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Quality and quantity: The association of state-level educational policies with later life cardiovascular disease

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Abstract

Education is a powerful predictor of cardiovascular morbidity and mortality. While the majority of the literature has focused on years of educational attainment or degree attainment, fewer studies examine the role of educational quality in the prevention of cardiovascular disease (CVD). We tested the hypothesis that average state-level educational quality was associated with CVD, linking state-level data on educational quality with individual demographic and health data from multiple waves of the National Health and Nutrition Examination Survey (N = 34,770). We examined thirteen CVD-related outcomes—including blood pressure, cholesterol, and heart attack—to understand the multiple pathways through which educational quality may influence CVD. The primary predictor was a composite index of educational quality, combining state-level measures of student-teacher ratios, per-pupil expenditures, and school term length. We fit multivariable models, regressing each outcome on the educational quality composite index and adjusting for individual- and state-level covariates. We also assessed whether the association between state educational quality and CVD differed for less educated individuals. Overall, higher educational quality was associated with less smoking (OR = 0.86, 95%CI: 0.77, 0.97), but there was no statistically significant association for the other 12 outcomes. Interaction tests indicated that less educated

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individuals benefited less from higher educational quality relative to those with more education for several outcomes. Our study suggests that state-level educational quality is not strongly associated with CVD, and that this null association overall may mask heterogeneous benefits that accrue disproportionately to those with higher levels of education.

INTRODUCTION

Educational attainment is a powerful predictor of cardiovascular morbidity and mortality across the lifespan and across international contexts (Galobardes et al., 2006; McFadden et al., 2008; Woodward et al., 2015). The hypothesized pathways linking education and cardiovascular disease (CVD) include increased employment and income leading to better healthcare access and nutrition, increased psychosocial resources leading to reduced stress, more advantageous social networks, and increased knowledge or altered social norms leading to improved health behaviors (Figure 1) (Feinstein, 1993; Ross and Wu, 1995).

Theory suggests that educational quality, quantity, and credentials are important and distinct features of educational experiences that may be decrease CVD risk (Glymour and Manly, 2018). Yet most of the literature has focused on educational quantity (i.e., years of educational attainment) and credentials, with a recent meta-analysis finding that policies to increase years of educational attainment led to improvements in obesity, smoking, and other CVD risk factors (Hamad et al., 2018). The literature on the health effects of educational quality, however, is sparse. A few small randomized trials of high-quality early childhood education programs have demonstrated its potential long-term positive impacts on CVD (Campbell et al., 2014; Heckman et al., 2010). For research on K-12 schooling, the few studies that exist use a range of constructs to capture quality, including resources invested in public education, test scores, and others. For example, a single study found that school term length was associated with reduced blood pressure among black women (Liu et al., 2015). Another found that improvements in several state-level measures of educational quality—term length, per-pupil expenditures, and student-teacher ratios—were associated with reduced dementia risk (Nguyen et al., 2016). Others have found that the association between school quality and cognitive function is stronger for those with lower levels of education (Crowe et al., 2013). Prior studies have found that improvements in these same measures of state-level educational quality led to improvements in earnings and employment (David Card and Alan Krueger, 1992; Card and Krueger, 2011), and one study found that increased spending at the school district level led to higher wages especially for low-income students (Jackson et al., 2016). These findings indicate that the relationship between educational quality and health is complex and requires further investigation, in particular due to its potential for addressing health disparities among individuals of lower socioeconomic status.

