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Impact of Educational Attainment on Time to Cognitive Decline among Marginalized Older Adults: Cohort Study of 20,311 Adults

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Abstract

Background: The effect of years of education on maintenance of healthy cognitive functioning may differ by race and ethnicity given historical and ongoing inequities in educational quality.

Methods: We examined 20,311 Black, Latinx, and White adults aged 51–100 from the Health and Retirement Study (2008–2016). Telephone Interview for Cognitive Status-27 data were used to measure cognitive functioning. Generalized additive mixed models were stratified by race and ethnicity and educational attainment (≥12 vs. <12 years). Selected social determinants of health, all-cause mortality, time-varying health and healthcare utilization characteristics, and study wave were included as covariates.

Results: On average, Black and Latinx adults scored lower at baseline compared to White adults regardless of educational attainment (p<.001), with a significant overlap in the distributions of scores. The rate of cognitive decline was non-linear for Black, Latinx, and White adults (p<.001), and a period of stability was witnessed for those with higher educational attainment irrespective of race and ethnicity. Compared to Black, Latinx, and White adults with lower educational attainment, higher-educated White adults received the greatest protection from cognitive decline

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(13 years; 64 vs. 51), followed by Latinx (12 years; 67 vs. 55), and Black adults (10 years; 61 vs. 51). Latinx adults experienced cognitive decline beginning at a later age.

Conclusions: The extent to which higher educational attainment protects adults from cognitive decline differs by race and ethnicity, such that higher-educated White adults received a greater benefit than higher-educated Black or Latinx adults.

Keywords

Cognitive Reserve; Educational Achievement; Cognitive Trajectory; African American; Hispanic

INTRODUCTION

Cognitive reserve protects individuals from displaying clinically-significant cognitive decline, even if Alzheimer's disease and related dementias (ADRD) neuropathology is present.[1–4] Moreover, greater number of years of education is associated with higher cognitive reserve (i.e., efficiency of neuronal networks to support cognitive functions) and higher brain reserve (i.e., neurobiological capital such as the number of available neurons or dendritic connections).[5,6] A meta-analysis of 15 prospective cohort studies suggested that, for each additional year of education, the risk of ADRD may be reduced by 6% to 8%, with a dose-response relationship.[7] However, *quality* of education in the United States (U.S.) is inequitable across racial and ethnic groups, and this inequity may affect cognitive/brain reserve for marginalized adults.[8]

Black and Latinx adults born in the early-1900s were subject to inequities in the quality of education during legal segregation, and although *Brown v. Board of Education* dismantled legal segregation in 1954, inequities in education quality and access to higher education have persisted through the *Jim Crow Era* to present day.[9] Though educational quality, student achievement, and attendance of higher education have improved for Black and Latinx children and young adults in the U.S.,[10] educational quality still remains inequitable, in part due to systemic racism[11] and disparities in public school funding that are influenced by income[12] and housing inequities.[13] In addition to educational quality, socioenvironmental factors such as occupational complexity,[14] access to leisure activities,[15] and social engagement[16] also impact cognitive/brain reserve and may be inequitable across racial and ethnic groups due to occupational segregation,[17] income inequity and neighborhood socioeconomic disadvantage,[18] and differences in social network size and frequency of socialization.[19]

Cognitive functioning does not decline linearly across the lifespan. In some domains, such as processing speed, the decline begins as early as 30 years of age.[20] Some have asserted a quadratic relationship between age and cognitive functioning (i.e., steeper rate of decline as one ages across the lifespan),[21] and this rate of decline is greater among those with lower years of education.[21–23] Previous work has examined cognitive decline by race and ethnicity using linear mixed effects models with a quadratic term, but found few differences.[24] It may be that meaningful differences in the rate of decline exist, but require non-linear modeling strategies to uncover unique underlying relationships in the data (e.g., a period of linear stability followed by a steep quadratic decline). Additionally, unlike linear models, non-

linear models can be used to measure inflection points to determine at what age cognitive decline begins.

Understanding whether years of education differentially affects the age at which cognitive decline begins by race and ethnicity is important for early deployment of services and supports to manage ADRD. In a recent study, inequities in educational attainment explained a greater proportion of the Latinx-White disparity in cognitive performance (40%) than the Black-White disparity (11%).[25] This may suggest that the effect of attaining additional years of education may not be equivalent among Black, Latinx, and White older adults. Therefore, our study sought to measure the number of *years* that high school or greater education protected adults from cognitive decline, and whether disparities existed when comparing higher-educated Black and Latinx adults to higher-educated White adults. We hypothesized that having completed more years of education (≥12 years vs. <12 years) would provide a protective "buffer" across all participants, but to a greater extent among White adults than among Black and Latinx adults.

