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Education and Life's Simple 7: An evaluation of differential returns by sex, race, and childhood socioeconomic status

A thesis submitted in partial satisfaction of
the requirements for the degree of Master of Science in Public Health
(MSPH)

by

Shaina Marie Sta. Cruz

The Research Project of Shaina Marie Sta. Cruz is approved, and it is acceptable in quality.

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Abstract

Education and Life's Simple 7: An evaluation of differential returns by sex, race, and childhood socioeconomic status

A thesis submitted by Shaina Marie Sta. Cruz in partial satisfaction of the requirements for the degree of Master of Science in Public Health (MSPH) at University of California, Merced in 2021. Committee chair: Dr. Irene H. Yen

Few studies have examined whether the benefits of education for health differ across sociodemographic subgroups. We investigated whether educational attainment is associated with cardiovascular health, as measured by the Life's Simple 7 (LS7) score, and whether the association differs by demographic characteristics. Data were obtained from the REasons for Geographic and Racial Differences in Stroke study (*N*=8,759 participants; mean age=63.8).

We used linear regression analyses with interactions by sex, race, childhood socioeconomic status (SES), and geography. Socially vulnerable groups (i.e., men from low childhood SES backgrounds, White people from low childhood SES backgrounds, Black people from low childhood SES backgrounds) benefitted less from each additional year of education than socially advantaged groups in predicting LS7 scores. However, we did not find evidence that differential returns extended to every group. Findings suggest that the inequalities present in the education system may further exacerbate the gap between advantaged and disadvantaged.

Introduction

As the leading cause of death and disability, cardiovascular disease (CVD) is a major public health issue in the United States (U.S.) (Mozaffarian et al., 2015). CVD comprises conditions, such as heart disease, heart attack, stroke, and heart failure (American Heart Association, 2017). As part of its 2020 Strategic Goals plan, the American Heart Association (AHA) aims to reduce cardiovascular diseases (CVD) of the U.S. population by 20%, as well as reduce deaths from CVD and stroke by 20% (Lloyd-Jones et al., 2010). Additionally, the World Health Organization (WHO) estimates that by 2030, 23.6 million people will die from CVD (World Health Organization, 2011). Developed by the AHA, the Life's Simple 7 (LS7) composite measure was designed to improve the overall CVD health of all Americans by targeting seven modifiable CV risk factors related to cardiovascular disease risk (Folsom et al., 2015). Specifically, the metric consists of seven modifiable components, including three physiological factors (total cholesterol, blood pressure, and fasting glucose), and four health behavior-related factors (cigarette smoking, diet, physical health, and body mass index). Previous studies have demonstrated that better CVD health, as defined by higher LS7 score, was associated with a lower risk of incident atrial fibrillation (Garg et al., 2018), as well as lower risk for inpatient encounters and lower inpatient and outpatient healthcare expenditures (Aaron et al., 2017).

CV outcomes vary by sex, socioeconomic status (SES), and ethnicity/race, and are more prevalent in minority or disadvantaged groups (Ski, Shier, & Thompson, 2014). Firstly, there is a large body of research on the socioeconomic disparities in cardiovascular health (Singh, Siahpush, Azuine, & Williams, 2015; Centers for Disease Control and Prevention, 2005; Sharma, Malarcher, Giles, & Myers, 2004; Kaplan & Keil, 1993; Millar & Wifle, 1986). SES markers are suggested to increase risk (Gerber, Goldbourt, & Frory, 2008). Socioeconomically disadvantaged populations experience higher rates of cardiovascular disease burden and mortality (Mendis, Puska, & Norrving, 2011). Additionally, low SES groups are more exposed to cardiovascular risk factors, such as smoking, alcohol consumption, physical inactivity, and poor diet (Ramsay et al., 2009). Individuals with less than a high school education are more likely to experience a myocardial infarction compared to those with a college degree (Kelly & Weitzen 2010).

In addition to socioeconomic disparities, previous studies have demonstrated racial and sex disparities in cardiovascular health. Women with myocardial infarction are more likely to have asymptomatic cardiac arrest in comparison to men, and, compared to men, younger women are more likely to die in the hospital due to receiving delayed treatment (Canto et al., 2012). Ethnic and racial groups have higher rates of CVD and related risk factors (Kurian & Cardarelli 2007; King, Khan, & Quan, 2009). For example, there are higher rates of fatal incident coronary heart disease in Blacks than Whites (Safford et al., 2012). These disparities may be the result of social inequalities(Ski, Shier, & Thompson, 2014).

In order to improve CV health, it is important that we address social inequalities, including racial and socioeconomic disparities. One possible way of addressing these disparities is through education. Education attainment is a recognized social determinant of health (Adler & Rehkopf, 2008; Cohen & Syme, 2013; Yen & Moss, 1999). People who have more education have better mental and physical health than those with less education (Assari, Farokhnia, & Mistry, 2019; Kaplan, Howard, Safford, & Howard, 2015; Ross & Mirowsky, 2006). Most conventional analyses assume health returns to education are the same for men and women, or for Whites and Black people. Because public health strives toward achieving health equity, it is important to evaluate whether different groups experience more health benefits from education than others. Increasing evidence suggests there are often differences in health gains by sex or race/ethnicity (Bauldry, 2015; Cohen, Rehkopf, Deardoff, & Abrams, 2013; Conti, Heckman, & Urzua, 2010; Liu, Manly, Capistrant, & Glymour, 2015; Mirowsky & Ross, 2007; Ross & Mirowksy, 2010; Vable et al., 2018a; Zajacova & Hummer, 2009). Studies have also explored the influence of social determinants on CV health, such as SES (Schultz et al., 2018) and education (Fletcher, 2014; Fonseca & Zheng, 2011). Specifically, CVD has been shown to be strongly associated with education (Kubota et al., 2017; Mackenbach et al., 2014; Adler & Glymour, 2017; Vargas, Ingram, Gillum, 2000). There are several theories that attempt to explain the reasons behind these differences. Theories from the field of education have shaped research on differential returns are resource substitution theory and resource multiplication. Below we describe two of these theories and studies that corroborate them.

