Title

The effect of intergenerational education on cognitive outcomes for and among Latinos in the US

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Publication Date

2023

Peer reviewed|Thesis/dissertation

The effect of intergenerational education on cognitive outcomes for and among Latinos in the United States

by
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DISSERTATION
Submitted in partial satisfaction of the requirements for degree of
DOCTOR OF PHILOSOPHY

in

Epidemiology and Translational Science

in the

GRADUATE DIVISION
of the
UNIVERSITY OF CALIFORNIA, SAN FRANCISCO

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Dedication

This dissertation is dedicated to my parents, Jesus and Margarita Meza, who instilled in me the importance of education. To my late great aunt Francisca Alvarado, a trailblazer who came to this country in search of a better future and gave my father that opportunity as well. To my grandfather Papa Pedro who passed away during my time in this program.

Acknowledgments

This dissertation was inspired by my experience as a daughter of immigrants and the first in my family to graduate high school and college. This work is the culmination of five years of mentorship, guidance, and support from many people in my life, and I would like to thank everyone that helped me achieve this goal.

I want to express my heartfelt gratitude to my dissertation committee. Thank you to my dissertation chair and academic advisor, Dr. Jacqueline Torres, for the opportunities to take on projects I am passionate about, for challenging my thinking on multiple methods to ensure the robustness of findings, and for all the time you invested in me. To Dr. Isabel Elaine Allen, thank you for sharing your expertise and enthusiasm for my work. To Dr. Hector González, thank you for your unique insight and expertise, and for welcoming me into the Study of Latinos - Investigation of Neurocognitive Aging (SOL-INCA) team. To Dr. Maria Glymour, my co-sponsor, academic advisor, and program director, thank you for the opportunity to pursue my degree at UCSF, for chairing my qualification exams, and for your unwavering guidance and sponsorship throughout my time in the program. I am honored to have had the privilege to work with you all. Thank you for believing in me and providing your support every step of the way.

Thank you to the mentors that I have worked with throughout my time at UCSF, Drs. April Bell, Alicia Fernández, Suzanna Martinez, Megha Mehrotra, Kala Mehta, Wassim Tarraf, Anusha Vable, and Rachel Whitmer. I learned so much from each of you and your unique perspectives. Thank you to all my mentors prior to UCSF, especially my undergraduate mentors, Drs. Herbert Medina, and Edward Mosteig, who first introduced me to academic research and without whom I would not have pursued graduate school. Thank you to the faculty and staff at the UCSF Department of Epidemiology and Biostatistics, especially Eva Wong-Moy, for supporting me through program milestones. To my peers in the Ph.D. program, especially my cohort, thank you for all the peer-learning opportunities and encouragement, and for making me feel part of a group. Also, thank you to my friends and peers outside of the Ph.D. program, especially Drs. Carla Alvarado, Beatrice Martinez, Claudia Rodriguez, and the Writing Warriors who all helped keep me accountable to my own goals. This journey would not have been the same without you all!

I would like to thank the Health and Retirement Study and the Study of Latinos investigators, staff, and participants for their contributions and the National Institute on Aging for funding my research. This work would not have been possible without you.

Finally, this accomplishment was possible with the unconditional love and support of my family and with God's grace. Thank you to my *familia* Meza, my parents Jesus and Margarita, my brother Franky, and my sisters Liz and Gigi for reminding me of my roles outside of being a student with every family celebration. Thank you to my husband, Jeremy Luman, for taking care of me and for your patience with me at the height of seemingly never-ending deadlines. Thank you, God, for your love and abundance, "For I know the plans I have for you" – Jeremiah 29:11.

The effect of intergenerational education on cognitive outcomes for and among Latinos in the United States

Erika Meza

ABSTRACT

By 2060, the number of individuals in the United States with Alzheimer's disease and related dementias (ADRDs) is projected to triple to about 13.9 million, with Latinos experiencing the largest increase. Research has shown that both parental and own education impact late-life cognitive health, and upward educational mobility from one generation to the next may partially compensate for the adverse cognitive health effects of low parental education. However, it remains unclear to what extent gains in educational attainment may help individuals with low parental education attain cognitive health benefits similar to those with multiple generations of high levels of education. Given the significance of education as a modifiable risk factor for ADRDs, it is critical to understand how generational increases in education in the US impact cognitive health, especially among marginalized racial and ethnic groups with historically limited access to education. Understanding how the cognitive health benefits of higher education compare for individuals who are first-generation and individuals who have benefited from multiple generations of high levels of education and how this varies across race and ethnicity can inform social policies to address cognitive health disparities due to low education levels.

This dissertation aims to examine the relationship between intergenerational education and cognitive health using data from the US Health and Retirement Study (HRS) and the Study of Latinos – Investigation of Neurocognitive Aging (SOL-INCA), a large cohort of Latino older adults, and investigate whether the association differs for older Black, Hispanic, and White adults and within Latino heritage subgroups (e.g. Cuban, Dominican, etc.). Additionally, this

dissertation makes a significant contribution to the literature as the first study to evaluate the relationship between highly educated offspring and cognitive health for Latinos in the US.

The first chapter of my dissertation examined the association between being a first-generation high school graduate (i.e., neither parent graduated high school) vs. being a multi-gen high school graduate (i.e., at least one parent graduated high school) and cognitive performance, decline, and incidence of possible cognitive impairment no dementia (CIND) or probable dementia for Black, Latino, and White older adults. Compared to multi-generational high school graduates, first-generation graduates had notably lower baseline verbal learning and memory z-scores. Black and White first-generation graduates experienced a faster rate of decline in verbal learning compared to their multi-generational counterparts; rates did not differ for Hispanic graduates. First-generation high school graduates also had higher hazard ratios of possible CIND or probable dementia compared to multi-generational high school graduates, with the greatest difference among White respondents.

Recognizing that Hispanic and Latino older adults are not a monolithic group, the second chapter examined the association between upward intergenerational educational mobility and cognitive outcomes *within* Latino subgroups. Specifically, we evaluated the association between being a first-generation (vs. multi-generation) high school graduate and cognitive performance and cognitive change, by Latino heritage group and nativity (US-born vs. non-US born). Compared to their multi-gen counterparts, first-generation Cuban, Mexican, and Puerto Ricans scored significantly lower on verbal learning. First-generation respondents born outside the US scored significantly lower across domain-specific and global cognitive outcomes.

Finally, the third chapter focuses on the education of younger generations and examines how the education of older adults' offspring is associated with their cognitive function, decline, and incidence of possible CIND or probable dementia. We found that each year of offspring education over 12 years was associated with higher baseline verbal learning and memory z-scores and a slightly faster rate of decline in verbal learning. Furthermore, Hispanic participants had a lower risk of possible CIND or probable dementia compared to their White counterparts with each additional year of offspring education over 12 years. Together, these studies provide further evidence into the importance of investing in education across generations, particularly when considering differences by race and ethnicity. Our findings suggest that dementia risk reductions attributable to higher levels of intergenerational educational attainment may continue to accrue in the future, which could help address inequities in cognitive health between populations with different educational backgrounds.

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LIST OF ABBREVIATIONS

ADRD – Alzheimer's disease and related dementias

B-SEVLT-sum – Brief-Spanish English Verbal Learning Test sum of three trials

B-SEVLT-recall – Brief-Spanish English Verbal Learning Test post-interference trial

CI – Confidence Interval

CIND – Cognitive Impairment, no Dementia

DLRC – Delayed recall tests of memory

DSS – Digit Symbol Subtest

HCHS/SOL – Hispanic Community Health Study/Study of Latinos

HR – Hazard Ratio

HRS – US Health and Retirement Study

IMRC – Immediate recall tests of memory

SOL-INCA – Study of Latinos -Investigation of Neurocognitive Aging

TICS – Telephone Interview for Cognitive Status

WF - Word Fluency test

Chapter 1

Intergenerational upward mobility in educational attainment and cognitive function, decline and risk of dementia across older White, Black, and Hispanic adults in the US

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Funding sources: NIH NIA F31AG071111 (PI: Meza)

ABSTRACT

Introduction: First-generation students, who have higher education than their parents, tend to have better cognitive health than those with consistently low parental and own education. It remains unclear how educational benefits may differ between first-generation and multi-generation individuals with consistently high parental and own education. We examine differences between first-gen and multi-gen cognitive health and whether the association varied by racial and ethnic subgroup.

Methods: We analyzed data from 23,667 US Health and Retirement Study participants aged >50 who completed high school from 1998-2018. We estimated the associations between being a first-generation versus a multi-generation high school graduate and cognitive performance and rate of change in verbal learning and memory z-scores using linear mixed models. We estimated the relative risk of incident possible cognitive impairment, no dementia (CIND), or probable dementia for first-generation vs multi-generation using Cox proportional hazards models. We also analyzed if these associations differed among Black, Hispanic, and White participants.

Results: Compared to multi-gen, first-gen high school graduates had significantly lower verbal learning and memory z-scores at baseline. Black and White first-gen respondents also experienced a faster rate of decline in verbal learning z-scores (β_{Black}: -0.006; [95% -0.012, -0.001]); β_{White}: -0.012; [95% CI: -0.015, -0.010]). Among Hispanic respondents, results were in the same direction, but included the null (β_{Hispanic}: -0.006; [95% -0.015, 0.002]). Results for verbal memory followed similar patterns but did not vary by race and ethnicity. First-gen high school graduates had a higher hazard ratio (HR) for possible CIND or probable dementia, with the highest estimates among White participants (HR: 1.28 [95% CI: 1.20, 1.26]).

Conclusion: Higher education levels across generations may lead to better cognitive health and reduce the risk of dementia, especially for marginalized racial and ethnic groups historically excluded from educational opportunities.

INTRODUCTION

Research has established a positive association between parental educational attainment - a marker of socioeconomic position (SEP) in childhood - and late-life cognitive function and risk of dementia.[1–10] Prior studies suggest that upward educational mobility (i.e. obtaining a higher level of education than one's parents) may partially offset the negative health effects of low parental education compared to individuals who maintain consistently low levels of parental and own education.[9,11–15] However, few studies have examined the impact of upward educational mobility (e.g., first-generation high school graduates) compared to individuals who benefit from consistently high parental and own levels of education (e.g., multi-generation high school graduates).[12,13,15] The direct comparison between these two groups can better inform how gains in educational opportunities may help individuals with low parental education "catch up" to the cognitive health benefits of individuals with two or more generations of high levels of education. This specific comparison is particularly critical given the growing number of first-generation students in the US.[16]

Due to historically unequal access to educational opportunities in previous generations, some racial and ethnic groups are more likely to be represented among first-generation students. To our knowledge, no studies have evaluated the relationship between intergenerational upward educational mobility and cognitive health outcomes across a diverse racial and ethnic sample of older adults in the US. Since the early 20th century, social policies and programs to improve access to a K-12 education have led to dramatic upward shifts in education in the U.S.[16] In 1965, only 24% of the older population had graduated from high school; by 2008, this number had increased to 77%. Historically, race and ethnicity have played a central role in educational opportunity gaps and a class-structured school system in the US.[17] While federal court cases, including *Mendez v. Westminster* and *Brown v. Board of Education,* initiated formal integration of schools and desegregation strategies, educational opportunities in the US continue to be linked to race and ethnicity. Systemic and structural barriers have continued to challenge educational opportunities available to Black, Latino, and other marginalized racial and ethnic groups who are also more likely to live in lower-income neighborhoods and attend under-resourced schools.[17] Additionally, while educational attainment has increased across all racial and ethnic groups over time, Latinos continue to have the lowest high school completion rate compared to non-Hispanic White and Black adults in the US. In addition, societal systems and structures impose disparate opportunities for racial and ethnic population subgroups to accrue the long-term benefits of high school education (e.g., lifetime earnings, accumulated wealth, retirement benefits, access to and quality of medical care) that systematically disadvantage people of color and stifle the progress of the next generation.[18,19]

Using data from the US Health and Retirement Study, this study provides a direct comparison between high school graduates who are first-generation (i.e. individuals with neither parent high school graduate) with those who are multi-generation (i.e., individuals with at least one parent high school graduate) and late-life cognitive outcomes. Specifically, we evaluate the association between being a *first-generation* high school graduate (i.e., first-gen) compared to being a *multi-generation* high school graduate (i.e., multi-gen) and cognitive performance and decline as well as the relative risk of possible cognitive impairment, no dementia (CIND) or probable dementia, including how these vary by race and ethnicity. Understanding how upward educational attainment from one generation to the next compares to multi-generational high school graduates and to what extent this may narrow or exacerbate the potentially adverse impact of socioeconomic disadvantage in childhood or even the playing field, could offer valuable insights for policymakers and health professionals aimed at supporting individuals from disadvantaged socioeconomic backgrounds and improving late-life cognitive health.

We draw on two competing theories to hypothesize potential relationships between intergenerational educational mobility and late-life cognitive outcomes, as well as how these relationships might vary by race and ethnicity. *Resource substitution theory* suggests a greater health benefit from additional socioeconomic resources among individuals from disadvantaged social backgrounds because the additional resources in adulthood substitute or compensate for their disadvantage.[18] In the context of this study, resource substitution theory would predict that the difference between first-gen and multi-gen high school students would be smaller among Black and Hispanic participants and greater among White participants given the historical educational opportunity disadvantages of minoritized racial and ethnic groups (i.e., an additional level of social disadvantage). In contrast, *resource multiplication theory* suggests a greater health benefit from additional socioeconomic resources among individuals from advantaged social backgrounds because the additional resources multiply the benefits of their initial socioeconomic advantage.[18] In the context of this study, resource multiplication theory would predict that the difference between first-gen and multi-gen high school students would be smaller among White participants and greater among Black and Hispanic participants.

METHODS

Study Population

The U.S. Health and Retirement Study (HRS) is a longitudinal national survey of community-dwelling adults 50 years and older and their spouses. HRS participants undergo in-person or telephone interviews approximately every two years from cohort entry until death or dropout, with new cohorts entering every six years to replenish the sample. Study recruitment and design have been published elsewhere.[19,20] Our study sample consisted of HRS participants 50+ years old, who self-identified as non-Hispanic White (henceforth White) or Hispanic (the predominant Hispanic group represented in our data identify as Mexican), completed a high school degree or higher and had complete covariate data. Participants must have also participated in at least one memory assessment between 1998 and 2018 to be included in the cognitive function and decline analysis (n=23,667).

Participants must have completed Langa-Weir classification scores and classified as cognitively impaired, no dementia (CIND), or dementia-free at baseline to be included in the incident possible CIND or probable dementia analysis (n=17,593). Data for participants enrolled in 1992, 1993, and 1998 cohorts were merged in 1998 and followed biennially afterward (analytical sample flow diagram in Supplemental Figure S1.1).

Primary Exposure

Our primary exposure, intergenerational educational attainment, was based on both participants' and their parents' (highest of mother's or father's) completed years of education: *multi-gen high school graduates* were HRS participants with at least one parent who completed 12 years or more of education (reference group), and *first-gen high-school graduates* were HRS participants with neither parent who completed 12 or more years of education. We excluded participants with less than a high school education, given the focus of our research question to directly compare multi-gen and first-gen high school graduates and that the adverse effects of consistently low education and downward education mobility have been established in prior literature.[9,12]

Cognitive Outcomes

The HRS assessed cognitive function using tests adapted from the Telephone Interview for Cognitive Status (TICS) at baseline and subsequently every two years (i.e. every follow-up wave). These tests included 1) Immediate (IMRC) and Delayed (DLRC) 10-noun recall tests (0 to 20 points); 2) Serial Sevens Subtraction Test (0 to 5 points); and 3) a Counting Backwards Test (0 to 2 points). For cognitive decline models, we evaluated verbal episodic learning using the immediate recall test scores and verbal memory using delayed recall test scores. At each study wave, respondents were read a list of 10 words and asked to recall as many words as possible, immediately and then after a 5-minute delay (range: 0-10 per test). Scores are analyzed separately as immediate recall captures encoding (i.e. the storage of incoming information into a mental representation) and delayed recall captures memory.[21,22] To improve interpretability, raw scores were z-standardized using the baseline sample mean and standard deviation, such that a score of 0 represents the baseline sample mean, and a score of 1 represents one standard deviation above the baseline sample mean.

Possible Cognitive Impairment no Dementia (CIND), or probable dementia was classified using the Langa-Weir 27-point scale derived from the TICS measures. The 27-point scale categorizes participants into: individuals with probable dementia (0-6), individuals with possible cognitive impairment but no dementia (7-11), and individuals with normal cognition (12-27). Proxy respondents were also included in the Langa-Weir scale. Full details of the methods used to make these classifications based on the diagnostic information from the ADAMS have been published elsewhere.[27] Due to sample size constraints, we dichotomized the categories to reflect normal cognition vs possible CIND or probable dementia.

