factors, as the effect of educational quality may vary by mechanistic pathway. The self-reported outcomes, assessed biennially from 1992 onwards, were self-reported hypertension, diabetes, heart disease, stroke, obesity (body mass index was calculated from self-reported height and weight; obesity was considered body mass index ≥ 30), and ever-smoking. The objectively measured outcomes, assessed for a randomly selected half of the sample each year in 2006 or 2008 and quadrennially thereafter, were uncontrolled blood pressure (systolic blood pressure > 140 mmHg or diastolic blood pressure > 90 mmHg), uncontrolled blood sugar (glycosylated hemoglobin A1c ≥ 6.5%), high-density lipoprotein cholesterol (HDL, i.e., "good cholesterol", mg/dl), total cholesterol (mg/dl), and C-reactive protein (CRP, a marker of inflammation, mg/dl). Values of CRP > 10 mg/dl indicate acute infection (Morley & Kushner, 1982) and were set to missing (n = 1752 observations; 8.7% of values) to ensure CRP values reflected CVD risk and not infection at the time of the blood draw.

We used time-to-event coding for the dichotomous outcomes, to reduce the possibility of selection bias induced by excluding prevalent cases and to improve statistical efficiency. We adopted coding such that individuals already diagnosed at the beginning of follow-up were

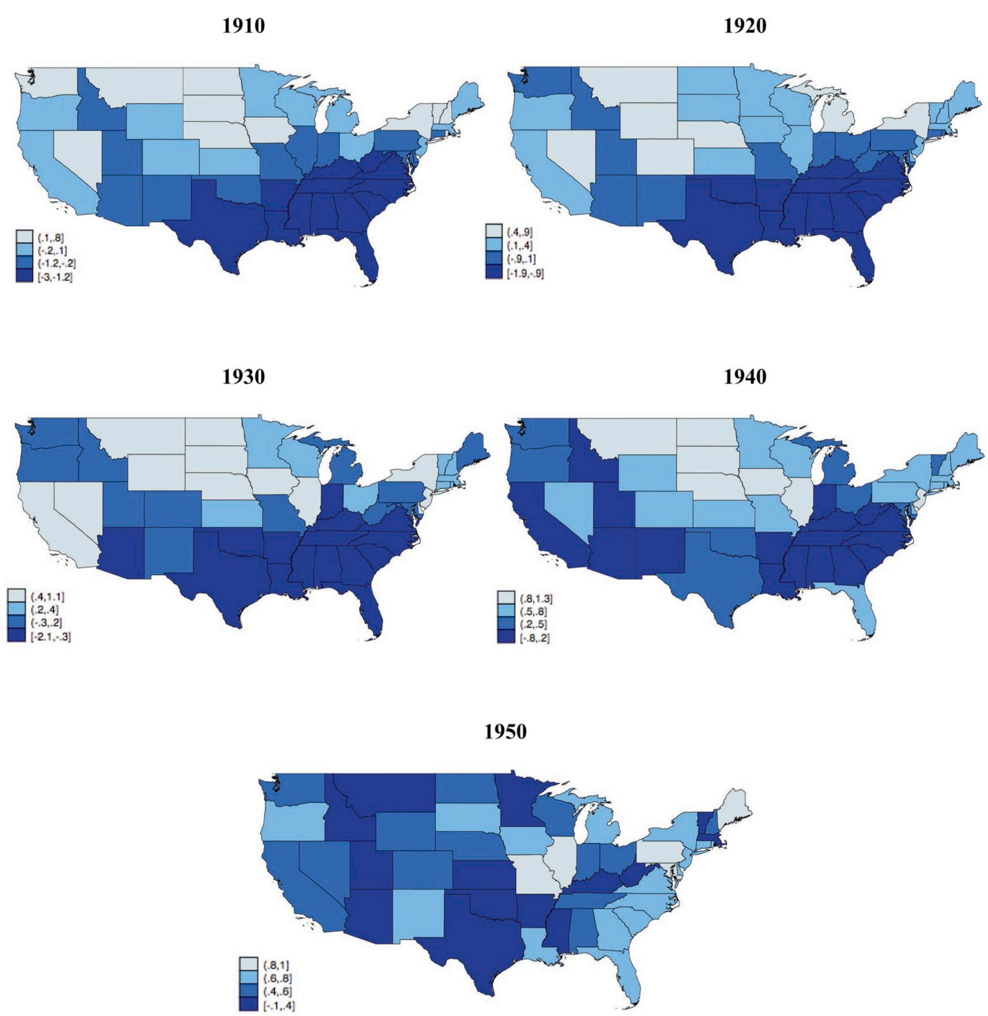

Fig. 2. State-level educational quality varies by state and over time. Colors reflect education quality quartiles in each year. Darker colors reflect lower state-level educational quality quartiles and lighter colors reflect higher state-level educational quality quartiles. There is geographic patterning of state-level educational quality such that states in the south east tend to have lower quality. There is also temporal patterning of state-level educational quality such that it improves over time. For maps that more clearly show the secular changes in educational quality over time, please see appendix Fig. 2. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

retained in the analysis by assigning their age of onset as one year before the individual entered the study. Dichotomous outcomes were coded as 0 until disease onset, and disease onset was coded as 1; once the respondent had the disease, they were no longer included in the analysis. Individuals who died or were lost to follow up were censored at their last observation. Results were similar, but less statistically efficient, for alternative operationalizations (ever vs. never having the disease; repeated measures).

Effect modifier

We evaluated self-reported race/ethnicity as a potential effect modifier (non-Hispanic White (ref), non-Hispanic Black, Hispanic/Latino, and other/missing). Those classified other race/missing were included in analysis to improve statistical efficiency, but results are not discussed or presented due to small numbers and ambiguity in interpretation.

Covariates

We adjusted all models for potential individual-level and state-level confounders. Individual-level covariates were gender and cubic splines for birth year to adjust for secular trends. Age was the time scale in Cox models discussed below; age and age-squared were also included in the generalized estimating equations, discussed below. State-level covariates were percent urban, percent foreign born, percent Black, average manufacturing jobs per capita, and average inflation-adjusted manufacturing wages; we included these sociodemographic factors which are potential shared prior causes (confounders) of both the exposure and the outcomes. We included state-of-birth "fixed effects" (i.e., indicator variables) to account for unobserved time-invariant state characteristics; inclusion of state fixed-effects should address variations in cost of living across states. We do not adjust for educational attainment in primary analyses as educational attainment is a downstream consequence of educational quality (Card & Krueger, 1996) (that is, educational attainment is a potential mediator of the relationship between educational quality and CVD outcomes, not a confounder) (Victora, Huttly, Fuchs, & Olinto, 1997), however in sensitivity analyses, we estimated results stratified by educational attainment.

Analysis

For dichotomous outcomes, we implemented Cox models, with age as the time scale for the analysis. For continuous outcomes, we used generalized estimating equations (GEE models) with an exchangeable correlation structure. Model 1 included state-level educational quality, race, and the individual-level and state-level covariates. Model 2 additionally included race-by-educational-quality interaction terms to examine heterogeneities by race, which we used to estimate race-specific hazard ratios.

