



Original article

Do the health benefits of education vary by sociodemographic subgroup? Differential returns to education and implications for health inequities



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ABSTRACT

Purpose: Evidence suggests education is an important life course determinant of health, but few studies examine differential returns to education by sociodemographic subgroup.

Methods: Using National Longitudinal Survey of Youth 1979 ($n = 6158$) cohort data, we evaluate education attained by age 25 years and physical health (PCS) and mental health component summary scores (MCS) at age 50 years. Race / ethnicity, sex, geography, immigration status, and childhood socioeconomic status (cSES) were evaluated as effect modifiers in birth year adjusted linear regression models.

Results: The association between education and PCS was large among high cSES respondents ($\beta = 0.81$ per year of education, 95% CI: 0.67, 0.94), and larger among low cSES respondents (interaction $\beta = 0.39$, 95% CI: 0.06, 0.72). The association between education and MCS was imprecisely estimated among White men ($\beta = 0.44$; 95% CI: -0.03 , 0.90), while, Black women benefited more from each year of education (interaction $\beta = 0.91$; 95% CI: 0.19, 1.64). Similarly, compared to socially advantaged groups, low cSES Blacks, and low and high cSES women benefited more from each year of education, while immigrants benefited less from each year of education.

Conclusions: If causal, increases in educational attainment may reduce some social inequities in health.

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Introduction

Substantial evidence suggests education is an important social determinant of health over the life course [1,2]; however, little work has examined potential differential returns to education by sociodemographic factors such as sex, race/ethnicity, socioeconomic status, geography, or immigration status. The implicit

assumption in conventional analyses is that the effect of education is homogenous across diverse demographic groups; in addition to being at odds with current theories, such as intersectionality [3], there is also empirical evidence of differential returns to education. For example, compared to men, women benefit more from each year of education in predicting mental health [4], while Black women benefit more than Black men and Whites from increases in education quality in predicting blood pressure [5]. Alternatively, Whites seem to benefit more than Blacks from education in predicting obesity [6] and current smoking [7], and the education-health gradient is flatter (i.e., lower health returns to education) for Hispanics/Latinos [8,9] and immigrants [10] than for other groups.

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Although relatively little work examines differential returns to education by sociodemographic factors, we know health is strongly patterned by social factors such as childhood socioeconomic status (cSES), race/ethnicity, sex, geography, and immigration status. Research on the “long arm” of childhood disadvantage demonstrates that individuals who experience low cSES also have worse health in adulthood [11] and earlier mortality [12], suggesting it may not be possible to fully ameliorate adverse exposures in early life. Racial disparities in a variety of health outcomes are well documented [13,14]. Women tend to live longer than men [15]; however, they experience worse mental health [16]. Health also varies by geography such that people in rural areas experience worse health than those in urban areas [17], while individuals in the U.S. South experience worse health than individuals in other areas of the country [18]. Finally, health varies by immigration status such that Hispanic/Latino immigrants to the United States have lower mortality than native-born Hispanics/Latinos [19,20].

Motivated by the theories of resource substitution [4] and intersectionality [3], we examine differential returns to education by sex, race/ethnicity, cSES, geography, and immigration status. Resource substitution suggests that individuals who are marginalized within society will benefit more from education because they are prevented from accessing alternative health-promoting resources such as power, authority, earnings, etc., (potential mediators of the education-health relationship; Fig. 1), making socially marginalized groups more dependent on the resources to which they do have access (e.g., education). Resource substitution suggests socially vulnerable individuals will benefit more from each year of education (that is, have larger differential returns to education) than socially advantaged individuals.

Intersectionality offers a potential explanation for the non-additive effects of race and gender [3], such as prior work suggesting structural racism is particularly punishing for Black men [5,21–24]. Intersectionality theory formalizes the idea that the experience of being both Black and male are unique from those of Blacks overall and males overall; that is, we cannot sum the regression coefficients of “Black” and “male” to understand the experiences of Black men. Given that race, sex, and socioeconomic status can intersect in complex ways [25–27], we examine potential differential returns to education at the intersection of these identities.

Understanding differential returns to education is important for identifying solutions to health inequities. If certain vulnerable sociodemographic groups benefit more than socially advantaged groups (i.e. high SES White men) from each year of education in

predicting health outcomes, programs and policies that increase educational attainment, such as Pell Grants, could be a powerful mechanism to reduce health inequities. If, on the other hand, certain sociodemographic groups benefit less than White men from each year of education in predicting health outcomes, programs and policies that increase educational attainment may lead to an exacerbation of health inequities.

Methods

Sample

Data come from the National Longitudinal Survey of Youth 1979 cohort; we use outcome data through the 2014 wave of data collection ($n = 7071$ eligible for analysis). We excluded 83 individuals who were missing data on the exposure (i.e. did not report their educational attainment between ages 23 and 25 years, see [Exposure](#) section for details), 74 who were missing data on the outcomes, 743 who were missing data on one or more of the confounders, and 13 individuals who reported less than 7 years of education (to reduce the effect these outliers would have on our results), yielding a total analytic sample of 6158 (87.1%).

Exposure

We operationalized education as the highest level completed by age 25 years (0–20 years of education); if education was missing at age 25 years ($n = 683$), we used highest level at age 24 years ($n = 624$), then age 23 years ($n = 59$). Because we were interested in evaluating effect modification, it was important to specify the best primary model for education. We considered several options for operationalizing the associations between education and each outcome motivated by prior literature, including nonparametric (i.e. an indicator variable for each year of education), continuous, credentials (i.e. less than high school, high school graduate, college graduate, etc.), and a spline with a knot at 12 years and allowing for a discontinuity at 16 years [28]. We also evaluated a data-driven approach (one for each outcome, see [Appendix Fig. S1](#) for details and plots) based on the mean outcome for each year of education ≥ 7 years (below 7 years were excluded due to data sparseness). The best model specification was selected based on the lowest Bayesian information criterion and Akaike information criterion for each outcome and interpretability (see [Appendix Table S1](#) for details). We operationalized education continuously for the

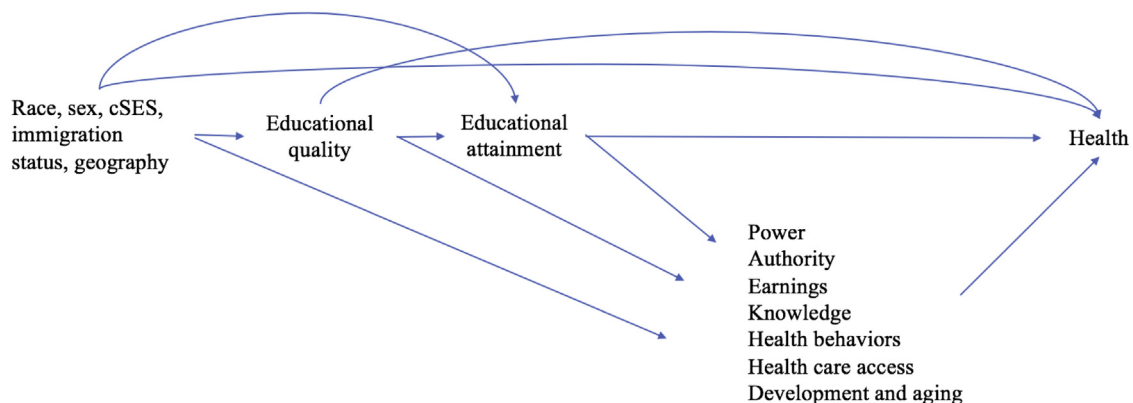


Fig. 1. Pathways through which sociodemographic factors may lead to differential returns to education. Figure adapted from Cohen and Syme 2013. Differential returns to education may arise because groups that are socially marginalized due to race/ethnicity, sex, childhood socioeconomic status (cSES), immigration status, and/or geography have less access to important health-promoting alternatives to education (quality or quantity), such as power, authority, earning, knowledge, etc., which are also potential mediators of the education-health relationship. Lack of access to alternative health-promoting resources may result in increased dependence on the resources to which one has access (e.g. education), potentially contributing to larger returns to education for socially marginalized groups.