Covariates

We used a directed acyclic graph (DAG) to represent our hypothesized causal structure and select parental characteristics expected to confound the association between intergenerational education and late-life cognitive outcomes. We consider HRS participant age at baseline, sex (male or female), ethnicity (non-Hispanic White or Hispanic), marital status at baseline (married or partnered, divorced or separated, widowed, never married, or unknown), birthplace based on US census region (US Northeast, US Midwest, US South, US West, Outside the US including foreign countries and US territories) and HRS cohort effects based on participant's birth year (AHEAD cohort born < 1924, CODA cohort born 1924-1930, HRS cohort born 1931-1941, War Babies Cohort born 1942-1947, Early Baby Boomers born 1948-1953, Mid Baby Boomers born 1954-1959, and Late Baby Boomers born 1960-1965). Given that cognitive test performance can improve when the same test is taken repeatedly, we adjust for practice effects in models of cognitive decline by including an indicator at the participant's first cognitive test encounter.[28]

Statistical Analysis

First, we evaluate the association between upward intergenerational education and cognitive level and decline using linear mixed-effect models allowing for subject-specific random intercepts and random slopes. Mixed models included the 2-category measure of first-gen vs. multi-gen educational attainment, a time term reflecting years since participants' baseline wave, a multiplicative interaction between first-gen education and years since baseline, demographic covariates, and our practice effects indicator. Possible differences in the association between first-gen high school educational attainment and cognitive level and decline by race and ethnicity were assessed using multiplicative interaction terms (i.e. first-gen education*time*ethnicity, first-gen education*time*nativity) and using stratified models.

Second, we examine the association between a first-gen high school education and the relative risk of possible CIND or probable dementia with Cox Proportional Hazards Models. Participants were censored at the first wave of data in which 1) possible CIND or probable dementia was first recorded, 2) participants dropped out of the study (due to death or loss to follow-up), or 3) at the end of follow-up in 2018. Models were also adjusted for age, sex, race and ethnicity, marital status, birthplace, and HRS cohort. Since prior research has shown that socioeconomic status and race affect health independently and mutually,[21,22] we assessed for possible effect modification by race and ethnicity with interaction terms and in models stratified by race and ethnicity. The proportional hazards assumption was checked graphically using log cumulative hazard plots. The proportional hazards assumption was assessed for all the Cox models presented based on the Schoenfeld residuals.[29] We present results stratified by race and ethnicity. Analyses were conducted using Stata v.17 (StataCorp LLC, College Station, TX).

Sensitivity Analysis

We conducted a sensitivity analysis for each of our aims. To test the robustness of our cognitive function and decline models, we repeated our analysis using age as the time scale specification centered at the mean age of respondents (age 61). To test the sensitivity of our Cox Proportional Hazards models to survival and attrition bias, from selective survival or study dropout since this population is at a higher risk of death or poor health, we calculated weighted estimates using Inverse Probability of Censoring Weights.

RESULTS

The baseline characteristics of HRS participants included in our linear mixed models are summarized in Table 1. Among the overall sample of 23,667 participants, HRS respondents were 61 years old (sd: 9.7) at baseline cognitive assessment. On average, Black and Hispanic participants were younger than White participants. Most of our sample (74%) self-identified as White, 17% as Black, and 8% as Hispanic. Notably, 59% of Black participants reported being born in the US South, and 52% of Hispanic participants reported being born outside of the US. Overall, 57% of participants were multi-generation high school graduates, and 43% were first-gen graduates. On average, own education and parental education were highest among White participants (13.8 years and 11.6 years) and lowest among Hispanic participants (13.2 years and 9.4 years). The average verbal memory scores at baseline were 5.7 (sd: 1.7) on immediate word recall and 4.6 (sd: 2.0) on delayed word recall tests. On average, each participant contributed three waves of cognitive score data.

Table 1.1 Baseline characteristics of the study participants by racial and ethnic group, U.S. Health and Retirement Study (HRS: 1998-2018)

	Black (n=4,121)		Hispanic (n=1,963)		White (n=17,583)		Overall (n=23,667)	
Baseline age, mean (sd)	57.5	(7.2)	56.7	(6.4)	62.2	(10.1)	61.0	(9.7)
Sex								
Female	2,438	59.2%	1,052	53.6%	9,555	54.3%	13,045	55.1%
Male	1,683	40.8%	911	46.4%	8,028	45.7%	10,622	44.9%
Marital Status								
Married/partnered	2,216	53.8%	1,382	70.4%	12,979	73.8%	16,577	70.0%
Divorced/separated	1,027	24.9%	370	18.8%	1,975	11.2%	3,372	14.2%
Widowed	379	9.2%	94	4.8%	1,921	10.9%	2,394	10.1%
Never Married	493	12.0%	114	5.8%	697	4.0%	1,304	5.5%
Unknown	6	0.1%	3	0.2%	11	0.1%	20	0.1%
Place of birth								
US non-South	1,384	33.6%	686	34.9%	12,369	70.3%	14,439	61.0%
US South	2,444	59.3%	254	12.9%	4,462	25.4%	7,160	30.3%
Outside US	293	7.1%	1,023	52.1%	752	4.3%	2,068	8.7%
Intergenerational Education								
Multi-gen	2,235	54.2%	769	39.2%	10,540	59.9%	13,544	57.2%
First-gen	1,886	45.8%	1,194	60.8%	7,043	40.1%	10,123	42.8%
Years of Education	13.5	(2.1)	13.2	(2.5)	13.8	(2.1)	13.7	(2.2)
Parent Years of Education	10.8	(3.4)	9.4	(4.4)	11.6	(3.3)	11.3	(3.5)

Associations with Baseline Cognitive Function and Decline by Race and Ethnicity

Compared to multi-gen high school graduates, first-gen high school graduates had significantly lower verbal learning (immediate recall) and memory (delayed recall) z-scores at baseline. The estimated effect of being a first-gen (vs. multi-gen) high school graduate on baseline cognitive levels was largest within Hispanic participants (β_{learning}: -0.13 [95% CI: -0.20, -0.06]; and β_{memory}: -0.12 [95% CI: -0.19, -0.05]). The estimated effects were of slightly smaller magnitude for both Black (β_{learning}: -0.08 [95% CI: -0.13, -0.03] and β_{memory}: -0.07 [95% CI: -0.12, -0.02]) and White participants (β_{learning}: -0.08 [95% CI: -0.10, -0.05]; and β_{memory}: -0.07 [95% CI: -0.09, -0.04]). However, tests for 2-way multiplicative interaction (i.e. *first-gen x race and ethnicity*) indicated no heterogeneity (p-values>0.30) in the estimated effect of first-gen on baseline cognitive level.

Tests for 3-way multiplicative interaction (i.e. *first-gen x time since baseline x race and ethnicity*) indicated heterogeneity in the estimated effect of first-gen on cognitive decline by race and ethnicity (3-way interaction term p-value: 0.05). In stratified models, being a first-gen (vs. multi-gen) high school graduate was associated with a faster rate of decline in verbal learning scores for White (β_{learning}: -0.012; [95% CI: -0.015, -0.010]) and Black respondents (β_{learning}: -0.006; [95% -0.012, -0.001]). Results were in the same direction, but the confidence interval included the null for Hispanic respondents (β_{learning}: -0.006; [95% -0.015, 0.002]) (Figure 1.1). Results for verbal memory generally followed similar patterns; however, tests for 3-way multiplicative interaction indicated no heterogeneity by race and ethnicity (Figure 1.2).

Table 1.2 Beta coefficients and 95% confidence intervals for linear mixed models of the association between being a first-gen high school graduate and *verbal learning* z-scores for Black, Hispanic, and White high school graduates

	Black (n=4,121)		**Hispanic (n=1,963)**		**White (n=17,583)**	
	Beta	**(95% CI)**	**Beta**	**(95% CI)**	**Beta**	**(95% CI)**
Education						
Multi-gen HS graduate	1.00	**ref**	1.00	**ref**	1.00	**ref**
First-gen HS graduate	-0.082	(-0.133, -0.031)	-0.130	(-0.202, -0.059)	-0.077	(-0.103, -0.050)
Time (years since baseline)	-0.036	(-0.040, -0.031)	-0.028	(-0.035, -0.020)	-0.041	(-0.042, -0.040)
Education x Time						
Multi-gen x years since baseline	1.00	**ref**	1.00	**ref**	1.00	**ref**
First-gen x years since baseline	-0.006	(-0.012, -0.001)	-0.006	(-0.015, 0.002)	-0.013	(-0.015, -0.010)

Source: U.S. Health and Retirement Study (1998-2018)
2-way Interaction (First-gen x Black) p-value=0.67
2-way Interaction (First-gen x Hispanic) p-value=0.31
3-way Interaction (First-gen x years since baseline x Black) p-value=0.05
3-way Interaction (First-gen x years since baseline x Hispanic) p-value=0.21

Table 1.3 Beta coefficients and 95% confidence intervals for linear mixed models of the association between being a first-gen high school graduate and *verbal memory* z-scores for Black, Hispanic, and White high school graduates

	Black (n=4,121)		Hispanic (n=1,963)		White (n=17,583)	
	Beta	**(95% CI)**	**Beta**	**(95% CI)**	**Beta**	**(95% CI)**
Education						
Multi-gen HS graduate	1.00	**ref**	1.00	**ref**	1.00	**ref**
First-gen HS graduate	-0.072	(-0.125, -0.019)	-0.117	(-0.186, -0.048)	-0.065	(-0.092, -0.035)
Time (years since baseline)	-0.036	(-0.041, -0.032)	-0.028	(-0.035, -0.021)	-0.036	(-0.037, -0.035)
Education x Time						
Multi-gen x years since baseline	1.00	**ref**	1.00	**ref**	1.00	**ref**
First-gen x years since baseline	-0.008	(-0.013, -0.002)	-0.006	(-0.014, 0.002)	-0.012	(-0.014, -0.010)

Source: U.S. Health and Retirement Study (1998-2018)
2-way Interaction (First-gen x Black) p-value=0.55
2-way Interaction (First-gen x Hispanic) p-value=0.45
3-way Interaction (First-gen x years since baseline x Black) p-value=0.38
3-way Interaction (First-gen x years since baseline x Hispanic) p-value=0.18

In sensitivity analysis using current age as the time scale specification, findings were substantively similar. However, the estimated effect of being first-gen (vs. multi-gen) on baseline verbal learning and verbal memory was of slightly larger magnitude, and the estimated effect of first-gen on the rate of decline was slightly slower for all racial and ethnic groups.

Incident Dementia and CIND

During follow-up (mean=10.5 years; range: 2-20 years), 31% of respondents were classified as having possible cognitive impairment or probable dementia; 37% had died by 2018. Our models evaluating incident possible CIND or probable dementia included 20,545 individuals (107,590 person-years) and 6,278 events. The average age for this group was 60 years old. Compared to multi-gen high school graduates, first-gen graduates had higher hazard ratios of possible CIND or probable dementia. However, effect estimates differed by racial and ethnic group (first-gen*race/ethnicity interaction p-value: 0.04). White first-gen participants had the highest hazard ratio compared to their multi-gen counterparts over the 20-year follow-up period (HR: 1.28; 95% CI: 1.20, 1.36). Black first-gen participants had an incidence hazard ratio of 1.26

(95% CI: 1.12, 1.42), and Hispanic first-gen participants had the lowest incidence hazard ratio of 1.21 (95% CI: 1.00, 1.48). Using Cox models with inverse probability weights for attrition yielded consistent results.

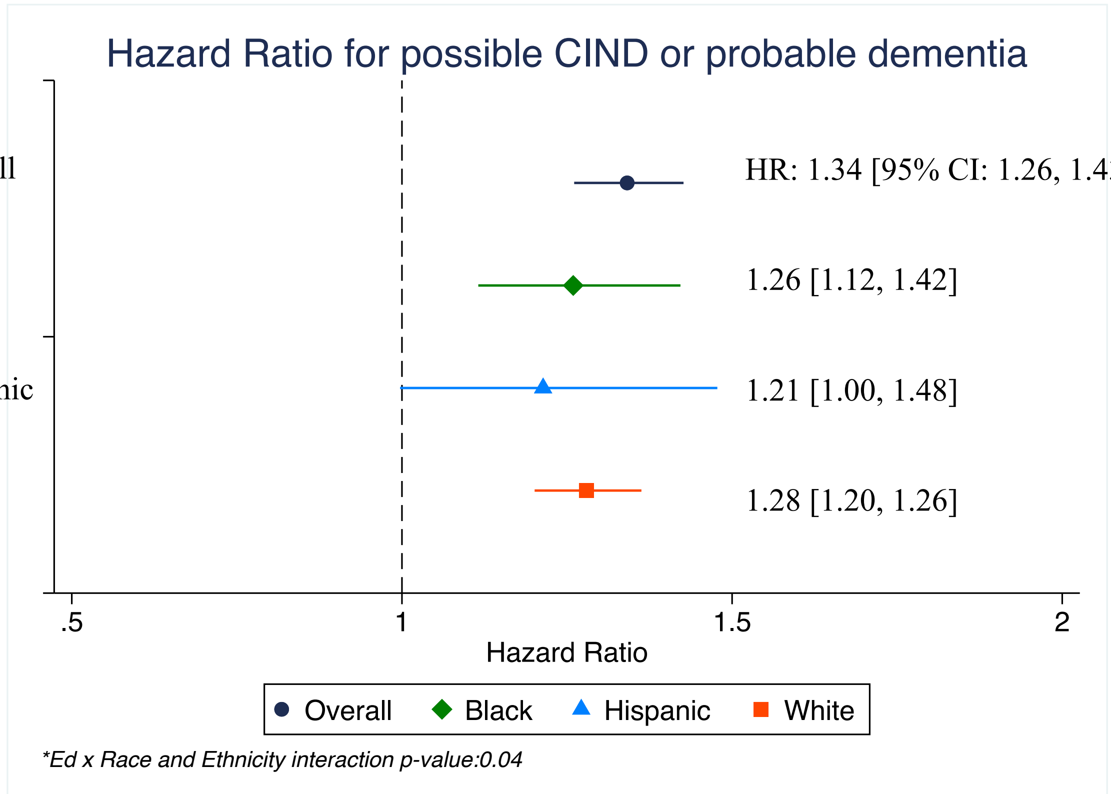

Figure 1.1 Hazard Ratios and 95% confidence intervals for possible CIND or probable dementia for first-generation (vs multi-generation) high school graduates by race and ethnicity, U.S. HRS (1998-2018)

DISCUSSION

Using population-based, national-level data from White, Black, and Hispanic middle-aged and older adults followed for up to 20 years, we found that first-gen high school graduates had lower baseline cognitive performance scores than their multi-gen counterparts across all racial and ethnic groups. Compared to multi-gen, first-gen high school graduates also had an accelerated rate of cognitive decline and a higher hazard ratio of possible CIND or probable dementia among White and Black participants but not among Hispanic participants. To our knowledge, this is the first study to examine the association between being a first-gen (vs. multi-gen) high school graduate and cognitive performance, cognitive decline, and incidence of possible CIND or probable dementia across a diverse sample of White, Black, and Hispanic older adults in the US. Our paper provides a unique perspective and contributes significantly to the literature by comparing upwardly mobile individuals to the consistently highly educated group to better understand how upward educational mobility may confer opportunities for better health and narrow cognitive health inequities among high school graduates with different childhood socioeconomic origins.

Contrary to what we expected under resource substitution theory but consistent with resource multiplication theory, we found that first-gen high school graduates had lower cognitive function at baseline and a faster cognitive decline rate than multi-gen high school graduates. Our findings are consistent with prior studies more broadly showing higher late-life cognitive function among the most advantaged socioeconomic group (i.e., multi-gen high school graduates).[12,23] However, unlike prior work that did not consider heterogeneity by race or ethnicity, we observed a faster rate of cognitive decline in the upwardly mobile group (i.e., first-gen high school graduates) only among White and Black participants.[12] Among Hispanic participants, we found a similar rate of cognitive decline for first-gen and multi-gen high school graduates.

Also, contrary to resource substitution theory but consistent with resource multiplication theory, the incidence of possible CIND or probable dementia was higher for first-gen compared to multi-gen high school graduates among White and Black participants. Among Hispanic participants, the estimated hazard ratio included the null. Our results are consistent with findings from a cohort of older adults from the Sacramento area of California, in which there were similar rates of decline in cognitive function and verbal memory and similar hazards of dementia or CIND among individuals with intergenerational upward educational mobility and individuals with consistently high intergenerational education compared to individuals with consistently low parental and own education.[13,15] Our paper builds on this work with a national sample of Hispanic participants and a direct comparison of the estimated effect of upward mobility relative to consistently high educational attainment.