The resource substitution theory (Ross & Mirowsky, 2011; Ross, Masters, & Hummer, 2012) posits education improves health and well-being more for disadvantaged groups than advantaged groups. This is because disadvantaged individuals begin with fewer alternative resources related to socioeconomic status, such as power and authority. SES, or socioeconomic position (SEP), predict health in numerous domains, and SEP may help shape health over the life course (Adler & Ostrove, 1999). Disadvantaged individuals without one socioeconomic resource can substitute with another (e.g., education) and therefore gain more health benefits from this resource than advantaged individuals. Some evidence supports the resource substitution theory for minority health returns to education (Ross & Mirowsky, 2006; Walsemann, Gee, & Ro, 2013). For example, Black women benefit more than Black men and Whites from increases in education quality in terms of blood pressure levels (Liu, Manly, Capistrant, & Glymour, 2015). Similarly, Vable et al. (2018a) found that, compared to socially advantaged groups, Black women, Blacks from low childhood SES backgrounds, and women from high and low childhood SES appeared to benefit more from each year of education in predicting mental health than their White, male, or high childhood SES counterparts. Studies such as these draw from intersectionality theory (Bauer, 2014), which considers the concurrent effects of multiple social statuses of disadvantage. As per the intersectionality theory and the double disadvantage hypothesis, adults who hold more than one disadvantaged status (e.g., Blacks from low childhood SES) may experience a "double disadvantage" in psychological distress and physical health, in comparison to their more advantaged counterparts (Grollman, 2014). These multiple statuses of disadvantage may contribute to differential returns to education.

The resource multiplication theory suggests the opposite of resource substitution theory: disadvantaged status systematically lessens the potential health gains from educational attainment (Farmer & Ferraro, 2005; Ross & Mirowsky, 2006). The resource multiplication theory predicts that advantaged groups gain more health from educational attainment than disadvantaged groups because already advantaged individuals are in a better position to exploit any new resource. Recent studies have suggested diminished health returns to education for Blacks in comparison to Whites (Assari, 2017, 2018; Everett, Rehkopf, & Rogers, 2013; Hayward & Hummer, 2015; Holmes & Zaiacova, 2014). One study suggested Blacks do not benefit from education, while Whites do in predicting obesity (Cohen, Rehkopf, Deardorff, & Abrams, 2013). The current study will consider these theories in examining differential CVD health returns to education.

We also aim to investigate whether the findings reported by Vable et al. (2018a) are robust in a different population and birth cohort. Vable et al. (2018a) examined differential returns for mental and physical health in the National Longitudinal Survey of Youth (NLSY) 1979 cohort, a national sample of U.S. middle-aged adults. The current study draws from the nationwide REasons for Geographic and Racial Differences in Stroke (REGARDS) study, which was designed to examine factors contributing to the racial and regional differences in stroke in the U.S. (Howard et al., 2005). The samples differ in that REGARDS participants are older adults born 1911 to 1962, while Vable's cohort comprised individuals born 1957 to 1964. Additionally, the NLSY sample primarily comprised non-Hispanic Whites, non-Hispanic Blacks, Hispanic/Latinos, and Asians, while the REGARDS sample consists of White and Black people. Furthermore, the REGARDS study oversamples for Blacks and residents from the stroke belt (North Carolina, South Carolina, and Georgia, Tennessee, Mississippi, Alabama, Louisiana, and Arkansas).

We expand upon previous work (Vable et al., 2018a) by taking a nuanced look at geographic differences. U.S. Southern residents have been shown to experience worse health in many domains compared to the rest of the country (Chowdhury et al., 2007; Moy et al., 2017). Vable's study (2018a) examined rural residence at age 14 and foreign birth as potential effect modifiers. In contrast, we consider childhood residence in the Southeastern U.S. stroke belt, as it has been identified as an area with unusually high stroke mortality (Howard et al., 2005). Furthermore, our study extends previous work (Vable et al., 2018a) to LS7 outcomes. While Vable et al. (2018a) used self-report measures of mental and physical health, our study utilizes a measure that incorporates both objective, clinical factors (e.g., fasting glucose levels, height) and self-reported health behavior factors (e.g., diet, physical activity levels). Our study examined whether members of socially vulnerable groups (specifically, Black people, women, and people from low childhood SES backgrounds) experience more or less cardiovascular health returns to education than their advantaged counterparts.

The current study aims to examine the differential benefits of education on cardiovascular health, as measured by the LS7, in an older population. We investigate the effect of educational attainment on self-reported mental health and physical health in the National Longitudinal Survey of Youth (NLSY) (Vable et al., 2018a).

We hypothesize that educational attainment is positively associated with CV health (as measured by LS7). The estimated effects of education on CV health, as measured by the LS7 summary score, will vary by sex, race, geography, and childhood SES. In alignment with previous analyses (Vable et al., 2018a), we also hypothesize that the socially disadvantaged groups (e.g., women, Black people, stroke belt-born participants, low childhood SES participants) will benefit more from education in regard to CVD, in comparison to socially advantaged groups.

Methods

Sample

Data come from the Reasons for Geographic and Racial Differences in Stroke (REGARDS) study, a National Institutes of Health (NIH)-sponsored project that enrolled a national sample of U.S. Black and White non-Hispanic adults to examine reasons for differential risk of stroke by race and geography. Overall, 30,239 Black and White adults, aged 45 and older, were enrolled in the study between January 2003 and October 2007. A detailed description of REGARDS methods has been published elsewhere (Howard et al., 2005).

REGARDS participants were recruited through a combination of mail and telephone. Trained staff conducted structured computer-assisted telephone interviews (CATI) to collect information on demographics (age, race, sex), socioeconomic factors (household income, education), medical history, and lifestyle factors. After the CATI, a health professional conducted an in-home visit, which collected data on the respondents' body blood pressure measurements, blood and urine samples, and height and weight. During the in-person assessment, participants received self-administered questionnaires to be returned by self-addressed prepaid envelopes. Questionnaires included food frequency information, as well as residential history information recording city/state (or country) of birth, and every city/state where participant had lived for at least one year, and age at which he/she moved from each location. A description of data cleaning and coding of the residential history dataset can be found elsewhere (Howard et al., 2005).

In July 2012, a supplemental childhood circumstances questionnaire was mailed to active participants ($N = 20{,}671$). The childhood questionnaire asked respondents to provide information on some of their early and later life experiences and family background, including schools attended and parents' education level. Figure 1 shows the steps involved to arrive at the analytic sample of 8,759 participants from the full REGARDS cohort.