We carried out sensitivity analyses to evaluate the robustness of our model to alternative specifications. First, we examined each educational quality measure separately to determine if results were driven by a single quality marker. Second, we restricted the analysis of self-reported outcomes to the smaller subsample of individuals who also had objectively measured data, to ensure results from the larger (self-reported outcomes) sample and smaller (objectively measured outcomes) sample were comparable. Third, we included a validated childhood socioeconomic status index (Vable, Gilsanz, Nguyen, Kawachi, & Glymour, 2017), which reflected childhood socioeconomic conditions before age 16. Finally, we estimated heterogeneities between educational quality and race stratified by educational attainment (less than high school vs. high school or more).

In all models, the standard errors were clustered at the state level to account for correlated observations. Analyses and data cleaning were performed using Stata 14.

Results

Sample characteristics

The analytic sample was 79.4% White, 15.0% Black, and 4.3% Latino (Table 1). Respondents were born in the 1930s on average and

Table 1
Sample characteristics by race (N = 24,339).

Variable	White (N = 19,317; 79.4%)	Black (N = 3649; 15.0%)	Latino (N = 1037; 4.3%)
Individual-level characteristics			
Birth year (mean ± sd)	1931 ± 12	1934 ± 12	1936 ± 11
Female (%)	54.9	59.7	53.6
State-level characteristics in the respondent's birth year			
Proportion urban (mean ± sd)	0.57 ± 0.20	0.43 ± 0.20	0.56 ± 0.17
Proportion foreign-born (mean ± sd)	0.09 ± 0.08	0.03 ± 0.05	0.06 ± 0.05
Proportion Black (mean ± sd)	0.09 ± 0.11	0.26 ± 0.14	0.09 ± 0.08
Manufacturing wages (inflation-adjusted USD; mean ± sd)	11,033 ± 3675	9683 ± 3784	12,496 ± 3815
Manufacturing jobs per capita (mean ± sd)	0.07 ± 0.04	6.01 ± 3.24	3.93 ± 2.54
State-level educational quality			
Composite educational quality index (mean ± sd)	0.11 ± 0.93	−0.59 ± 1.18	−0.01 ± 0.78
Student to teacher ratio (mean ± sd)	30 ± 5	33 ± 5	30 ± 3
Per-pupil expenditure (inflation-adjusted USD, mean ± sd))	531 ± 263	335 ± 237	522 ± 276
Term length (mean ± sd)	174 ± 12	166 ± 17	171 ± 11
Self-reported outcomes at baseline			
High blood pressure (%)	40.6	59.6	42.9
Heart disease (%)	20.1	17.7	13.5
Stroke (%)	6.2	7.8	6.8
Obese (%)	20.0	34.5	31.0
Diabetes (%)	10.2	20.5	20.8
Smoker (%)	60.0	60.4	58.4
Measured outcomes (N = 10,704; mean value at first assessment)			
Uncontrolled blood pressure among all respondents (%)	33.9	44.7	38.0
Uncontrolled diabetes among all respondents (%)	11.1	23.4	22.6
HDL cholesterol (mg/dL; mean ± sd)	54 ± 16	55 ± 16	54 ± 16
Total cholesterol (mg/dL; mean ± sd)	200 ± 42	198 ± 41	202 ± 45
C-reactive protein (mg/L; mean ± sd)	4.2 ± 7.9	6.3 ± 11.13	4.1 ± 5.7

sd: standard deviation.
HDL: high-density lipoprotein.

over half were female. Black respondents lived in states with lower state-level educational quality than White or Latino respondents. Black respondents were most likely to have self-reported high blood pressure at baseline, and objectively measured uncontrolled blood pressure at the first assessment. White respondents were most likely to have heart disease at baseline, while Black respondents were more likely to report stroke and obesity. Black and Latino respondents had similar proportions of diabetes and objectively measured uncontrolled blood sugar. Ever-smoking was equally common across racial groups. Compared to those with self-reported outcome data (N = 24,339; Table 1), those with objectively measured outcome data only (N = 10,704; Appendix Table 1), were younger (born later), more likely to be female, and averaged better state-level educational quality; better educational quality is expected in younger cohorts since state-level educational quality improved over time (Fig. 2).

Race-pooled estimates

In the overall sample (Fig. 3; Appendix Table 1, Model 1), better state-level educational quality was associated with lower obesity (HR = 0.92; 95%CI:0.87,0.98), and borderline associated with lower self-reported diagnosis of high blood pressure (HR = 0.96; 95%CI:0.92,1.00), and higher ever-smoking (HR = 1.03; 95%CI:1.00,1.05).

Interaction and race-specific estimates

In interaction analyses, we examined whether the association between state-level educational quality and CVD differed by race (Fig. 3). Among White Americans, better educational quality was associated with lower self-reported diagnosis of high blood pressure (HR = 0.95; 95%CI:0.91,0.99).

Interaction analyses indicated the relationship between state-level educational quality and CVD outcomes was different among Black compared to White respondents for obesity, heart disease, stroke, smoking, high blood pressure, and HDL cholesterol (Appendix Table 1, Model 2). In race-specific estimates among Black respondents (Fig. 3), better educational quality was associated with lower obesity (Black HR = 0.88; 95%CI:0.84,0.93), but higher rates of heart disease (Black HR = 1.07; 95%CI:1.01,1.12), stroke (Black HR = 1.20; 95%CI:1.08,1.32), and smoking (Black HR = 1.05; 95%CI:1.02,1.08).

The relationship between state-level educational quality and CVD outcomes was different among Latino compared to White respondents for obesity, stroke, high blood pressure, and CRP (Appendix Table 1, Model 2). In race-specific estimates among Latino respondents (Fig. 3), better state-level educational quality was associated with lower obesity (Latino HR = 0.78; 95%CI:0.07,0.87), but higher rates of stroke (Latino HR = 1.19; 95%CI:1.00,1.04), high blood pressure (Latino HR = 1.07; 95%CI:1.00,1.15), and smoking (Latino HR = 1.05; 95%CI:0.98,1.12), although the smoking confidence interval included the null.