physical health component summary score (PCS) and used a data-driven approach for the mental health component summary score (MCS), with education linearly related to MCS until 13 years of school, and no additional benefit of education above 13 years (see [Appendix Fig. S1](#) and [Table S1](#) for more information).

Outcomes

Our primary outcomes were the PCS and MCS from the 12-item short form survey, at age 50 years. These self-reported measures of physical health include such questions as (paraphrased): (1) Does your health now limit you from climbing several flights of stairs? Response options: yes, limited a lot; yes, limited a little; no, not limited at all; and (2) During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc.)? Response options: all of the time; most of the time; some of the time; a little of the time; none of the time. Both measures were found to have good reliability (2-week test-retest reliability ≥ 0.76) and validity [29]. We present results from age 40 years in the appendix ([Appendix Tables S3](#) and [S4](#)). Both PCS and MCS were standardized such that numbers above 50 indicate better health than the typical U.S. respondent and numbers below 50 reflect poorer health than the typical U.S. respondent [30].

Effect modifiers

We examined demographic and geographic factors as potential effect modifiers of the relationship between education and the PCS and MCS at age 50 years. The demographic effect modifiers tested were female sex, race (non-Hispanic White = ref, non-Hispanic Black, Hispanic/Latino, and other race/missing; Asians were combined with the other/missing category due to small numbers, $n = 38$), and low cSES (mother's education < 12 years; results for father's education < 12 years presented in the [Appendix](#)). Because race, sex, and socioeconomic status may have intersectional effects [3], we examined combined race-sex, cSES-sex, and race-cSES categories as potential effect modifiers. The geographic effect modifiers tested were Southern birth [18], foreign birth (we refer to those who were born outside the United States as "immigrants"), and rural residence at age 14 years [17]. For all potential effect modifiers, we also included main effect terms in the regression models. We set the most socially advantaged group (i.e. high cSES White men) as the reference group for these analyses to more clearly highlight differential returns among socially marginalized groups; because each analytic model (detailed below) varies in the interaction terms included, the interpretation of the main effect for education similarly varies across models.

Confounder

In addition to the effect modifiers, we adjusted all models for birth year; birth year ranged from 1957 to 1964.

Analysis

We used linear regression models to predict PCS and MCS adjusted for the confounder and all effect modifiers. The base model included the main effects only. In separate models, we then added two-way multiplicative interactions to the base model between education and (1) sex, (2) race, (3) low cSES, (4) immigrants, (5) Southern birth, and (6) rural residence at age 14 years. We next specified the intersectionality models, including main effect indicator variables for each (7) race-sex, (8) cSES-race, (9) cSES-sex combination, and then added interactions by education for each,

(10) race-sex, (11) cSES-race, and (12) cSES-sex combination. All data cleaning and analyses were performed in Stata 15. All models were weighted to the U.S. population in 2014. In additional analyses to examine the potential impact of clustering on variance, we estimated the design effect for all models to be <9% (data not shown); therefore, no additional variance adjustment was necessary. These analyses were determined exempt by the University of California, San Francisco Institutional Review Board.

Results

Sample

Respondents were, on average, born in 1961 ([Table 1](#)), completed 13 years of education by age 25 years, and most were White (76%). Almost 32% experienced low cSES, 32% were born in the South, and 22% lived in rural areas at age 14 years. They reported similar physical health to the typical person in the general U.S. population (mean PCS = 50) and reported better mental health than the typical person in the general U.S. population (mean MCS = 53). The mean educational attainment for each demographic subgroup is presented in [Appendix Table S2](#).

Differential returns to education

In main effects models, PCS ([Table 2](#), base model) was predicted by years of education ($\beta = 0.91$; 95% CI: 0.78, 1.04), female sex ($\beta = -1.71$; 95% CI: -2.25 , -1.17), and low cSES ($\beta = -1.56$; 95% CI: -2.25 , -0.87). The interaction terms represent the additional difference in PCS for each year of education; positive interaction terms indicate the demographic group benefitted more from each year of education than the reference group (the most socially advantaged), while negative interaction terms indicate the demographic group benefitted less from each year of education than the reference group. In interaction models, the estimated effect of each year of education was large among high cSES respondents ($\beta = 0.81$; 95% CI: 0.67, 0.94) and larger among those who experienced low cSES (interaction $\beta = 0.39$; 95% CI: 0.06, 0.72). Geographic factors did not modify the relationship between education and PCS ([Appendix Table S3](#)). Results for PCS at age 40 years were similar [Appendix Tables S5](#) and [S6](#)).

In main effects models, MCS ([Table 3](#), base model) was predicted by years of education ($\beta = 0.73$; 95% CI: 0.44, 1.02), female sex ($\beta = -2.39$; 95% CI: -2.90 , -1.89), race/ethnicity (β for Hispanic/

Table 1
Distribution of variables ($n = 6158$)

Variable	Unweighted	Weighted
	N (%) / mean (SD)	% / mean
Birth year (mean, SD)	1960.7 (2.2)	1960.5
Educational attainment at 25 (y; mean, SD)	12.8 (2.1)	13.1
Female (N, %)	3219 (52.3)	49.4
Race/ethnicity (N, %)		
White	3159 (51.3)	75.9
Black	1888 (30.7)	13.4
Hispanic	847 (13.8)	4.5
Other race/missing	264 (4.3)	6.2
Low cSES (N, %)	2616 (42.5)	31.8
Immigrant (N, %)	296 (4.8)	3.0
Southern birth (N, %)	2348 (38.1)	31.5
Rural residence at age 14 y (N, %)	1267 (20.6)	22.4
Outcomes		
PCS at age 50 y (mean, SD)	49.4 (10.0)	50.0
MCS at age 50 y (mean, SD)	53.0 (8.8)	53.0

Low cSES is low childhood socioeconomic status, defined as mother's educational attainment < 12 years (sensitivity analyses examine father's education < 12 years).