This study helps to fill this gap in the literature, using a large nationally representative dataset to determine if state-level educational quality is associated with CVD and related risk factors. We examined multiple outcomes to assess pathways through which educational quality may influence CVD. For instance, changes in diabetes and cholesterol may suggest changes in health behaviors such as nutrition and physical activity. Alternatively, changes in C-reactive protein (CRP) and telomere length may reflect altered inflammatory pathways or chronic stress (Gotlib et al., 2014; Grau et al., 1996; Hamad et al., 2016; Lindqvist et al., 2015; Pollitt et al., 2007; Nalini Ranjit et al., 2007; Rehkopf et al., 2016; Shrivastava et al., 2015; Zhan et al., 2017). We further examined whether there was an interaction between educational quality and quantity by estimating whether associations differ by different levels of educational attainment. Prior work suggests economic returns to education may be higher if schooling is completed in a setting with higher educational quality (David Card and Alan Krueger, 1992). These analyses inform theoretical work on the importance of different aspects of educational attainment, and provide evidence on specific forms of state-level educational investments to inform future interventional work.

METHODS Data Sets

The sample was constructed by pooling survey waves from National Health and Nutrition Examination Survey (NHANES): 1971–1974 (NHANES I), 1976–1980 (NHANES II), 1988–1994 (NHANES III), and biennial waves since 1999. For this study, we used NHANES waves through 2012, the most recently available data at study inception. NHANES is a serial cross-sectional study; i.e., different individuals are interviewed in each wave. We restricted the sample to U.S.-born adults age 18 and over for whom there were data on state-of-birth and the health outcomes of interest. We also restricted the sample to white and black individuals due to inconsistencies in the categorization of other racial groups across waves of NHANES. State-level characteristics were compiled using state and federal reports for 1900–1950 (U.S. Department of Commerce, 1878–2012). Note that Alaska and Hawaii did not become states until 1959 and were therefore not included.

The final sample size was 34,770, although sample sizes were smaller for outcomes that were not obtained for all participants in all waves (Table 1).

Educational Quality

The primary predictor was a composite index that combined three separate measures of educational quality in each participant's state of birth when the participant was 6 years old: student-teacher ratios, inflation-adjusted per-pupil expenditures, and school term length. Similar measures to capture state investments in education have been used in prior work examining the effects of educational quality on economic and health outcomes (Brenowitz et al., Under review; David Card and Alan Krueger, 1992; Card and Krueger, 2011; Nguyen et al., 2016). As in prior work, measures were interpolated for the years between reports. Each measure was then standardized to a mean of zero and standard deviation of one. We reverse-coded student-teacher ratio so that higher levels indicated "better" quality, consistent with the other measures. Of note, some prior studies measured school quality using components such as test scores or teacher salaries (Long, 2008; Rivkin, 2000; Staiger et al., 2006), although such variables were not available at the state level throughout our study period.

We then averaged the three individual quality measures to create the composite index; if one of the three measures was missing in a given year in a given state, the index was created by averaging the remaining non-missing measures. We chose to create a composite index because these three measures of quality are likely to be associated with one another in terms of state educational policymaking. Ideally, this index would also include other aspects of state-level educational quality to fully capture the state education policymaking environment, although these are the only three that are currently available for all states during the study period and thus are also the most commonly used in prior work (David Card and Alan Krueger, 1992; Crowe et al., 2013; Glymour et al., 2008; Vable et al., 2019; Jackson et al., 2016; Liu et al., 2015). Temporal and state variation in this composite index is illustrated in Supplemental Figure 1.

We examined educational quality at the state level for several reasons. Measures of quality at the school district level are not available nationwide during the years of our study period, and information on school district is not available for NHANES respondents. While this approach introduces measurement error due to the heterogeneity of educational quality within states, policy during this time period was often set by state governments (Hanushek, 1989). Prior work has used state-level measures of educational quality and other educational policies and demonstrated significant associations with health and economic outcomes (David Card and Alan Krueger, 1992; Glymour et al., 2008; Hamad et al., 2019; Liu et al., 2015).

Outcomes

We examined outcomes that have been previously correlated with educational attainment, including objective outcomes such as blood pressure and serum measures of CVD risk such as cholesterol and telomere length (Brouilette et al., 2007; Hamad et al., 2016), as well as self-reported CVD outcomes and risk factors such as smoking (Table 1). We included multiple outcomes to better understand the different mechanistic pathways through which education may influence CVD (Figure 1).