Robustness checks

Results were substantively similar across sensitivity analyses examining each measure of state-level educational quality separately (Appendix Tables 3–5), the subsample with objectively measured data only (Appendix Table 6), and after adjustment for a childhood socioeconomic status index (Appendix Table 7). That is, point estimates were largely in the same direction, although significance varied. Higher state-level educational quality as operationalized by student–to-teacher

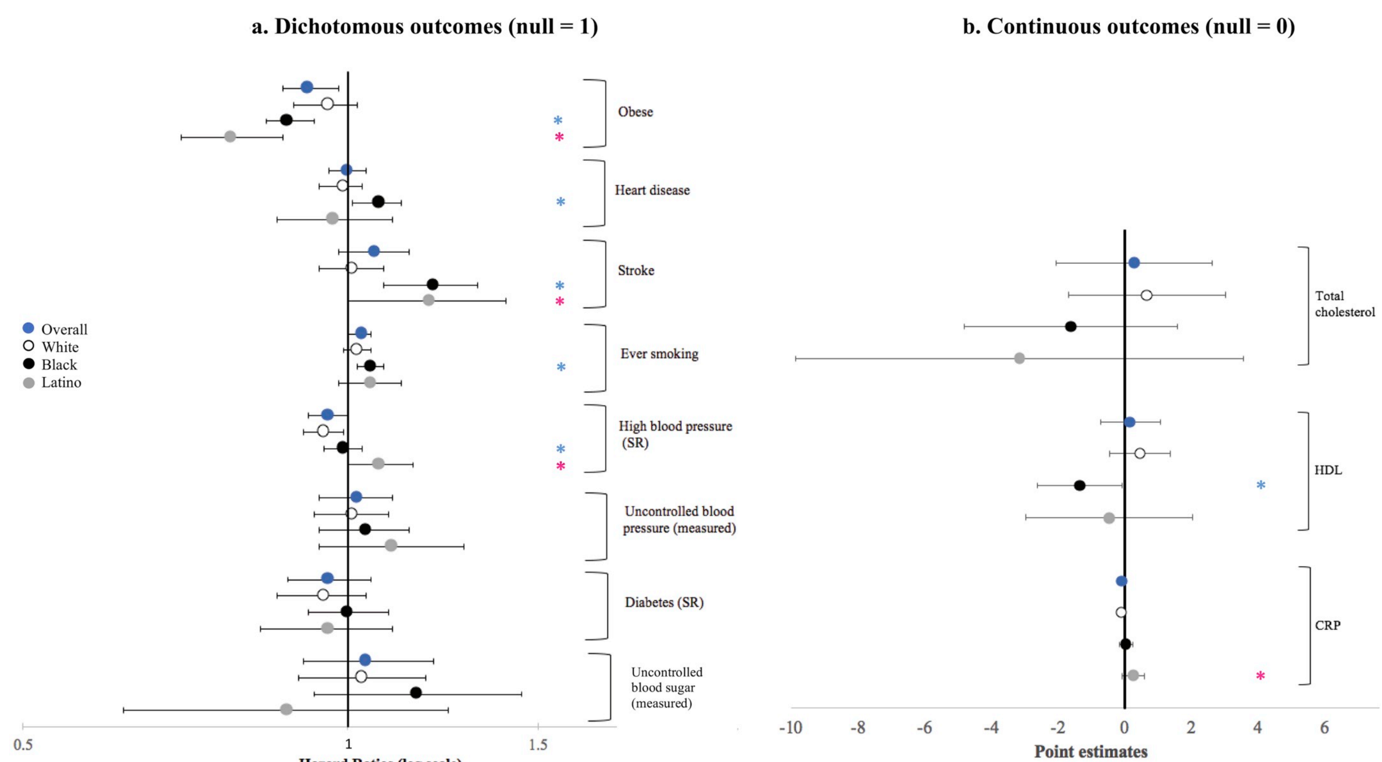

Fig. 3. Associations between state-level education quality and cardiovascular disease, overall and by race Fig. 3a. Dichotomous outcomes (null = 1) Fig. 3b. Continuous outcomes (null = 0).
* indicates relationship between state-level educational quality is statistically different for Black compared to White respondents (see Appendix Table 2 for details).
* indicates relationship between state-level educational quality is statistically different for Latino compared to White respondents (see Appendix Table 2 for details).
Race-specific estimates presented. The Hazard Ratios (HRs) are plotted on the log scale. All point estimates are adjusted for the individual- and state-level covariates, including state of birth fixed effects and a cubic spline to adjust for secular trends. For all outcomes higher values reflect poorer health, except for HDL cholesterol (i.e., "good" cholesterol), where higher values reflect better health.

ratio was particularly detrimental for Black respondents (Appendix Table 3, Model 2), while higher state-level educational quality as operationalized by term length was detrimental for both Black and Latino respondents (Appendix Table 4, Model 2). In results stratified by educational attainment, among Black respondents with less than a high school education (Appendix Table 8a), better state-level educational quality was not associated with ever-smoking or CRP. However, among Black respondents with a high school education or more (Appendix Table 8b), better state-level educational quality was associated with both higher rates of ever smoking (HR = 1.04; 95%CI: (1.00, 1.08), and elevated CRP (β = 0.23; 95%CI: (0.03, 0.44)).

Discussion

We used a large, longitudinal dataset to provide among the first estimates of the association between state-level educational quality and CVD outcomes and risk factors; we examined a range of CVD outcomes and tested for heterogeneities among racial/ethnic subgroups to explore the potential mechanisms linking educational quality and health. We found evidence of differential associations between state-level educational quality and CVD outcomes by race such that better state-level educational quality was protective for high blood pressure among White Americans and obesity among minorities; however, among minorities, better state-level educational quality was associated with worse CVD outcomes for heart disease, stroke, and smoking. These relationships were largely consistent across numerous sensitivity analyses.

Our results suggest the mechanistic pathway from state-level educational quality to CVD varies by both race and outcome. Educational quality may be linked to better CVD outcomes such as lower obesity through better health behaviors (Fig. 1). Those with better educational quality typically go on to attain more schooling (Card & Krueger, 1996), which in turn can lead to better health behaviors, such as eating heathier foods (Kushi et al., 2018, pp. 1–2) and exercising more (He & Baker, 2005), or living in areas with better access to nutritious food (Cummins, Flint, & Matthews, 2014) and more salubrious social norms (McNeill, Kreuter, & Subramanian, 2006). Both nutrition and physical activity are predictors of lower obesity (Ayyad & Andersen, 2000); results for total and HDL cholesterol, which are also associated with diet and exercise (Mann, Beedie, & Jimenez, 2014) did not fit this pattern, suggesting the situation may either be more nuanced, or there may be variations by health outcome. Racial/ethnic minorities have been hypothesized to benefit more from improved educational quality than White Americans due to resource substitution (Ross & Mirowsky, 2006). This theory posits that the effect of educational quality on health may be more pronounced for minorities because they have less access to alternative resources such as power, authority, and earnings (Ross & Mirowsky, 2006); resource substitution suggests minorities are more dependent on the limited resources to which they have access (e.g. better educational quality), while White Americans are less impacted by any one specific resource, resulting in larger effect sizes for minorities compared to White Americans.

Resource substitution may explain our heterogenous findings for obesity. Two recent reviews of quasi-experimental analyses on quantity of education also found inconsistent results, with one study reporting a beneficial effect of years education on obesity (Hamad et al., 2018), while another study found little evidence that education effects obesity (Galama, Lleras-muney, & Kippersluis, 2018). Our results indicate there are heterogeneities in the relationship between education and health by outcome and population, and resource substitution helps explain how these differential associations arose.