Table 2
PCS at age 50 years; main effects and demographic interactions, weighted to 2014

Variables	Base model: main effects			Female interaction			Race interaction			cSES interaction			Immigrant interaction		
	Beta	95% CI	P-value	Beta	95% CI	P-value	Beta	95% CI	P-value	Beta	95% CI	P-value	Beta	95% CI	P-value
Constant	50.62	50.11, 51.13	<.0005	50.08, 51.16	50.08, 51.14	<.0005	50.61	50.08, 51.14	<.0005	50.80	50.27, 51.33	<.0005	50.63	50.11, 51.14	<.0005
Education	0.91	0.78, 1.04	<.0005	0.76, 1.07	0.77, 1.07	<.0005	0.92	0.77, 1.07	<.0005	0.81	0.67, 0.94	<.0005	0.91	0.77, 1.04	<.0005
Female	-1.71	-2.25, -1.17	<.0005	-2.38, -1.04	-2.25, -1.17	<.0005	-1.71	-2.25, -1.17	<.0005	-1.72	-2.26, -1.18	<.0005	-1.71	-2.25, -1.17	<.0005
Black	-0.45	-1.12, 0.23	.195	-1.13, 0.23	-1.11, 0.39	.350	-0.36	-1.11, 0.39	.350	-0.53	-1.21, 0.15	.126	-0.45	-1.13, 0.23	.192
Hispanic/Latino	0.87	-0.12, 1.86	.085	-0.12, 1.86	-0.11, 1.97	.079	0.93	-0.11, 1.97	.079	0.85	-0.14, 1.84	.093	0.89	-0.10, 1.89	.079
Other race/missing	0.62	-0.54, 1.77	.297	-0.54, 1.77	-1.23, 1.89	.675	0.33	-1.23, 1.89	.675	0.65	-0.50, 1.80	.269	0.60	-0.55, 1.76	.307
Low cSES	-1.56	-2.25, -0.87	<.0005	-2.26, -0.87	-2.25, -0.87	<.0005	-1.56	-2.25, -0.87	<.0005	-1.71	-2.43, -1.00	<.0005	-1.56	-2.25, -0.87	<.0005
Southern birth	-0.95	-1.57, -0.32	.003	-1.57, -0.32	-1.57, -0.31	.003	-0.94	-1.57, -0.31	.003	-0.89	-1.52, -0.27	.005	-0.95	-1.58, -0.33	.003
Immigrant	-0.20	-1.95, 1.54	.818	-1.95, 1.54	-1.96, 1.54	.813	-0.21	-1.96, 1.54	.813	-0.20	-1.94, 1.55	.824	-0.45	-2.48, 1.57	.660
Rural residence at 14	-0.15	-0.81, 0.52	.662	-0.81, 0.52	-0.80, 0.53	.685	-0.14	-0.80, 0.53	.685	-0.19	-0.85, 0.48	.581	-0.15	-0.81, 0.52	.661
Birth year	-0.01	-0.13, 0.11	.840	-0.13, 0.11	-0.14, 0.11	.823	-0.01	-0.14, 0.11	.823	-0.01	-0.13, 0.11	.885	-0.01	-0.14, 0.11	.833
Female × education	-0.00	-0.25, 0.24	.992	-0.25, 0.24	-0.43, 0.13	.301	-0.15	-0.43, 0.13	.301						
Black × education					-0.48, 0.19	.402	-0.14	-0.48, 0.19	.402						
Hispanic × education					-0.31, 0.73	.419	0.21	-0.31, 0.73	.419						
Other race × education															
Low cSES × education										0.39	0.06, 0.72	.020			
Immigrant × education													0.24	-0.28, 0.75	.367

Education is centered at 12 years, and birth year is centered at 1960 so the constant is interpretable. Education is coded linearly as years of education; a 1-unit increase in education is a 1-year increase in schooling. The reference group is White men born in the United States, outside the South, who lived in nonrural areas at age 14 years and whose mothers completed 12 or more years of schooling; because each analytic model varies in the interaction terms included, the interpretation of the main effect for education similarly varies across models. Interaction term coefficients indicate the additional difference in PCS associated with each year of education; positive interaction terms indicate the demographic group benefited more from each year of education than the reference group, while negative interaction terms indicate the demographic group benefited less from each year of education than the reference group. To calculate the change in PCS for a 1-year increase in education for a specific demographic group, sum the coefficient for the main effect for education with the coefficient for the interaction term.

Latino ethnicity = 1.17; 95% CI: 0.34, 2.00), low cSES ($\beta = -0.61$; 95% CI: -1.24, 0.02), and birth year ($\beta = 0.16$; 95% CI: 0.04, 0.27). The effect of each year of education was large among those born in the United States ($\beta = 0.76$; 95% CI: 0.46, 1.05), but smaller among immigrants to the United States (interaction $\beta = -0.94$; 95% CI: -1.86, -0.02). Geographic factors did not modify the relationship between education and MCS (Appendix Table S4). Results for MCS at age 40 years were smaller in magnitude, but in the same direction (Appendix Tables S7 and S8).

Intersectionality models

There was no evidence of differential returns in predicting PCS in models that examined intersectional effect modification by sex and race/ethnicity (Table 4). However, in predicting MCS, there was evidence of differential returns such that the association was imprecisely estimated for White men ($\beta = 0.44$; 95% CI: -0.03, 0.90), while Black women benefited from each year of education (interaction $\beta = 0.91$; 95% CI: 0.19, 1.64). Similarly, in intersectional models for effect modification by cSES and race/ethnicity, there was no evidence of differential effects of education in predicting PCS; in predicting MCS, on the other hand, MCS was higher with each year of education for high cSES Whites ($\beta = 0.19$; 95% CI: 0.03, 0.35) and higher still for low cSES Blacks (interaction $\beta = 0.61$; 95% CI: 0.21, 1.00). Finally, in intersectional models for effect modification by cSES and sex, there was no evidence of differential effects of education in predicting PCS; in predicting MCS, there was no relationship between education and MCS among high cSES men ($\beta = 0.07$; 95% CI: -0.39, 0.54); however, high cSES women ($\beta = 1.32$; 95% CI: 0.46, 2.18), and low cSES women ($\beta = 0.75$; 95% CI: 0.01, 1.49), benefited from each year of education.

Discussion

Among a national sample of U.S. middle-aged adults, we found evidence that the benefits of education for self-reported measures of physical and mental health differed across sociodemographic groups. In terms of physical health, individuals who experienced childhood socioeconomic disadvantage benefited more from each year of education than socially advantaged groups. In terms of mental health, immigrants to the United States benefitted less from each year of education while Black women, low cSES Blacks, and low and high cSES women benefitted more than socially advantaged groups. These findings have implications for addressing health inequities.

Work examining the Korean War and Vietnam War GI Bills, which provided generous college education subsidies to qualifying veterans, found that such education-promoting policies predicted smaller socioeconomic disparities in physical [31], mental [32], and cognitive [33] health among older adults by disproportionately benefiting low cSES veterans. The current findings are consistent with those results for physical health and extend results to a middle-aged sample and more recent birth cohorts. This suggests that the disproportionate benefit from educational attainment for low cSES subgroups is not isolated to specific birth cohorts or age groups. Investing in programs and policies that facilitate increased educational attainment among low cSES groups in the present may pay dividends toward a future with smaller health inequities. Our results add additional weight to the argument that interventions to increase educational attainment could be a powerful mechanism for reducing health inequities among individuals who experienced socioeconomic adversity in early life.