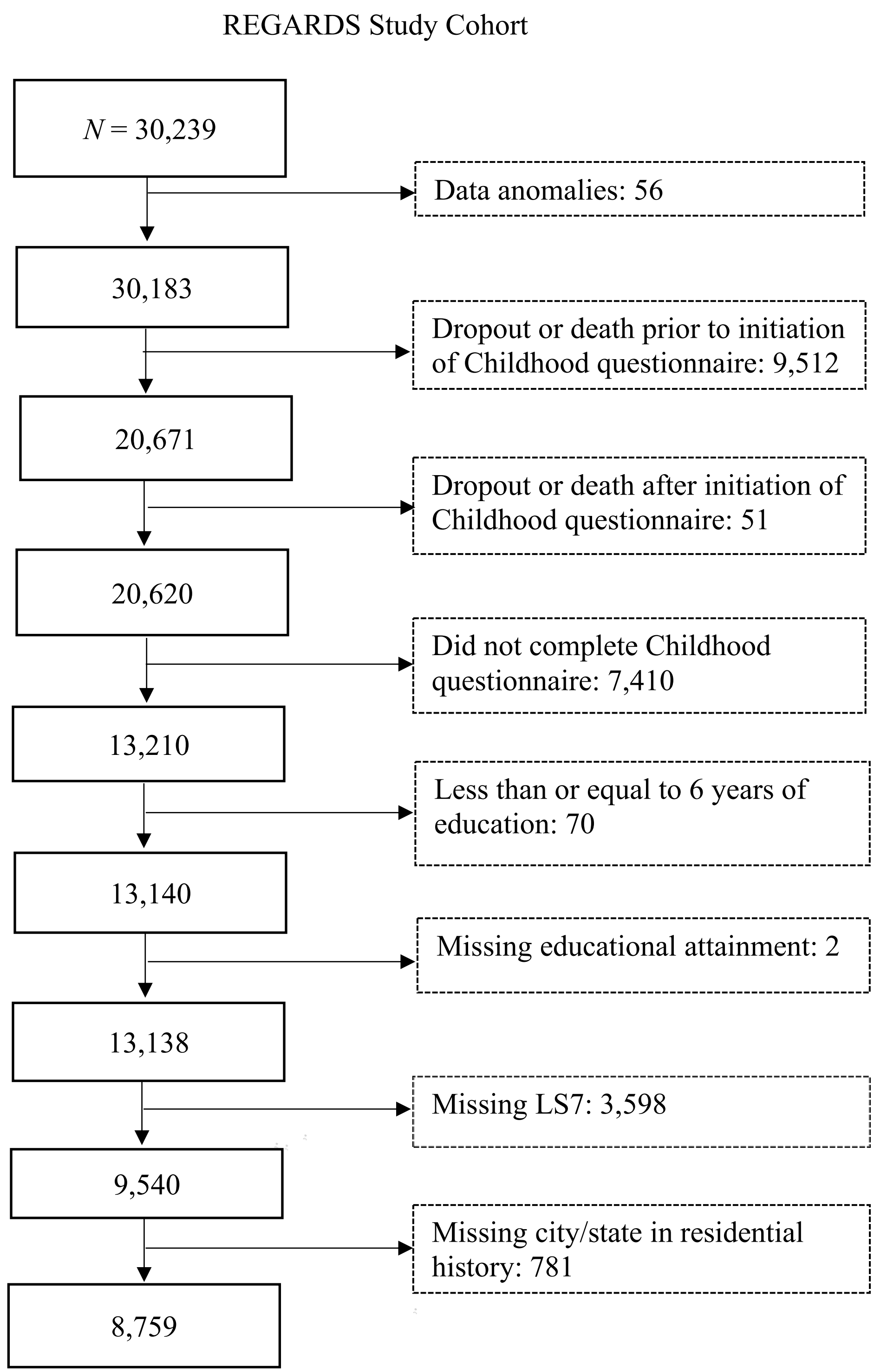


Fig 1. Steps for narrowing down the REGARDS sample included in the analyses.

Measures

Exposure

The educational attainment measure was created using information from the baseline questionnaire and childhood questionnaire. In the baseline questionnaire, participants were asked, "What is the highest grade or year of school you have completed?", with the following options: Never attended or kindergarten only, Eighth grade or less, Some high school (9^{th} – 11^{th} grade), High school graduate or GED certificate, Some technical school, Technical school graduate, Some college, College graduate, Postgraduate or professional degree, Don't Know/Not Sure, and Refused.

The childhood questionnaire contained more detailed measures related to education. Participants were asked, "Please circle the last grade in school you completed and got credit for," with a range of 1 to 12 years and "Don't Know." As a result, the childhood questionnaire provides a continuous measure of education up to 12 years. Finally, participants were asked to report the names of all schools or programs attended after high school, as well as any degrees and certificates earned post-high school.

We created a continuous measure of education (i.e., highest number of years of educational attainment) incorporating information from the baseline survey and childhood questionnaire. In creating the measure, we referred to participants' responses to the childhood questionnaire items to determine years of education. For those who did not have responses, we used the baseline survey to fill in values. The following codes were assigned to participants by education attainment: Those who graduated from high school or received a GED were coded as having attained 12 years of education. For participants with less than high school education, the childhood questionnaire item, "Please circle the last grade in school you completed and got credit for (range 1-12 and 'Don't Know')," was used to measure educational attainment. If participants had missing values for the childhood questionnaire items and were classified in the baseline questionnaire as "Eighth grade or less" or "Some high school (9^{th}-11^{th} grade)", the mode value of the last grade completed among participants with measures in both the baseline and childhood circumstances questionnaire was imputed.

Participants who reported having technical training were coded as 13 years (+1 year additional education after high school); "some college" was coded as 14 years (averaged +2 years education after high school). Because college graduation typically takes approximately 4 years of full-time education, college graduates were assigned 16 years of education (12 years through the end of high school + 4 years through the end of college). Since post-graduate degrees are often an additional 2 to 4+ years of education after college graduation, post-graduates (e.g., those with Masters', PhDs, etc.) were coded as having 18 years.

The resulting educational attainment measure ranged from 1 through 18 years. In sensitivity analyses, we considered different ways of operationalizing education (i.e., categorical variables with participants grouped by their degrees, such as "Some college" and "High school graduate"). Our primary analyses used a continuous measure of education in order to best compare our findings with the previous study.