Among minorities, better state-level educational quality was associated with poorer CVD outcomes for heart disease, stroke, and smoking. We consider two possible explanations for these findings especially pertinent. First, these associations could be explained by increased racial discrimination (Fig. 1). Better educational quality leads to higher educational attainment (Card & Krueger, 1996); among Black Americans, those with higher education report more discrimination than those with less education (Krieger et al., 2011), perhaps due to living and moving through social environments where their presence is more unique and therefore less "expected." Discrimination, in turn, is associated with a higher prevalence of hypertension (Krieger, 1990) and higher rates of smoking, a potential discrimination/stress coping mechanism (Guthrie, Young, Williams, Boyd, & Kintner, 2002). Both hypertension and smoking are risk factors for stroke (Gilsanz et al., 2017), and heart disease (Fagard, 2009), outcomes that were associated with higher educational quality among Black people. In this way, it is possible that higher educational quality leads to more discrimination among minorities, resulting in poorer cardiovascular health for outcomes on stress- or discrimination-related pathways. Our results are also consistent with the John Henryism Hypothesis, which posits that using effortful active coping to persevere given discrimination/structural inequities can result in poorer health outcomes (James, 1994). This explanation that minorities with higher levels of education may experience more discrimination was supported by estimates of educational quality stratified by educational attainment: compared to similarly educated White Americans, Black Americans with a high school education or greater had higher rates of ever-smoking (more racial discrimination is correlated with higher smoking prevalence (Landrine & Klonoff, 2000)), and CRP (a marker of inflammation that is correlated with experiences of discrimination among more highly educated African Americans (Van Dyke et al., 2017)).

A second explanation for these findings could be that educational quality was aggregated to the state-level, masking variations in educational quality within states (Crowe et al., 2013). The birth cohorts included in these analyses (born 1900–1951) were born before segregation was determined illegal by the U.S. Supreme Court in the landmark 1954 case, *Brown vs. Board of Education*. Higher average state-level educational quality over time, therefore, may reflect better educational quality that is accruing for Whites only, resulting in a *relative* decrease in educational quality among Black compared to White students, and therefore subsequent poorer health outcomes for Black older adults. Repeating these analyses with educational quality measures disaggregated by race is an important area for future research; additionally, developing a reproduceable metric of educational inequality would advance research in this area.

An important reason to evaluate state-level educational quality is the potential for state-level interventions to reduce inequalities. State policies, for example, can be implemented statewide or targeted towards low-performing school districts. Conversely, interventions originating at the local level may exacerbate inequalities as high-performing districts are more likely to have the resources necessary to implement change.

Our results may not generalize to younger cohorts as our study is restricted to individuals born before 1951, and there were important social changes following school desegregation and the Civil Rights movement. Replication of these analyses in datasets including younger birth cohorts is an important area for future research, although younger cohorts may not yet be old enough to develop the health conditions we examined.

There are limitations to these analyses. First, self-reported health outcomes may be subject to standard reporting biases, which may be more severe for those with lower levels of educational attainment. Second, we were unable to account for within-state variations in educational quality because these data were not available and because the state was the smallest geographic unit of childhood residence available in HRS data. Since educational quality data were aggregated to the state-level and the study period was prior to desegregation, Black and Latino Americans included in this analysis were likely assigned higher educational quality than they actually received from their school district; we found assigning minorities lower educational quality did not substantively change estimates, or our conclusions (results not displayed).

Prior work has noted that aggregation of educational-quality data to the state-level, as opposed to measurement at the district- or individual-level, does not bias estimates (Card & Krueger, 1996). This prior work, combined with our sensitivity analyses, gives us confidence that our results accurately reflect the differential associations between state-level educational quality and CVD outcomes by race. However, given the long history within the U.S. of school funding coming from property taxes, and residential segregation based on race (Owens, 2017) and socioeconomic status (Owens, 2016), linking data on educational quality at the school-district level to individual-level health outcomes is an important area of future research. Third, the potential for differential survival may have biased our estimates. Minorities may die at younger ages than White Americans and may therefore appear disproportionately healthy, potentially biasing results towards the null (Mayeda, Filshtein, Tripodis, Glymour, & Gross, 2018, pp. 1507–1517). Alternatively, minorities from states with low educational quality may have died at younger ages and were therefore not included in our study, compared with minorities from states with higher educational quality. This would result in minorities from states with low educational quality being disproportionately healthy, and could explain the relationships we observed that higher state-level educational quality was predominantly associated with poorer CVD outcomes among minorities. Overall, the direction of bias due to selective survival is uncertain. Finally, these analyses use observational data and do not examine natural experiments, so we view these relationships as associational, not causal. Despite these limitations, this is among the first analyses to examine heterogeneities in the relationship between educational quality and long-term CVD outcomes by race, and is therefore an important contribution to the field. A better understanding of heterogeneities by race is an important area for future research.

We found that better state-level educational quality was associated with better CVD outcomes among Whites, but both better and worse CVD outcomes among minorities. These mixed findings among minorities may be due to different mechanistic pathways through which educational quality impacts different CVD outcomes. Repeating these analyses to determine if our findings are robust to variations in time and population is an important area for future research. Our results suggest policies to improve state-level educational quality may differentially affect racial minorities compared to Whites, and that policies to improve educational quality alone may not eliminate health disparities due to broader structural inequities.

Ethics approval

Ethics approval was provided by the institutional review board of the University of California, San Francisco.

Conflicts of interest

We declare no conflicts of interest.

Funding

Funders of this work paid no role in the analysis, framing, or decision to publish.

Acknowledgments

This work was supported by the National Institutes of Health (K08 HL132106 to RH, K01 AG047280 to DH, and UL1 TR001085 from the Stanford Clinical and Translational Science Award to Spectrum). This research was also supported by a grant from the American Educational Research Association which receives funds for its AERA Grants Program from the National Science Foundation under NSF Grant #DRL-0941014. Opinions reflect those of the author(s) and do not necessarily reflect those of the granting agencies. The funders played no role in study design; collection, analysis, or interpretation of data; writing of the article; or the decision to submit for publication.

Appendix

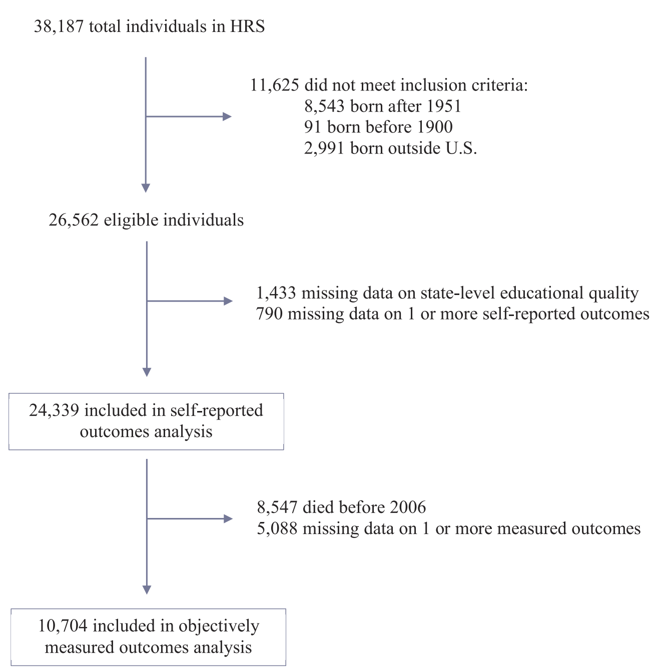

Fig. 1. Flowchart of sample exclusions for the analysis of self-reported and objectively measured outcomes.
The Health and Retirement Study is a national biennial sample of adults aged 50 + years and their spouses; outcome data from 1992 to 2014. N = 336 individuals who reported their race as "other race" or "missing" were included in analysis to improve statistical efficiency, but are not discussed due to small numbers and ambiguity in interpretation. For this reason, the number of White, Black and Latino individuals does not sum to 24,339.