We additionally found that immigrants to the United States benefitted less from each year of education in terms of their mental health. These findings could reflect that immigrants to the United

Table 3
MCS at age 50 years: main effects and demographic interactions, weighted to 2014

Variables	Base model			Female interaction			Race interaction			cSES interaction			Immigrant interaction		
	Beta	95% CI	P-value	Beta	95% CI	P-value	Beta	95% CI	P-value	Beta	95% CI	P-value	Beta	95% CI	P-value
Constant	53.88	53.42, 54.33	<.0005	53.91	53.46, 54.37	<.0005	53.88	53.42, 54.34	<.0005	53.91	53.43, 54.39	<.0005	53.87	53.42, 54.32	<.0005
Education	0.73	0.44, 1.02	<.0005	0.51	0.14, 0.87	.007	0.74	0.37, 1.11	<.0005	0.65	0.24, 1.07	.002	0.76	0.46, 1.05	<.0005
Female	-2.39	-2.90, -1.89	<.0005	-2.48	-3.01, -1.95	<.0005	-2.39	-2.90, -1.89	<.0005	-2.39	-2.90, -1.89	<.0005	-2.40	-2.90, -1.89	<.0005
Black	0.26	-0.34, 0.86	.390	0.24	-0.35, 0.84	.422	0.26	-0.34, 0.87	.394	0.25	-0.35, 0.85	.417	0.26	-0.33, 0.86	.387
Hispanic/Latino	1.17	0.34, 2.00	.006	1.16	0.33, 1.99	.006	1.15	0.32, 1.98	.006	1.16	0.33, 1.99	.006	1.10	0.27, 1.93	.009
Other race/missing	0.74	-0.30, 1.77	.162	0.71	-0.32, 1.75	.134	0.84	-0.26, 1.95	.134	0.75	-0.29, 1.78	.156	0.75	-0.28, 1.79	.153
Low cSES	-0.61	-1.24, 0.02	.056	-0.60	-1.23, 0.03	.061	-0.62	-1.25, 0.01	.054	-0.62	-1.26, 0.01	.054	-0.61	-1.24, 0.02	.056
Southern birth	0.01	-0.57, 0.59	.968	0.01	-0.57, 0.58	.986	-0.00	-0.58, 0.58	.993	0.02	-0.56, 0.60	.953	0.02	-0.56, 0.60	.944
Immigrant	-0.61	-2.05, 0.83	.407	-0.60	-2.03, 0.84	.415	-0.61	-2.04, 0.83	.408	-0.61	-2.05, 0.83	.408	-0.62	-1.85, 0.99	.550
Rural residence at 14	0.70	0.09, 1.30	.024	0.70	0.09, 1.30	.024	0.69	0.08, 1.29	.026	0.69	0.08, 1.29	.026	0.70	0.09, 1.30	.024
Birth year	0.16	0.04, 0.27	.009	0.16	0.04, 0.27	.009	0.16	0.04, 0.27	.009	0.15	0.04, 0.27	.009	0.16	0.04, 0.27	.009
Female × education			.082	0.49	-0.06, 1.04										
Black × education							0.25	-0.33, 0.83	.400						
Hispanic × education							-0.19	-0.80, 0.41	.535						
Other race × education							-0.47	-1.54, 0.59	.386						
cSES × education										0.14	-0.44, 0.71	.635			
Immigrant × education													-0.94	-1.86, -0.02	.046

Education is centered at 12 years, and birth year is centered at 1960 so the constant is interpretable. Education is coded linearly as years of education until 13 years, and flat thereafter (i.e., everything after 13 years of schooling is recoded as 13 years because we found this specification was the best fit for the MCS data). A 1-unit increase in education is a 1-year increase in schooling until 13 years.
 The reference group is White men born in the United States, outside the South, who lived in nonrural areas at age 14 years and whose mother's completed 12 or more years of schooling; because each analytic model varies in the interaction terms included, the interpretation of the reference group similarly varies across models.
 Interaction term coefficients indicate the additional difference in MCS associated with each year of education; positive interaction terms indicate the demographic group benefited more from each year of education than the reference group, while negative interaction terms indicate the demographic group benefited less from each year of education than the reference group. To calculate the change in MCS for a 1-year increase in education for a specific demographic group, sum the coefficient for the main effect for education with the coefficient for the interaction term.

States, unlike their U.S.-born peers, are made to navigate hostile environments, resulting in poorer mental health [9]. The chronic stress of possible deportation could deteriorate the mental health of immigrant communities as prior work suggests that immigration raids predict more stress, poorer self-rated health [34], and higher rates of low birth weight babies [35] among remaining community members following the raid. Our results may additionally reflect that immigrants to the United States are employed in higher stress jobs, which have been linked to poorer mental health [36], or that non-native English speakers gain less knowledge and skills from each year of education, resulting in smaller health returns to education.

Finally, in intersectionality models, we found that Black women, low cSES Blacks, and low and high cSES women benefited more in terms of their mental health from each year of education than socially advantaged groups, suggesting that programs and policies to increase educational attainment among these groups could reduce racial and socioeconomic inequities in mental health. These findings are particularly important given that Black women tend to have worse mental health than other groups [37–39]. Our finding that certain vulnerable subgroups benefit more from each year of education in terms of their mental health suggests these groups may be leveraging the additional skills and resources that come with each year of education to attain better mental health. These results are consistent with previous findings that women [4], low cSES groups [31–33], and Black women [5] benefit more from education in predicting health.

Our analyses were motivated by a conceptual model of multiple pathways through which sociodemographic groups may be differentially impacted by educational attainment (Fig. 1). Our findings that socially vulnerable groups (low cSES, Black women, low cSES Blacks, and high and low cSES women) benefit more than socially advantaged groups from each year of education is consistent with the resource substitution theory [4]. For example, resources including education (quality or quantity), power, authority, earnings, and knowledge all impact health such that more of these resources predicts better health. Socially marginalized groups have less access to all of these resources compared to socially advantaged groups, making marginalized groups more dependent on the resources to which they have access, such as education. This may explain why we found that certain population subgroups benefit more than socially advantaged groups from each year of schooling—because these resources can substitute for each other, those who have limited access to alternative resources are more dependent on education, and therefore they benefit more from each year of education [4,5].

Differences in access to resources exist because certain groups are marginalized within society. We believe these larger societal determinants of health are the reason socially marginalized groups have fewer alternative resources such as empowerment, knowledge, and earnings. That is, we observe that socially marginalized groups benefit more from each year of education in predicting health because, on a population level, society has created structural barriers to prevent them from accessing these health-promoting alternatives.