Outcome

The outcome was the LS7 measure, which was based on definitions published by the American Heart Association (Lloyd-Jones et al., 2010). The components comprised different risk factors of CV health. Specifically, the metric consists of seven modifiable components, including three physiological factors (total cholesterol, blood pressure, and fasting glucose), and four health behavior-related factors (cigarette smoking, diet, physical health, and body mass index). To create a LS7 composite score, each component was assigned a score, with 0 points indicating poor performance, 1 indicating intermediate performance, and 2 indicating ideal performance. Definitions of poor, intermediate, and ideal levels of each component have been documented in a previous study on the REGARDS dataset (Thacker et al., 2014). All seven component scores were then summed to create a total score ranging from zero (worst CV health) to 14 points (best CV health). We utilized the total score for the LS7 measure.

Effect modifiers

We examined demographic and geographic factors as potential effect modifiers of the relationship between education and LS7. Demographic effect modifiers included sex (male, female), race (Black, White), and childhood SES. Mother’s educational attainment was used as a measure for childhood SES, as prior work has noted it is a stronger predictor of education and adult health outcomes than alternative operationalizations of childhood SES. Consistent with prior literature examining mother’s education in similar birth cohorts, we dichotomized mother’s education at 8 years, with low childhood SES coded as less than 8 years (Vable et al., 2018b; Vable et al., 2018c, Glymour, Avendano, Haas, & Berkman, 2008). We considered dichotomizing mother’s education at 12 years, but the dichotomization at 8 years produced a more reasonable distribution of childhood SES in our sample.

In recognition that the effects of education may depend on the intersection of multiple dimensions of social identity, we studied combined race-sex, childhood SES-sex, and race- childhood SES combinations as potential effect modifiers. The geographic modifier was childhood residence in the stroke belt. Participants living in 8 Southeastern U.S. states (North Carolina, South Carolina, Georgia, Alabama, Mississippi, Tennessee, Arkansas, and Louisiana) at age 5 were coded as having childhood residence in the stroke belt. The most socially advantaged group (e.g., White men, in comparison to Black men, Black women, and White women) was set as the reference group in all analytic models.

Confounder

All models were adjusted for age at baseline, and we included both linear and quadratic terms. Quadratic terms were included due to the curvilinear relationship between age and health.

Analyses

We used linear regression models to examine whether education predicted LS7 scores. Model assumptions have been included in the appendix. We investigated possible effect modification by including interaction terms by sex, race, childhood socioeconomic status (SES), and geography. Model 1 examined whether the association between education and

LS7 differed by race (i.e., Whites vs Blacks). Model 2 examined whether the association between education and LS7 differed by sex (i.e., men vs women). Model 3 examined differential returns to education by childhood SES (e.g., high childhood SES vs low childhood SES), and Model 4 examined returns by childhood residence in the stroke belt (i.e., childhood residence in the stroke belt regions vs childhood residence in non-stroke-belt regions).

Additionally, we fit models with interactions by education for each intersectional combination: race-sex (Model 5), childhood SES-race (Model 6), and childhood SES-sex (Model 7). Specifically, Model 5 examined whether the association between education and LS7 differed by race-sex combinations (i.e., White men, Black men, White women, Black women). Model 6 examined whether the association between education and LS7 differed by childhood SES-race combinations (i.e., high childhood SES Whites, low childhood SES Whites, high childhood SES Blacks, low childhood SES Blacks). Finally, Model 7 examined whether the association between education and LS7 differed by childhood SES-sex combinations (i.e., high childhood SES men, low childhood SES men, high childhood SES women, low childhood SES women).

The study has issues with missing outcome data due to loss-to-follow-up (e.g., selection bias). Since the analytic sample comprised only those who completed the childhood circumstances questionnaire, we applied inverse probability weights to the analyses to reflect the original REGARDS population and address the potential selection bias. Inverse probability weights address unequal probabilities of selection in a study by applying a weighted estimation (Mansournia & Altman, 2016). Each individual is assigned a weight inversely proportional to their probability of selection; here, the individuals who are oversampled are given smaller weights compared to individuals who are under-sampled (Mansournia & Altman, 2016).
The methods of inverse probability weighting adjusts for confounding and selection bias (Cole & Hernán, 2008).

The method required building a logistic regression model for the probability the data are missing. Specifically, this logistic regression model estimates the probability of a person being exposed to a specific condition. The weights accounted for the inverse probability of censorship (e.g., being active to be invited to participate in the childhood circumstances questionnaire) and response (e.g., whether or not the participant actually completed the childhood circumstances questionnaire when they received it). The separate logistic models for each of the outcomes described were selected using a stepwise selection model, which allowed features to enter or leave the regression model one step at a time based on p-value thresholds (Kuhn & Johnson, 2019). This model had a significance entry criterion of 0.20 and exit criterion of 0.05; in other words, a variable needed to have a p-value less than 0.20 to be included in the model and greater than 0.05 to be removed from the model. Variables are added and removed one step at a time until the model meets convergence. Ultimately, the selected logistic models were the same for both the censorship model and the childhood questionnaire response model. Using the predicted probabilities for each of the models, we then calculated the weight of censorship and childhood questionnaire response as the inverse of the probability of having the response that the respondent had. We then trimmed each weight at the 99% percent. Finally, to calculate the ultimate selection weight, we multiplied the participant weight for censorship with the weight for childhood response. All analyses were conducted in Stata 15.1.