METHODS

Participants

The Health and Retirement Study (HRS) is a publicly available prospective cohort study conducted by the University of Michigan and funded by the National Institute on Aging (U01AG009740). This present report used data from the HRS Longitudinal File. Waves from 2008 to 2016 were used because of their greater inclusion of Black and Latinx adults. Inclusion criteria were: 1) aged 51–100 years, 2) identified as non-Latinx Black, Hispanic/Latinx, or non-Latinx White (later referred to as Black, Latinx, and White), and 3) reported years of formal education. Adults identifying as Black, "Other", or White *and* Latinx were categorized as Latinx. Participants were excluded from the analyses if they were missing data on race and ethnicity (n=134), identified as "Other" and not Latinx (n=1,233), were missing data on education (n=97), were not between the ages of 51–100 years (n=1,124), or had missing data on the study covariates (*n*=5,462 excluded; Supplemental Figure 1; see the Limitations section in the Discussion for sensitivity analyses).

Time-varying covariates were included whenever possible. Our analytic sample included 20,331 adults aged 51–100 years from 2008–2016: 3,517 Black, 2,654 Latinx, and 14,160 White. When asked about racial identity, the 2,654 Latinx older adults identified as White (59%, *n*=1,564), "Other" (39%, *n*=1,031), or Black (2%, *n*=59). In order to capture selective attrition due to death, all-cause mortality was dummy coded if the participant died within the follow-up time from 2008–2017 (n=3,864 decedents; 533 Black, 257 Latinx, 3,074 White) and the participants' remaining timepoints were used in the analyses.

Outcome

Global cognition was measured using the Telephone Interview for Cognitive Status (TICS) Langa-Weir 27-point composite approach (see Table 1 Notes).[26] The TICS-27 scoring system is more sensitive to "cognitive impairment no dementia" (CIND; 7–11 points) and suspected ADRD (0–6 points) than the 35-point modified TICS.[27] Global cognition was

measured from 51–100 years, with age used as the x-axis, TICS-27 score as the y-axis, and race and ethnicity as the main independent variable. Models were stratified by education (≥12 years of education vs. <12 years of education).

Covariates

Selected social determinants of health included mother's education (years), father's education (years), number of years worked (years; time-varying), marital status (dummy coded as married, married with an absent spouse, or partnered[1], vs. separated, divorced, widowed, or never married[0]; time-varying), veteran status (yes[1] vs. no[0]), Southern U.S. resident (dummy coded as South[1] vs. or Northeast, Midwest, West, Other U.S. resident[0]; time-varying), nativity status (non-U.S.-born[1] vs. U.S.-born[0]), annual household income in natural-logged U.S. dollars (time-varying), employer-sponsored health insurance coverage (yes[1] vs. no[0]; time-varying), Medicare coverage (yes[1] vs. no[0]; time-varying), and Medicaid coverage (yes[1] vs. no[0]; time-varying). Southern residence was highlighted to capture some of the variability associated with educational disparities in the Jim Crow South.[28,29]

Several health characteristics were included: depressive symptomatology as measured by the Center for Epidemiological Studies-Depression 8 [CES-D; Range 0–8; time-varying], multimorbidity as measured continuously by eight chronic conditions (see Table 1 Notes) [Range 0–8; time-varying], body mass index (BMI; time-varying), whether the participant visited a physician or nurse practitioner within the past two years (yes[1] vs. no[0]; time-varying), and whether the participant had an overnight stay in a hospital within the past two years (yes[1] vs. no[0]; time-varying). Finally, HRS study wave was included as a covariate as well as all-cause mortality during the study (deceased at follow-up[1] vs. living[0]).

Statistical Analyses

We provide descriptive statistics of the baseline characteristics for Black, Latinx, and White participants. Though most were first assessed at Time 1 in 2008 (61%), others had their baseline assessment in 2010 (20%), 2012 (4%), 2014 (2%), or 2016 (13%).

The first goal of this study was to determine whether higher educational attainment would provide a period of cognitive stability equally among Black, Latinx, and White adults (i.e., a flat line suggesting little to no decline before a steep decline in cognitive functioning) compared to those with lower educational attainment. Because cognitive decline is non-linear, we used generalized additive mixed models (GAMMs). GAMMs[30] are a type of machine learning non-linear mixed model that employs smoothing spline functions to estimate polynomial relationships in the data.[31] These models are not restricted to a specific number of "wiggles" or "curves" specified through polynomial terms (e.g., x^2, x^3) like in linear mixed effects models. Each racial and ethnic group was given a smoothing function to model the non-linear relationship between age and cognitive functioning by race and ethnicity.