Covariates

Analyses included individual- and state-level covariates: birth year, race (to capture family history of migration that might influence the exposure), indicator variables (i.e., "fixed effects") for state-of-birth; and state-level characteristics that have been theorized to be potential confounders in prior studies of educational policies (percentage black, urban, and foreign-born; manufacturing jobs per capita; and inflation-adjusted manufacturing wages per manufacturing job). State-level variables were compiled from Statistical Abstracts of the United States and linearly interpolated for years between reports (Glymour et al., 2008; U.S. Department of Commerce, 1878–2012). There may be other unmeasured state-level characteristics—e.g., contemporaneous shifts in other unobserved policies—that confound the relationship between educational quality and CVD.

Data Analysis

We first tabulated sample characteristics. We then carried out multivariable regressions, regressing each outcome on the composite index of educational quality while adjusting for the individual- and state-level covariates described above. We used linear regressions for continuous outcomes, and logistic regressions for binary outcomes. Robust standard errors were clustered at the state level to account for correlated observations (see Supplement).

We further examined whether there was an interaction between educational quality and level of educational attainment. To do so, we stratified the primary analyses by educational attainment (high school or less versus more than high school), thereby deriving separate effect estimates for people with higher and lower educational attainment. To test whether estimates from these stratified models were statistically significantly different from one another, we carried out regressions that included an interaction term between individual-level educational attainment and the educational quality index, in addition to the main effects for each of these variables. These analyses adjusted for the individual- and state-level covariates described above, with robust standard errors clustered at the state level.

Finally, because educational quality likely affected white and black students differently during this time period because of school segregation, we conducted our primary analysis stratified by race (black versus white). We also included an interaction term between race and educational quality to determine whether any differences by race were statistically significantly different. Similarly, we conducted subgroup analyses by gender.

Additional sensitivity analyses were carried out as described in the Supplement and Supplemental Tables 3–5.

Ethics Approval

Ethics approval for this study was provided by the University of California San Francisco Institutional Review Board (protocol # 17–21575).

RESULTS

Sample Characteristics

The average birth year of participants was 1928 (Table 1). Roughly 80% of participants were white. Slightly more than half were female. About 30% had more than a high school education. The average age at interview was 58. Note that *higher* levels of HDL and telomere length and *lower* levels of the other biomarkers are thought to be beneficial.

Association between State-Level Educational Quality and CVD

In the overall sample (Table 2), higher state-level educational quality was associated with reduced odds of smoking (OR 0.86 per standard deviation of the educational quality index, 95% CI: 0.77, 0.97). We were unable to reject the null that educational quality was not associated with the other outcomes.

Interaction between Educational Quality and Quantity

When next examined heterogeneity by educational attainment in the association between educational quality and CVD (Table 3). The educational quality index was associated with higher (i.e., better) HDL cholesterol among those with more than high school education, but lower HDL cholesterol among those with high school education or less, and this difference was statistically significant although neither effect was significantly different from the null in stratified models. Educational quality was associated with lower (i.e., better) triglycerides among those with more than high school, but slightly higher triglycerides among those with high school or less, and these effect estimates were significantly different from each other. Higher educational quality was associated with lower odds of current smoking among those with more than high school education, an effect estimate that was significantly different from the null and from the estimate among people with high school or less education. Meanwhile, those with a high school education or less were more likely to demonstrate longer telomere length.

Subgroup Analyses

We next examined whether each of the associations above differed by race, which yielded mixed findings (Supplemental Table 1). Higher educational quality was associated with improved HDL and triglycerides as well as reduced smoking among white students. These associations were statistically significantly different than those for black students, who did not benefit to the same extent. Higher educational quality was associated with higher CRP among white students, which was statistically significantly different than the associations among black students, who were more likely to have lower CRP.