Results

Summary

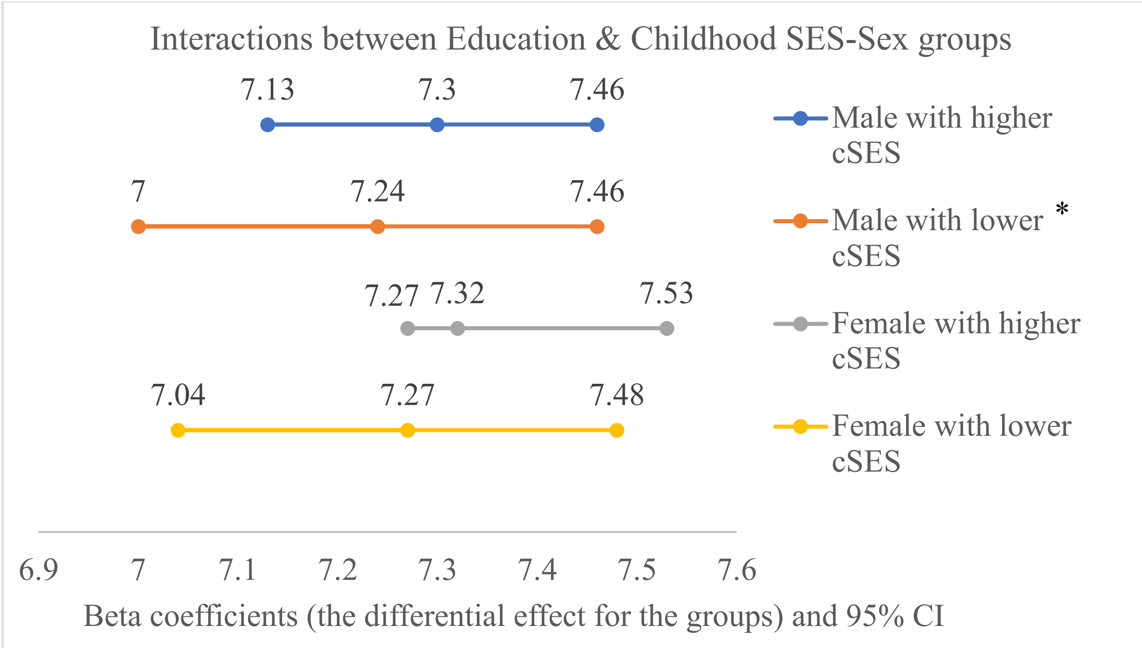
There were 8,759 respondents in the final sample (Figure 1). At baseline, the respondents were 45 to 94 years old (mean = 63.8, Table 1). The majority were women (56.9%). Respondents, on average, completed 14.5 years of education. Most respondents were White (N = 6,557; 74.9%), and from high childhood SES backgrounds (N = 5,880; 67.1%). Almost half of participants were born in the stroke belt region (44.3%).

Differential Cardiovascular Disease Health Returns to Education

In main effects models, years of education predicted cardiovascular health (Table 2, base model: β = 0.19; 95% CI: 0.17, 0.21). The effects of education on cardiovascular health differed only by childhood SES. In comparison to respondents from high childhood SES backgrounds, each additional year of education was associated with lower gains in cardiovascular health for respondents from low childhood SES backgrounds (β for differential effect for low childhood SES vs high childhood SES = -0.05; 95% CI: -0.09, -0.01, Table 2, Model 3). There was no evidence of differential returns to education by race/ethnicity, sex, or childhood residence in the stroke belt regions (Table 2, Models 1, 2, and 3).

Life Simple 7 Returns to Education in Intersectionality-defined Groups

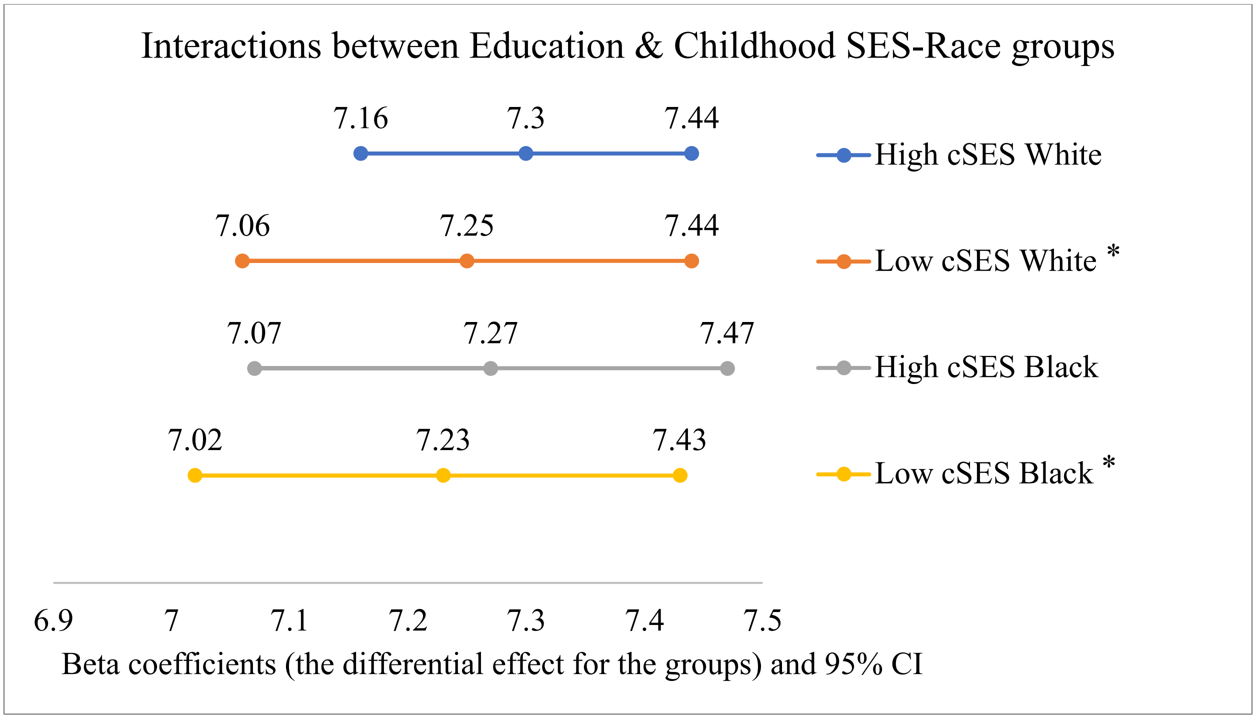
In predicting cardiovascular health, there was evidence of differential returns in models that examined intersectional effect modification by sex and childhood SES, as well as race/ethnicity and childhood SES (Table 4). In examining sex and childhood SES combinations by education, men from low childhood SES backgrounds benefited less toward cardiovascular health functioning from each year of education than men from high childhood SES backgrounds (β for differential effect for low childhood SES men vs high childhood SES men = -0.06, 95% CI: -0.13, -0.002, Figure 2 and Table 3, Model 7). Compared to high childhood SES men, low childhood SES women and high childhood SES women did not differ in their cardiovascular health returns to education.



* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[1]The dot in the middle of the lines represent the beta coefficient estimate, and the width of the individual bars represent the confidence interval associated with each estimate, with the lower and upper CIs represented by the left and right dots. Significant differences between the groups were assessed using regression analyses.
Abbreviations: socioeconomic status (SES) and childhood socioeconomic status (cSES).