Those missing data on educational quality were more likely to be minorities (21% of those not missing data on educational quality were minorities vs. 65% of those missing data on educational quality, $p < 0.0005$); all individuals missing data on educational quality were also missing data on all of the self-reported outcomes.

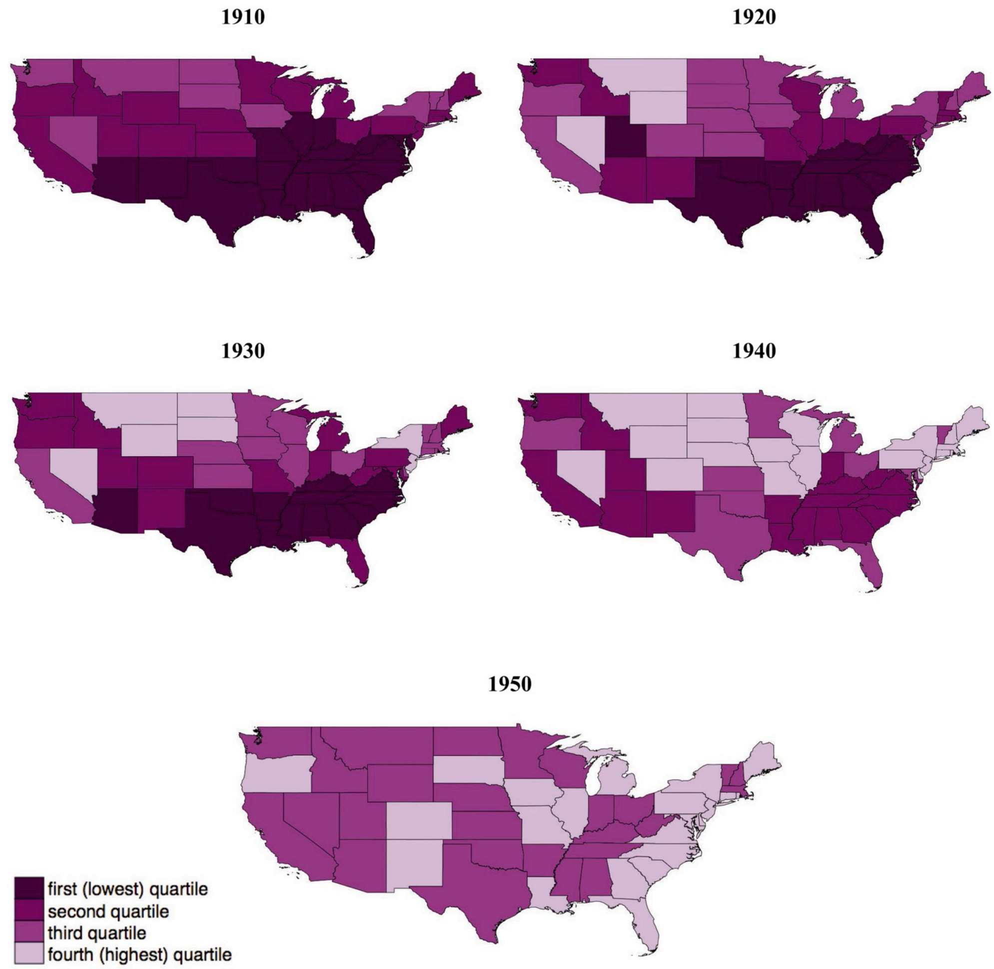

Fig. 2. Variation in composite measure of educational quality (in quartiles) over time.

There were secular improvements in educational quality from 1910 to 1950.

Table 1
Sample characteristics by race for those with objectively measured outcome data (N = 10,704)

Variable	White (N = 8756; 81.8%)	Black (N = 1345; 12.6%)	Latino (N = 469; 4.4%) (Wong et al., 2002)
Individual-level characteristics			
Birth year (mean ± sd)	1936 ± 9	1938 ± 9	1939 ± 8
Female (%)	57.0	64.4	59.9
State-level characteristics			
Proportion urban (mean ± sd)	0.58 ± 0.19	0.46 ± 0.19	0.59 ± 0.15
Proportion foreign-born (mean ± sd)	0.08 ± 0.07	0.03 ± 0.04	0.06 ± 0.04
Proportion Black (mean ± sd)	0.09 ± 0.10	0.25 ± 0.14	0.08 ± 0.07
Manufacturing wages (inflation-adjusted; mean ± sd)	12,416 ± 3377	10,808 ± 3340	13,580 ± 3247
Manufacturing jobs per capita (mean ± sd)	0.07 ± 0.04	0.06 ± 0.03	0.04 ± 0.03
State-level educational quality			
Composite educational quality index (mean ± sd)	0.33 ± 0.74	−0.23 ± 0.90	0.18 ± 0.54
Student to teacher ratio (mean ± sd)	29 ± 4	32 ± 4	29 ± 3
Per-pupil expenditure (inflation-adjusted USD, mean ± sd)	593 ± 281	392 ± 249	606 ± 280
Term length (mean ± sd)	176 ± 8	171 ± 12	174 ± 6

sd: standard deviation.
HDL: high-density lipoprotein cholesterol; higher values reflect better health.
Distribution of outcomes presented in the main paper body.

The Health and Retirement Study is a national biennial sample of adults aged 50 + years and their spouses; outcome data from 1992 to 2014. N = 134 individuals who reported their race as “other race” or “missing” were included in analysis to improve statistical efficiency, but are not discussed due to small numbers and ambiguity in interpretation. For this reason, the number of White, Black and Latino individuals does not sum to 10,703.