We were surprised to find little evidence of a differential effect of education among Black men, given prior work suggesting the effects of structural racism are particularly damaging for Black boys [21,22] (i.e. we hypothesized that Black men would benefit less from each year of education than other groups [5,23,24]). It is possible that our self-reported outcome measures were not sensitive enough to detect these changes, that health differentials among Black men may not yet be detectable at age 50 years, or that the Black men most affected were excluded from our sample due to incarceration or early mortality [40,41]. Our analysis included birth

Table 4
Intersectionality models, weighted to 2014

Sociodemographic groups	PCS						MCS					
	Intersectionality: race × sex											
	Base model			Race × sex interactions			Base model			Race × sex interactions		
	Beta	95% CI	P-value	Beta	95% CI	P-value	Beta	95% CI	P-value	Beta	95% CI	P-value
Constant (White men)	50.62	50.08, 51.16	<.0005	50.61	50.01, 51.22	<.0005	53.95	53.47, 54.43	<.0005	54.01	53.51, 54.50	<.0005
Education	0.91	0.79, 1.04	<.0005	0.92	0.73, 1.10	<.0005	0.73	0.44, 1.02	<.0005	0.44	-0.03, 0.90	.066
White women	-1.73	-2.39, -1.08	<.0005	-1.74	-2.58, -0.89	<.0005	-2.54	-3.16, -1.91	<.0005	-2.68	-3.35, -2.01	<.0005
Black men	0.09	-0.80, 0.97	.848	0.22	-0.76, 1.19	.661	-0.11	-0.90, 0.67	.773	-0.18	-0.96, 0.61	.658
Black women	-2.72	-3.62, -1.83	<.0005	-2.77	-3.81, -1.73	<.0005	-1.89	-2.69, -1.10	<.0005	-2.03	-2.84, -1.22	<.0005
Hispanic/Latino men	0.46	-0.70, 1.63	.437	0.48	-0.78, 1.74	.456	0.63	-0.41, 1.68	.234	0.58	-0.47, 1.63	.279
Hispanic/Latino women	-0.50	-1.89, 0.89	.484	-0.38	-1.84, 1.08	.612	-0.86	-2.00, 0.27	.136	-0.97	-2.10, 0.17	.095
White women × education				0.00	-0.29, 0.30	.990				0.65	-0.06, 1.37	.075
Black men × education				-0.30	-0.68, 0.08	.119				0.22	-0.62, 1.06	.608
Black women × education				0.06	-0.33, 0.45	.763				0.91	0.19, 1.64	.014
Hispanic men × education				0.00	-0.44, 0.43	.983				0.36	-0.42, 1.14	.364
Hispanic/Latino women × education				-0.29	-0.77, 0.20	.249				-0.13	-0.99, 0.74	.775
	Intersectionality: cSES × race											
	Base model			cSES × race interactions			Base model			cSES × race interactions		
	Beta	95% CI	P-value	Beta	95% CI	P-value	Beta	95% CI	P-value	Beta	95% CI	P-value
Constant (White, high cSES)	50.65	50.13, 51.18	<.0005	50.77	50.20, 51.33	<.0005	53.76	53.26, 54.26	<.0005	53.90	53.37, 54.43	<.0005
Education	0.91	0.78, 1.04	<.0005	0.83	0.67, 0.99	<.0005	0.26	0.14, 0.39	<.0005	0.19	0.03, 0.35	.023
White, low cSES	-1.64	-2.51, -0.78	<.0005	-1.75	-2.65, -0.84	<.0005	-0.78	-1.59, 0.03	.058	-0.90	-1.74, -0.06	.035
Black, high cSES	-0.82	-1.63, -0.00	.049	-0.64	-1.66, 0.38	.216	0.01	-0.74, 0.76	.983	-0.26	-1.17, 0.65	.573
Black, low cSES	-1.71	-2.63, -0.79	<.0005	-1.88	-2.85, -0.92	<.0005	-0.08	-0.85, 0.70	.848	-0.27	-1.09, 0.55	.518
Hispanic/Latino, high cSES	0.84	-0.62, 2.30	.259	1.15	-0.85, 2.15	.261	1.68	0.51, 2.85	.005	1.54	0.05, 3.04	.043
Hispanic/Latino, low cSES	-0.72	-1.83, 0.40	.208	-0.86	-1.99, 0.27	.136	0.27	-0.67, 1.21	.575	0.15	-0.81, 1.10	.762
White, low cSES × education				0.38	-0.08, 0.83	.105				0.21	-0.23, 0.65	.356
Black, high cSES × education				-0.21	-0.58, 0.15	.254				0.19	-0.18, 0.57	.309
Black, low cSES × education				0.19	-0.21, 0.58	.354				0.61	0.21, 1.00	.002
Hispanic/Latino, high cSES × education				-0.22	-0.74, 0.30	.415				0.08	-0.35, 0.51	.725
Hispanic/Latino, low cSES × education				0.01	-0.49, 0.50	.978				0.33	-0.09, 0.76	.127
	Intersectionality: cSES × sex											
	Base model			cSES × sex interactions			Base model			cSES × sex interactions		
	Beta	95% CI	P-value	Beta	95% CI	P-value	Beta	95% CI	P-value	Beta	95% CI	P-value
Constant (high cSES men)	50.68	50.16, 51.21	<.0005	50.87	50.27, 51.46	<.0005	53.92	53.46, 54.38	<.0005	54.19	53.70, 54.68	<.0005
Education	0.91	0.78, 1.04	<.0005	0.80	0.64, 0.96	<.0005	0.73	0.44, 1.02	<.0005	0.07	-0.39, 0.54	.760
High cSES women	-1.85	-2.47, -1.22	<.0005	-1.87	-2.76, -0.99	<.0005	-2.49	-3.09, -1.89	<.0005	-3.06	-3.83, -2.30	<.0005
Low cSES men	-1.78	-2.66, -0.90	<.0005	-1.92	-2.85, -0.99	<.0005	-0.77	-1.56, 0.02	.056	-1.02	-1.80, -0.23	.012
Low cSES women	-3.21	-4.10, -2.31	<.0005	-3.39	-4.34, -2.44	<.0005	-2.96	-3.78, -2.14	<.0005	-3.19	-4.02, -2.36	<.0005
High cSES women × education				0.02	-0.26, 0.30	.886				1.32	0.46, 2.18	.003
Low cSES men × education				0.38	-0.05, 0.82	.085				0.68	-0.04, 1.40	.064
Low cSES women × education				0.41	-0.06, 0.89	.086				0.75	0.01, 1.49	.048

Education is centered at 12 years, and birth year is centered at 1960 so the constant is interpretable.

For PCS, education is coded linearly as years of education; a 1-unit increase in education is a 1-year increase in schooling.

For MCS, education is coded linearly as years of education until 13 years, and flat thereafter (i.e., everything after 13 years of schooling is recoded as 13 years because found this specification was the best fit for the data). A 1-unit increase in education is a 1-year increase in schooling until 13 years.

Models adjusted for all effect modifiers and confounders; we modeled main effects and interactions for other race men and other race women but did not display these results due to ambiguity in interpretation.

The reference group is White men born in the United States, outside the South, who lived in nonrural areas at age 14 years and whose mothers completed 12 or more years of schooling; because each analytic model varies in the interaction terms included, the interpretation of the reference group similarly varies across models.

Interaction term coefficients indicate the additional difference in PCS/MCS associated with each year of education; positive interaction terms indicate the demographic group benefited more from each year of education than the reference group, while negative interaction terms indicate the demographic group benefited less from each year of education than the reference group. To calculate the change in PCS/MCS for a one-year increase in education for a specific demographic group, sum the coefficient for the main effect for education with the coefficient for the interaction term.

cohorts from 1957 to 1964; substantial social changes associated with the Civil Rights Act of 1964 means these results may not be generalizable to older and younger populations. For these reasons, repeating these analyses in other populations with measured health outcomes is an important area for future research.