Models were adjusted for the covariates above, and a smoothed random effect of the intercept was added. Fit was determined with adjusted-R^2. Parametric effects were reported with conventional beta coefficients, standard errors, and *p*-values. Smoothing terms were

added with effective degrees of freedom (EDF) and *p*-values. EDF can be interpreted as the following: a value of 1 represents a linear (straight) line, a value of 2 represents a quadratic line, and so on with greater numbers representing a "wigglier" curve. *p*-values of the smoothing parameters were statistically significant when a horizontal line could not be drawn through the 95% confidence interval of the smoothed line, suggesting a curvilinear relationship.

The second goal of this study was to determine the number of years of "protection" that higher educational attainment would provide before cognitive decline began. In order to determine the age of cognitive decline, the predicted value of cognition (i.e., the GAMM regression line) was split into 1,000 equal sections and the first derivative was computed. In this context, the first derivative characterizes the rate of change (slope) in cognition in each section (i.e., time epoch). A first derivative of zero would indicate a perfectly straight line, whereas a positive first derivative would indicate a positive slope and a negative first derivative would indicate a negative slope. Greater values of the first derivative reveal steeper rates of change (i.e., −0.5 would reflect a steeper rate of decline than −0.1). Derivatives and 95% confidence intervals were plotted, the ages with the shallowest slope were extracted (local maxima), and GAMM regression lines were inspected by race and ethnicity and educational attainment to determine the approximate age of decline (i.e., defined as the age at which future years revealed a steeper negative slope without a period of remittance).

RESULTS

See Table 1 for unadjusted participant characteristics by race and ethnicity. Compared to White adults, Black and Latinx adults were younger, had fewer years of education, came from parents with fewer years of education, worked for fewer years, were less likely to be a veteran, were more likely to live in the U.S. South, reported a lower income, were more likely to be reimbursed through Medicaid and not Medicare, reported higher depressive symptomatology, and were less likely to die during follow-up. Latinx adults were more likely to be born outside of the U.S., had fewer chronic conditions, and had lower utilization of physician visits and inpatient hospital services when compared to Black and White adults, and Black adults were less likely to be married/partnered when compared to Latinx and White adults. Considerable overlap exists in cognitive performance among Black, Latinx, and White participants (Figure 1), suggesting that although mean differences do exist, participants are more alike than they are different on average.

Before fully adjusting the models for covariates (Table 2), Black and Latinx adults obtained lower TICS-27 scores (indicating worse cognitive performance) at baseline on average compared to White adults among those with higher and lower years of education (all $p<.001$; unadjusted results not shown). These findings remained significant after adjusting for covariates (all $p<.001$). Slopes differed by race and ethnicity and by high/low years of education (Figure 2). All smoothing parameters were statistically significant (all $p<.001$), and the EDFs suggested that the rate of cognitive decline was non-linear for Black, Latinx, and White adults (all $p<.001$). Though the rate of cognitive decline was similar among Black, Latinx, and White adults when analyzed in the full sample (Figure 2 Panel 1),

only Black and White adults had a similar rate of decline (with different intercepts) when stratified by years of education (Figure 2 Panels 2 and 3). Notably, Latinx adults' rate of decline was steeper, but it also started at a later age. In the older ages, 95% confidence intervals expanded, suggesting a decrease in prediction accuracy due to smaller sample sizes.

A period of cognitive stability was witnessed in adults with ≥12 years of education regardless of race and ethnicity (Figure 2 Panel 2; Supplemental Figure 2). On average, cognitive decline began to accelerate at age 61 for Black adults, age 67 for Latinx adults, and age 64 for White adults. However, for those with <12 years of education, Black and White adults' acceleration in cognitive decline was evident at age 51, and Latinx adults experienced cognitive decline at age 55 (Figure 2 Panel 3). Compared to those with lower educational attainment, White adults with higher educational attainment received the greatest protection from cognitive decline (13 years; 64 vs. 51), followed by Latinx adults (12 years; 67 vs. 55), and Black adults (10 years; 61 vs. 51).

DISCUSSION

Our study measured the effect of years of education completed on time to cognitive decline among Black, Latinx, and White community-dwelling adults in the U.S. Though cognitive health inequities were found at baseline among Black and Latinx adults, a period of cognitive stability was achieved regardless of race and ethnicity for those with higher educational attainment. The beneficial effect of higher years of education on time to cognitive decline was different across racial and ethnic groups, such that White adults, on average, evidenced the longest benefit of 13 years, followed by Latinx adults with 12 years, and Black adults with 10 years. These findings were consistent after controlling for a variety of socioeconomic, medical, and psychosocial inequities[25,32] that are known to affect cognitive functioning among Black and Latinx adults in addition to selective attrition and decline due to all-cause mortality.