Table 2
Associations between state-level educational quality (composite measure) and CVD outcomes overall, and with interactions by race / ethnicity

Dichotomous Outcomes (null = 1)	Model 1: Overall	Model 2: interaction		
		Reference group (Whites)	Differential effect for Blacks	Differential effect for Latinos
Obese (self-reported)	0.92*	0.96	0.93**	0.82**
	(0.87, 0.98)	(0.89, 1.02)	(0.88, 0.97)	(0.74, 0.90)
Heart disease (self-reported)	1.00	0.99	1.08**	0.99
	(0.96, 1.04)	(0.94, 1.03)	(1.03, 1.13)	(0.89, 1.09)
Stroke (self-reported)	1.06	1.01	1.18**	1.17*
	(0.98, 1.14)	(0.94, 1.08)	(1.09, 1.28)	(1.01, 1.37)
Ever smoking (self-reported)	1.03*	1.02	1.03**	1.03
	(1.00, 1.05)	(0.99, 1.05)	(1.01, 1.05)	(0.97, 1.10)
High blood pressure (self-reported)	0.96	0.95*	1.04**	1.13**
	(0.92, 1.00)	(0.91, 0.99)	(1.01, 1.07)	(1.06, 1.20)
Uncontrolled high blood pressure (measured)	1.02	1.01	1.03	1.09
	(0.94, 1.10)	(0.93, 1.09)	(0.95, 1.11)	(0.94, 1.26)
Diabetes (self-reported)	0.96	0.95	1.05	1.01
	(0.88, 1.05)	(0.86, 1.04)	(0.98, 1.13)	(0.90, 1.12)
Uncontrolled diabetes (measured)	1.04	1.03	1.13	0.85
	(0.91, 1.20)	(0.90, 1.18)	(0.92, 1.38)	(0.63, 1.16)
Continuous Outcomes (null = 0)				
HDL cholesterol (measured)	0.18	0.46	−1.80**	−0.91
	(-0.72, 1.08)	(-0.45, 1.37)	(-2.78, −0.82)	(-3.34, 1.53)
Total cholesterol (measured)	0.29	0.68	−2.30	−3.82
	(-2.05, 2.62)	(-1.69, 3.04)	(-4.79, 0.20)	(-10.34, 2.69)
CRP (measured)	−0.07	−0.10	0.14	0.36*
	(-0.20, 0.07)	(-0.24, 0.04)	(-0.02, 0.31)	(0.03, 0.68)

Outcomes listed as the rows.
All models adjusted for gender, birth year, percent urban, percent foreign born, percent Black, average manufacturing jobs per capita, and average inflation-adjusted manufacturing wages.
Model 1 is the overall relationship between state-level education quality and each outcome.
Model 2 includes a state-level education quality by race interaction term.
* indicate 95% confidence intervals that do not include the null.

Table 3
Associations between state-level educational quality as operationalized by student to teacher ratio and CVD outcomes overall, and with interactions by race / ethnicity

Dichotomous Outcomes (null = 1)	Model 1: Overall	Model 2: interaction		
		Reference group (Whites)	Differential effect for Blacks	Differential effect for Latinos
Obese (self-reported)	0.98	1.00	0.93**	0.89*
	(0.93, 1.03)	(0.95, 1.06)	(0.88, 0.98)	(0.80, 0.99)
Heart disease (self-reported)	1.01	1.00	1.06	0.91
	(0.97, 1.05)	(0.96, 1.04)	(0.99, 1.13)	(0.77, 1.07)
Stroke (self-reported)	1.06	1.01	1.20**	1.11
	(0.99, 1.13)	(0.94, 1.09)	(1.09, 1.31)	(0.84, 1.47)
Ever smoking (self-reported)	1.00	0.99	1.04**	1.04
	(0.97, 1.02)	(0.97, 1.01)	(1.01, 1.07)	(0.96, 1.11)
High blood pressure (self-reported)	0.98	0.97	1.03*	1.11
	(0.95, 1.01)	(0.94, 1.00)	(1.01, 1.05)	(0.98, 1.25)
Uncontrolled high blood pressure (measured)	1.03	1.03	1.03	1.05
	(0.96, 1.11)	(0.95, 1.11)	(0.94, 1.12)	(0.80, 1.39)
Diabetes (self-reported)	0.99	0.97	1.06	1.11
	(0.92, 1.06)	(0.90, 1.05)	(0.98, 1.14)	(0.98, 1.27)
Uncontrolled diabetes (measured)	1.06	1.02	1.16	1.15
	(0.93, 1.21)	(0.88, 1.17)	(0.93, 1.44)	(0.88, 1.52)
Continuous Outcomes (null = 0)				
HDL cholesterol (measured)	0.08	0.41	−2.19*	−0.61
	(-0.78, 0.93)	(-0.47, 1.29)	(-3.38, −0.99)	(-2.87, 1.65)
Total cholesterol (measured)	−0.16	0.35	−3.21*	−4.05
	(-2.33, 2.01)	(-1.90, 2.59)	(-6.19, −0.24)	(-9.90, 1.81)
CRP (measured)	−0.04	−0.07	0.16	0.21
	(-0.17, 0.08)	(-0.20, 0.05)	(-0.05, 0.36)	(-0.12, 0.54)

Outcomes listed as the rows.
All models adjusted for gender, birth year, percent urban, percent foreign born, percent Black, average manufacturing jobs per capita, and average inflation-adjusted manufacturing wages.
Model 1 is the overall relationship between state-level education quality and each outcome.
Model 2 includes a state-level education quality by race interaction term.
* indicate 95% confidence intervals that do not include the null.

Table 4
Associations between state-level educational quality as operationalized by term length and CVD outcomes overall, and with interactions by race / ethnicity

Dichotomous Outcomes (null = 1)	Model 1: Overall	Model 2: interaction		
		Reference group (Whites)	Differential effect for Blacks	Differential effect for Latinos
Obese (self-reported)	0.94*	0.98	0.92**	0.81**
	(0.88, 0.99)	(0.91, 1.06)	(0.88, 0.97)	(0.73, 0.89)
Heart disease (self-reported)	1.01	1.00	1.06*	0.99
	(0.98, 1.05)	(0.96, 1.04)	(1.01, 1.10)	(0.93, 1.06)
Stroke (self-reported)	1.05	1.01	1.16**	1.19**
	(0.98, 1.12)	(0.95, 1.07)	(1.08, 1.25)	(1.06, 1.33)
Ever smoking (self-reported)	1.01	1.00	1.03**	1.01
	(0.98, 1.04)	(0.97, 1.03)	(1.01, 1.05)	(0.97, 1.05)
High blood pressure (self-reported)	0.99	0.98	1.03*	1.12**
	(0.97, 1.02)	(0.95, 1.01)	(1.00, 1.06)	(1.07, 1.18)
Uncontrolled high blood pressure (measured)	1.01	1.01	1.00	0.99
	(0.95, 1.08)	(0.94, 1.09)	(0.94, 1.07)	(0.85, 1.15)
Diabetes (self-reported)	0.99	0.99	1.04	1.00
	(0.91, 1.08)	(0.89, 1.09)	(0.97, 1.11)	(0.91, 1.09)
Uncontrolled diabetes (measured)	1.14*	1.11*	1.13	0.83
	(1.03, 1.27)	(1.00, 1.22)	(0.94, 1.37)	(0.65, 1.06)
Continuous Outcomes (null = 0)				
HDL cholesterol (measured)	0.11	0.53	−1.79*	−0.12
	(-0.81, 1.03)	(-0.42, 1.48)	(-2.77, −0.81)	(-2.75, 2.51)
Total cholesterol (measured)	−0.36	0.29	−2.46	−2.86
	(-2.80, 2.09)	(-2.23, 2.82)	(-4.95, 0.03)	(-11.14, 5.43)
CRP (measured)	−0.11	−0.14	0.13	0.23
	(-0.25, 0.04)	(-0.29, 0.00)	(-0.04, 0.30)	(-0.14, 0.60)

Outcomes listed as the rows.
All models adjusted for gender, birth year, percent urban, percent foreign born, percent Black, average manufacturing jobs per capita, and average inflation-adjusted manufacturing wages.
Model 1 is the overall relationship between state-level education quality and each outcome.
Model 2 includes a state-level education quality by race interaction term.
* indicate 95% confidence intervals that do not include the null.

