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## Do the benefits of educational attainment for late-life cognition differ by racial/ethnic group? Evidence for heterogeneous treatment effects in the Kaiser Healthy Aging and Diverse Life Experience (KHANDLE) study

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### Abstract

**INTRODUCTION:** Educational attainment is associated with late life cognitive performance and dementia; few studies have examined diverse racial/ethnic groups to assess whether the association differs by race/ethnicity.

**METHODS:** We investigated whether the association between educational attainment and cognition differed between White, Black, Asian, and Latino participants in the Kaiser Healthy Aging and Diverse Life Experiences study (n=1,348). Covariate-adjusted multivariable linear regression models examined domains of verbal episodic memory, semantic memory, and executive functioning.

**RESULTS:** We observed significant effect heterogeneity by race/ethnicity only for verbal episodic memory (p=0.0198), for which any schooling between high school and college was beneficial for White, Asian, and Black participants, but not Latino participants. We found no evidence of heterogeneity for semantic memory or executive function.

**DISCUSSION:** With the exception of Latino performance on verbal episodic memory, more education consistently predicted better cognitive scores to a similar extent across racial/ethnic groups, despite likely heterogeneous educational and social experiences.

## Keywords

Education; Cognitive reserve; Disparities; Cognition; Cohort; Epidemiology; Race; Ethnicity

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## 1. Introduction

Education is associated with later-life cognitive performance and subsequent dementia risk.<sup>1,2</sup> Most prior research conceptualizes education assuming that the suggested causal benefits of education are consistent across demographic subgroups.<sup>3,4</sup> Recent studies have highlighted social patterning of health-related benefits from education in subgroups, such as racial/ethnic classifications.<sup>5,6</sup> However, to our knowledge, no prior studies have examined differential returns of education for cognitive outcomes. Further, the literature on differential returns of education has not included Asians or Latinos, who may have had distinct educational and resulting downstream experiences.

Identifying differences in the effects of education across racial/ethnic groups is critical for understanding drivers of disparities in late-life cognitive performance. Some research has hypothesized the concept of resource substitution, which posits that additional education may differentially benefit structurally disadvantaged individuals. The resource substitution hypothesis implies that education compensates for decreased access to other resources such as power and earnings available to advantaged groups. The resource substitution hypothesis implies that racial minorities, due to structural disadvantage, would benefit more from increased education than non-Latino whites benefit.<sup>7,8</sup>

Opportunity constraints may however lead to the opposite pattern, in which degree attainment delivers fewer benefits for racial/ethnic minorities in the US compared to non-Latino Whites. Such decreased benefits may arise from differences in educational content, as current older adults were likely to have attended at least some schooling during periods of legal racial segregation,<sup>9</sup> or from structural or interpersonal racism preventing racial/ethnic minorities from fully reaping the advantages of additional education<sup>10</sup>. For example, racial/ethnic minorities who attain higher education may face barriers in the labor market when they seek positions commensurate with their education, as evidenced by research highlighting increased exposure to interpersonal racism with increases in educational attainment for Black individuals.<sup>11,12</sup> This hypothesis has been supported by studies showing that at equal levels of education, Black and White Americans differ in earnings and occupational outcomes.<sup>13</sup> Such findings have been expanded to highlight disadvantages for Latino and Asian men with limited English proficiency.<sup>14-16</sup>

The resource substitution and opportunity constraints hypotheses have opposite implications for the potential differential effects of education on late life cognition across racial/ethnic groups. Despite the significant scientific attention to race and education as predictors of dementia<sup>1</sup>, many studies investigating racial/ethnic subgroups focus on independent influences of race and education in ethnically homogenous populations or compare just two racial/ethnic groups. This study was conducted to evaluate whether the estimated benefit of educational degree attainment for cognition differed by race/ethnicity within in a diverse sample of Latino, Asian, Black, and White community-residing older adults. We

hypothesized that the effect of education on cognition would be attenuated for Black, Asian, and Latino participants compared to White participants.