It should be noted that although significant differences were found in group means and the group rate of cognitive decline across the older adult lifespan by race and ethnicity (Figure 2), these differences do not adequately highlight the *variance* within each group. Notably Black, Latinx, and White adults perform more similarly than differently (Figure 1), and generalizations of group means and group rates of decline to individuals' expected performance should not be made. When racial and ethnic differences are found in cognitive test performance, it is important to distinguish between differences in *test performance* vs. differences in the *actual cognitive ability* that the test score is being used to estimate.

Our findings suggest that Black, Latinx, and White older adults with similar years of formal education may test differently and decline at different ages. While part of this disparity may be due to differences in educational quality borne during childhood, another explanation could be test bias. The TICS has shown excellent diagnostic validity for racially and ethnically diverse older adults,[33] but outside of diagnosis, validity may be a concern due to differential item functioning (DIF) (i.e., two adults from different racial or ethnic identities may score differently even if their underlying abilities are equivalent).[34] Forms of test bias

such as stereotype threat, test-wiseness (e.g., knowledge on test-taking strategies that inflate scores), and reaction to test content (e.g., familiarity, practice effects) may lead to inaccurate estimation of performance via DIF.[35–38] Though DIF does explain part of the racial disparity in performance between Black and White adults in the HRS, it does not explain the entire disparity,[34] which does suggest that inequities in educational quality could serve a role. This provides one more of many cogent reasons toward a more equitable distribution of educational dollars and resources to address historical and ongoing disparities in educational access and quality.[9–11]

Though our study attempted to control for potential confounding factors such as socioeconomic status[32] and medical comorbidity,[39,40] it is conceivable that other contextual factors such as educational quality,[41] literacy rates,[41] perceived discrimination,[36,37] stereotype threat,[35] test bias,[38] and inequities in psychosocial health and social determinants of health[25,32,42] influenced participants' cognitive performance. While previous studies have found similar rates of cognitive decline among Black, Latinx, and White adults in the HRS,[24] our study found different rates of decline using non-linear modeling.

Although Black and White adults had modest differences in the rate of decline when examined visually by educational attainment, Latinx adults experienced decline at an older age, which may have been influenced by The Healthy Immigrant Paradox.[43] Compared to U.S.-born Latinx adults, non-U.S.-born Latinx adults appear healthier in population-based studies due to selective migration to their country of origin when becoming ill.[43] Non-U.S.-born Latinx adults have a higher risk of cognitive impairment and ADRD than U.S.-born Latinx and White adults,[44,45] but educational and socioeconomic inequities fully attenuate this disparity. That is, non-U.S.-born Latinx adults have an equivalent or *lower* risk of cognitive impairment and ADRD than White adults when educational and socioeconomic inequities are considered.[44,45] Given that nativity status, socioeconomic status, and health covariates were adjusted for in the present study, it may not be surprising that Latinx adults' rate of cognitive decline was minimal for a longer period of time than White adults and that the benefit of higher educational attainment compared to lower educational attainment was appreciable to White adults.

The most dramatic differences found in this study were between those with and without ≥12 years of education, although racial and ethnic disparities were present between both levels of educational attainment. Thus, there is significant potential for interventions that help build cognitive reserve throughout young adulthood and middle-age. Cognitive reserve is thought to be malleable over the lifecourse[15] and some have suggested that cognitive reserve-enhancing activities such as occupational complexity in middle-age and late-life psychosocial engagement (i.e., physical activity, mental activity, social activity) can bolster cognitive reserve and protect community-dwelling adults from significant cognitive decline regardless of ADRD-related genetic risk.[14,46,47] Across all groups, decline began before the age of 65, suggesting that interventions aimed at prevention of cognitive decline in older adulthood should begin in middle-age or earlier. Seeing that most sociostructural inequities accumulate over the lifespan for marginalized older adults,[48] future work is needed to determine activities that could bolster cognitive reserve for persons experiencing barriers to access, including those related to systemic racism. While efficacy trials of leisure activities

are promising,[49,50] investigators must prioritize the cultural appropriateness, effectiveness, and translatability of their intervention for older adults in diverse and marginalized communities.