Table 5
Associations between state-level educational quality as operationalized by per-pupil expenditure and CVD outcomes overall, and with interactions by race / ethnicity

Dichotomous Outcomes (null = 1)	Model 1: Overall	Model 2: interaction		
		Reference group (Whites)	Differential effect for Blacks	Differential effect for Latinos
Obese (self-reported)	0.98	0.99	0.92*	0.90
	(0.89, 1.08)	(0.90, 1.09)	(0.86, 0.99)	(0.81, 1.00)
Heart disease (self-reported)	1.03	1.03	1.11**	1.06
	(0.96, 1.11)	(0.96, 1.10)	(1.04, 1.19)	(0.96, 1.16)
Stroke (self-reported)	1.07	1.07	1.06	1.07
	(0.96, 1.20)	(0.96, 1.19)	(0.94, 1.18)	(0.90, 1.27)
Ever smoking (self-reported)	1.02	1.01	1.02	1.05
	(0.96, 1.07)	(0.96, 1.07)	(0.99, 1.06)	(0.99, 1.11)
High blood pressure (self-reported)	0.95*	0.94*	1.01	1.09*
	(0.91, 0.99)	(0.90, 0.99)	(0.96, 1.07)	(1.00, 1.19)
Uncontrolled high blood pressure (measured)	1.05	1.04	0.98	1.12
	(0.96, 1.14)	(0.96, 1.13)	(0.88, 1.09)	(0.95, 1.31)
Diabetes (self-reported)	1.02	1.02	1.04	0.97
	(0.93, 1.12)	(0.93, 1.11)	(0.91, 1.20)	(0.86, 1.10)
Uncontrolled diabetes (measured)	1.28*	1.30*	1.09	0.78
	(1.01, 1.63)	(1.04, 1.63)	(0.92, 1.30)	(0.56, 1.09)
Continuous Outcomes (null = 0)				
HDL cholesterol (measured)	−0.69	−0.57	−0.65	−1.43
	(-2.21, 0.83)	(-2.09, 0.95)	(-2.06, 0.77)	(-3.49, 0.62)
Total cholesterol (measured)	−1.59	−1.36	0.60	−4.25
	(-5.69, 2.52)	(-5.48, 2.77)	(-3.13, 4.32)	(-9.07, 0.56)
CRP (measured)	−0.01	−0.04	0.08	0.36*
	(-0.24, 0.23)	(-0.27, 0.20)	(-0.13, 0.29)	(0.07, 0.66)

Outcomes listed as the rows.
All models adjusted for gender, birth year, percent urban, percent foreign born, percent Black, average manufacturing jobs per capita, and average inflation-adjusted manufacturing wages.
Model 1 is the overall relationship between state-level education quality and each outcome.
Model 2 includes a state-level education quality by race interaction term.
* indicate 95% confidence intervals that do not include the null.

Table 6
Associations between state-level educational quality (composite measure) and self-reported CVD outcomes overall, and with interactions by race / ethnicity in the sample that had measured outcome data (N = 10,704)

Dichotomous Outcomes (null = 1)	Model 1: Overall	Model 2: interaction		
		Reference group (Whites)	Differential effect for Blacks	Differential effect for Latinos
Obese (self-reported)	0.88**	0.90*	0.92	0.81*
	(0.81, 0.96)	(0.82, 0.99)	(0.84, 1.02)	(0.67, 0.97)
Heart disease (self-reported)	0.95	0.93	1.07	1.24
	(0.88, 1.02)	(0.86, 1.00)	(0.98, 1.16)	(0.91, 1.68)
Stroke (self-reported)	1.05	1.03	1.08	1.04
	(0.87, 1.26)	(0.85, 1.25)	(0.93, 1.26)	(0.78, 1.38)
Ever smoking (self-reported)	1.02	1.01	1.09**	0.99
	(0.97, 1.08)	(0.95, 1.08)	(1.03, 1.17)	(0.86, 1.15)
High blood pressure (self-reported)	0.92*	0.92*	1.01	1.14
	(0.85, 1.00)	(0.85, 0.99)	(0.96, 1.06)	(0.99, 1.30)
Uncontrolled high blood pressure (measured)	1.02	1.01	1.03	1.09
	(0.94, 1.10)	(0.93, 1.09)	(0.95, 1.11)	(0.94, 1.26)
Uncontrolled diabetes (measured)	1.04	1.03	1.13	0.85
	(0.91, 1.20)	(0.90, 1.18)	(0.92, 1.38)	(0.63, 1.16)
Diabetes (self-reported)	0.99	1.00	1.05	0.78*
	(0.86, 1.15)	(0.86, 1.17)	(0.91, 1.21)	(0.63, 0.96)

Outcomes listed as the rows.
All models adjusted for gender, birth year, percent urban, percent foreign born, percent Black, average manufacturing jobs per capita, and average inflation-adjusted manufacturing wages.
Model 1 is the overall relationship between state-level education quality and each outcome.
Model 2 includes a state-level education quality by race interaction term.
*indicate 95% confidence intervals that do not include the null.

Table 7
Associations between state-level educational quality and CVD outcomes overall, and with interactions by race / ethnicity after adjustment for childhood SES

Dichotomous Outcomes (null = 1)	Model 1: Overall	Model 2: interaction		
		Reference group (Whites)	Differential effect for Blacks	Differential effect for Latinos
Obese (self-reported)	0.92**	0.95	0.93**	0.81**
	(0.86, 0.98)	(0.89, 1.02)	(0.89, 0.97)	(0.74, 0.89)
Heart disease (self-reported)	1.00	0.99	1.07**	0.99
	(0.96, 1.04)	(0.94, 1.03)	(1.02, 1.12)	(0.88, 1.10)
Stroke (self-reported)	1.04	1.00	1.18**	1.14
	(0.97, 1.12)	(0.93, 1.07)	(1.09, 1.28)	(0.98, 1.32)
Ever smoking (self-reported)	1.02	1.01	1.03**	1.03
	(0.99, 1.05)	(0.99, 1.04)	(1.01, 1.04)	(0.97, 1.09)
High blood pressure (self-reported)	0.95*	0.94*	1.03*	1.13**
	(0.92, 1.00)	(0.90, 0.99)	(1.00, 1.06)	(1.06, 1.20)
Uncontrolled high blood pressure (measured)	1.02	1.01	1.03	1.09
	(0.94, 1.10)	(0.93, 1.09)	(0.96, 1.11)	(0.94, 1.26)
Diabetes (self-reported)	0.95	0.94	1.04	1.00
	(0.87, 1.04)	(0.86, 1.03)	(0.97, 1.12)	(0.90, 1.12)
Uncontrolled diabetes (measured)	1.04	1.03	1.13	0.85
	(0.90, 1.20)	(0.89, 1.18)	(0.92, 1.40)	(0.62, 1.17)
Continuous Outcomes (null = 0)				
HDL cholesterol (measured)	0.18	0.47	−1.83**	−0.91
	(-0.72, 1.08)	(-0.44, 1.38)	(-2.81, −0.85)	(-3.37, 1.54)
Total cholesterol (measured)	0.29	0.69	−2.35+	−3.83
	(-2.04, 2.62)	(-1.67, 3.06)	(-4.84, 0.14)	(-10.35, 2.69)
CRP (measured)	−0.07	−0.10	0.15+	0.36*
	(-0.20, 0.07)	(-0.24, 0.04)	(-0.01, 0.31)	(0.03, 0.69)