Finally, we conducted subgroup analyses by gender (Supplemental Table 2). For systolic and diastolic blood pressure, total cholesterol, triglycerides, and self-reported diabetes, men demonstrated a greater improvement in response to improved educational quality, relative to women. For HDL cholesterol, CRP, and self-reported hypertension, women demonstrated greater improvements in response to improved educational quality, relative to men. For the remaining outcomes, differences between men and women were not statistically significantly different.

DISCUSSION

This study is among the first to provide evidence on the relationship between educational quality and health, specifically examining the association of a composite measure of state-level educational quality with CVD. While improved educational quality was associated with reduced smoking in the sample overall, for the remaining 12 outcomes we were unable to rule out the null hypothesis of no association. When examining the interaction between educational quality and quantity, we found a greater benefit among more educated individuals for HDL cholesterol, triglycerides, CRP, and smoking, and a greater benefit for less educated individuals for telomere length. These findings were robust to numerous sensitivity tests, and analyses stratified by race and gender demonstrated mixed results.

Our finding that higher state-level educational quality was associated with reduced smoking is consistent with a long literature that finds that other aspects of education—and particularly years of educational attainment—are associated with less tobacco use (de Walque, 2007; Hamad et al., 2018; Ross and Mirowsky, 1999). There are several pathways through which improved educational quality may reduce smoking. First, it may be that some of the increase in per-pupil expenditures was spent on health education, although smoking was not acknowledged as a cause of health problems until the 1950s (Doll and Hill, 1950). In any case, state-level data on health education funding is not available for our study period. Future studies can examine this possibility using more recent cohorts. Second, since prior work has documented that better educational quality has positive effects on educational attainment, earnings, and employment (David Card and Alan Krueger, 1992; Card and Krueger, 2011; Muennig et al., 2011), it may be that those exposed to higher educational quality are more able to afford healthcare and receive smoking cessation counseling. Alternatively, increased income may reduce stress and financial strain, which have been associated with smoking in prior work (Golden and Perreira, 2015; Shaw et al., 2011). Because NHANES did not include a consistent measure of psychological stress in all survey waves, we are unable to determine the role of this pathway in explaining the reduction in smoking. In the overall sample, results were not statistically significant for CRP and telomere length—two biomarkers that have been previously associated with education and psychosocial adversity (Geronimus et al., 2015; Gotlib et al., 2014; Gouin et al., 2012; Hanssen et al., 2017; Juster et al., 2010; Lindqvist et al., 2015; Panagiotakos et al., 2004; N. Ranjit et al., 2007)—or for the other CVD-related outcomes, although this may be due to the smaller sample size for these outcomes. Alternately, it may be that the effects of educational quality during childhood weaken over the lifespan, such that they may no longer be detectable later in life. It is also possible that state-level measures of educational quality provide too coarse of an exposure relative to more local measures at the school district or county level, although one prior study found that the economic benefits of educational quality are similar when the exposure is measured at school district and state levels (Card and Krueger, 2011). Finally, it may be that state-level measures are positively or negatively correlated with other policies that may affect CVD—e.g., public health policies—such that our results are confounded by other state characteristics.

Previous studies disagree regarding whether educational quality affects years of educational attainment (Coleman et al., 1966; Dearden et al., 2002; Deming et al., 2014); the two were associated in our sample, suggesting that educational attainment may be a mediator of the relationship between educational quality and CVD. Because 12 of the 13 outcomes examined did not demonstrate a meaningful association with educational quality, however, we were unable to conduct mediation analysis to test this possible mechanism, or others illustrated in Figure 1.

While few studies have examined the association between educational quality and CVD, a handful of studies have examined other health and social outcomes and demonstrate mixed findings. Several studies have found educational quality to be associated with dementia and late-life cognitive outcomes (Crowe et al., 2013; Nguyen et al., 2016). It may be that improved educational quality increases cognitive function and reserve, which reduce the risk of dementia (Stern, 2012), while it plays less of a role on the mechanisms proposed for CVD (Figure 1). One prior randomized trial found that lower student-to-teacher ratios (typically associated with better educational quality) may paradoxically increase mortality through age 29 (Muennig et al., 2011), although this study was based on a small number of deaths and has subsequently been critiqued on methodological grounds (Chetty et al., 2011; Garcy and Berliner, 2018; Sohn, 2016).