Our study had several strengths and limitations. Wherever possible, we included time-varying covariates. This helped to model the non-linear relationships among race and ethnicity, years of education, and cognitive decline. Two covariates had missing data at greater levels than 5% (mother's education at 9%, father's education at 16%). GAMMs were reanalyzed with the 4,910 additional participants excluded due to these covariates, and findings were largely unchanged (Supplemental Figure 3). We also had a large sample of Black and Latinx participants, whereas most studies of cognitive aging are limited in racial and ethnic diversity.

One major limitation was the arbitrary age cutoff of 51 that is used by the HRS. It may be that those with <12 years of education began declining before the age of 50, which should be examined in the future. Another limitation is that the HRS does not capture where the participants received their education (e.g., private vs. public systems, within vs. outside of the U.S.), which may associate with educational quality. The sole measure of cognition was the TICS-27, which is a cognitive screening instrument; future work should examine these patterns across a variety of instruments and cognitive domains. Although the regression splines are more accurate than linear models, estimation error still exists and may be influenced by sample size and practice effects. Notably, our adjusted-R^2 statistics were modest (24%−34%) and suggest that work is needed to more accurately model heterogenous cognitive trajectories.

There also exists some level of sampling bias in the HRS. Latinx participants were predominantly Mexican American immigrants, and Black participants were oversampled from the South where educational quality was particularly poor during the Jim Crow Era. Black segregated school systems in the South pre-1954 had shorter school terms, lower attendance rates, lower per pupil expenditures, and greater rates of illiteracy than White segregated school systems in the South pre-1954.[28,29] Systemic racism and educational bias borne throughout one's lifespan will have substantial impacts on cognitive health in older age, yet we were unable to measure these confounding factors directly. Furthermore, contextual factors that further marginalize Black and Latinx adults such as occupational complexity, job demands and control, and psychosocial support and engagement were not measured and deserve further investigation.

Younger generations of Black and Latinx children and adults have received considerably better educational opportunities in recent years due to federal, state, and community funding/policies that affect social mobility. Our study predominantly included adults from the Greatest Generation, Silent Generation, and Baby Boomer cohorts; therefore, future investigation will be needed to understand whether the inequities recorded by this study will have reduced or widened in future cohorts as Generation X, the Millennials, and Generation Z age.

CONCLUSION

A greater number of years of education is protective of cognitive decline, though this may reflect differences in access to higher-quality education. The effect of years of education on maintenance of healthy cognitive functioning differs by race and ethnicity on average (albeit with substantial overlap of the distributions of the three racial and ethnic groups). White adults with ≥12 years of education show a greater benefit than do similarly educated Latinx or Black adults, even after controlling for potential confounds. Our findings suggest that efforts to improve access to high quality education and social mobility may have long-lasting effects on the risk of cognitive decline in older age.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Key Points:

- The rate of cognitive decline was non-linear for Black, Latinx, and White adults.
- A period of stability was witnessed for those with higher educational attainment irrespective of race and ethnicity.
- Compared to Black, Latinx, and White adults with lower educational attainment, higher-educated White adults received the greatest protection from cognitive decline (13 years; 64 vs 51), followed by Latinx (12 years; 67 vs 55), and Black adults (10 years; 61 vs 51), though Latinx adults experienced cognitive decline beginning at a later age.

Why does this matter?

The effect of years of education on maintenance of healthy cognitive functioning differs by race and ethnicity on average. Our findings suggest that efforts to improve access to high quality education and social mobility may have long-lasting effects on the risk of cognitive decline in older age.