The heterogeneity observed in our results provides evidence of the vital role that race and ethnicity play as additional axes of social status and socioeconomic mobility in the US, a country with a steep wealth gradient.[24] For example, in Denmark, about 15% of children from low-income families may achieve socioeconomic mobility as adults. In the US, however, only 8% of children from the bottom 20% of the income distribution can make it to the top 20% as adults.[25,26] Additionally, communities in the US are often segregated by socioeconomic status, race and ethnicity. As such, low-income communities of color often encounter additional systemic barriers, including low economic development and underfunded schools, which may lead to additional financial stressors (e.g. housing instability, food insecurity), and lower quality of education for non-White first-gen high school graduates.[27–29] In addition to their parents' low levels of education, these experiences may affect cognitive health due to their significance in shaping the early-life environment and impacting brain and cognitive development.[30,31] In adulthood, one's own educational attainment has been linked with increased cognitive function and lowered risk of ADRD via biological and behavioral pathways, including cognitive reserve, diet, exercise, and the management of other dementia risk factors like hypertension.[32–34] Quality of education can also have an impact on cognitive function.[29] These are also more likely to impact employment opportunities and professional-social networks. Finally, heterogeneity in the associations by race and ethnicity could also reflect ongoing changes in intergenerational mobility across racial and ethnic groups.[35] Although there is no clear indicator of how many generations of higher education it takes to overcome the adverse health effects of low childhood SEP, upward social mobility can be an isolating process for Black and Hispanic participants. Different experiences of discriminatory structural policies and practices, particularly among first-gen individuals navigating predominantly White education and workplace settings[36] could also influence late-life cognitive health. Understanding how the associations between intergenerational education and cognitive outcomes differ between Black, Latino, and other minoritized racial and ethnic groups compared to White older adults is crucial for recognizing the varying opportunities for socioeconomic mobility and the mechanisms underlying the association between socioeconomic position and cognitive health.

While we have noted where our findings align with prior work, there are challenges to making direct comparisons. First, studies evaluating the role of both parental and own educational attainment on cognitive health often model these as independent exposures or focus more on intergenerational socioeconomic trajectories relative to those in the most socioeconomically disadvantaged group (i.e., individuals with low parental and low educational attainment). [7,37,38] Limited studies have examined the impact of intergenerational upward educational mobility relative to consistently high intergenerational education on cognitive function, decline, and incident dementia among a diverse sample of older adults.[12,13,15] In addition, different measures of socioeconomic positions (i.e. educational attainment, income, occupation) and different ways to operationalize socioeconomic trajectories often result in mixed findings.[11,12,37]

Our study has several limitations. First, there is potential bias due to selective participation and attrition due to loss to follow-up or death. Educational level and risk of cognitive impairment may each affect the chances of being observed at baseline and in each successive wave. While we tried to address this by applying inverse probability censoring weights to our models, this approach assumes missingness is random and is conditional on the variables included in our weight-generating models. Our primary models using inverse probability weights provided consistent results suggesting this was not a major source of bias. Next, while we controlled for all conceivable confounders measured in HRS, we cannot rule out residual confounding by other life course exposures (e.g. country of participant or parental education and quality of education) that were not measured. While we account for the respondent's place of birth, it is important to acknowledge systemic differences in opportunities for educational mobility for foreign-born individuals or individuals with immigrant parents who may not have completed their education in the US.[34] Finally, our data include a US-based sample of White, Black, and Hispanic older adults and may not be generalizable to other population subgroups with different education patterns. Additionally, although our study did not find a significant difference in the rate of cognitive decline for Hispanic first-gen vs multi-gen high school graduates, prior work has found differences in educational patterns and dementia risk between Latino subgroups more broadly. Future work should assess these differences in a more diverse group of Hispanic/Latino older adults.

Despite these limitations, our work provides a unique perspective for understanding cognitive outcomes among high school graduates with different childhood socioeconomic origins by comparing cognitive outcomes for upwardly mobile, first-gen individuals to a group who benefitted from at least two generations of high educational attainment. Our findings also expand on the prior literature by examining cognitive performance, rate of change, and incident possible CIND or probable dementia across White, Black, and Hispanic older adults in the US. Our analytic sample provides a greater representation than prior epidemiologic studies of cognitive change and dementia.[12,15] Our longitudinal data also provides a unique opportunity to examine cognitive change across time. This is important to capture any socio-cultural patterns consistent with changes in access to educational attainment that may not be observed in more static cross-sectional studies or single racial or ethnic group comparisons. While it is apparent that cognition is sensitive to educational attainment intergenerationally, our findings suggest that upward mobility in one generation does not erase the disadvantage of low parental education and that investment in education is an influential determinant of cognitive performance. From a social policy perspective, our results demonstrate how higher education across multiple generations elevates baseline cognitive performance levels.

CONCLUSION

In a national sample of middle-aged and older adults, we found that being a first-gen high school graduate was associated with lower baseline cognitive function and an increased risk of cognitive impairment or probable dementia compared to being a multi-gen high school graduate. Compared to their multi-gen counterparts, Black and White - but not Hispanic - first-gen high school graduates also showed a faster cognitive decline. First-gen (vs. multi-gen) educational attainment was also associated with a greater risk of probable cognitive impairment but with no evidence of heterogeneity by race and ethnicity. Future studies assessing the role of education and cognitive outcomes should continue to contextualize the socioeconomic opportunities or constraints across different population subgroups and consider how these may result in differential returns of higher intergenerational education. Adjusting for additional community-level characteristics or education quality may provide further insight into the racial and ethnic differences observed. Our findings suggest that increases in baseline cognitive performance and declines in dementia risk potentially attributable to growing educational attainment may persist in the future. This may be particularly beneficial for racial and ethnic groups historically excluded from educational policies rendering high school completion.

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SUPPLEMENTARY MATERIAL

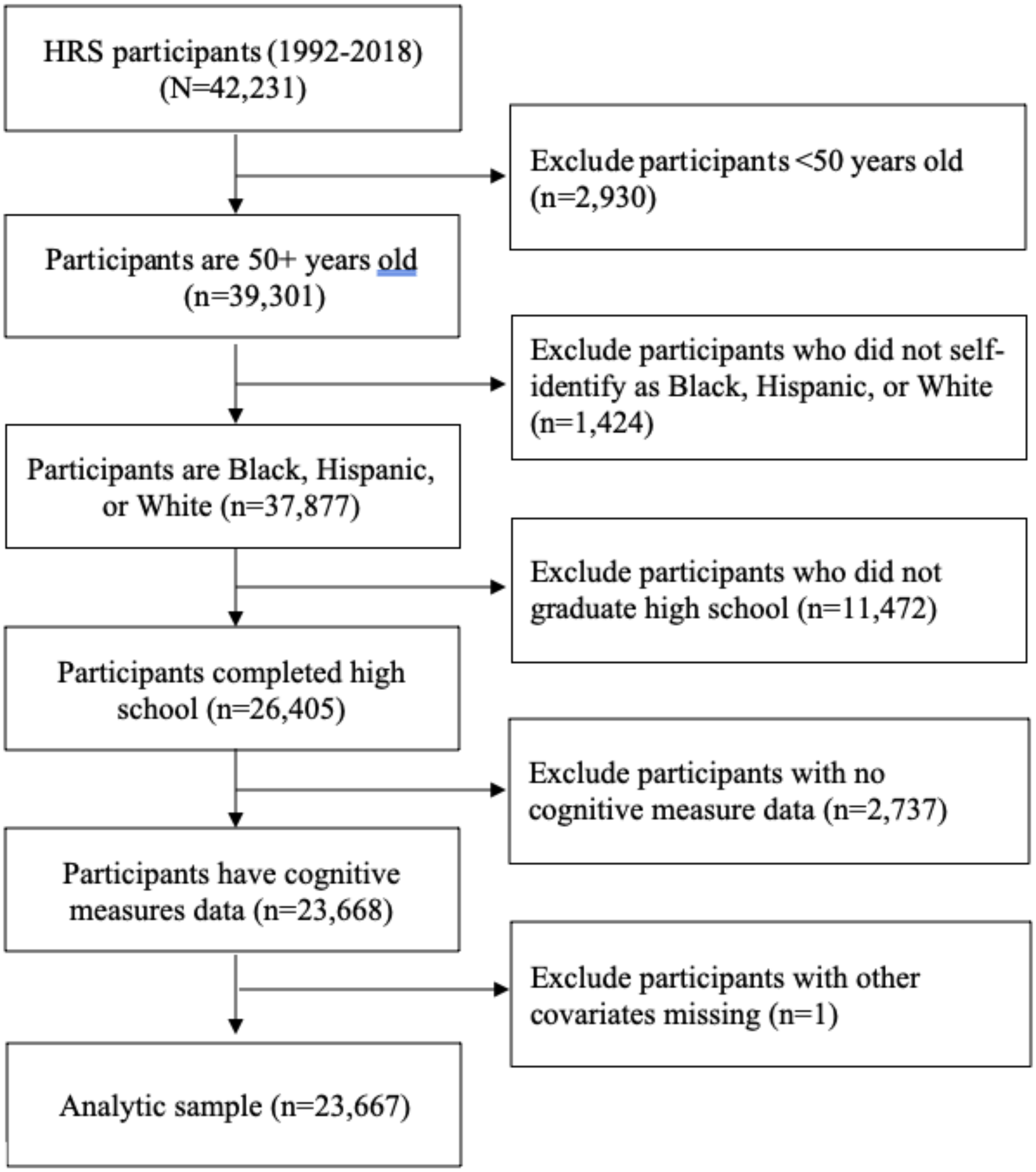

Figure S1.1 Analytic sample flow diagram for cognitive decline analysis (n=23,667)

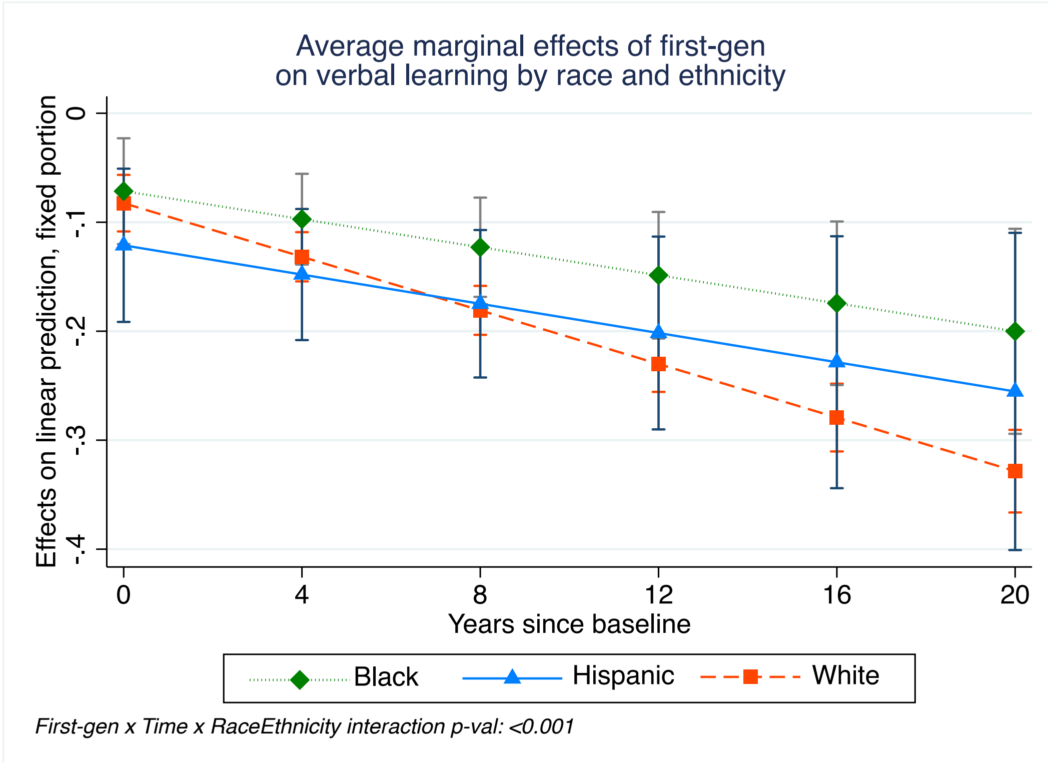

Figure S1.2 Average marginal effects of being a first-gen high school graduate on verbal *learning* z-scores by race and ethnicity, U.S. Health and Retirement Study (1998-2018)

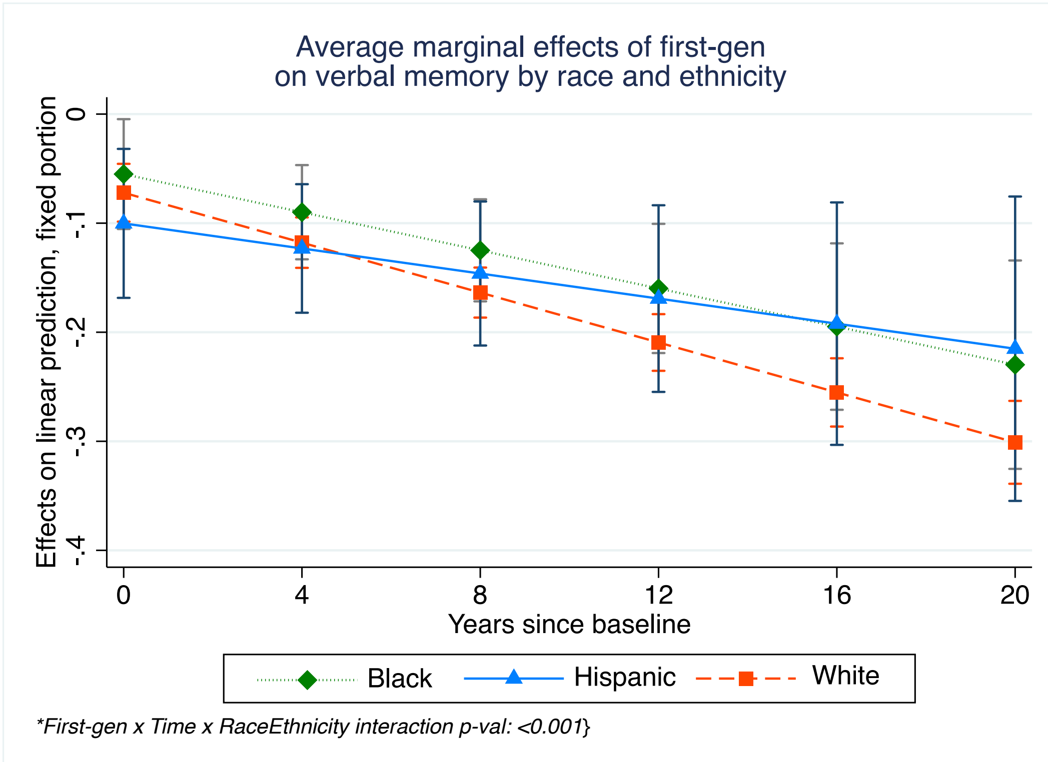

Figure S1.3 Average marginal effects of being a first-gen high school graduate on verbal *memory* z-scores by race and ethnicity, U.S. Health and Retirement Study (1998-2018)

Table S1.1 Beta coefficients and 95% confidence intervals for linear mixed models of the association between being a first-gen high school graduate and verbal learning z-scores, age as the time scale

	Black (n=4,121)		Hispanic (n=1,963)		White (n=17,583)	
	Beta	**(95% CI)**	**Beta**	**(95% CI)**	**Beta**	**(95% CI)**
Education						
Multi-gen HS graduate	1.00	**ref**	1.00	**ref**	1.00	**ref**
First-gen HS graduate	-0.111	(-0.155, -0.066)	-0.161	(-0.223, -0.099)	-0.105	(-0.130, -0.080)
Time (Age)	-0.037	(-0.041, -0.033)	-0.031	(-0.037, -0.025)	-0.043	(-0.044, -0.041)
Education x Time						
Multi-gen x Age	1.00	**ref**	1.00	**ref**	1.00	**ref**
First-gen x Age	-0.002	(-0.007, 0.002)	-0.002	(-0.008, -0.005)	-0.008	(-0.010, -0.007)

Source: U.S. Health and Retirement Study (1998-2018)

2-way Interaction (First-gen x Black) p-value=0.39

2-way Interaction (First-gen x Hispanic) p-value=0.04

3-way Interaction (First-gen x years since baseline x Black) p-value=0.05

3-way Interaction (First-gen x years since baseline x Hispanic) p-value=0.18

Table S1.2 Beta coefficients and 95% confidence intervals for linear mixed models of the association between being a first-gen high school graduate and verbal memory z-scores for Black, Hispanic, and White high school graduates, age as the time scale

	Black (n=4,121)		Hispanic (n=1,963)		White (n=17,583)	
	Beta	**(95% CI)**	**Beta**	**(95% CI)**	**Beta**	**(95% CI)**
Education						
Multi-gen HS graduate	1.00	**ref**	1.00	**ref**	1.00	**ref**
First-gen HS graduate	-0.109	(-0.155, -0.063)	-0.143	(-0.203, -0.082)	-0.090	(-0.116, -0.065)
Time (Age)	-0.038	(-0.042, -0.034)	-0.032	(-0.038, -0.026)	-0.038	(-0.039, -0.036)
Education x Time						
Multi-gen x Age	1.00	**ref**	1.00	**ref**	1.00	**ref**
First-gen x Age	-0.004	(-0.008, 0.000)	0.000	(-0.007, -0.176)	-0.008	(-0.010, -0.007)

Source: U.S. Health and Retirement Study (1998-2018)

2-way Interaction (First-gen x Black) p-value=0.59

2-way Interaction (First-gen x Hispanic) p-value=0.16

3-way Interaction (First-gen x years since baseline x Black) p-value=0.22

3-way Interaction (First-gen x years since baseline x Hispanic) p-value=0.50

Chapter 2

Intergenerational upward educational mobility and cognitive performance among diverse older Latino adults

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ABSTRACT

Introduction: First-generation students, whose parents did not complete high school or college, have better cognitive health than individuals with consistently low parental and own education. Less is known about how educational benefits compare to multi-generation individuals with consistently high parental and own education or how this varies across diverse Latino subgroups.