Our findings that suggest heterogeneous benefits of school quality among those with different levels of educational attainment are an important contribution to the existing literature. One prior study found greater effects of educational quality on cognitive outcomes for individuals with a high school education or less (Crowe et al., 2013). Relatedly, studies of school district per-pupil expenditures also found improvements in educational attainment, wages, and poverty that were greater for black and low-income students (Jackson et al., 2016; Johnson, 2011). This previous study examined more recent cohorts, and prior work has suggested that the relationship between educational attainment and health may have changed across historical contexts (Everett et al., 2013; Karlsson et al., 2018). This may explain the inconsistent findings relative to our study, in which we found that individuals with low educational attainment may have benefited less from improved educational quality for several outcomes. Alternatively, the conflicting findings may be due to the fact that our educational quality measures were captured at the state level and may not reflect the experiences of individual students, as there is substantial heterogeneity within states. Future studies can attempt to collect measures at the school district level, although very few cohorts of older people would permit linkage to school district of residence in childhood, and historical data on school district level quality measures is incomplete. In recent years, 10% of students do not graduate from high school, such that the interaction of educational quality and quantity remains an important question (National Center for Education Statistics, 2018).

Our study also demonstrated heterogeneous effects by race, although there was no consistent benefit for students of either race. The finding that white students exposed to higher state-level educational quality were more likely to have reduced smoking relative to black students is consistent with findings of another study that examined racial heterogeneity in the association of state-level educational quality with CVD in a sample of older adults (Vable et al., 2019). Here we also demonstrated differential benefits among white students for triglycerides and HDL, but improved CRP among black students; the prior study did not examine the same range of objective measures that was included here. Prior research suggests that black students had improved economic outcomes relative to white students in response to improvements in school quality (David Card and Alan B Krueger, 1992), although it is also possible that improvements in educational quality disproportionately accrued to white schools during this highly segregated period, particularly in the South. Future work should replicate these analyses using post-desegregation cohorts. Unfortunately, NHANES did not query participants on the specific school districts attended. Alternately, it may also be that black students who were exposed to higher educational quality and subsequently increased employment were subject to discrimination due to changes in their social networks. Prior work has found that black students with higher educational attainment are more likely to report increased discrimination relative to those with lower educational attainment (Krieger et al., 2011). Another possible explanation is that black students with higher educational attainment who persevere in the face of adversity may suffer increased psychological distress—and subsequent worsened health—consistent with the John Henryism hypothesis (James, 1994).

Our study also investigated heterogeneous effects by gender. Most of these demonstrated greater improvements for men than women. This may be because men were more likely to benefit from improvements in educational quality during this study period due to their greater opportunities for employment after the completion of schooling (Schofer and Meyer, 2005; Schultz, 1993), with consequently increased income and healthcare access. For HDL and CRP, women experienced greater improvements in response to improved educational quality. It may be that the improvements in HDL and CRP operate through different pathways than the other outcomes. For example, blood pressure and total cholesterol may benefit from increased healthcare access, while HDL and CRP may be more responsive to health behaviors such as exercise (Kasapis and Thompson, 2005; Kokkinos and Fernhall, 1999). Notably, findings for objectively measured blood pressure were contrary to those for self-reported hypertension; this may be because self-reported measures suffer from reporting bias, e.g., due to diagnostic access.