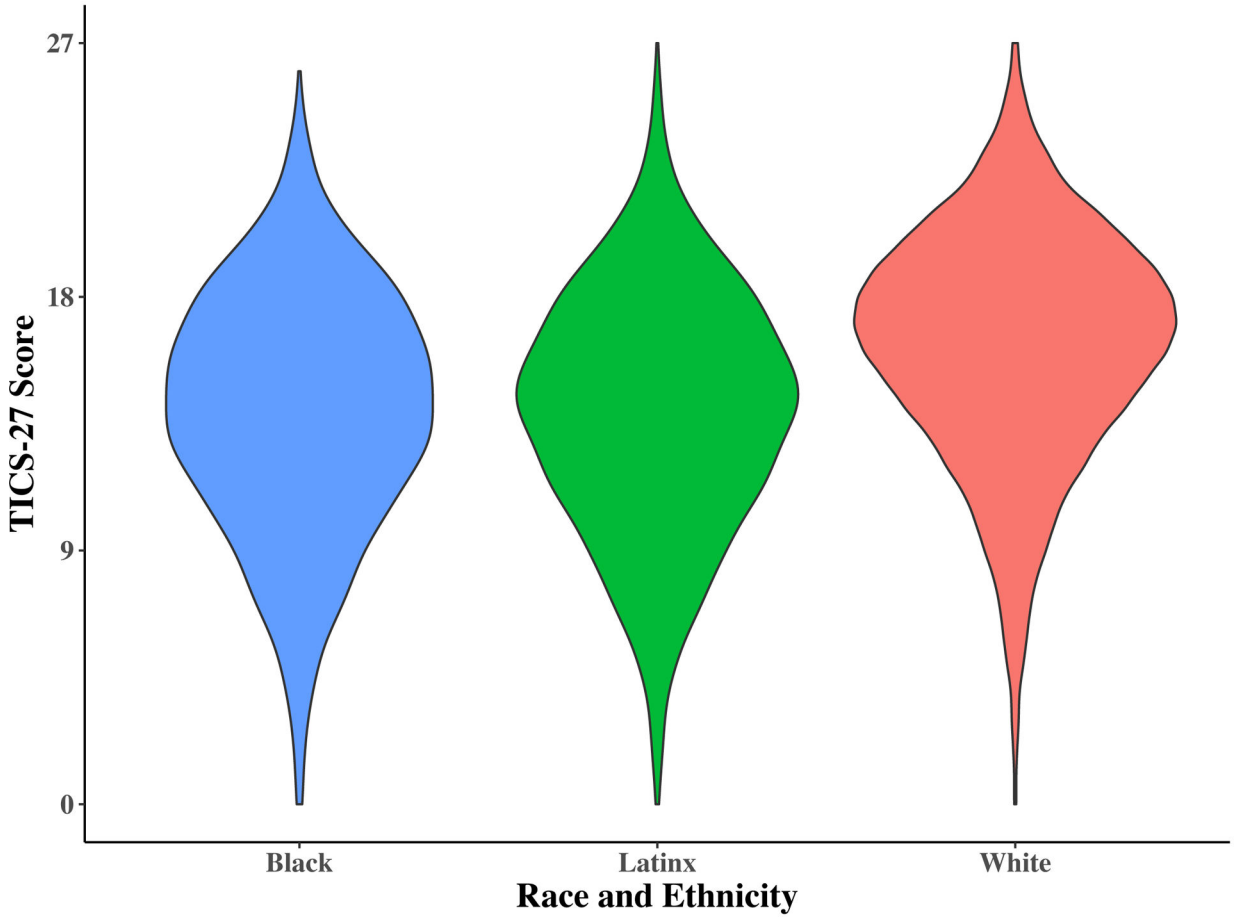

Figure 1.

Violin plot showing considerable overlap in the distributions of TICS-27 score by race and ethnicity at baseline