Limitations

There are some limitations to these analyses. Unmeasured confounding is a concern in this observational study, so causal

inferences merit substantial caution. The broad demographic categories we defined included heterogeneous individuals; for example, immigrants from high-, medium-, and low-income countries were modeled together with a single indicator variable. All data were self-reported; repeating these analyses using objectively measured data to evaluate differential returns to education on health conditions that may not yet be noticed, and therefore cannot be self-reported, is an important area for future research. Because data on the primary sampling units were not available, the standard errors are likely biased downward; estimated design

effects were small, suggesting clustering minimally impacted variance. Our analyses examined quantity of education, so we cannot comment on how variations in quality of education could impact these findings. Finally, we used a complete case approach, meaning those with missing data on the exposure, outcomes, or effect modifiers were excluded from analysis; prior work has argued that complete case approaches can exclude the most socially vulnerable, potentially biasing estimates [42]; given that only 13% of the eligible sample were excluded due to missing data, we expect these biases to be relatively small. Despite these limitations, our article adds to the nascent literature on differential returns to education among socially vulnerable subgroups and is therefore an important contribution to the field.

Conclusion

We found that those who experienced socioeconomic adversity in childhood benefited more from each year of education in predicting physical health, while Black women, low cSES Blacks, and high and low cSES women benefited more from each year of education in predicting mental health compared to socially advantaged groups. We also found that immigrants benefited less from each year of education in predicting mental health compared to those born in the United States. Our results suggest policies and programs that increase quantity of education may help reduce population-level socioeconomic and racial health inequities. Our results further suggest that policies and programs that increase quantity of education will not reduce health inequities among immigrants. We suggest that these differential returns to education exist because of differential access to alternative resources, making socially marginalized groups more dependent on the resources to which they have access, such as education. Replicating these analyses in independent data sources with different birth cohorts and populations would be informative to assess if these findings persist across time, place, and population.

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Appendix

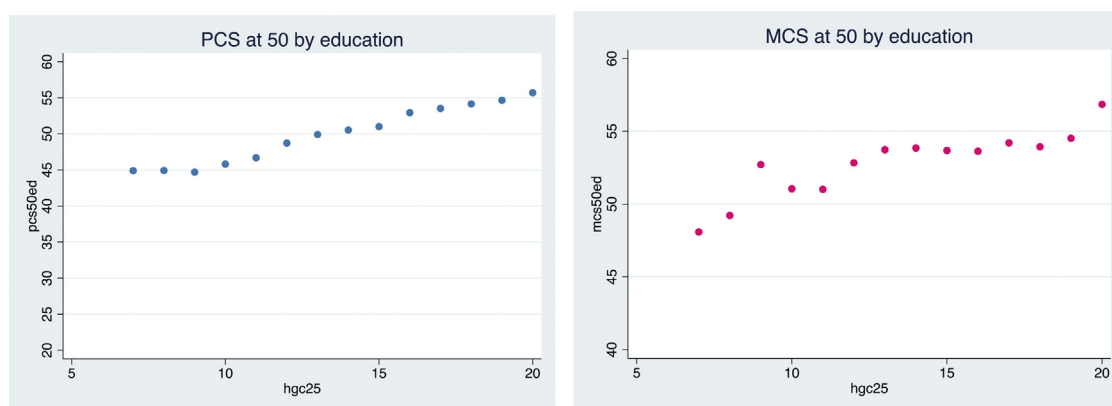


Figure S1. Scatterplots of mean PCS and MCS by each the highest grade attained at age 25 years. PCS appears to have a mostly linear relationship with education, although it may be flat under 9 years. The “data driven” approach we tested for PCS is flat under 9 years, then linear. For the MCS, the relationship with education is linear until 13 years, then flat, which is the “data driven” approach we tested for MCS.

Table S1

Options for modeling education

	PCS		MCS	
	BIC	AIC	BIC	AIC
Nonparametric	507278.1*	7.397166	390815.6*	7.163119
Continuous	508023.1	7.394599	392894.8†	7.163963†
Education credential	510690.4†	7.399685†	392633.7	7.163696
Montez spline	507406.8	7.394471*	391880.7	7.162639
Data driven for PCS: flat relationship under 9 years, then linear ¹	507955.4	7.394478		
Data driven for MCS: flat relationship after 13 years ²			391972.2	7.161882*

Lower BICs and AICs indicate better model fit.

For PCS, the AICs and BICs were similar across different operationalization's of education. There was not persuasive evidence for or against any particular model; for this reason, we operationalized education continuously because it made the most sense in terms of interpretability.

For MCS, the AICs and BICs were similar across different operationalization's of education, although both metrics indicated that continuous education had the worst model fit, so there was evidence not to use continuous. However, because results were not consistent on which model was best, we used the data-driven approach for MCS because it makes sense in terms of the interpretability and it is the best fit by AIC.

* Indicates the best model fit.

† Indicates the worst model fit.

Table S2
Mean educational attainment by age 25 years for demographic subgroups analyzed

Variable	Weighted educational attainment at 25 y
Race—sex subgroups	
Non-Hispanic white men	13.24
Non-Hispanic white women	13.19
Non-Hispanic black men	12.44
Non-Hispanic black women	12.75
Hispanic men	12.38
Hispanic women	12.38
Other race men	13.25
Other race women	13.40
Low cSES	11.93
High cSES	13.65
U.S. born, but outside the South	13.26
Southern born	12.78
Immigrant	13.03
U.S. urban residence at age 14 y	13.17
U.S. rural residence at age 14 y	12.54

Table S3
PCS at 50 years—Geographic interactions, weighted to 2014.

Variables	Southern birth interaction			Rural residence at 14 interaction		
	Beta	95% CI	P-value	Beta	95% CI	P-value
Constant	50.67	50.14, 51.19	<.0005	50.60	50.07, 51.12	<.0005
Education	0.87	0.72, 1.03	<.0005	0.93	0.79, 1.07	<.0005
Female	−1.72	−2.26, −1.18	<.0005	−1.71	−2.25, −1.17	<.0005
Non-Hispanic black	−0.44	−1.12, 0.23	.200	−0.44	−1.12, 0.24	.203
Hispanic	0.86	−0.13, 1.85	.089	0.88	−0.11, 1.88	.081
Other race/missing	0.64	−0.52, 1.79	.282	0.61	−0.55, 1.77	.300
Childhood SES	−1.55	−2.24, −0.86	<.0005	−1.56	−2.26, −0.87	<.0005
Southern birth	−1.05	−1.79, −0.31	.005	−0.95	−1.58, −0.33	.003
Immigrant	−0.21	−1.96, 1.53	.810	−0.21	−1.95, 1.54	.817
Rural residence at 14	−0.15	−0.81, 0.52	.661	−0.05	−0.85, 0.74	.895
Birth year	−0.01	−0.14, 0.11	.830	−0.01	−0.13, 0.11	.853
Southern birth × education	0.11	−0.15, 0.36	.415			
Rural residence at 14 × education				−0.10	−0.40, 0.20	.518

Education is centered at 12 years, and birth year is centered at 1960 so the constant is interpretable.