Our study has several limitations. First, analyses were conducted using older cohorts, since state-level educational quality data were available for 1900–1950. Future work can extend these analyses to more recent years, in particular after school desegregation since the 1950s, although these analyses will always require analyzing historical data given the length of follow-up required for these outcomes. Relatedly, our restricted data agreement with NHANES required us to use masked state identifiers; this precluded us from studying the differential effects of educational quality in the Northern versus Southern U.S., where segregation may have played an important role. Future studies should be conducted using data sets with fewer restrictions. Additionally, our exposure captured educational quality in public schools. During this time period, roughly 90% of students attended public schools, so the 10% of students in private schools were misclassified (National Center for Education Statistics, 1993). We are unable to identify these in our sample. Also, the use of cross-sectional NHANES data may be biased by differential follow-up time, since those with longer follow-up are more likely to develop the outcomes of interest. That is, if improved educational quality increases longevity, it would increase chance of developing the outcomes because there would be more time at risk. Unfortunately NHANES does not provide diagnosis dates, which precludes a time-to-event analysis. Additionally, our study involved correlational analyses which do not necessarily reflect causal effects. While we have attempted to reduce confounding by controlling for a range of state characteristics, residual confounding may nevertheless result in biased estimates if other unmeasured state characteristics influence both educational quality as well as CVD. Our use of state fixed effects models accounts for unobserved time-invariant characteristics of states, thereby exploiting within-state longitudinal variation in educational quality. Plausible state-level confounders would need to be time-varying state level characteristics that changed in tandem with educational quality. A major advantage of this approach is that we avoid confounding by many individual-level confounders that cannot plausibly affect state educational investments, e.g., gender, although future studies should attempt to conduct this analysis in data sets with richer information on students' socioeconomic status in childhood. Although selective migration of more advantaged families to communities with higher quality schools could be a source of bias, prior work has found that 90% of individuals during this time period remained in the state of their birth throughout their years of schooling (David Card and Alan Krueger, 1992). Finally, the analyses examining educational attainment as a modifier of the relationship between educational quality and CVD should be interpreted with caution, as they may represent conditioning on a collider, i.e., endogenous selection bias, which could bias estimates in either direction (Elwert and Winship, 2014).

CONCLUSION

To conclude, this study provides some of the first evidence on the association between educational quality and CVD, demonstrating that higher state-level educational quality may improve some CVD outcomes, but that benefits accrued disproportionately to more educated individuals. In other words, greater educational quality is only likely to improve health if students actually stay in school long enough to benefit, otherwise disparities may actually increase. Given the difficulties in conducting randomized trials of educational interventions at the population level with sufficient follow-up, observational work is important in informing the literature in this field. Future studies could examine the effects of coordinated interventions to improve the quality of education while ensuring that disadvantaged students are able to stay in school.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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ABBREVIATIONS:

CVD	cardiovascular disease
CRP	C-reactive protein
HDL	high-density lipoprotein
NHANES	National Health and Nutrition Examination Survey

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HIGHLIGHTS

- We tested whether state-level educational quality was associated with heart disease.
- Higher quality predicted less smoking, but was not associated with other outcomes.
- Those with higher educational attainment benefited more from increased quality.
- Educational interventions may need to focus on improving both quality and quantity.