Note. TICS-27 = Telephone Interview for Cognitive Status – Modified 27-item

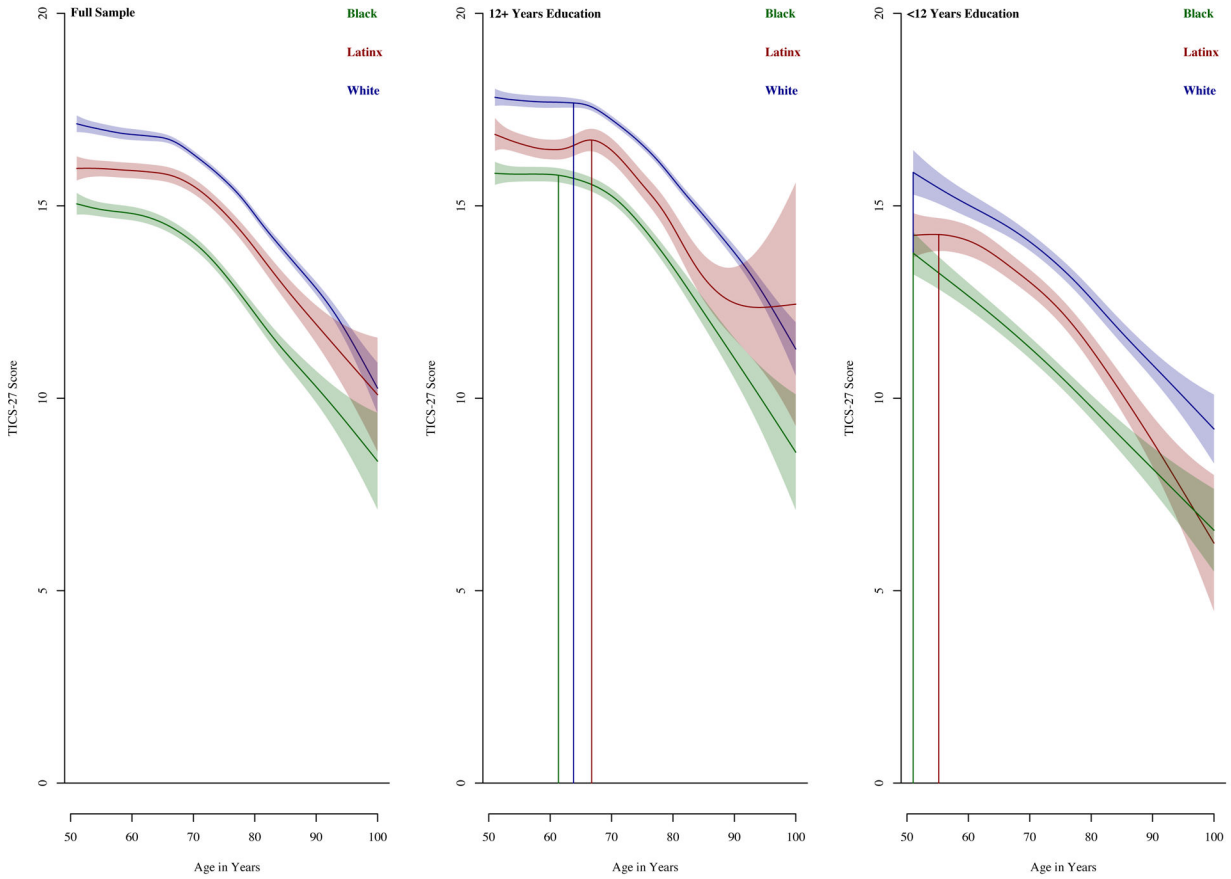

Figure 2.

Generalized additive mixed models measuring the non-linear associations of race and ethnicity, years of education, and TICS-27 score from 51 to 100 years of age

Note. Vertical lines represent the approximate age of cognitive decline. TICS-27 = Telephone Interview for Cognitive Status – Modified 27-item

Table 1.
Participant characteristics by race and ethnicity

Variables	Black		Latinx		White	
Social Determinants of Health	**Mean / %**	**SD / N**	**Mean / %**	**SD / N**	**Mean / %**	**SD / N**
Age (Years)	60.84	9.36	60.29	9.13	65.83	11.07
Male	41%	1,434	45%	1,197	44%	6,198
Education (Years)	12.86	2.75	10.31	4.46	13.50	2.51
Mother's Education (Years)	9.87	3.55	5.98	4.58	10.83	3.03
Father's Education (Years)	9.04	3.83	6.27	4.87	10.53	3.58
Number of Years Worked	25.39	15.53	20.10	15.50	31.89	15.18
Marital Status (Married/Partnered)	51%	1,798	69%	1,841	69%	9,833
Veteran Status	16%	561	8%	222	21%	2,988
Southern U.S. Resident	58%	2,030	41%	1,094	37%	5,264
Nativity Status (Non-U.S.-Born)	8%	271	60%	1,603	4%	604
Income (log-transformed)	$10.03	2.27	$9.66	2.90	$10.80	1.38
Median Income in USD	$32,860		$28,001		$53,637	
Covered by Employer	37%	1,296	26%	679	37%	5,215
Covered by Medicaid	17%	582	18%	486	5%	653
Covered by Medicare	38%	1,352	32%	845	54%	7,596
Health Characteristics	**Mean / %**	**SD / N**	**Mean / %**	**SD / N**	**Mean / %**	**SD / N**
TICS-27 Score	13.88	4.34	13.87	4.29	16.24	4.11
CES-D 8	1.69	2.01	1.90	2.26	1.30	1.88
# of Chronic Conditions	1.91	1.42	1.54	1.39	1.90	1.44
Body Mass Index	30.36	6.75	29.42	5.98	28.10	5.86
Doctor Visit	90%	3,181	81%	2,148	95%	13,399
Hospitalization	25%	870	19%	517	25%	3,601
Mortality	15%	533	10%	257	22%	3,074
Number of Participants	3,517		2,654		14,160	

Note. Baseline date varied, though most were assessed at Time 1 in 2008 (61%). Others had their first assessment in 2010 (20%), 2012 (4%), 2014 (2%), or 2016 (13%). The TICS-27 total score is comprised of immediate recall (10 points), delayed recall (10 points), serial 7s (5 points), and backwards count from 20 and 86 (2 points) subscores. Chronic conditions included: high blood pressure or hypertension; diabetes or high blood sugar; cancer or a malignant tumor of any kind except skin cancer; chronic lung disease except asthma such as chronic bronchitis or emphysema; heart attack, coronary heart disease, angina, congestive heart failure, or other heart problems; stroke or transient ischemic attack; emotional, nervous, or psychiatric problems; and arthritis or rheumatism.