Education is coded linearly as years of education; a 1-unit increase in education is a 1-year increase in schooling.

Table S4
MCS at 50 years—Geographic interactions, weighted to 2014

Variables	Southern birth interaction			Rural residence at 14 interaction		
	Beta	95% CI	P-value	Beta	95% CI	P-value
Constant	53.91	53.44, 54.37	<.0005	53.86	53.40, 54.32	<.0005
Education	0.63	0.24, 1.03	.002	0.80	0.47, 1.13	<.0005
Female	-2.40	-2.90, -1.89	<.0005	-2.39	-2.90, -1.89	<.0005
Non-Hispanic black	0.26	-0.34, 0.85	.401	0.26	-0.33, 0.86	.387
Hispanic	1.15	0.31, 1.98	.007	1.18	0.35, 2.01	.005
Other race/missing	0.76	-0.27, 1.80	.148	0.72	-0.31, 1.75	.172
Childhood SES	-0.62	-1.25, 0.01	.054	-0.61	-1.24, 0.02	.057
Southern birth	-0.01	-0.60, 0.58	.975	0.01	-0.57, 0.59	.971
Immigrant	-0.62	-2.05, 0.82	.400	-0.61	-2.05, 0.83	.409
Rural residence at 14	0.69	0.09, 1.30	.025	0.73	0.11, 1.36	.022
Birth year	0.15	0.04, 0.27	.009	0.16	0.04, 0.27	.008
Southern birth × education	0.20	-0.35, 0.75	.474			
Rural residence at 14 × education				-0.31	-0.93, 0.32	.335

Education is centered at 12 years, and birth year is centered at 1960 so the constant is interpretable. Education is coded linearly as years of education until 13 years, and flat thereafter (i.e., everything after 13 years of schooling is recoded as 13 years because we found this specification was the best fit for the MCS data). A 1-unit increase in education is a 1-year increase in schooling until 13 years.

Table S5
PCS at 40 years—main effects and demographic interactions, weighted to 2004 (N = 5682)

Variables	Base model			Female interaction			Race interaction			cSES interaction		
	Beta	95% CI	P-value	Beta	95% CI	P-value	Beta	95% CI	P-value	Beta	95% CI	P-value
Constant	52.88	52.45, 53.31	<.0005	52.91	52.45, 53.36	<.0005	52.84	52.40, 53.29	<.0005	53.04	52.60, 53.48	<.0005
Education (y)	0.57	0.46, 0.68	<.0005	0.54	0.41, 0.67	<.0005	0.59	0.46, 0.72	<.0005	0.47	0.36, 0.59	<.0005
Female	-1.34	-1.78, -0.90	<.0005	-1.40	-1.96, -0.83	<.0005	-1.33	-1.77, -0.89	<.0005	-1.35	-1.79, -0.91	<.0005
Non-Hispanic black	-0.12	-0.65, 0.42	.672	-0.12	-0.66, 0.42	.662	0.03	-0.58, 0.63	.924	-0.19	-0.72, 0.34	.488
Hispanic	0.74	0.03, 1.44	.040	0.74	0.03, 1.44	.040	0.81	0.06, 1.56	.035	0.73	0.03, 1.43	.042
Other race/missing	0.60	-0.21, 1.41	.147	0.60	-0.21, 1.41	.149	0.49	-0.62, 1.60	.385	0.64	-0.18, 1.45	.124
Childhood SES	-1.06	-1.63, -0.49	<.0005	-1.05	-1.63, -0.48	<.0005	-1.06	-1.63, -0.49	<.0005	-1.20	-1.80, -0.60	<.0005
Southern birth	-0.33	-0.84, 0.17	.196	-0.34	-0.84, 0.17	.195	-0.33	-0.84, 0.17	.198	-0.28	-0.79, 0.22	.272
Immigrant	1.00	0.13, 1.87	.025	1.00	0.13, 1.88	.025	1.00	0.13, 1.88	.024	1.00	0.13, 1.87	.024
Rural residence at 14	0.41	-0.11, 0.92	.123	0.41	-0.11, 0.92	.123	0.42	-0.10, 0.93	.115	0.37	-0.14, 0.89	.157
Birth year	-0.00	-0.10, 0.09	.925	-0.01	-0.10, 0.09	.921	-0.01	-0.10, 0.09	.919	-0.00	-0.10, 0.10	.968
Female × education				0.05	-0.16, 0.26	.649						
Non-Hispanic black × education							-0.22	-0.45, 0.01	.063			
Hispanic × education							-0.13	-0.41, 0.14	.340			
Other race × education							0.08	-0.28, 0.43	.667			
cSES × education										0.35	0.07, 0.62	.013

Education is centered at 12 years, and birth year is centered at 1960 so the constant is interpretable. Education is coded linearly as years of education; a 1-unit increase in education is a 1-year increase in schooling.

Table S6
PCS at 40 years—geographic interactions, weighted to 2004 (N = 5682)

Variables	Immigrant interaction			Southern birth interaction			Rural residence at 14 interaction		
	Beta	95% CI	P-value	Beta	95% CI	P-value	Beta	95% CI	P-value
Constant	52.87	52.44, 53.29	<.0005	52.87	52.43, 53.32	<.0005	52.88	52.44, 53.32	<.0005
Education (y)	0.58	0.47, 0.69	<.0005	0.57	0.45, 0.70	<.0005	0.57	0.44, 0.69	<.0005
Female	-1.34	-1.78, -0.90	<.0005	-1.34	-1.78, -0.90	<.0005	-1.34	-1.78, -0.90	<.0005
Non-Hispanic black	-0.11	-0.65, 0.43	.686	-0.12	-0.66, 0.42	.670	-0.12	-0.65, 0.42	.673
Hispanic	0.70	-0.00, 1.40	.050	0.74	0.04, 1.44	.039	0.74	0.03, 1.44	.041
Other race/missing	0.63	-0.18, 1.43	.129	0.60	-0.22, 1.41	.151	0.60	-0.21, 1.41	.148
Childhood SES	-1.06	-1.63, -0.49	<.0005	-1.06	-1.63, -0.49	<.0005	-1.06	-1.63, -0.49	<.0005
Southern birth	-0.33	-0.84, 0.18	.205	-0.31	-0.94, 0.31	.329	-0.33	-0.84, 0.17	.196
Immigrant	1.48	0.59, 2.37	.001	1.00	0.13, 1.88	.025	1.00	0.13, 1.87	.025
Rural residence at 14	0.41	-0.11, 0.92	.121	0.41	-0.11, 0.92	.123	0.41	-0.24, 1.05	.218
Birth year	-0.00	-0.10, 0.09	.944	-0.00	-0.10, 0.09	.930	-0.00	-0.10, 0.09	.926
Immigrant × education	-0.43	-0.79, -0.07	.020						
Southern birth × education				-0.02	-0.25, 0.20	.840			
Rural residence at 14 × education							-0.00	-0.24, 0.24	.994

Education is centered at 12 years, and birth year is centered at 1960 so the constant is interpretable.

Education is coded linearly as years of education; a 1-unit increase in education is a 1-year increase in schooling.