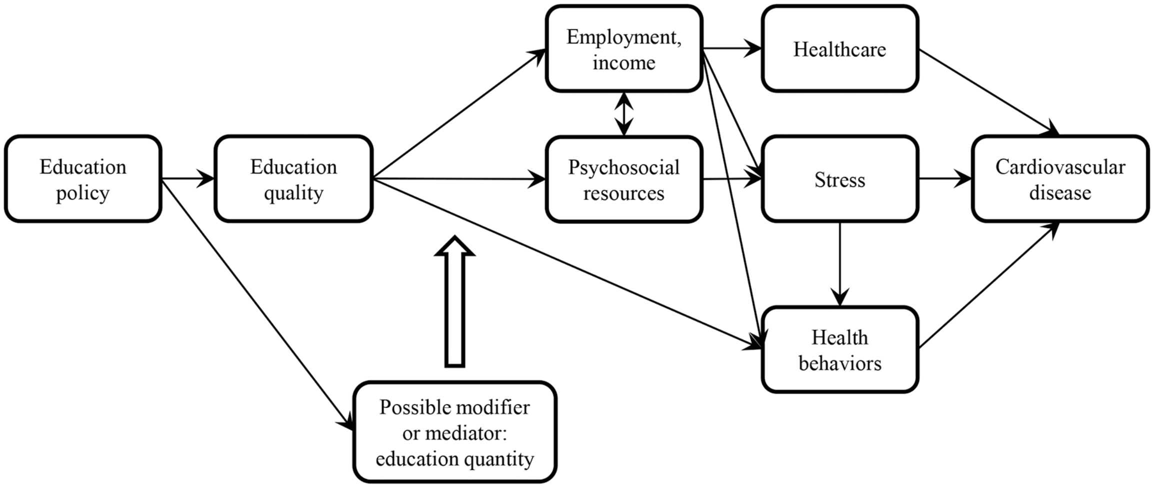

Figure 1.
Conceptual model linking education and cardiovascular disease

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Table 1.

Sample Characteristics

Panel A. Demographics	Mean ± SD or %	
Year of birth	1928 ± 14	
Race		
White	80.2	
Black	19.8	
Female	54.8	
Household size	2.7 ± 1.5	
Education		
Less than high school	38.0	
High school	31.3	
More than high school	30.7	
Age at interview	58.0 ± 16.4	
Panel B. Education Quality	**Mean ± SD or %**	
Student-teacher ratio	30.9 ± 5.5	
Per-pupil expenditures[a] (USD)	62.3 ± 36.3	
Term length (days)	170.8 ± 15.8	
Panel C. Health Outcomes	**Mean ± SD or %**	**Sample size**
Objective		
Systolic blood pressure (mmHg)	134.1 ± 22.8	32,440
Diastolic blood pressure (mmHg)	78.1 ± 14.8	32,429
Total cholesterol (mg/dL)	216.5 ± 46.8	32,277
High-density lipoprotein cholesterol (mg/dL)	52.3 ± 16.5	20,539
Triglycerides (mg/dL)	152.2 ± 119.0	13,530
Low-density lipoprotein cholesterol (mg/dL)	125.9 ± 38.4	6,119
C-reactive protein (mg/dL)	0.5 ± 1.0	13,863
Telomere length (base pairs)	5,523 ± 557	2,546
Diabetes[b]	12.8	16,766
Self-reported		
Heart attack	6.1	34,224
Hypertension	39.7	32,538
Diabetes	10.1	32,344
Current smoking	23.1	24,377

N = 34,770 overall, with smaller sample sizes for outcomes that were not collected in all waves or for all respondents. Study sample was drawn from repeated cross-sectional waves of the National Health and Nutrition Examination Survey (NHANES).

[a]Per-pupil expenditures were inflation-adjusted to 1982–1984 U.S. dollars.

[b]For serum testing of diabetes, earlier waves of NHANES used 2-hour glucose testing, while later waves used hemoglobin A1c. For consistency, we transformed these into a binary measure of whether they exceeded the cut-off for diabetes (i.e., glucose ≥ 200, hemoglobin A1c ≥ 6.5).

Table 2.

Association of educational quality composite index with cardiovascular outcomes (difference per standard deviation of index)

	Beta coefficient [95% CI]	Odds ratio [95% CI]
Objective Health Outcomes		
Systolic blood pressure	−0.79 [−1.80, 0.21]	
Diastolic blood pressure	−0.62 [−1.35, 0.10]	
Total cholesterol	−0.31 [−2.08, 1.46]	
HDL cholesterol	0.38 [−0.47, 1.24]	
Ln(Triglycerides)	−0.018 [−0.050, 0.015]	
LDL cholesterol	−0.12 [−4.46, 4.21]	
Ln(C-reactive protein)	0.0099 [−0.047, 0.067]	
Ln(Telomere length)	0.008 [−0.0082, 0.024]	
Diabetes[a]		0.98 [0.80, 1.10]
Self-reported Health Outcomes		
Heart attack		0.93 [0.79, 1.10]
Hypertension		1.01 [0.93, 1.10]
Diabetes		1.06 [0.93, 1.20]
Smokes now		0.86* [0.77, 0.97]