Abbreviations: CES-D = Center for Epidemiological Studies-Depression. TICS-27 = Telephone Interview for Cognitive Status – Modified 27-item. USD = U.S. Dollars.

Table 2.

Generalized additive mixed models measuring the non-linear effect of race and ethnicity on TICS-27 score from 51 to 100 years of age

Parametric Coefficients	**Model 1 Full Sample**		**Model 2 ≥12 Years Education**		**Model 3 <12 Years Education**		**Model 1 *p***	**Model 2 *p***	**Model 3 *p***
Social Determinants of Health	**Beta**	**SE**	**Beta**	**SE**	**Beta**	**SE**			
Race and Ethnicity									
White (Ref)	-	-	-	-	-	-	-	-	-
Latinx	−0.920	0.060	−1.096	0.075	−1.206	0.129	<.001	<.001	<.001
Black	−2.270	0.042	−2.061	0.048	−2.609	0.106	<.001	<.001	<.001
Male	−1.006	0.035	−0.888	0.038	−1.244	0.092	<.001	<.001	<.001
Education (Years)	0.360	0.006	-	-	-	-	<.001	-	-
Mother's Education (Years)	0.038	0.006	0.065	0.006	0.071	0.015	<.001	<.001	<.001
Father's Education (Years)	0.024	0.005	0.064	0.005	0.035	0.013	<.001	<.001	.01
Number of Years Worked[TV]	0.020	0.001	0.020	0.001	0.029	0.002	<.001	<.001	<.001
Marital Status[TV]	−0.014	0.032	−0.068	0.036	−0.089	0.085	.66	.06	.29
Veteran Status	−0.023	0.043	−0.115	0.046	0.444	0.132	.59	.01	<.001
Southern U.S. Resident[TV]	−0.041	0.028	0.003	0.031	0.052	0.076	.15	.93	.49
Nativity Status (Non-U.S.-Born)	0.501	0.053	0.243	0.062	0.791	0.117	<.001	<.001	<.001
Income (log-transformed)[TV]	0.134	0.009	0.224	0.011	0.119	0.017	<.001	<.001	<.001
Covered by Employer[TV]	0.148	0.034	0.225	0.035	0.340	0.117	<.001	<.001	.004
Covered by Medicaid[TV]	−0.837	0.055	−1.074	0.070	−0.548	0.098	<.001	<.001	<.001
Covered by Medicare[TV]	−0.325	0.055	−0.358	0.061	−0.135	0.131	<.001	<.001	.303
Health Characteristics	**Beta**	**SE**	**Beta**	**SE**	**Beta**	**SE**	***p***	***p***	***p***
CES-D 8[TV]	−0.184	0.008	−0.176	0.009	−0.217	0.018	<.001	<.001	<.001
# of Chronic Conditions[TV]	−0.145	0.011	−0.124	0.013	−0.257	0.029	<.001	<.001	<.001
Body Mass Index[TV]	0.026	0.002	0.018	0.003	0.040	0.006	<.001	<.001	<.001
Doctor Visit[TV]	0.624	0.054	0.740	0.064	0.872	0.107	<.001	<.001	<.001
Hospitalization[TV]	−0.279	0.034	−0.317	0.037	−0.193	0.086	<.001	<.001	.03
Mortality	−0.977	0.046	−1.059	0.051	−0.767	0.107	<.001	<.001	<.001
Study Wave[TV]	−0.054	0.011	−0.057	0.011	−0.038	0.028	<.001	<.001	.18
Smoothing Terms	**EDF**		**EDF**		**EDF**		***p***	***p***	***p***
s(Age) Black	4.878		4.718		1.846		<.001	<.001	<.001
s(Age) Latinx	4.572		5.977		3.854		<.001	<.001	<.001
s(Age) White	7.813		7.332		3.231		<.001	<.001	<.001
s(Random Intercept)	0.448		0.134		0.543		.20	.29	.13
Adjusted-R^2	34.1%		24.3%		24.5%				
Number of Participants	20,331		16,844		3,487				
Number of Observations	67,386		56,510		10,876				

Note. "s()" refers to the smoothing function from the generalized additive mixed models. Doctor visit and hospitalization refer to utilization within the prior two years. Mortality includes all deaths through 2017. All estimates provided in Table 2 are fully adjusted.

Abbreviations: CES-D = Center for Epidemiological Studies-Depression. EDF = Effective Degrees of Freedom. TICS-27 = Telephone Interview for Cognitive Status – Modified 27-item. TV = Time-varying.