Methods: We used data from participants 50-86 in the multi-center Hispanic Community Health Study/Study of Latinos (HCHS/SOL) and its ancillary study SOL-Investigation of Neurocognitive Aging (SOL-INCA). We estimated associations between first-generation vs. multi-generation high school graduates (i.e. neither parent vs. 1+ parent graduated high school) and baseline domain-specific (i.e. verbal learning, memory, verbal fluency, executive function) and global cognitive performance and change scores. Models included interaction terms evaluating effect modification by heritage group (e.g. Central American, Cuban) and nativity.

Results: Among Cuban, Mexican, and Puerto Rican respondents, first-generation high school graduates had significantly lower baseline cognitive scores than their multi-gen counterparts. In contrast, among Dominican, Central, and South Americans, first-generation and multi-generation high school graduates had generally similar baseline cognitive scores. We found limited evidence that nativity modified the relationship between first-gen educational attainment and cognitive performance scores. Cognitive change was similar for first-gen and multi-gen high school graduates across heritage and nativity groups.

Conclusion: We found select differences in cognitive health benefits of upward educational mobility among Latino heritage groups. Policies supporting intergenerational educational mobility could positively influence cognitive health, although potential impacts may vary among Latinos.

INTRODUCTION

Currently, the Latino/Hispanic population comprises the largest ethnic minority group in the US. By 2060, the number of Latinos 65 years and older is expected to quadruple, and Latinos are projected to experience the steepest increase in the number of Alzheimer's disease and related dementias (ADRDs) cases.[8–10] Accordingly, there is a critical need to understand how modifiable, societal-level drivers of ADRDs influence Latinos in the US. Prior studies suggest that upward educational mobility (i.e. obtaining a higher level of education than one's parents) may partially offset the negative health effects of low parental education, including late-life cognitive function and risk of dementia, compared to individuals who maintain consistently low levels of parental and own education.[1–6] Few studies have examined the impact of upward educational mobility (e.g., first-generation high school graduates) compared to individuals who benefit from consistently high parental and own levels of education (e.g., multi-generation high school graduates).[3,4,6] The direct comparison between these two groups can better inform how gains in educational opportunities may help individuals with low parental education "catch up" to the cognitive health benefits of individuals with two or more generations of high levels of education. This comparison is especially important for older Latino older adults who have experienced dramatic shifts in intergenerational educational attainment and are increasingly becoming first-generation high school and college graduates in the US.

Work examining racial and ethnic differences in the association between educational mobility and cognitive health in the US has mainly focused on White-Black differences, or differences within a single Hispanic or Latino group (e.g., Mexican Americans in California).[1,4,6,11] It remains unclear whether the potential advantages of upward educational mobility extend across a diverse group of Hispanic and Latino older adults. Latinos have made important educational gains, including improved high school graduation rates since the 1960s.[12] However, provided that Latinos are not a monolithic group, different countries of origin and unique immigration experiences have shaped inequitable opportunities and access to quality education for Latinos in the US, including patterns of educational mobility across generations. Therefore, it is crucial to identify and disentangle different Latino experiences, including the impact of being *first-generation* compared to *multi-generational* high school graduates (i.e. neither parent vs. at least one parent graduated high school) on one's cognitive function or cognitive impairment.

The objective of this study was to understand the relationship between intergenerational upward educational attainment and midlife cognitive function among a diverse group of older Latinos, with a specific focus on the outcomes of first-gen high school graduates compared to their multi-gen counterparts. Our study extends prior studies on upward educational mobility by examining how associations differed by Latino heritage group and nativity. To our knowledge, no study has examined whether and to what extent intergenerational upward educational mobility affects cognitive health across Latino heritage groups.

METHODS

Study Population

The Hispanic Community Health Study/Study of Latinos (HCHS/SOL) is a Hispanic and Latino (hereafter Latino) population-based, prospective cohort study of individuals 18-74 years old probability-sampled from four US metropolitan areas with substantial Latino population concentrations: 1) Bronx, NY; 2) Chicago, IL; 3) Miami, FL; and 4) San Diego, CA. The HCHS/SOL was designed to yield representative data for diverse Latinos in the four targeted areas using a stratified two-stage area probability sample with probability clusters from the 2000 census and households within clusters characterized by Latino surname.[13] In total, 16,415 eligible self-identified Latinos participated in the baseline HCHS/SOL wave from 2008-2011 (visit 1); participants 45-74 years old completed a brief cognitive battery during this initial visit. Participants who completed the cognitive battery during visit 1 and were 50 years and older between 2014 and 2017 were invited to participate in the Study of Latinos-Investigation of Neurocognitive Aging (SOL-INCA) and complete a follow-up cognitive assessment which involved an extensive neuropsychological battery on average seven years after their baseline (visit 2). Out of 7,240 eligible individuals, 6,377 (88.7% response rate) participated in SOL-INCA. Target population characteristics were used to generate probability weights to adjust for non-response from HCHS/SOL (visit 1) to SOL-INCA (visit 2). Full details on HCHS/SOL and SOL-INCA study designs and rationales have been previously published and are available at the study website: https:// sites.cscc.unc.edu/hchs.[13–15] In this study, we include individuals 45 years and older who completed HCHS/SOL and SOL-INCA neurocognitive assessments (n=6,377) and self-identified as Central American, Cuban, Dominican, Mexican, Puerto Rican, or South American. We restricted our analysis to respondents who reported completing high school, (defined as obtaining a high school degree, GED equivalent, or higher) and provided data on at least one parent's years of education (n=3,428) since our primary research question was to evaluate differences for first-gen and multi-gen high school graduates. We only included participants with complete outcomes and covariate data (n=3,344) in our final analytic sample.

Exposure

Our primary exposure for *upward educational attainment* was based on measures of respondents' education and their parents' education (highest of mother's or father's education). *Multi-gen* high school graduates were respondents who completed high school and had at least one parent who also completed high school or higher. *First-gen* high-school graduates were respondents who completed high school and had neither parent completed high school.

Cognitive Performance

Participants 45-74 years old completed a brief cognitive battery at visit 1 (2008-2011) in their preferred language. This included the following tests: 1) the Brief-Spanish English Verbal Learning Test sum of three trials (B-SEVLT-sum), which measures *verbal episodic learning*, 2) the B-SEVLT post-interference trial (B-SEVLT-recall); which measures *verbal episodic memory*, 3) the Word Fluency (WF) which measures phonemic *verbal fluency*, and 4) the Digit Symbol Subtest (DSS) which measures mental processing speed and *executive function*. For the current study, we considered the 4 domain-specific cognitive measures modeled independently, as well as a *global composite measure* of cognitive performance. We z-score transformed [(test score-mean)/standard deviation] all continuous measures to facilitate score comparisons across tests. We generated the global measure of cognitive performance at visit 1 by averaging the standardized scores from the B-SEVLT-Sum, B-SEVLT-Recall, DSS, and WF. Full details of visit 1 testing and scoring procedures used in HCHS/SOL have been previously documented.[15]

Cognitive Change

Participants of the SOL-INCA (visit 2) repeated the cognitive battery taken at visit 1 and completed the Trails Making Test parts A (TMT part A; processing speed) and B (TMT part B; executive functioning). For the current study, we only average the standardized scores from the four repeated tests (B-SEVLT-Sum, B-SEVLT-Recall, DSS, and WF) since we wanted to generate comparable domain-specific and global measures of cognitive performance. Cognitive change between visits 1 and 2 was calculated by subtracting the cognitive score at visit 2 from the cognitive score at visit 1 and adjusting by the time elapsed between visits (in years).

Covariates

All models controlled for age at baseline, sex, US nativity (defined as the 50 states and District of Columbia), country of education (US vs non-US education), Latino heritage group (Dominican, Central American, Cuban, Mexican, Puerto Rican, South American) and study site (Bronx, Chicago, Miami, San Diego).

Statistical Analysis

We estimated a series of linear regression models to examine the associations between first-gen (vs. multi-gen) high school completion and domain-specific (i.e. B-SEVLT-sum, B-SEVLT-recall, WF, DSS) or global cognitive performance z-scores. Our first series of models evaluated the association between first-gen and cognition at visit 1. The second series evaluated the association between first-gen and change in cognitive score between visits 1 and 2 in domain-specific and global cognitive performance.

First, we evaluated the association between first-gen (vs. multi-gen) and baseline cognitive performance in the overall sample. Next, we included 2-way interaction terms between first-gen and heritage group, and separately between first-gen and nativity (US vs non-US born) to evaluate if the association differed by heritage and nativity. We also evaluated models stratified by heritage group and by nativity. Similarly, we evaluated the association between first-gen and cognitive change (in domain-specific and global cognitive scores) first in the overall sample and then used interactions and stratified models to evaluate heterogeneity. All models adjusted for age, sex, nativity, and Latino heritage group (unless stratified by nativity or Latino heritage group).

RESULTS

Among 3,344 high school graduate SOL-INCA respondents, the mean age at visit 1 was 55 ± 9.4 years old. More than half (57%) of respondents were female, and 34% self-identified as Mexican, 22% as Cuban, 16% as Puerto Rican, 10% as Central American, 10% as South American, and 8% as Dominican (Table 2.1). Among Central American respondents, the largest represented groups were from Nicaragua (39%) and Honduras (23%). Among South American respondents, the largest represented groups were from Colombia (34%) and Ecuador (21%). The majority of our sample (91%) were born outside the 50 US states and the District of Columbia (i.e. in another country or the island of Puerto Rico), and 72% completed their education in another country or on the island of Puerto Rico. More than half of the respondents (54%) were first-generation, and 46% were multi-generation high school graduates. Dominican respondents had the highest proportion of first-gen high school graduates (64%), and South American respondents had the highest proportion of multi-gen high school graduates (61%).

Table 2.1 Baseline characteristics of participants by Latino heritage group in the analytic sample, % weighted, SOL-INCA

	Central American	Cuban	Dominican	Mexican	Puerto Rican	South American	Overall
Unweighted *n*	**333**	**737**	**278**	**1,143**	**522**	**331**	**3,344**
Age, mean (sd)	53.6 (11.0)	57.0 (8.1)	52.5 (7.4)	53.9 (9.3)	56.5 (9.9)	54.8 (9.7)	55.3 (9.4)
Sex %							
Female	58.8	51.5	68.9	57.3	60.7	54.8	56.7
Male	41.3	48.6	31.1	42.7	39.4	45.2	43.3
Place of Birth %							
Outside US mainland	99.0	98.5	99.2	85.1	69.8	99.0	90.6
US (50 states+DC)	1.0	1.5	0.8	14.9	30.2	1.1	9.4
Nativity							
Outside US	98.6	98.5	99.2	85.1	1.1	99.0	80.6
US (including territories)	1.4	1.5	0.8	14.9	98.9	1.1	19.4
Place of Education %							
Outside US	78.6	87.1	79.2	65.3	33.9	86.3	71.8
US (50 states+DC)	21.5	12.9	20.8	34.7	66.2	13.7	28.2
Own Ed %							
lt HS							
HS/GED	29.3	31.1	35.1	34.7	32.4	27.3	32.2
gt HS	70.7	68.9	64.9	65.4	67.6	72.7	67.8
Parents Ed %							
lt HS	57.9	53.0	64.2	55.8	53.9	38.6	54.1
HS/GED	14.9	23.6	15.8	20.7	30.4	30.6	23.1
gt HS	27.1	23.4	20.0	23.5	15.8	30.8	22.9
Intergenerational Education%							
Multi-gen HS grad	42.1	47.0	35.8	44.2	46.2	61.4	46.0
First-gen HS grad	57.9	53.0	64.2	55.8	53.9	38.6	54.1
Site %							
Bronx	18.8	1.1	90.7	1.3	65.5	21.9	20.7
Chicago	13.1	0.8	1.1	13.9	22.8	15.6	9.8
Miami	60.6	98.1	6.5	2.0	9.3	58.4	44.2
San Diego	7.5	0.0	1.7	82.8	2.4	4.1	25.4

Overall, first-generation (vs. multi-gen) high school graduates averaged lower global and domain-specific baseline cognitive performance (Figure 2.1). We found evidence that an individual's heritage group significantly modified the effect estimate of being first-gen on verbal learning (global test p-value: 0.05), word fluency (p-value: 0.02), and global cognitive z-scores (p-value: 0.02) in models with 2-way (*first-gen x Latino heritage group*) interactions. In models stratified by heritage group, first-gen Cuban, Mexican, and Puerto Rican high school graduates had significantly lower verbal learning (β_{Cuban}:-0.25 [95% CI: -0.38, -0.13]; β_{Mexican}: -0.24 [95% CI: -0.38, -0.10]; $\beta_{\text{PuertoRican}}$: -0.22 [95% CI: -0.38, -0.06]) and significantly lower global cognitive performance z-scores (β_{Cuban}:-0.23 [95% CI: -0.36, -0.12]; β_{Mexican}: -0.24 [95% CI: -0.35, -0.1]; $\beta_{\text{PuertoRican}}$: -0.23 [95% CI: -0.36, -0.09]) compared to their multi-gen counterparts. First-gen Cuban and Puerto Rican high school graduates also had significantly lower verbal fluency scores (β_{Cuban}: -0.14 [95% CI: -0.24, -0.04]; $\beta_{\text{PuertoRican}}$: -0.23 [95% CI: -0.38, -0.08]). Notably, first-gen Dominicans had significantly higher verbal fluency scores ($\beta_{\text{Dominican}}$: 0.26 [95% CI: 0.06, 0.47]) than their multi-gen counterparts.

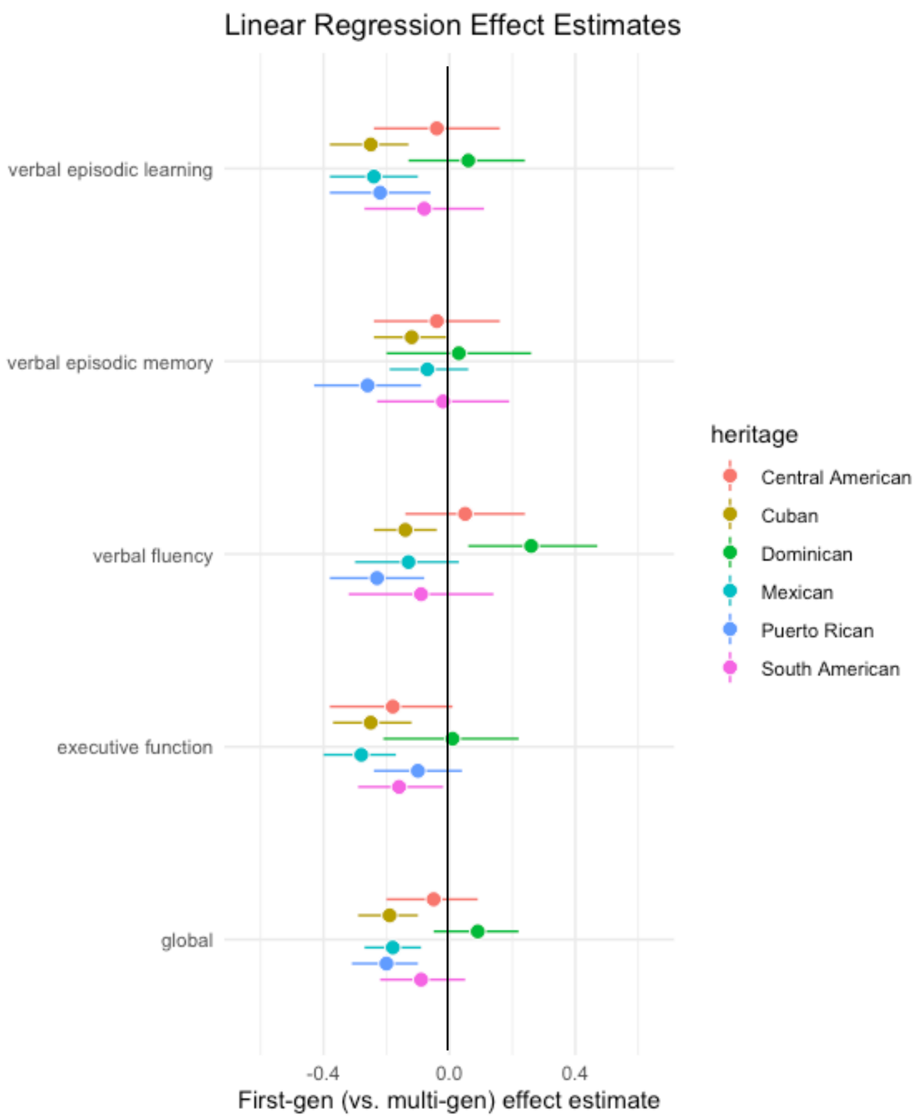

Figure 2.1 Linear regression coefficients for first-gen (vs. multi-gen) high school graduates and cognitive outcomes by Latino heritage group

Among respondents born outside the US, first-gen had significantly lower baseline z-scores than their multi-gen counterparts across all cognitive domains (Figure 2.2). Among respondents born in the 50 US states or DC, first-gen and multi-gen had similar baseline cognitive z-scores; however, confidence intervals were wide. We found evidence that nativity modified the effect estimate of being first-gen only for the executive function domain (first-gen x nativity interaction p-value: 0.04). First-gen high school graduates born outside of the US had significantly lower executive function z-score at baseline ($\beta_{\text{non-US-born}}$: -0.22 [95% CI: -0.29, -0.15]) than their multi-gen counterparts. In contrast, first-gen high school graduates born in the US had similar executive function z-scores ($\beta_{\text{US-born}}$: -0.03 [95% CI: -0.20, 0.14]) compared to their multi-gen counterparts.