*p<0.05

N = 34,770 overall, with smaller sample sizes for outcomes that were not collected in all waves or for all respondents (see Table 1). Study sample was drawn from repeated cross-sectional waves of the National Health and Nutrition Examination Survey, 1971–2012. Analyses involved multivariable regressions, with robust standard errors clustered by state of birth. All models adjust for race, birth year, and state of birth, as well as state percent black, percent foreign-born, manufacturing jobs per capita, and inflation-adjusted manufacturing wages per manufacturing job.

[a]For serum testing of diabetes, earlier survey waves used 2-hour glucose testing, while later survey waves used hemoglobin A1c. For consistency, we transformed these laboratory measures into a binary measure of whether the level exceeded the cut-off for diabetes (i.e., glucose ≥ 200 or hemoglobin A1c ≥ 6.5).

Table 3.

Association of educational quality composite index with cardiovascular outcomes, by level of educational attainment (difference per standard deviation of index)

	High School Education or Less		More than High School Education		p-value on interaction term, testing difference by educational attainment[b]
	Beta coefficient [95% CI]	Odds ratio [95% CI]	Beta coefficient [95% CI]	Odds ratio [95% CI]	
Objective Health Outcomes					
Systolic blood pressure	−0.95 [−2.21, 0.30]		−0.057 [−1.48, 1.36]		0.23
Diastolic blood pressure	−0.12 [−0.96, 0.71]		−1.66 * [−2.63, −0.69]		0.58
Total cholesterol	−0.25 [−2.03, 1.53]		−0.68 [−4.18, 2.82]		0.68
HDL cholesterol	−0.14 [−1.36, 1.09]		1.37 [−0.50, 3.24]		0.001
Ln(Triglycerides)	0.0036 [−0.038, 0.046]		−0.059 [−0.13, 0.0092]		0.001
LDL cholesterol	−2.33 [−7.25, 2.59]		3.84 [−3.49, 11.2]		0.86
Ln(C-reactive protein)	0.045 [−0.040, 0.13]		−0.055 [−0.14, 0.028]		0.03
Ln(Telomere length)	0.0069 [−0.013, 0.027]		0.0050 [−0.017, 0.028]		0.006
Diabetes		0.98 [0.79, 1.21]		0.97 [0.68, 1.39]	0.01
Self-reported Health Outcomes					
Heart attack		0.86 [0.71, 1.04]		1.17 [0.83, 1.66]	0.15
Hypertension		0.99 [0.90, 1.08]		1.06 [0.91, 1.24]	0.03
Diabetes		1.06 [0.94, 1.19]		0.99 [0.74, 1.31]	0.28
Smokes now		0.95 [0.83, 1.09]		0.66 * [0.54, 0.80]	< 0.001

* $p<0.05$

N = 34,770 overall, with smaller sample sizes for outcomes that were not collected in all waves or for all respondents (see Table 1). Study sample was drawn from repeated cross-sectional waves of the National Health and Nutrition Examination Survey, 1971–2012. Analyses involved multivariable regressions, with robust standard errors clustered by state of birth. Continuous outcomes were modeled using linear regressions, and binary outcomes were modeled using logistic regressions. All models adjust for race, birth year, and state of birth, as well as state percent black, percent foreign-born, manufacturing jobs per capita, and inflation adjusted manufacturing wages per manufacturing job.

[a] For serum testing of diabetes, earlier survey waves used 2-hour glucose testing, while later survey waves used hemoglobin A1c. For consistency, we transformed these laboratory measures into a binary measure of whether the level exceeded the cut-off for diabetes (i.e., glucose ≥ 200 or hemoglobin A1c ≥ 6.5).

[b] To determine whether the difference by educational attainment was statistically significantly different, we carried out each of the primary analyses while including an interaction term between educational quality and educational attainment. This column illustrates the p-value on this interaction term.