Fig 2. Differential effect of education on LS7 across childhood socioeconomic status-sex groups.

In examining race/ethnicity and childhood SES combinations by education, White people from low childhood SES backgrounds benefited less toward cardiovascular health than White people from high childhood SES backgrounds (β for differential effect for low childhood SES Whites vs high childhood SES Whites = -0.05, 95% CI: -0.10, -0.005, Table 3, Model 6). Additionally, Black people from low childhood SES backgrounds benefitted less toward cardiovascular health than White people from high childhood SES backgrounds (β for differential effect for low childhood SES Black people vs high childhood SES White people = -0.07, 95% CI: -0.13, -0.01, Figure 3 and Table 3, Model 6). Compared to White people from high childhood SES backgrounds, high childhood SES Black people did not differ in their returns to cardiovascular health from education.



* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[1]The dot in the middle of the lines represent the beta coefficient estimate, and the width of the individual bars represent the confidence interval associated with each estimate, with the lower and upper CIs represented by the left and right dots. Significant differences between the groups were assessed using regression analyses.
Abbreviations: socioeconomic status (SES) and childhood socioeconomic status (cSES).

Fig 3. Differential effect of education on LS7 across childhood SES-race groups.

Finally, there was no evidence of differential returns from education by sex and race/ethnicity combinations.

Discussion

Using a nationally representative sample of older adults, we found socially vulnerable groups (i.e., men from low childhood SES backgrounds, White people from low childhood SES backgrounds, Black people from low childhood SES backgrounds) benefitted less from each additional year of education than socially advantaged groups in predicting LS7 scores. However, we did not find evidence that differential returns extended to every group: some socially vulnerable groups did not differentially benefit compared to socially advantaged groups. For example, compared to men from high childhood SES backgrounds, women from low childhood SES backgrounds and women from high childhood SES backgrounds did not differ in their cardiovascular health returns to education. We also found no evidence of differential returns from education by sex and race/ethnicity groups (e.g., Black women).

Our findings highlight the importance of the relationship between education and health outcomes throughout the life course. Education has been regarded as an impactful social determinant of health, and it is generally held that more education translates into more benefits. However, our study found evidence that multiple socially disadvantaged groups benefit less from each year of education toward mental health than their socially advantaged counterparts. This is an important finding, as it highlights potential disparity between the socially advantaged and socially disadvantaged. In alignment with the resource multiplication theory, the education system may disproportionately benefit those with existing resources (e.g., wealth, status), while neglecting the socially disadvantaged. Our findings point to the importance of addressing the structural pieces of education (the mechanisms) that disproportionally serve the socially advantaged, as opposed to the socially disadvantaged. It is possible there is a causal relationship between education and cardiovascular health; however, the inequalities that exist in the education system may only exacerbate the disparities between the advantaged and disadvantaged.

We conducted this study in order to determine whether previous findings were robust to variations in time, place, and population. This is important in light of the replication crisis, in which replicated studies fail to produce similarly statistically significant patterns. Drawing from past work, our findings point to evidence of differential returns to education, with socially venerable groups benefitting less than their advantaged counterparts. In contrast with previous literature exploring the education-health relationship (Conti, Heckman, & Urzua, 2010; Hammond, 2002), our results suggest education may further exacerbate disparities in U.S. populations.

We were surprised to find our results contrasted with a previous study (i.e., Vable et al. (2008)). There were multiple differences between our findings and those published by Vable et al (2018a), who used different outcome measures (i.e., mental health and physical health, as measured by the SF-12 questionnaire). For example, while Vable et al. (2018a) found Black women gain more from each year of education in predicting mental health functioning than White men, our study found no evidence of differential cardiovascular health returns among Black men, Black women, or White women, in comparison to White men. The largest difference between the two studies can be found in the intersectionality models for effect modification by childhood SES. Firstly, Vable et al. (2018a) found only low childhood SES Black people to benefit more than high childhood SES Whites. We found evidence of the relationship in the opposite direction: Black people from low childhood SES backgrounds benefitted less. Similarly, the current study found men from low childhood SES backgrounds benefiting less than men from high childhood SES backgrounds. Contrastingly, childhood SES women and low childhood SES women benefitted more than men with high childhood SES in the previous study. A plausible explanation is the difference in samples: Vable's analytic sample comprised individuals born 1957 to 1964, whereas members of the REGARDS birth cohort were born 1911 to 1962. Cardiovascular health is strongly affected by age; for example, adults age 65 and older are more likely than younger people to suffer from cardiovascular disease (NIH, 2018), and aging is generally associated with greater vulnerability to disease (Almeida, Norman, Hankey, Jamrozik, & Flicker, 2006). Age at outcome assessment and chance are both plausible explanations for the differences in results between our samples.

Another difference between the two studies is that Vable et al. (2018a) found people with low childhood SES benefited more from each year of education in predicting physical health. Similarly, we had expected education to offset disadvantage for cardiovascular health and were surprised to find the opposite. In the current study, we found that multiple groups from low childhood SES backgrounds (i.e., men from low childhood SES backgrounds, Whites from low childhood SES backgrounds, Blacks from low childhood SES backgrounds) benefitted less in predicting cardiovascular health from education, in comparison to those from high childhood SES backgrounds. Education may play different roles in cardiovascular health and physical health, respectively. Past studies suggest that low SES is related to increased cardiovascular reactivity to stressful situations (Chen & Matthews, 2001; Everson et al., 2001; Gump et al., 1999; Wilson, Kliewer, Plybon, & Sica, 2000). Men with excessive blood pressure reactivity have greater risk of stroke, and this effect is stronger among those with less education (Everson et al., 2001). Those who have high stress responses, in combination with low education, were three times more likely to have a stroke in comparison to those who had more education and low stress responses. It is possible that, in the current study, disadvantage may lessen cardiovascular health benefits, especially for double disadvantaged groups, such as Blacks from low childhood SES backgrounds. These groups may be impacted by the stress brought on from low childhood SES and, as a result, less able to translate any possible benefits they gain from education into cardiovascular health.

Additionally, these differences may be due to the studies' difference in birth cohort and population. REGARDS oversampled Black Americans in the southeastern US, while the previous study's sample, the NLSY 79, did not. Furthermore, Black men did not experience differential gains from education when compared to White men in either study, though Vable et al. (2018) had hypothesized they would benefit less. This is particularly interesting, since this finding seems to be consistent across birth cohorts.