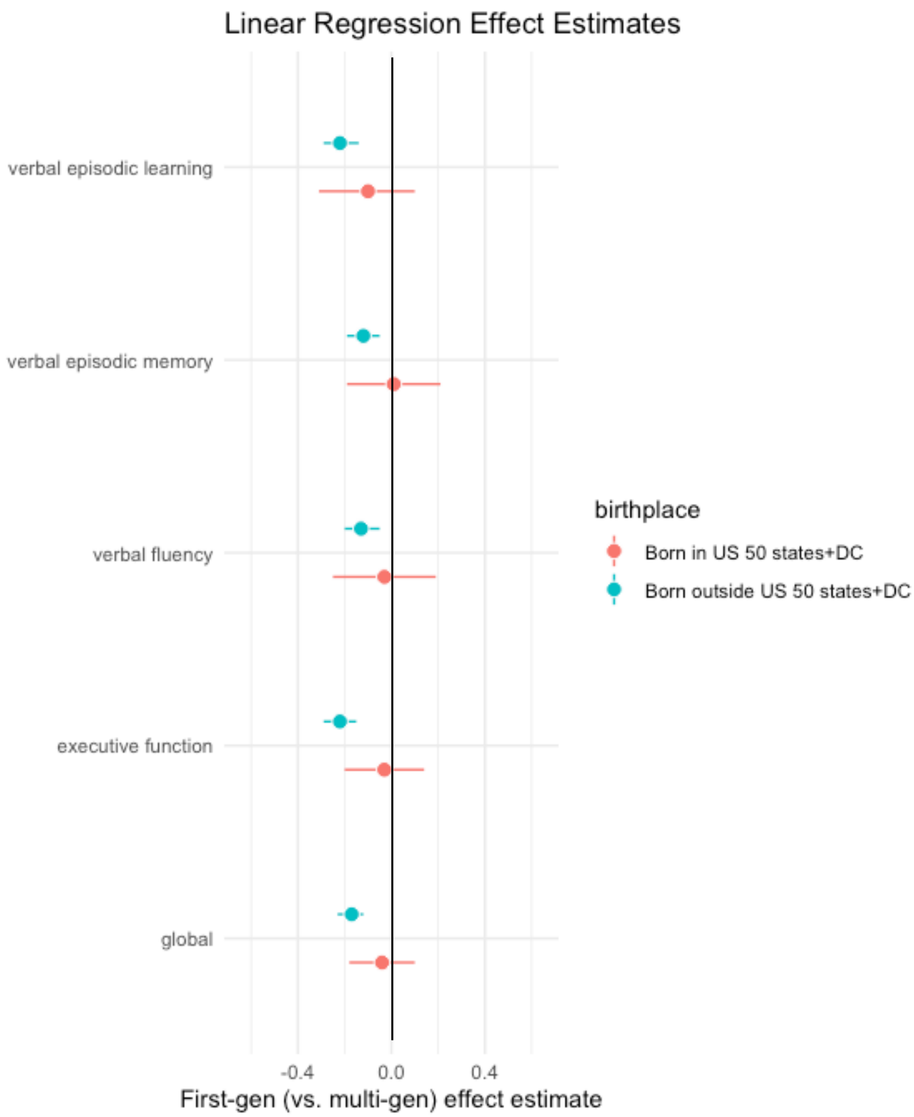

Figure 2.2 Linear regression coefficients for first-gen (vs. multi-gen) high school graduates and cognitive outcomes by nativity

On average, between visits 1 and 2, first-generation high school graduates had a slight increase in verbal learning score (β: 0.07 [95% CI: -0.02, 0.17]) indicating a possible practice effect, and a decrease in verbal fluency (β: -0.07 [95% CI: -0.16, 0.03]) and executive function (β: -0.06 [95% CI: -0.17, 0.06]) scores compared to their multi-generational counterparts. However, effect estimates did not reach statistical significance (Figure 2.3). We found no evidence of heterogeneity by heritage group (first-gen x Latino heritage group interaction p-values >0.10) or nativity (first-gen x nativity interaction p-values >0.40) across domain-specific and global cognitive change scores.

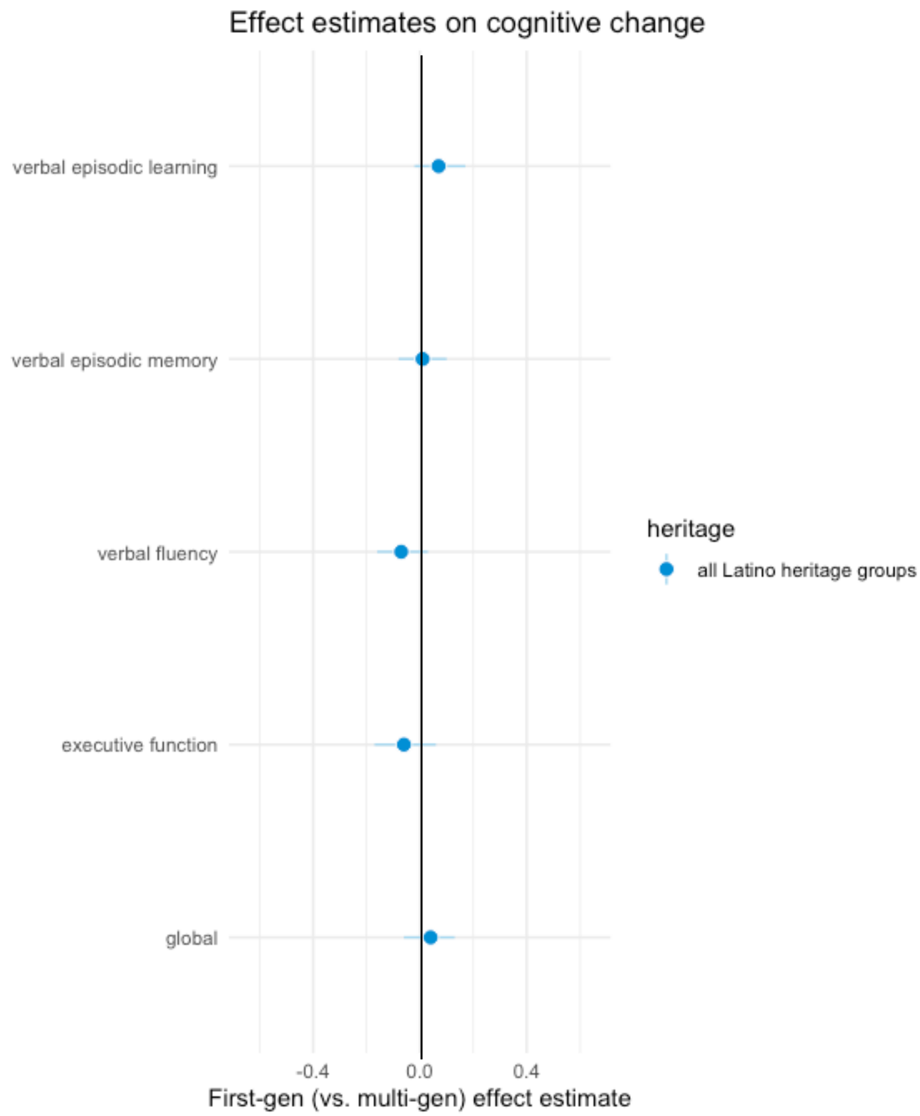

Figure 2.3 Linear regression coefficients for first-gen (vs. multi-gen) high school graduates and average change in cognitive scores from Visit 1 to Visit 2

DISCUSSION

In a study of 3,344 middle- to older-aged Latino adults who graduated high school, more than half were considered first-generation high school graduates. We found differences in the association between being a first-gen (vs. multi-gen) high school graduate and domain-specific baseline cognitive z-scores by Latino heritage group. Among respondents of Cuban, Mexican, and Puerto Rican heritage, first-generation high school graduates had significantly lower baseline cognitive scores compared to their multi-gen counterparts. In contrast, among respondents of Dominican, Central, and South American heritage, first-generation and multi-generation high school graduates had generally similar baseline cognitive scores. First-gen high school graduates born outside of the 50 US states and DC had significantly lower cognitive scores compared to their multi-gen counterparts, while associations were null among US-born respondents. We did not find significant differences between first-gen and multi-gen high school graduates on cognitive change scores from visit 1 to visit 2, on average 7 years later.

Our primary results are consistent with prior research suggesting that an individual's low parental education may negatively impact late-life cognitive function.[3,4,6] Our findings identifying differences in the association between upward intergenerational education and cognitive function within Latino heritage group may highlight the importance of considering external drivers influencing the different lived experiences within and between Latino heritage groups in the US. Heterogeneity in the association between first-gen high school completion and baseline cognitive function by Latino heritage group may reflect the historical and political relationships each group has had with the US. For example, Mexican, Puerto Rican, and Cubans are the three largest groups represented in the current study and three of the four largest groups of Latinos in the US (59.5% Mexican, 9.3% Puerto Rican, 4% Salvadoran, and 3.8% Cuban).[16] The local density of immigrants or other members of the same ethnic or heritage group and the extent of community-wide social power of any particular group may exacerbate differences in the educational benefits of a high school education for first-gen vs multi-gen groups. Different waves of immigration and immigration policies in the US may have influenced economic strains and opportunities for additional social stratification within each of these Latino heritage groups.

For example, we found clear evidence of differences in the cognitive performance of Cuban first-generation high school graduates compared to their multi-gen counterparts. Compared to other Latinos in the US, Cubans have higher levels of education and higher median household incomes.[17] However, among Cuban immigrants, there are key differences based on the context of emigration. Waves of Cuban immigrants before 1980 consisted of upper- and middle-class families coming to the US seeking political refuge and better assisted by US federal programs to be integrated into the US class-structured society more quickly.[18] In contrast, Cuban immigrants coming to the US in the 1980s and the 1990s consisted of Cubans with lower levels of education seeking economic opportunities and political asylum under different refugee immigration policies. These differences are further reflected in US citizenship status. Among Cubans who arrived in the US before 1980, about 90% are US citizens, compared to 60% among those who arrived between 1980 and 1990 and 18% among those who arrived after 1990.[17] Differences in the association between intergenerational education and cognitive performance could reflect changes in opportunities for economic growth and assimilation across different waves of immigrants within Latino heritage group.

In addition to experiences of migration and political relationships, first-gen individuals may have experienced similar forms of social stratification and discrimination within their respective heritage groups. While some studies on ethnic density and health have found a protective health effect, others have reported detrimental or null effects on health. It is possible that within their respective ethnic clusters, there are similar patterns of school and neighborhood segregation and discrimination, particularly among first-gen respondents more likely to live in low-income, working-class neighborhoods. For example, similar patterns in under-resourced schools may lead to lower education quality, fewer prospects for a college or professional degree, and lower lifetime earnings. Our findings emphasize the importance of disaggregating Latino groups to better understand the pathway and underlying mechanisms of the observed associations. Future studies should examine how educational mobility may impact physical mobility or relocation, for example, if first-gen graduates are more likely to move into more affluent neighborhoods.

There are a few possible explanations for why we found no substantial differences in the cognitive performance of first-gen and multi-gen high school graduates among participants of Central and South American heritage. First, compared to Mexicans and Puerto Ricans, Central, and South Americans comprise a smaller portion of Latinos in the US and are more geographically dispersed. Due to the smaller sample size of these groups in our study, we combined respondents who identified as Central American or South American into these larger groups. For instance, among Central American respondents, the largest groups represented were Nicaraguan (39%), Honduran (23%), and Guatemalan (20%). Given differences in educational attainment across these countries, clustering these groups could have masked heterogeneity by country of origin. Alternately, first-gen and multi-gen high school graduates may be more similar within these groups. For example, immigrants from South American countries have higher average levels of education compared to the US Latino average. In 2011, 31% of Colombians and 18% of Ecuadorians 25 years and older in the US held a bachelor's degree compared to the 13% average of other Latino adults in the US.[19] South American parents of first-gen high school graduates could have been closer in educational attainment to high school and more similar to parents of the multi-gen group, such that first-gen high school graduates within these groups had to make smaller strides in education from their parent's generation to theirs.

Our findings showing no substantial differences in cognitive change scores for first-gen versus multi-gen high school graduates are in line with prior work among older Mexican and Mexican American adults in California, which suggest that participants with upward educational mobility had similar cognitive decline.[4,6] However participants in our study were, on average, 55 years old, notably younger than participants in the aforementioned study. Our findings showing no cognitive change differences could also be due to having a relatively young sample with minimal cognitive change in mid-life. Substantial methodologic limitations to change score analyses have been well-documented, including lack of power, potential regression to the mean bias, and practice effects. Our study does not include enough repeated measures to tease out practice effects and may not capture functionally impactful cognitive change. However, our findings contribute important insights to the growing literature on cognitive health earlier in life. Future work to replicate these findings in diverse cohorts with longer follow-up time and older participants.

This study has some notable limitations. First, self-reported education and parental education are subject to measurement error due to recall bias, particularly for parental education. Additionally, the misclassification of the exposure could be differential with respect to cognitive performance. Research has shown education misclassification is higher at lower levels of education.[20,21] Next, while we observed no differences in cognitive change for first-gen and multi-gen high school graduates, our analysis was limited to two time points. Two waves of cognitive assessments in individuals 45 years and older may not capture enough variance between subjects to detect differences in cognitive trajectories. Future studies should corroborate our findings across Latino cohorts with more waves of data. Finally, although our data includes a diverse group of Latino respondents from different countries of origin, we only present clustered findings from Central and South American groups due to small samples. Results for these groups should be interpreted with caution and replicated in future work.

Despite these limitations, the current study also has major strengths. First, our study sample represents a diverse cohort of older Latinos in four of the top metropolitan US cities with high concentrations of US Latinos: Bronx, NY, Chicago, IL, Miami, FL, and San Diego, CA.[22] While prior US studies on cognitive health have focused on Hispanic and Latino individuals from California and New York, (mostly Mexican or Mexican American, and Caribbean Latinos), less is known about the state of other Latino heritage groups. Our findings extend prior work by identifying differences in the association between upward intergenerational education and cognitive health in a national and diverse group of Latinos. Finally, the current study provides a unique intersectional approach to the study of upward intergenerational educational mobility among Latino older adults; future studies should continue to focus on how multiple social status markers and identities may shape the cognitive health consequences of educational mobility.

CONCLUSION

Our study underscores the potential impact of rising population average education across generations on cognitive health and has important policy implications. Our findings show that multi-generation high school graduates have significantly higher cognitive performance than first-generation graduates. Policies that support higher educational attainment and help transition Latinos from first-generation to multi-generational high school graduates could have a significant impact on long-term cognitive health. This could be especially true for certain heritage and nativity subgroups, where the differences between first-generation and multi-generational graduates were particularly pronounced. Moreover, while we did not find any differences between first-gen (vs. multi-gen) education and cognitive change, our findings on initial levels of cognitive performance are critical for informing estimates of dementia burden. Given the importance of education as a modifiable risk factor for ADRDs, understanding how differences in generational increases in education may impact cognitive health across population subgroups, especially in communities with historically less education, is critical for ADRDs disparities research. As generations of parents with a high school education become more common, we could see reduced cognitive health disparities.