Outcomes listed as the rows.
All models adjusted for gender, birth year, percent urban, percent foreign born, percent Black, average manufacturing jobs per capita, and average inflation-adjusted manufacturing wages.
Model 1 is the overall relationship between state-level education quality and each outcome.
Model 2 includes a state-level education quality by race interaction term.
*indicate 95% confidence intervals that do not include the null.

Table 8a
Associations between state-level educational quality CVD outcomes overall, and with interactions by race / ethnicity among those with less than a high school education

Dichotomous Outcomes (null = 1)	Model 1: Overall	Model 2: interaction		
		Reference group (Whites)	Differential effect for Blacks	Differential effect for Latinos
Obese (self-reported)	0.89*	0.94	0.94	0.81**
	(0.80, 0.99)	(0.84, 1.04)	(0.87, 1.03)	(0.71, 0.92)
Heart disease (self-reported)	0.97	0.95	1.09*	1.01
	(0.89, 1.05)	(0.87, 1.03)	(1.01, 1.17)	(0.90, 1.14)
Stroke (self-reported)	1.01	0.94	1.21**	1.20+
	(0.88, 1.17)	(0.82, 1.07)	(1.09, 1.34)	(0.98, 1.48)
Ever smoking (self-reported)	1.03	1.03	0.99	0.99
	(0.97, 1.08)	(0.97, 1.09)	(0.96, 1.03)	(0.89, 1.09)
High blood pressure (self-reported)	0.92*	0.89**	1.05*	1.21**
	(0.86, 0.98)	(0.83, 0.96)	(1.01, 1.10)	(1.12, 1.30)
Uncontrolled high blood pressure (measured)	1.13	1.14	0.99	0.99
	(0.93, 1.37)	(0.95, 1.36)	(0.85, 1.16)	(0.81, 1.21)
Diabetes (self-reported)	0.90	0.88+	1.00	1.15**
	(0.79, 1.03)	(0.77, 1.02)	(0.92, 1.10)	(1.04, 1.27)
Uncontrolled diabetes (measured)	0.89	0.93	1.04	0.66+
	(0.69, 1.15)	(0.69, 1.24)	(0.71, 1.55)	(0.43, 1.00)
Continuous Outcomes (null = 0)				
HDL cholesterol (measured)	1.05	1.14	−1.02	1.66
	(-0.85, 2.95)	(-0.83, 3.10)	(-2.67, 0.64)	(-1.50, 4.82)
Total cholesterol (measured)	0.12	0.02	−2.22	3.43
	(-5.37, 5.60)	(-5.75, 5.79)	(-6.81, 2.37)	(-5.98, 12.84)
CRP (measured)	−0.19	−0.19	−0.02	0.08
	(-0.52, 0.13)	(-0.53, 0.14)	(-0.32, 0.28)	(-0.38, 0.54)

Outcomes listed as the rows.
All models adjusted for gender, birth year, percent urban, percent foreign born, percent Black, average manufacturing jobs per capita, and average inflation-adjusted manufacturing wages.
Model 1 is the overall relationship between state-level education quality and each outcome.
Model 2 includes a state-level education quality by race interaction term.
* indicate 95% confidence intervals that do not include the null.

Table 8b
Associations between state-level educational quality CVD outcomes overall, and with interactions by race / ethnicity among those with a high school education or more

Dichotomous Outcomes (null = 1)	Model 1: Overall	Model 2: interaction		
		Reference group (Whites)	Differential effect for Blacks	Differential effect for Latinos
Obese (self-reported)	0.92**	0.94+	0.91**	1.03
	(0.87, 0.98)	(0.88, 1.00)	(0.85, 0.97)	(0.82, 1.29)
Heart disease (self-reported)	1.05+	1.04	1.04	0.97
	(1.00, 1.10)	(0.99, 1.09)	(0.96, 1.13)	(0.74, 1.26)
Stroke (self-reported)	1.13**	1.12*	1.09	1.03
	(1.03, 1.24)	(1.02, 1.22)	(0.97, 1.22)	(0.77, 1.37)
Ever smoking (self-reported)	1.02	1.01	1.04*	1.11+
	(0.99, 1.06)	(0.98, 1.05)	(1.00, 1.08)	(0.99, 1.23)
High blood pressure (self-reported)	0.99	0.99	1.03	1.02
	(0.94, 1.05)	(0.94, 1.04)	(0.99, 1.07)	(0.89, 1.17)
Uncontrolled high blood pressure (measured)	0.98	0.98	1.02	1.05
	(0.91, 1.06)	(0.91, 1.05)	(0.95, 1.09)	(0.86, 1.28)
Diabetes (self-reported)	0.99	0.99	1.05	0.86
	(0.89, 1.09)	(0.89, 1.10)	(0.96, 1.14)	(0.64, 1.14)
Uncontrolled diabetes (measured)	1.09	1.07	1.10	1.10
	(0.92, 1.28)	(0.91, 1.26)	(0.97, 1.24)	(0.67, 1.81)
Continuous Outcomes (null = 0)				
HDL cholesterol (measured)[1]	−0.10			
	(-1.12, 0.92)			
Total cholesterol (measured)	0.18	0.50	−0.45	−11.82*
	(-2.42, 2.78)	(-2.11, 3.11)	(-3.66, 2.76)	(-22.20, −1.43)
CRP (measured)	−0.02	−0.06	0.23*	0.67**
	(-0.17, 0.13)	(-0.21, 0.09)	(0.03, 0.44)	(0.17, 1.17)

1. The model with race interactions for HDL would not converge.
Outcomes listed as the rows.
All models adjusted for gender, birth year, percent urban, percent foreign born, percent Black, average manufacturing jobs per capita, and average inflation-adjusted manufacturing wages.
Model 1 is the overall relationship between state-level education quality and each outcome.
Model 2 includes a state-level education quality by race interaction term.
* indicate 95% confidence intervals that do not include the null.

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