Another factor to take into consideration is difference in policies experienced by the cohorts. In contrast with Vable's birth cohort, members of the REGARDS birth cohort (born 1911 to 1962) are more likely to have been exposed to the consequences of the Jim Crow local and state laws. Past studies have suggested the abolition of Jim Crow laws may have helped reduce some Black versus White health inequities (Kaplan, Ranjit, & Burgard, 2008; Krieger, Chen, Coull, Beckfield, Kiang, & Waterman, 2014; Krieger, Chen, Coull, Waterman, & Beckfield, 2013). However, other studies describe the long-lasting, existing Black versus White health inequities as a result of the Jim Crow laws (Smith, 2005). Additionally, there could be differences in the quality of schooling experienced by the cohorts, with Black children experiencing much shorter school term lengths than White children during the *de jure* segregation period (Liu, Manly, Capistrant, & Glymour, 2015). Due to differences in experiences of legalized racial discrimination, cardiovascular health benefits from education may be more apparent in the more recent birth cohorts.

Another possible reason for the conflicting results between our study and Vable et al. (2018a) is the difference between our outcome measures. Vable et al. (2018a) examined self-reported mental and physical health, both of which were measured by the SF-12 questionnaire. Our study utilized the LS7 composite scores, which included both self-report behavior items (e.g., smoking status, alcohol consumption, physical activity) and objective clinical measures (e.g., height, weight, blood pressure). In comparison to

Vable et al. (2018a), our findings are less likely to be affected by the biases that arise from self-reported measures, such as the effects of social desirability. In this case, there is a possible disconnect between objective and subjective measures of health. Specifically, compared to the objective truth, participants may be more likely to rate themselves as having better health in self-report questionnaires. In future analyses, we plan to separate LS7 scores into an objective clinical score (encompassing total cholesterol, blood pressure, fasting glucose, and body mass index) and a more subjective health behavior score (encompassing physical health, cigarette smoking, and diet). Using these separate scores, we will then examine whether returns to education will be different for the objective clinical measure and subjective behavior measure. It is possible that we find that socially disadvantaged participants benefit more toward subjective health but benefit less toward objective health; this will further highlight the disparity between the advantaged and disadvantaged.

Our study highlights the potentially wide health gaps between socially vulnerable groups and their advantaged counterparts. Changes across multiple systems are needed to address the structural racism that has contributed to well-documented and long-standing gaps in health. Initiatives, such as Federal TRIO Programs, have helped increase education attainment among minorities by extending opportunities to students from diverse social and economic backgrounds (Cowan Pitre & Pitre, 2009). Another example of a successful initiative is the G.I Bill's higher education program, which provided WWII veterans the opportunity to attend college (Olson, 1973) and, in comparison to nonveterans, was successful in achieving substantial gains in college attainment (Bound & Turner, 2002). Furthermore, Korean War G.I. Bill eligibility has been shown to predict smaller socioeconomic disparities in mental, physical, and cognitive health among veterans compared to non-veterans (Vable et al., 2016; Vable et al., 2018b). Such efforts can help address the overarching systems that contribute to the health disparities shown in our findings.

Similar to Vable et al. (2018a), our geography measure (i.e., childhood stroke belt residence) did not modify the relationship between education and cardiovascular health. While health returns from education did not vary by geography in our analyses, it is important to discuss its role in the association between education attainment and health for future studies. Past studies have suggested geography plays a large role in health, with Southern residents experiencing worse health compared to the rest of the country (Chowdhury et al., 2007; Hajjar & Kotchen, 2003; Mokdad et al., 2001; Moy et al., 2017). Drawing from previous studies (Howard et al., 2013), we expected childhood residents of the Southern U.S. stroke belt to be at a disadvantage to the rest of the U.S., and, thus, experience more health gains from education. Due to rurality's impact on the life course, future studies will want to account for childhood rural residence, as well as childhood stroke belt residence and current stroke belt residence, as effect modifiers.

Strengths and Limitations

There are limitations to this study. First, there may be confounders that we did not consider. In replicating the previous analysis, we did not account for other SES indicators that may lessen the effect of education, such as occupation, current SES, and childhood household income. Another variable to account for would be the participant's quality of education, as little is known about its role in contributing to health gains. The current models were constructed in accordance with a previous study (Vable et al., 2018a), and our future analyses will incorporate these variables. Additionally, a majority of the information examined in this study is self-reported, which may not be reliable.

It should be noted that our study also has several strengths. REGARDS provides a large national population sample of Black and White participants, with oversamples of Black Americans in the rural South. Additionally, we were able to consider the modifying effect of childhood stroke belt residence due to REGARDS' detailed residential history data and oversampling of residents of the stroke belt. The study also utilized inverse probability weights, which allowed us to address loss-to-follow-up and selection bias. Furthermore, the LS7 composite scores comprised both objective clinical measures and self-reported behavior measures. In examining returns to education, future research should continue to study more objective measures of health.

Conclusion

Among a nationwide sample of U.S. older adults, we found evidence of differential CVD health returns to educational attainment in subgroups defined by combinations of race, sex, and childhood circumstance. Interaction models indicated that, CVD health gains from education were smaller for men from low childhood SES backgrounds (in comparison to men from high childhood SES backgrounds), White people from low childhood SES backgrounds (in comparison to Whites from high childhood SES backgrounds), and Black people from low childhood SES backgrounds (in comparison to Whites from high childhood SES backgrounds). We found no evidence of differential returns from education by sex and race/ethnicity groups (e.g., Black women). Taken together, these findings provide inconsistent support for the resource multiplication theory, in which disadvantaged status systematically lessens health benefits from education. This suggests that the inequalities present in the education system may further exacerbate the gap between advantaged and disadvantaged.

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Tables

Table 1.
Distribution of variables (*N* = 8,759), weighted to original REGARDS population.

Variable	Unweighted	Weighted
	N(%)/mean (SD)	N(%)/mean
Education (years, mean, SD)	14.8 (14.3)	14.5
Age (years, mean, SD)	63.8 (8.5)	63.5
Female (N, %)	4,985 (56.9)	56.4
Black (N, %)	2,202 (25.1)	30.9
Low childhood SES (N, %)	2,879 (32.9)	36.4
Childhood residence in the stroke belt (N, %)	3,879 (44.3)	46.7
Life’s Simple 7 (mean, SD)	7.8 (2.0)	7.6

Table 2.
Life’s Simple 7 at baseline. Main effects and demographic interactions weighted to original REGARDS population.