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SUPPLEMENTARY MATERIAL

Table S2.1 Covariate-adjusted associations for first-gen (vs. multi-gen) high school graduates and cognitive outcomes at Visit 1, by Latino heritage group (weighted estimates).

Outcome at Visit 1	Central American Beta (95% CI)	Cuban Beta (95% CI)	Dominican Beta (95% CI)	Mexican Beta (95% CI)	Puerto Rican Beta (95% CI)	South American Beta (95% CI)	Interaction p-value
Verbal episodic learning	-0.04	**-0.25**	0.06	**-0.24**	**-0.22**	-0.08	**0.0539**
	(-0.24, 0.16)	**(-0.38, -0.13)**	(-0.13, 0.24)	**(-0.38, -0.10)**	**(-0.38, -0.06)**	(-0.27, 0.11)	
Verbal episodic memory	-0.04	**-0.12**	0.03	-0.07	**-0.26**	-0.02	0.237
	(-0.24, 0.16)	**(-0.24, -0.01)**	(-0.20, 0.26)	(-0.19, 0.06)	**(-0.43, -0.09)**	(-0.23, 0.19)	
verbal fluency	0.05	**-0.14**	**0.26**	-0.13	**-0.23**	-0.09	**0.0235**
	(-0.14, 0.24)	**(-0.24, -0.04)**	**(0.06, 0.47)**	(-0.30, 0.03)	**(-0.38, -0.08)**	(-0.32, 0.14)	
executive function	-0.18	**-0.25**	0.01	**-0.28**	-0.10	**-0.16**	0.1062
	(-0.38, 0.01)	**(-0.37, -0.12)**	(-0.21, 0.22)	**(-0.40, -0.17)**	(-0.24, 0.04)	**(-0.29, -0.02)**	
global composite score	-0.05	**-0.19**	0.09	**-0.18**	**-0.20**	-0.09	**0.0157**
	(-0.20, 0.09)	**(-0.29, -0.10)**	(-0.05, 0.22)	**(-0.27, -0.09)**	**(-0.31, -0.10)**	(-0.22, 0.05)	

Stratified models presented adjusted for age, sex, and nativity
***p-values reflect the F-test of the (First-gen high school graduate x Latino heritage group) interaction in pooled models for each cognitive outcome*

Table S2.2 Covariate-adjusted associations for first-gen (vs. multi-gen) high school graduates and cognitive outcomes at Visit 1 by nativity (weighted estimates)

Outcome at Visit 1	non-US Born Beta (95% CI)	US Born Beta (95% CI)	p-value for interaction with nativity**
verbal episodic learning	**-0.22**	-0.10	0.458
	(-0.29, -0.14)	(-0.31, 0.10)	
verbal episodic memory	**-0.12**	0.01	0.306
	(-0.19, -0.05)	(-0.19, 0.21)	
verbal fluency	**-0.13**	-0.03	0.582
	(-0.20, -0.05)	(-0.25, 0.19)	
executive function	**-0.22**	-0.03	**0.039**
	(-0.29, -0.15)	(-0.20, 0.14)	
global composite score	**-0.17**	-0.04	0.152
	(-0.23, -0.12)	(-0.18, 0.10)	

Stratified models presented adjusted for age, sex, and Latino heritage group
*** p-values reflect the F-test of the (First-gen high school graduate x nativity) interaction in pooled models for each cognitive outcome*

Table S2.3 Beta estimates and 95% confidence intervals for domain-specific cognitive change between first-gen and multi-gen high school graduates.

Cognitive Domain	Beta (95% CI)	p-value for interaction with Latino heritage	p-value for interaction with nativity
verbal episodic learning	0.07 (-0.02, 0.17)	0.297	0.988
verbal episodic memory	0.01 (-0.08, 0.10)	0.725	0.818
verbal fluency	-0.07 (-0.16, 0.03)	0.127	0.440
executive function	-0.06 (-0.17, 0.06)	0.216	0.837
global composite score	0.04 (-0.06, 0.13)	0.334	0.805

Models adjusted for age, sex, heritage group, and nativity

Chapter 3

Does my child's education slow my cognitive decline and reduce my risk of dementia?

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Funding sources: NIH NIA F31AG071111 (PI: Meza)

ABSTRACT

Introduction: A growing body of research suggests cognitive health benefits among older adults with highly educated adult children. It remains unclear if the association applies equally to ethnic minorities who have experienced differences in access to higher education.

Methods: Using data from the US Health and Retirement Study (1998-2018), we used linear mixed models to examine the association between offspring education and cognitive function (z-scored verbal learning and memory) for Hispanic and White older adults. We used Cox proportional hazard models to estimate the incidence of possible cognitive impairment, no dementia (CIND), or probable dementia. Among Hispanic participants, models also examined for effect modification by nativity (US vs. non-US-born).

Results: Each year of offspring education >12 years was associated with higher baseline verbal learning and memory z-scores (β: 0.043 [95% CI: 0.037, 0.049] and a slightly faster rate of decline in verbal learning (β: -0.001 [95% CI: -0.002, -0.001]). For each year of offspring education >12, Hispanic participants had a 5.1% lower hazard (Hazard Ratio (HR): 0.95; 95% CI: 0.92, 0.98), and White participants had a 3.6% lower hazard (HR: 0.96; 95% CI: 0.95, 0.98) for possible CIND or probable dementia. Associations did not vary by nativity (interaction term p-value: 0.58)

Conclusion: Findings suggest an association between offspring education and cognitive function for Hispanic and White older adults, with larger benefits for Hispanic parents. Future work should examine potential mechanisms underlying this association and assess for further heterogeneity by Hispanic and Latino subgroups.

INTRODUCTION

Socioeconomic position, including high levels of education, has been established as a robust protective factor associated with higher cognitive function and a lower risk of dementia.[1–7] However, embedded racial and ethnic inequities in access to higher education have produced unequal opportunities for healthy cognitive aging.[8–10] A growing body of research across different countries suggests that in addition to their own education, the education level of adult children may influence the cognitive health of older adults.[11–16] The lifecourse principle of "linked lives" proposes that individuals are linked in complex ways and that people in salient relationships, such as parents and their offspring, influence each other and share resources.[17] For instance, adult offspring with higher levels of education could influence their parents' behavioral outcomes (e.g., diet, smoking, and physical exercise), psychological well-being (e.g., lowered levels of depressive symptoms or stress), access to greater financial resources and medical care, or a combination of these factors benefiting cognitive health. In contrast, adult offspring with lower levels of education may rely more on the resources of their parents, which could lead to added psychosocial stressors and more limited financial resources that could negatively impact their cognitive health.[11,18] In the US, research has found that parents with well-educated offspring report higher memory scores over time,[16] and that protective associations between offspring education and risk of dementia are stronger for Black compared to White older adults.[14] To our knowledge, no studies have evaluated the association between adult-offspring education and cognitive health in a national sample of US Latino or Hispanic older adults.

Previous work has found that high levels of education are more protective against cognitive impairment for White than Mexican Americans.[19] Prior studies have also found little or no associations between educational attainment and different health outcomes, including mental health, self-reported general health, and mortality among some Latino groups (e.g., foreign-born Mexican Americans).[20–22] Thus, suggesting that the link between education and health may operate differently across ethnic groups. It is possible that some of the pathways linking higher levels of education to better health may be weakened by the additional stressors and discrimination faced by US and foreign-born Latino older adults.[23] However, given increments in educational attainment during more recent decades, particularly among communities with historically less education, adult children of US and foreign-born Latinos may have experienced greater educational mobility relative to their parents. While high school completion increased between 2011 and 2021 from 92.4% to 95.1% for non-Hispanic White adults, high-school completion increased from 64.3% to 74.2% for Latino adults 25 years and older.[24,25] These relative increases in intergenerational educational attainment may translate to heterogeneous relationships between offspring education and the late-life outcomes of Latino compared to White older adults. Evaluating how offspring's education may influence their Hispanic or Latino parent's cognitive function can improve our understanding of the underlying pathways through which social and structural factors impact health and help inform new strategies for addressing education-based health inequities in cognitive aging.

In this study, we evaluate 1) the association between adult-child education and their parent's cognitive function and decline and 2) the association between adult-child education and the development of possible cognitive impairment with no dementia (CIND) or probable dementia for Hispanic older adults compared to their White counterparts. Among Hispanic older adults, we also examine if these associations differ for US-born vs non-US-born. Based on the linked lives lifecourse theory, we hypothesized a positive association between participants' offspring education and cognitive outcomes. Based on the negative selection hypothesis, we also hypothesize that the benefits of adult-child education would be greater for Hispanic than White participants.

METHODS

Study Population

We used data from the Health and Retirement Study (HRS), a nationally representative longitudinal survey of community-dwelling adults over 50 and their spouses of any age. The first HRS participants were interviewed in 1992 and every two years from cohort entry until death or dropout. Since 1998, new cohorts have entered every six years to maintain the sample as representative of people over 50. Data collection includes sociodemographic information, physical health and functioning, cognitive functioning, and family relationships. Full study details have been published elsewhere.[26] We use the publicly available RAND HRS longitudinal file, which includes data for all respondents and their spouses from 1992 to 2018, and the RAND HRS Family Data file, which includes data on the children of HRS participants from 1992 to 2014. All HRS participants provided verbal informed consent for their participation in the study, and data collection was approved by the Health Sciences and Behavioral Sciences institutional review board at the University of Michigan.

Our study sample consisted of HRS participants 50+ who participated between 1992 and 2014, reported at least one living offspring (25 years and older) at their baseline wave (consistent with prior research, we exclude children under 25 years old who are more likely to still be in school),[15,27] had consistent parent-child relationship linkage documented across survey waves (i.e., no discrepancy such that offspring was reported as grandchild or stepchild from one survey wave to the next), and who self-identified as Hispanic or Latino (hereafter, Hispanic as reported by HRS) or non-Hispanic White (hereafter, White) (n=24,528). We additionally excluded participants with missing data on adult-offspring education (n=983), cognitive outcomes (n=1,031), or other covariates (n=14). In our secondary analysis of cognitive impairment or dementia, we excluded participants with possible CIND or probable dementia at baseline (n=5,660). The sample selection procedure included in this study is illustrated in Supplementary Figure S3.1.

Exposure

Our independent variable of interest was years of education across HRS participants' adult offspring, 25 years and older, reported at baseline. HRS participants reported the total number of living children and the total years of schooling for each child 18 years and older. For each HRS participant, we define adult-offspring education as the highest years of education (continuous 0-17) reported at baseline across all living adult children 25 years and older. For HRS participants who entered before 1998, we assigned the highest years of education across their living adult children 25 years and older reported in 1998 or the last reported period before 1998. As a proxy for a high school education, we centered adult child educational attainment at 12 years since HRS does not ask about the type of academic degree completed by each adult child. In sensitivity analysis, we also considered other ways to operationalize adult-offspring education (e.g., average years of schooling across offspring 25 and older).

Cognitive Outcomes

Our first outcome is verbal episodic memory scores; episodic memory impairment is among the most common early cognitive signs of dementia.[28] At each study wave, respondents were read a list of 10 words and asked to recall as many words as possible immediately and then after a 5-minute delay (range: 0-10 per test). Scores are analyzed separately as immediate recall captures encoding (i.e., the storage of incoming information into a mental representation), and the other score captures delayed recall.[28,29] To improve interpretability, raw scores were z-standardized using the baseline sample mean and standard deviation, such that a score of 0 represents the baseline sample mean, and a score of 1 represents one standard deviation above the baseline sample mean.

Possible Cognitive Impairment with no Dementia (CIND) or probable dementia was classified using the Langa-Weir 27-point scale. The 27-point scale categorizes participants into: individuals with probable dementia (0-6), individuals with possible cognitive impairment but no dementia (7-11), and individuals with normal cognition (12-27). Proxy respondents were also included in the Langa-Weir scale. Full details of the methods used to make these classifications based on the diagnostic information from the ADAMS have been previously published.[30] Due to sample size constraints, we dichotomized the categories to reflect normal cognition vs. possible CIND or probable dementia.

Covariates

We used a directed acyclic graph to represent our hypothesized causal structure and select parental characteristics expected to confound the association between adult-child education and late-life cognitive outcomes. We consider HRS participant (i.e., parental) age, sex (female, male), ethnicity (Hispanic, White), own educational attainment at baseline (less than high school (HS), HS or GED, some college, college and above), marital status at baseline (married/partnered, divorced/separated, widowed, never married, unknown), nativity (non-US born, US-born) total number of children at baseline (continuous), and cohort effects (based on respondent birth year). To analyze cognitive decline, we account for practice effects by including an indicator for the participant's initial cognitive test encounter in our models, since cognitive test performance can improve when the same test is taken repeatedly over time.[31]

Statistical Analysis

First, we evaluated the association between adult-child education and the level and rate of change in verbal episodic memory z-scores for Hispanic vs. White and among Hispanic US-born vs. non-US-born respondents. We fit linear mixed-effect models allowing for subject-specific random intercepts and random slopes. We included a continuous measure of offspring education (centered at 12 years), a time term reflecting years since participants' baseline, a multiplicative interaction between offspring education and years since baseline, and covariates. We evaluated effect modification by ethnicity and nativity via stratified models and multiplicative interaction terms (i.e., between offspring education, time, and ethnicity or, separately, by nativity).

Second, we evaluated the association between offspring education and the risk of possible CIND or probable dementia using Cox Proportional Hazards models. Participants were censored at the first wave of data in which 1) possible CIND or probable dementia was first recorded, 2) participants dropped out of the study (due to death or loss to follow-up), or 3) at the end of follow-up in 2018. These models also adjusted for age, sex, own education, marital status, nativity, and number of children. Separately, these models included a 2-way interaction term between offspring education and ethnicity and a 2-way interaction term between offspring education and nativity. The proportional hazards assumption was assessed based on the Schoenfeld residuals.[32]

Sensitivity Analysis

We conducted a sensitivity analysis. First, we repeated our analysis using average offspring education as an alternate way to operationalize adult-child education. Second, we used age as the time scale specification centered at the mean age of respondents (age 64) for our cognitive change models. We used Stata v.17 (StataCorp LLC, College Station, TX) to conduct all analyses.

RESULTS

In the analytic sample of 17,484 participants, the mean age and standard deviation at baseline were 64.9 $\pm$ 10.3 years (Table 3.1). On average, Hispanic participants were five years younger than White participants. Most of our sample (87%) self-identified as White. Notably, about 59% of Hispanic participants reported being born outside of the US. Increases in educational attainment between Hispanic and White participants and their offspring were evident in our sample. On average, Hispanic HRS participants had completed 8.9 years of education compared to 12.7 years among White participants. Across their offspring, the *highest-educated child* of Hispanic participants had completed, on average, 13.5 years of education compared to 14.7 years for the offspring of White participants. The *average years of education* across all their offspring were 12.5 years for Hispanic participants compared to 13.9 years for White participants. On average, participants scored 5.7 (sd: 1.8) on verbal learning (immediate recall z-scores) and 4.6 (sd: 2.1) on verbal memory (delayed word recall z-scores) at baseline.

Table 3.1 Baseline characteristics of study population by ethnicity, US Health and Retirement Study (1998-2018)

	Hispanic (n=2,325)		White (n=15,159)		Overall (n=17,484)	
Mean age at baseline (sd)	60.6	(8.9)	65.6	(10.3)	64.9	(10.3)
Sex						
Female	1,359	58.5%	8,652	57.1%	10,011	57.3%
Male	966	41.5%	6,507	42.9%	7,473	42.7%
Marital Status						
Married/Partnered	1,640	70.5%	11,152	73.6%	12,792	73.2%
Divorced/Separated	374	16.1%	1,476	9.7%	1,850	10.6%
Widowed	249	10.7%	2,489	16.4%	2,738	15.7%
Never Married	59	2.5%	36	0.2%	95	0.5%
Unknown	3	0.1%	6	0.0%	9	0.1%
Nativity						
US-born	960	41.3%	14,503	95.6%	15,463	88.4%
non-US born	1,365	58.7%	656	4.3%	2,021	11.6%
Own Education (cont)	8.9	(4.6)	12.7	(2.7)	12.2	(3.2)
Own Education (cat)						
< High school	1,325	57.0%	2,872	18.9%	4,197	24.0%
High school or GED	522	22.5%	5,954	39.3%	6,476	37.0%
Some college	344	14.8%	3,485	23.0%	3,829	21.9%
College+	134	5.8%	2,848	18.8%	2,982	17.1%
Mean number of offspring	3.0	(2.1)	2.7	(1.5)	2.7	(1.6)
Offspring Education, years						
Highest	13.5	(2.5)	14.7	(2.0)	14.6	(2.1)
Average	12.5	(2.6)	13.9	(1.9)	13.7	(2.1)

Linear mixed-effects models

Table 3.2 shows the estimates of association for every year of adult-child education above 12 and HRS respondents' verbal learning and memory scores, by ethnicity after adjusting for covariates. Each additional year of adult-offspring education above 12 years (for respondents' highest educated offspring) was associated with higher verbal learning and verbal memory z-scores (β: 0.043 [95% CI: 0.037, 0.049]) at baseline. Each additional year of adult child education above 12 years (for the highest educated child) was associated with a slightly faster decline in verbal learning ($\beta_{\text{immediate}}$: -0.001 [95% CI: -0.002, -0.001]) and verbal memory z-scores (β_{delayed}: -0.001 [95% CI: -0.002, -0.001]). Associations between offspring education and cognitive function and decline did not differ for Hispanic compared to White participants (interaction term p-values for verbal learning: 0.973 and verbal memory: 0.349).