Table S7
MCS at 40 years—main effects and demographic interactions, weighted to 2004 (N = 5682)

Variables	Base model			Female interaction			Race interaction			cSES interaction		
	Beta	95% CI	P-value	Beta	95% CI	P-value	Beta	95% CI	P-value	Beta	95% CI	P-value
Constant	54.09	53.64, 54.54	<.0005	54.09	53.63, 54.55	<.0005	54.05	53.59, 54.51	<.0005	54.08	53.63, 54.53	<.0005
Education (y)	0.59	0.31, 0.87	<.0005	0.56	0.18, 0.95	.004	0.71	0.33, 1.08	<.0005	0.60	0.25, 0.94	.001
Female	-2.21	-2.68, -1.73	<.0005	-2.22	-2.72, -1.71	<.0005	-2.20	-2.68, -1.72	<.0005	-2.21	-2.68, -1.73	<.0005
Non-Hispanic black	0.63	0.05, 1.21	.034	0.63	0.04, 1.21	.035	0.66	0.07, 1.25	.029	0.63	0.05, 1.21	.033
Hispanic	1.20	0.38, 2.03	.004	1.20	0.38, 2.03	.004	1.18	0.36, 2.00	.005	1.20	0.38, 2.03	.004
Other race/missing	0.81	-0.09, 1.70	.076	0.81	-0.09, 1.70	.078	0.90	-0.04, 1.85	.062	0.81	-0.09, 1.70	.077
Childhood SES	-0.89	-1.48, -0.29	.003	-0.88	-1.48, -0.29	.003	-0.87	-1.46, -0.28	.004	-0.88	-1.48, -0.29	.004
Southern birth	0.13	-0.42, 0.67	.651	0.12	-0.42, 0.67	.654	0.12	-0.42, 0.67	.653	0.12	-0.42, 0.67	.653
Immigrant	-0.88	-2.25, 0.49	.210	-0.88	-2.25, 0.49	.210	-0.87	-2.24, 0.50	.215	-0.88	-2.25, 0.49	.210
Rural residence at 14	0.25	-0.33, 0.84	.394	0.25	-0.33, 0.84	.394	0.25	-0.34, 0.84	.402	0.26	-0.33, 0.84	.392
Birth year	0.02	-0.09, 0.12	.772	0.02	-0.09, 0.12	.772	0.02	-0.09, 0.12	.741	0.02	-0.09, 0.12	.771
Female × education				0.05	-0.49, 0.59	.862						
Non-Hispanic black × education							-0.33	-0.85, 0.19	.218			
Hispanic × education							-0.46	-1.07, 0.16	.144			
Other race × education							-0.43	-1.32, 0.47	.349			
cSES × education										-0.02	-0.55, 0.52	.953

Education is centered at 12 years, and birth year is centered at 1960 so the constant is interpretable.

Education is coded linearly as years of education until 13 years, and flat thereafter (i.e., everything after 13 years of schooling is recoded as 13 years because we found this specification was the best fit for the MCS data). A 1-unit increase in education is a 1-year increase in schooling until 13 years.

Table S8
MCS at 40 years—geographic interactions, weighted to 2004 (N = 5682)

Variables	Southern birth interaction			Immigrant interaction			Rural residence at 14 interaction		
	Beta	95% CI	P-value	Beta	95% CI	P-value	Beta	95% CI	P-value
Constant	54.08	53.63, 54.53	<.0005	54.09	53.62, 54.56	<.0005	54.07	53.61, 54.52	<.0005
Education	0.60	0.31, 0.88	<.0005	0.57	0.16, 0.97	.006	0.67	0.35, 0.99	<.0005
Female	-2.21	-2.69, -1.73	<.0005	-2.21	-2.69, -1.73	<.0005	-2.21	-2.68, -1.73	<.0005
Non-Hispanic black	0.63	0.05, 1.21	.034	0.63	0.04, 1.21	.035	0.63	0.05, 1.21	.034
Hispanic	1.18	0.36, 2.01	.005	1.20	0.37, 2.03	.005	1.23	0.40, 2.06	.004
Other race/missing	0.81	-0.08, 1.71	.074	0.81	-0.08, 1.71	.074	0.78	-0.11, 1.68	.086
Childhood SES	-0.89	-1.48, -0.29	.003	-0.89	-1.48, -0.29	.003	-0.88	-1.48, -0.29	.003
Southern birth	0.13	-0.41, 0.67	.643	0.12	-0.44, 0.68	.671	0.13	-0.42, 0.67	.648
Immigrant	-0.81	-2.18, 0.56	.248	-0.88	-2.25, 0.49	.209	-0.87	-2.25, 0.50	.211
Rural residence at 14	0.25	-0.33, 0.84	.393	0.25	-0.33, 0.84	.398	0.31	-0.29, 0.91	.317
Birth year	0.02	-0.09, 0.12	.768	0.02	-0.09, 0.12	.775	0.02	-0.09, 0.12	.745
Immigrant × education	-0.33	-1.49, 0.84	.585						
Southern birth × education				0.04	-0.51, 0.59	.884			
Rural residence at 14 × education							-0.37	-0.99, 0.24	.231

Education is centered at 12 years, and birth year is centered at 1960 so the constant is interpretable. Education is coded linearly as years of education until 13 years, and flat thereafter (i.e., everything after 13 years of schooling is recoded as 13 years because we found this specification was the best fit for the MCS data). A 1-unit increase in education is a 1-year increase in schooling until 13 years.

Table S9
Differential returns to education by cSES, with cSES operationalized as father's education (N = 5417)

	PCS						MCS					
	Base model			cSES interaction			Base model			cSES interaction		
	Beta	95% CI	P-value	Beta	95% CI	P-value	Beta	95% CI	P-value	Beta	95% CI	P-value
Constant (high cSES)	50.60	50.07, 51.14	<.0005	50.81	50.25, 51.37	<.0005	53.88	53.39, 54.37	<.0005	53.82	53.29, 54.35	<.0005
Education	0.93	0.79, 1.06	<.0005	0.81	0.67, 0.96	<.0005	0.83	0.51, 1.16	<.0005	0.95	0.45, 1.44	<.0005
Low cSES	-1.17	-1.85, -0.49	.001	-1.38	-2.13, -0.64	<.0005	-0.31	-0.95, 0.32	.337	-0.28	-0.94, 0.38	.400
Low cSES × education				0.37	0.05, 0.68	.022				-0.19	-0.83, 0.46	.570

Education is centered at 12, and birth year is centered at 1960 so the constant is interpretable. For PCS, education is coded linearly as years of education; a 1-unit increase in education is a 1-year increase in schooling. For MCS, education is coded linearly as years of education until 13 years, and flat thereafter (i.e., everything after 13 years of schooling is recoded as 13 years because found this specification was the best fit for the data). A 1-unit increase in education is a 1-year increase in schooling until 13 years. Models adjusted for cSES, birth place, and rural residence at age 14 years; we modeled main effects and interactions for other race men and other race women but did not display these results due to ambiguity in interpretation. There were $n = 741$ individuals missing father's education, so the sample size for this analysis was smaller than the main analysis. Those missing father's education were disproportionately black (55%).