Variables	Base model: Main effects		Model 1: Race interaction		Model 2: Sex interaction		Model 3: Childhood SES interaction		Model 4: Stroke Belt Residence interaction	
	Beta	95% CI	Beta	95% CI	Beta	95% CI	Beta	95% CI	Beta	95% CI
Constant	7.39	(7.28 - 7.51)	7.35	(7.23 - 7.48)	7.45	(7.31 - 7.58)	7.33	(7.20 - 7.45)	7.41	(7.29 - 7.54)
Education	0.16	(0.14 - 0.18)	0.18	(0.15 - 0.20)	0.14	(0.11 - 0.17)	0.18	(0.16 - 0.21)	0.16	(0.13 - 0.18)
Black	-0.82	(-0.93 - -0.71)	-0.74	(-0.89 - -0.59)	-0.83	(-0.93 - -0.72)	-0.82	(-0.92 - -0.71)	-0.82	(-0.93 - -0.72)
Black x education			-0.04	(-0.08 - 0.00)						
Female	-0.04	(-0.13 - 0.06)	-0.03	(-0.13 - 0.06)	-0.13	(-0.28 - 0.01)	-0.04	(-0.13 - 0.06)	-0.04	(-0.13 - 0.05)
Female x education					0.04	(-0.00 - 0.08)				
Low cSES	-0.07	(-0.17 - 0.03)	-0.07	(-0.17 - 0.03)	-0.07	(-0.17 - 0.03)	0.05	(-0.09 - 0.19)	-0.07	(-0.17 - 0.03)
Low cSES x education							-0.05	(-0.09 - -0.01)		
Stroke belt residence	-0.08	(-0.17 - 0.01)	-0.08	(-0.17 - 0.02)	-0.08	(-0.17 - 0.01)	-0.08*	(-0.17 - 0.01)	-0.12*	(-0.26 - 0.02)

Stroke belt residence x education									0.02	(-0.02 - 0.05)
Age in decades (linear)	-0.08	(-0.15 - -0.01)	-0.08	(-0.15 - -0.01)	-0.08	(-0.15 - -0.01)	-0.08	(-0.15 - -0.01)	-0.08	(-0.15 - -0.01)
Age (quadratic)	0.16	(0.11 - 0.20)	0.16	(0.11 - 0.20)	0.15	(0.11 - 0.20)	0.16	(0.11 - 0.20)	0.16	(0.11 - 0.20)

The reference group is White Men who lived in the Stroke Belt region at age 5, from high childhood SES backgrounds.
Abbreviations: socioeconomic status (SES) and childhood socioeconomic status (cSES).

Table 3.
Intersectionality models weighted to original REGARDS population.

	Model 5: Intersectionality: race x sex			
	Base model: main effects		Education interaction with race-sex subgroups	
Variables	Beta	95% CI	Beta	95% CI
Constant (White Men)	7.32	(7.21 - 7.44)	7.33	(7.18 - 7.48)
Education (among White men)	0.17	(0.15 - 0.18)	0.16	(0.13 - 0.19)
Low cSES	-0.06	(-0.16 - 0.04)	-0.06	(-0.16 - 0.04)
Stroke belt residence	-0.08*	(-0.17 - 0.01)	-0.08	(-0.17 - 0.01)
White Women	0.08	(-0.02 - 0.19)	-0.01	(-0.18 - 0.16)
Black Women	-0.90	- (-1.03 - -0.77)	-0.88	(-1.07 - -0.69)
Black Men	-0.56	(-0.74 - -0.38)	-0.47	(-0.74 - -0.20)

White Women x Education			0.04	(-0.01 - 0.08)
Black Women x Education			-0.01	(-0.06 - 0.04)
Black Men x Education			-0.05	(-0.12 - 0.03)

Model 6: Intersectionality: cSES x race				
	Base model: main effects		Education interaction with cSES-race subgroups	
Variables	Beta	95% CI P-value	Beta	95% CI P-value
Constant (High cSES White)	7.40	(7.28 - 7.51)	7.30	(7.16 - 7.44)
Education	0.16	(0.14 - 0.18)	0.19	(0.16 - 0.22)
Female	-0.04	(-0.13 - 0.06)	-0.03	(-0.13 - 0.06)
Stroke belt Residence	-0.08	(-0.17 - 0.01)	-0.08	(-0.17 - 0.01)
Low cSES White	-0.09	(-0.21 - 0.04)	0.04	(-0.13 - 0.21)
High cSES Black	-0.84	(-0.98 - -0.70)	-0.74	(-0.96 - -0.53)
Low cSES Black	-0.88	(-1.03 - -0.74)	-0.73	(-0.92 - -0.53)

Low cSES White x Education			-0.05	(-0.10 - 0.00)
High cSES Black x Education			-0.03	(-0.09 - 0.03)
Low cSES Black x Education			-0.07	(-0.13 - -0.01)

	Model 7: Intersectionality: cSES x sex			
	Base model: main effects		Education interaction with cSES-sex subgroups	
Variables	Beta	95% CI	Beta	95% CI
Constant (High cSES Men)	7.33	(7.21 - 7.45)	7.30	(7.13 - 7.46)
Education	0.16	(0.14 - 0.18)	0.17	(0.14 - 0.21)
Black	-0.81	(-0.92 - -0.71)	-0.81	(-0.92 - -0.70)
Stroke belt residence	-0.08	(-0.17 - 0.01)	-0.08	(-0.17 - 0.01)
High cSES Women	0.06	(-0.05 - 0.17)	0.01	(-0.19 - 0.20)
Low cSES Men	0.09	(-0.06 - 0.24)	0.22	(-0.00 - 0.45)
Low cSES Women	-0.13	(-0.27 - 0.01)	-0.06	(-0.26 - 0.14)

High cSES Women x Education	0.02	(-0.03 - 0.07)
Low cSES Men x Education	-0.06	(-0.13 - 0.00)
Low cSES Women x Education	-0.03	(-0.09 - 0.02)

Education is centered at 12 years, and age is centered at 60. The reference group is White Men who lived in the Stroke Belt region at age 5, from high childhood SES backgrounds. Abbreviations: socioeconomic status (SES) and childhood socioeconomic status (cSES).