Table 3.2 Beta coefficients and 95% confidence intervals for linear mixed models of the association between offspring education (>12) and verbal learning and memory z-scores

	Verbal Learning		Verbal Memory	
Variable	Beta	(95% CI)	Beta	(95% CI)
Highest offspring education	**0.046**	**(0.041, 0.052)**	**0.044**	**(0.038, 0.050)**
Time (years since baseline)	-0.042	(-0.043, -0.040)	-0.038	(-0.039, -0.036)
Highest offspring education x Time	**-0.001**	**(-0.002, -0.001)**	**-0.001**	**(-0.002, -0.001)**

Note: Highest offspring education is centered at 12 years; Model adjusted for age, sex, ethnicity, own education, marital status, nativity, birth cohort, total number of kids, and practice effect.
3-way interaction (offspring education x time x ethnicity) p-values for verbal learning: 0.973 and verbal memory: 0.349

Table 3.3 shows the estimates of association for every year of adult-child education above 12 and verbal learning and memory scores by nativity among Hispanic participants after adjusting for covariates. Associations between offspring education and the rate of verbal learning and memory differed for US-born and non-US-born individuals (interaction term p-values for verbal learning: 0.027 and verbal memory: 0.070). Among non-US-born participants, each year of offspring education >12 showed a slightly faster decline in verbal learning ($\beta_{\text{immediate}}$: -0.002 [95% CI: -0.003, -0.001]) and verbal memory (β_{delayed}: -0.001 [95% CI: -0.003, -0.0001]); among US-born participants each year of offspring education >12 was associated with a slight increase in verbal learning and memory scores, though these estimates did not reach statistical significance (β: 0.001 [95% CI: -0.001, 0.003]). Effect estimates remained similar in sensitivity analysis using average adult-child education and when we used age as a time scale (Supplemental Table S3.2).

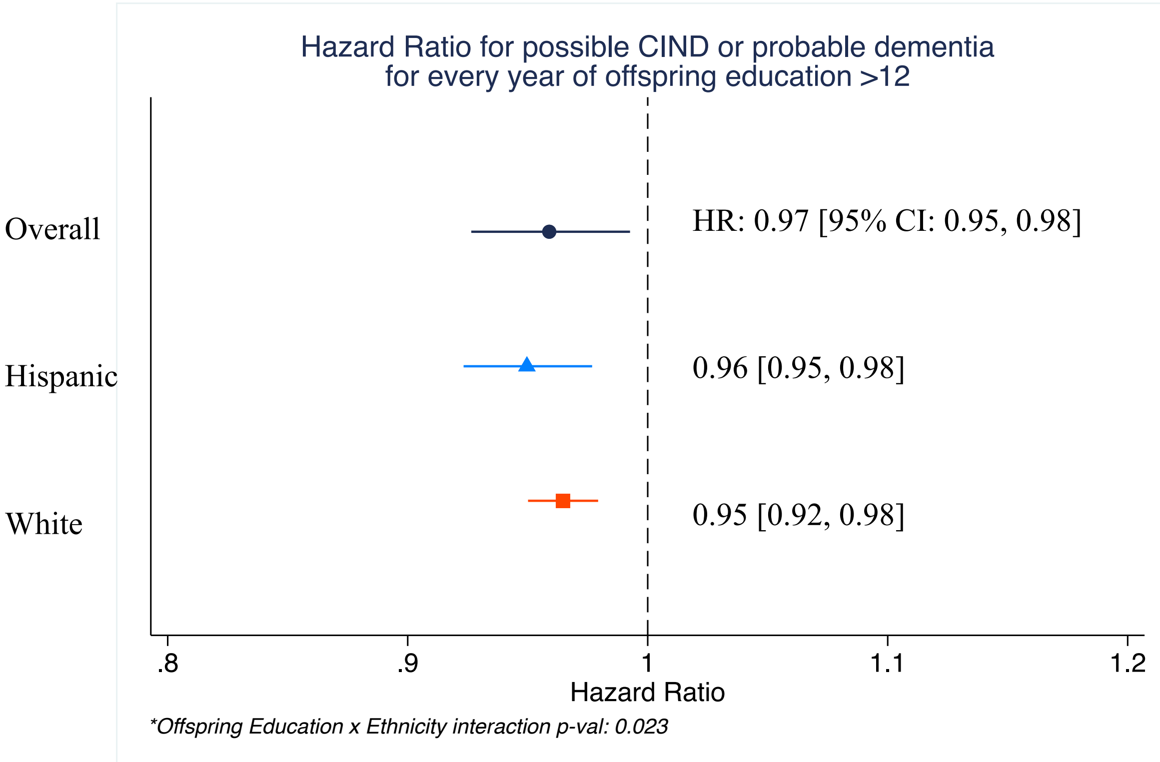
Table 3.3 Beta coefficients and 95% confidence intervals for linear mixed models of the association between offspring education (>12) and verbal learning and memory z-scores by nativity among Hispanic participants

	Verbal Learning			Verbal Memory		
Stratified by Nativity:	**Beta**	**(95% CI)**	**p-value**	**Beta**	**(95% CI)**	**p-value**
non-US-born						
Highest offspring education	**0.045**	**(0.031, 0.060)**	**0.000**	**0.035**	**(0.021, 0.049)**	**0.000**
Time (years since baseline)	-0.027	(-0.031, -0.023)	0.000	-0.028	(-0.033, -0.024)	0.000
Offspring education x Time	**-0.002**	**(-0.003, -0.001)**	**0.007**	**-0.001**	**(-0.003, 0.000)**	**0.025**
US-born						
Highest offspring education	**0.042**	**(0.019, 0.065)**	**0.000**	**0.038**	**(0.015, 0.061)**	**0.001**
Time (years since baseline)	-0.041	(-0.047, -0.035)	0.000	-0.039	(-0.045, -0.034)	0.000
Offspring education x Time	**0.001**	**(-0.001, 0.003)**	**0.379**	**0.001**	**(-0.001, 0.003)**	**0.441**

Note: Highest offspring education is centered at 12 years; Model adjusted for age, sex, ethnicity, own education, marital status, 3-way interaction (offspring education x time x nativity) p-values for verbal learning: 0.027 and verbal memory: 0.070

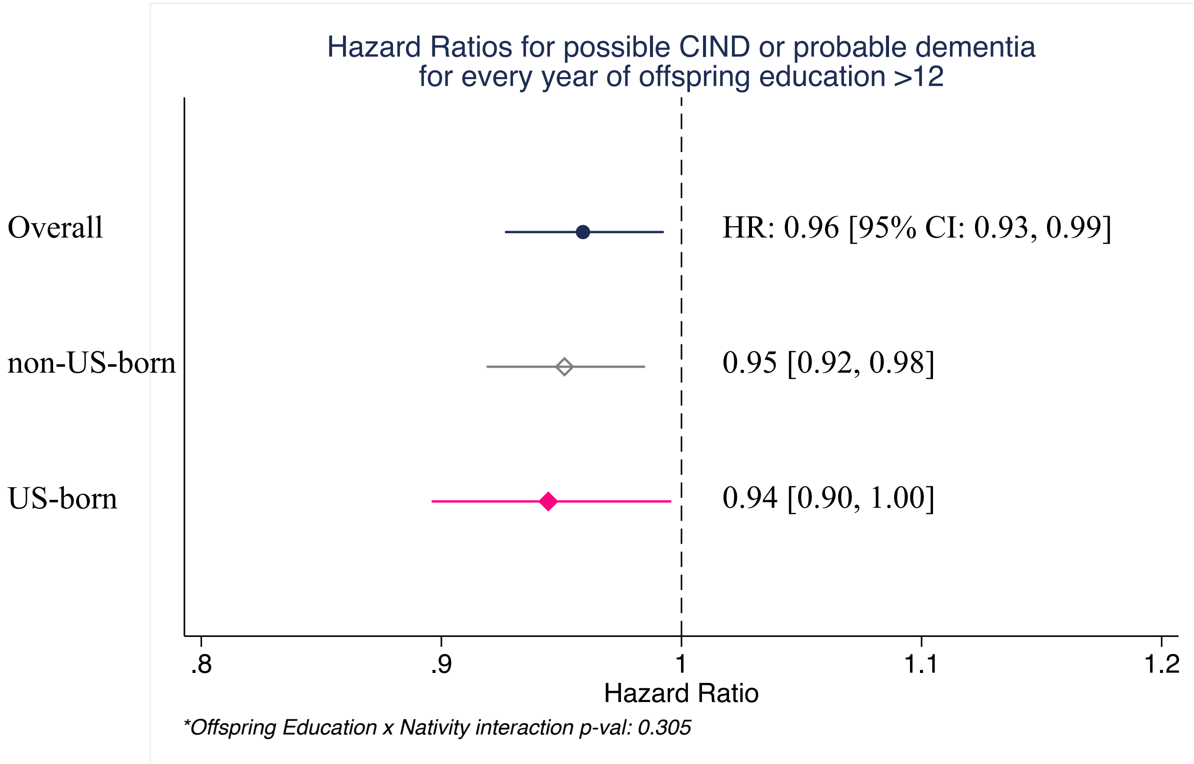
Incidence of possible CIND or probable dementia

During follow-up (mean:14.8 years; range 2-20 years) 42% of our sample met the criteria for possible CIND or probable dementia. Figure 3.5 shows the estimated hazard ratios and 95% confidence intervals for developing possible CIND or probable dementia for Hispanic and White participants. After adjusting for sociodemographic characteristics, for each one-year increase in adult child education greater than 12, Hispanic participants had a 5.1% decrease (HR: 0.95; 95% CI: 0.92, 0.98) in hazard of possible CIND or probable dementia, and White participants had a 3.6% decrease (HR: 0.96; 95% CI: 0.95, 0.98) in hazard of possible CIND or probable dementia (interaction term p-value: 0.02). The association between adult-child education and possible CIND or probable dementia did not vary by nativity (interaction term p-value: 0.58), as shown in Figure 3.6.



Models adjusted for age, sex, education, marital status, nativity, birth cohort, total number of children, and total number of children residing in the participant's home.

Figure 3.1 Hazard Ratios and 95% confidence intervals for possible CIND or probable dementia for each year of offspring education (>12) by ethnicity.



Models adjusted for age, sex, education, marital status, nativity, birth cohort, total number of children, and total number of children residing in the participant's home.

Figure 3.2 Hazard Ratios and 95% confidence intervals for possible CIND or probable dementia for each year of offspring education (>12) by nativity

DISCUSSION

Summary of findings

In this analysis of 17,484 Hispanic and White participants over the age of 50 with at least one living offspring 25 years and older, we observed a decrease in the educational gap between Hispanic and White HRS participants to that between their offspring. We found that each year of offspring education >12 was associated with higher cognitive function at baseline and a slightly faster rate of cognitive decline for Hispanic and White participants. Among Hispanic participants, each year of offspring education >12 was significantly associated with a faster rate of cognitive decline for participants born outside of the US. In the subsample of 14,205 cognitively healthy older adults, each year of offspring education >12 was associated with a decreased hazard of possible CIND or probable dementia, with a greater decrease among Hispanic participants.

Our results are consistent with studies in other countries showing that offspring education is associated with their parents' cognitive health and trajectories.[11–13] While we did not find differences in the associations between offspring education and cognitive health for Hispanic and White participants, it is possible that structural-level factors that influence opportunities for higher educational attainment and inequities in other aspects of educational attainment, such as quality of education, mask underlying differences and educational benefits across different population subgroups. For example, according to the National Center for Education Statistics, on average, Hispanic students trail White students academically by four grade levels by the time they finish high school. Additionally, Hispanic students attend schools with fewer resources than their White counterparts. These may include better college preparation courses, more qualified teachers, and smaller class ratios. This could lead to differences in college completion time if students from under-resourced schools need to take additional prerequisite or remedial courses. This could mean that the same years of education for Hispanic and White adult children does not equate to the same type of degree completed. For example, 16 years of education may result in a college degree for a White participant but not for a Hispanic participant. It is possible that among Hispanic participants, cognitive decline for those with higher offspring education does not differ from White participants because the same years of education do not confer the same benefits. Future studies should consider additional aspects of educational attainment, like education quality or the type of degree completed. Furthermore, Hispanic and Latino older adults from different countries of origin are concentrated in different parts of the US. This means Hispanic older adults in different parts of the country may face different challenges to equitable opportunities and access to quality education (i.e. eliminating bilingual education, limited funding for children of undocumented individuals). When possible, future work should disaggregate data on Hispanic and Latino older adults more fully.

Our findings showing that higher offspring education is associated with faster cognitive decline among non-US-born participants but not among US-born participants is also consistent with prior work suggesting greater benefits of social mobility among US-born participants.[33] Among Hispanic participants, differences between non-US-born and US-born older adults may suggest the influence of other sociopolitical factors. For instance, it is possible that despite higher levels of education, the offspring of undocumented individuals are limited by the resources available to undocumented older adults. This provides new evidence for the importance of an intersectional framework in future studies of Hispanic and Latino cognitive health.

Our findings showing the impact of offspring education on incident probable CIND or dementia in a Hispanic population is another important contribution to the existing literature on offspring education and cognitive health disparities. The notable difference in reduced hazards for Langa-Weir possible CIND or probable dementia in our findings suggests that higher levels of offspring education may be more beneficial for Hispanic than White parents' cognitive outcomes. This is similar to prior work showing that higher levels of offspring education may be more protective for Black than White parents' risk of dementia,[14] One explanation for lower hazard among Hispanic compared to White older adults with higher educated offspring could center around family-level cultural characteristics within Hispanic familial ties. For instance, compared to White families, Hispanic families are more likely to live in multigenerational households or with adult children near their older parents.[34] This proximity might facilitate frequent opportunities for adult children with higher education to share resources and provide more instrumental or direct caregiving support to their parents.

This study has a few limitations. First, our primary exposure, years of adult offspring education, is based on HRS participants' reported data. Although this could be subject to misreporting, prior work shows misclassification is more likely to occur at lower levels of education and potentially lead to an underestimate of the true effect of offspring education.[35,36] Additionally, while exposure in our primary analysis was based on the highest level of offspring education, our sensitivity analysis showed similar results when we averaged across all offspring's years of education per HRS participant. Next, our study used the Langa-Weir scale to classify participants into possible CIND or probable dementia and not a clinical diagnostic assessment for dementia. As more studies begin to incorporate the use of imaging and biomarker data, future work could examine markers of cognitive reserve or other biomarkers along the mechanistic pathway linking adult-child education and cognitive outcomes.[37] Third, although internal validity was strengthened by adjusting models for many confounders, some residual confounding may still be present from other factors such as the quality of education (for both respondents and their adult children), patterns of school and residential segregation, or different neighborhood level contextual factors influencing adult-child education and their parents' cognitive outcomes.[38] Finally, given the small Hispanic sample in our study, we may have been underpowered to detect differences by ethnicity in models of cognitive decline. For example, confidence intervals left meaningful uncertainty about the estimated effects on cognitive decline among Hispanic participants. Future research should confirm our results in additional national samples of ethnically diverse older adults. Despite these limitations, our study is strengthened by using a national sample of older adults with a special focus on Hispanic older adults and up to 20 years of follow-up. Additionally, our study is the first to evaluate Hispanic-White differences in the association between offspring education, cognitive function, decline, and probable dementia risk. Historically, given the different strides in increasing educational opportunities for Hispanic and Latino older adults, understanding how intergenerational education affects Hispanic and Latino heritage groups can have important implications for addressing racial and ethnic cognitive health disparities.

CONCLUSION

Our findings build on prior work by evaluating Hispanic and White differences in the association between offspring education, cognitive function, and dementia risk. Our findings suggest that offspring education may serve as a protective factor of their older parents' cognitive health and probable dementia risk and that the consequences of ensuring educational success for Latino and Hispanic students could be far-reaching, having an impact not only on their long-term health but that of their older adult parents. Understanding intergenerational education more broadly is an important topic for future work, especially among racial and ethnic minority groups who have not benefited from multigenerational access to education, and where multigenerational family ties and sharing of resources upstream may be more common. Our findings suggest that social policies to address the gaps in the education of younger generations could provide a new approach to protecting their older parents' cognitive health and addressing cognitive health inequities. Future research should also explore the potential physiological, behavioral, and psychosocial mechanisms underlying the relationship between offspring education and parents' cognitive health.

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SUPPLEMENTARY MATERIAL

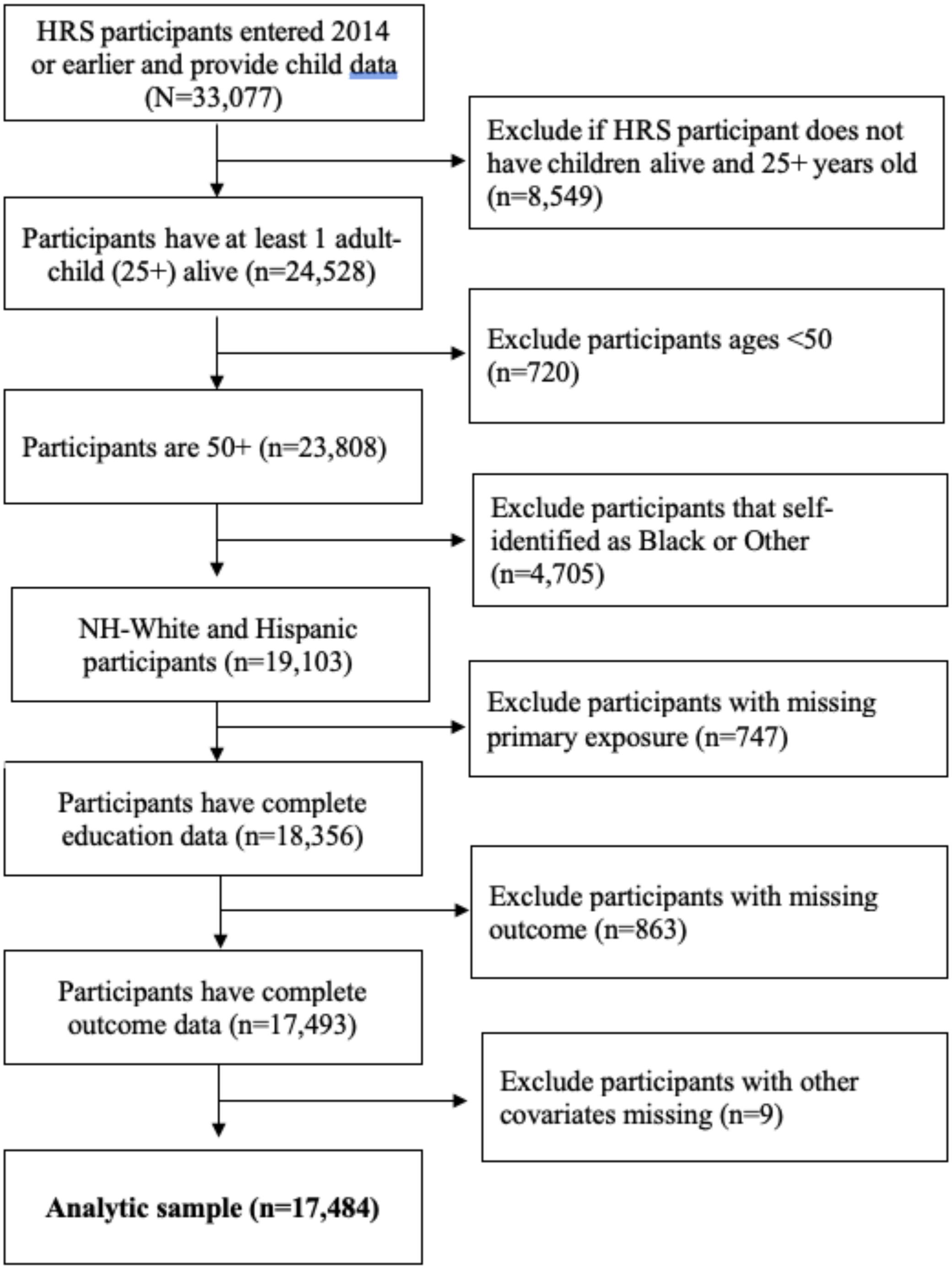

Figure S3.1 Analytic sample flow diagram for cognitive decline analysis (n=17,484)

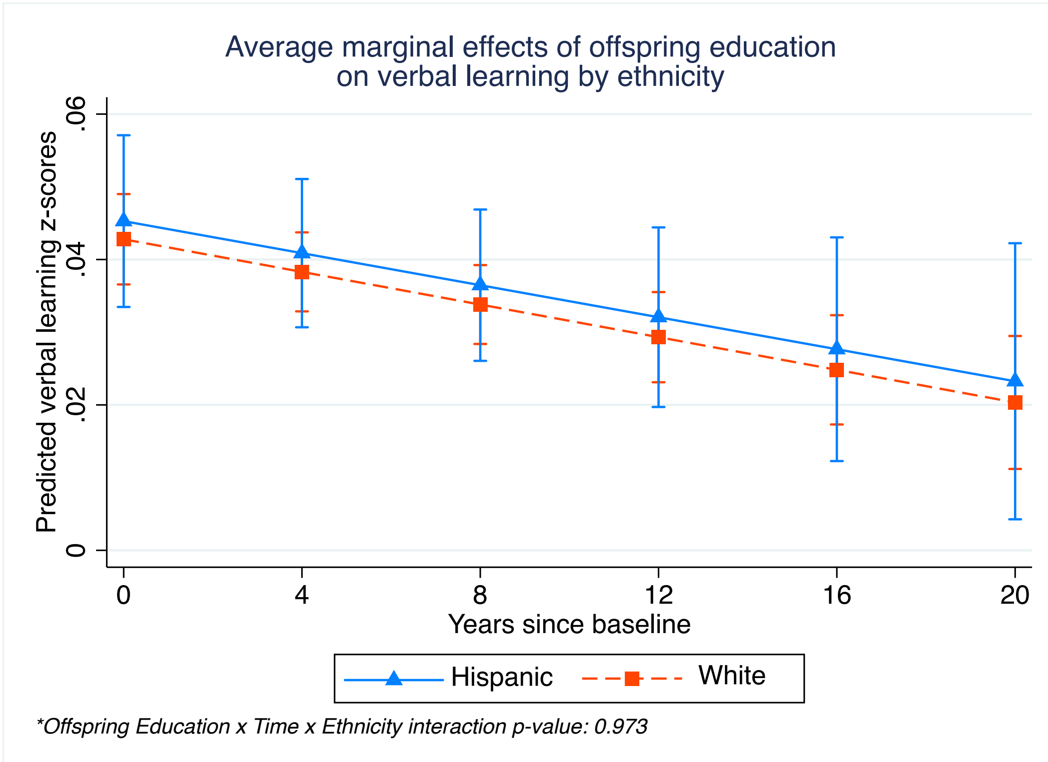

Figure S3.2 Average marginal effects for every 1-year increase in offspring education (>12) on verbal learning z-scores by ethnicity, U.S. Health and Retirement Study (1998-2014)

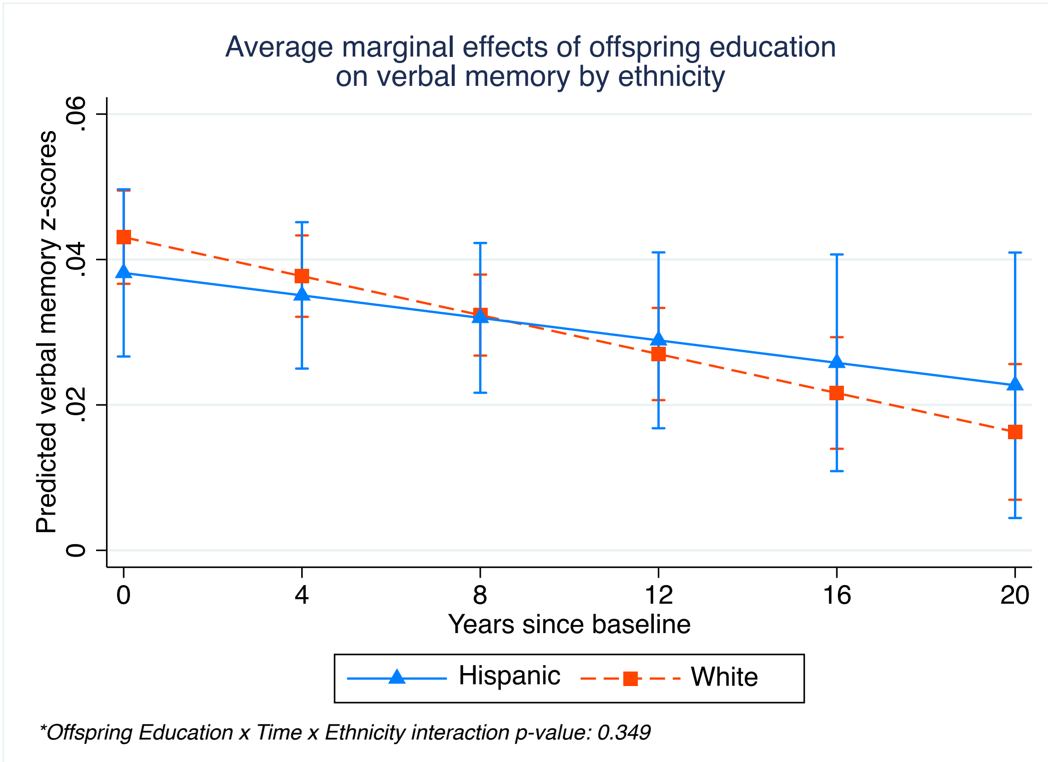

Figure S3.3 Average marginal effects for every 1-year increase in offspring education (>12) on verbal memory z-scores by ethnicity, U.S. Health and Retirement Study (1998-2014)

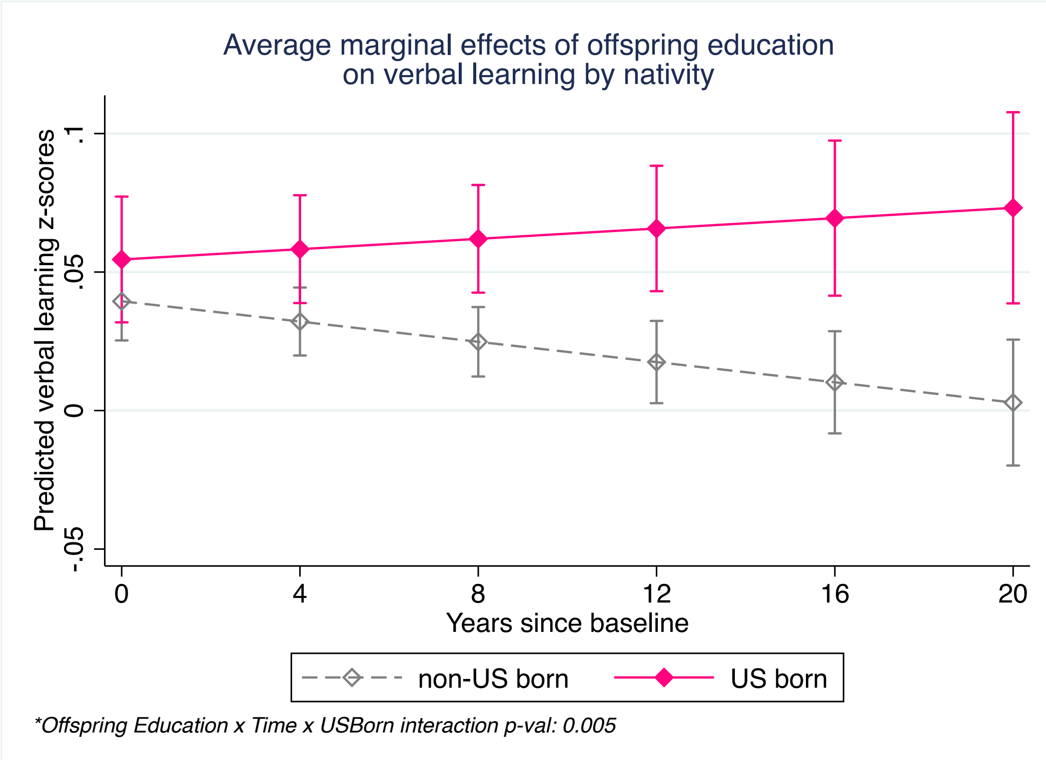

Figure S3.4 Average marginal effects for every 1-year increase in offspring education (>12) on verbal learning z-scores by nativity among Hispanic participants, U.S. HRS (1998-2014)

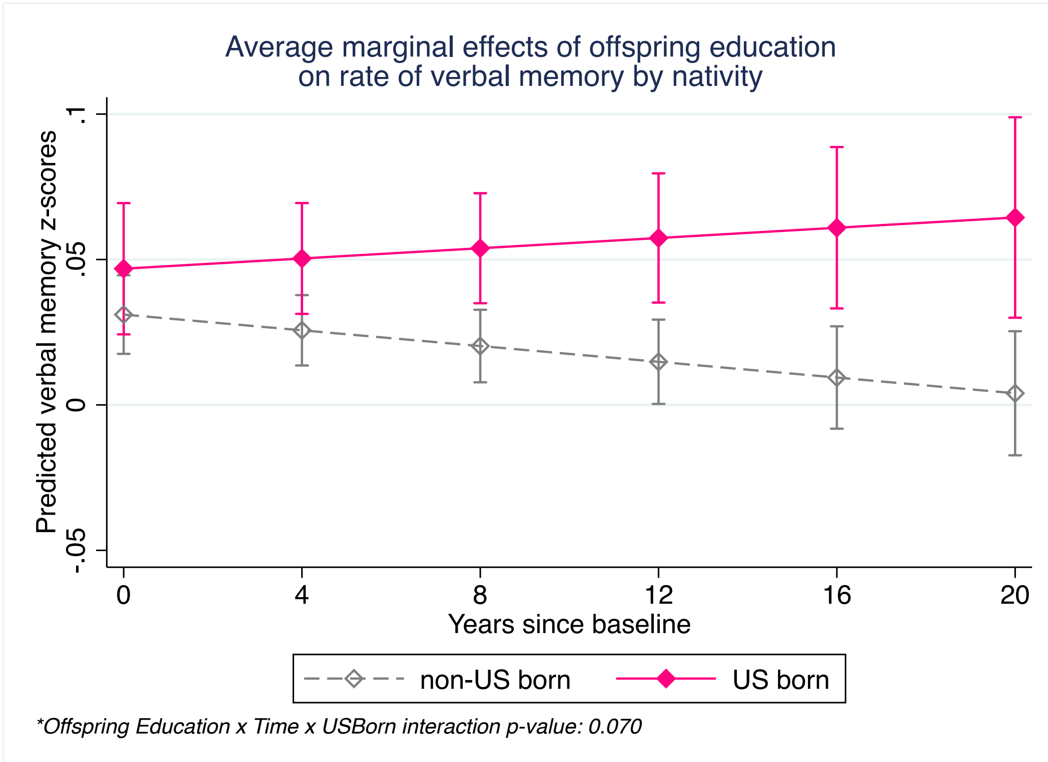

Figure S3.5 Average marginal effects for every 1-year increase in offspring education (>12) on verbal memory z-scores by nativity among Hispanic participants, U.S. HRS (1998-2014)

Table S3.1 (Age timescale) Beta coefficients and 95% confidence intervals for linear mixed models of the association between highest offspring education (>12) and verbal learning and memory z-scores

	Verbal Learning		Verbal Memory	
Variable	**Beta**	**(95% CI)**	**Beta**	**(95% CI)**
Highest offspring education	**0.045**	(0.039, 0.051)	**0.045**	(0.039, 0.050)
Time (years since baseline)	-0.043	(-0.044, -0.041)	-0.038	(-0.040, -0.037)
Highest offspring education x Time	**-0.001**	(-0.002, -0.001)	**-0.001**	(-0.002, -0.001)

Note: Highest offspring education is centered at 12 years; Model adjusted for age, sex, ethnicity, own education, marital status, nativity, birth cohort, total number of kids, and practice effect.

3-way interaction (offspring education x time x ethnicity) p-values for verbal learning: 0.079 and verbal

Table S3.2. Beta coefficients and 95% confidence intervals for linear mixed models of the association between *average* offspring education (>12) and verbal learning and memory z-scores

	Verbal Learning		Verbal Memory	
Variable	**Beta**	**(95% CI)**	**Beta**	**(95% CI)**
Average offspring education	**0.046**	(0.039, 0.053)	**0.044**	(0.037, 0.051)
Time (years since baseline)	-0.040	(-0.048, -0.032)	-0.033	(-0.041, -0.025)
Average offspring education x Time	**0.000**	(-0.001, 0.000)	**-0.001**	(-0.001, 0.000)

Note: Average offspring education is centered at 12 years; Model adjusted for sex, ethnicity, own education, marital status, nativity, birth cohort, total number of kids, and practice effect.
3-way interaction (offspring education x time x ethnicity) p-values for verbal learning: 0.654 and verbal memory: 0.732

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