## 2. Methods

### 2.1 Study Population

We used baseline data from the Kaiser Healthy Aging and Diverse Life Experiences (KHANDLE) cohort, comprised of community-dwelling older adults residing in the San Francisco Bay Area. KHANDLE aims to evaluate how race/ethnicity and lifecourse health and sociocultural factors influence late-life brain health and cognitive decline. Individuals eligible for KHANDLE were long-term members of Kaiser Permanente Northern California (KPNC) over the age of 65 on January 1, 2017, who previously participated in the Kaiser Permanente multiphasic health checkups (MHC) between 1964–1973 or 1977–1985 and had no prior diagnoses of dementia at enrollment. A total of 1,712 individuals were enrolled at baseline with efforts to recruit approximately equal proportions of Asian, Black, Latino, White participants and overrepresentation of individuals with lower levels of educational attainment. Participants were excluded from the analytic sample if they reported immigrating after the age of 14 to restrict the sample to those who would have likely attended high school in the US ( $n=339$  or 19.57% of the total baseline sample), given the likelihood that educational experiences in other countries were not comparable to those in the US. Further exclusions include those who reported only Native American Indian or Alaska Native ancestry or were missing/refused to report race/ethnicity ( $n=4$ ), missing education ( $n=1$ , refused), missing place of birth ( $n=1$ ), missing any of the cognitive measures ( $n=18$ ), or withdrawn from the study for a final analytic sample of 1,348.

### 2.2 Measures

**Education**—Education was self-reported at baseline as years attained if less than a high school degree was obtained, and as highest level of degree attainment if the participant completed schooling past the completion of high school (some college, associate degree, bachelor's degree, master's degree, or doctoral degree). Completion of the general education diploma (GED;  $n=46$ ) or high school diploma and/or certifications were also obtained. For the primary exposure of educational degree attainment, individuals with any degree attainment less than some college were categorized as “High school or less” regardless of whether a diploma was obtained, due to the percentage of participants with less than a high school degree being too small for independent comparisons. Bachelor's, master's, and doctoral degrees were collapsed into a single category for a total of four operationalized levels of educational attainment (1. High school degree or less, 2. Some college; 3. Associate degree; 4. College degree or more).

**Race/Ethnicity Assignment**—Participants were recruited using their Kaiser Permanente health record classification of race, henceforth called participant primary enrollment race/ethnicity. Race/ethnicity was also self-reported at KHANDLE enrollment, in which participants self-reported racial/ethnic group (White, Black, Asian, Latino, Native American) and any of 24 ethnicities in addition to an open field write-in category. Fractional assignment was used to account for multiracial individuals in our sample (6.30% of the

overall sample). For those reporting multiple responses for race or ethnicity, all recorded responses related to race/ethnicity were reviewed. Those marking multiple ethnicities within the same major racial/ethnic group (i.e. Chinese and Filipino as both Asian ethnic groups) were categorized as single race. For those reporting multiple ethnicities across major racial/ethnic groups, duplicate observations were created for each additionally reported racial/ethnic group of that individual and were assigned a weight of 1 divided by the number of reported racial/ethnic groups. As a result, an individual reporting two racial/ethnic groups would contribute equally to each reported racial/ethnic group. Fractional assignment using equal fractions has been previously shown to be a reasonable bridging method to link single- and multi-race responses across national US census waves.<sup>17</sup> An indicator reflecting reporting two or more racial/ethnic groups was also included in all models to account for the experiences of multiracial individuals as being distinct from those reporting a single race/ethnicity.

**Cognitive Measurements**—Three cognitive domains (verbal episodic memory, semantic memory, and executive functioning) were derived from the Spanish and English Neuropsychological Assessment Scales (SENAS), which was given to all participants at baseline in their preferred language (English or Spanish). The SENAS is a battery of cognitive tests that has previously undergone extensive development for valid comparisons of cognitive change across racial/ethnic and linguistically diverse groups.<sup>18</sup> Verbal episodic memory composite scores were derived from a multitrial word-list-learning test. Semantic memory composite scores were derived from verbal (object-naming) and nonverbal (picture association) tests. Executive function composite scores were obtained using component tasks of category fluency, phonemic (letter) fluency, and working memory (digit-span backward, visual-span backward, list sorting). Details of the administration procedures, development, and psychometric characteristics have been extensively described in previous publications.<sup>18,19</sup> Each domain was z-standardized using the full baseline sample mean and standard deviation to represent standard deviation units.

**Covariates**—Demographic covariates included age, gender, nativity, and parental (both maternal and paternal) education. Age was calculated as time of baseline interview date from participant date of birth, obtained from Kaiser Permanente medical record data, and was centered at the age of 75. Gender, nativity, and parental education were reported by participants in baseline surveys. Gender was considered as self-reported male or female – those who stated “other” or “refused” had values for biologic sex imputed from Kaiser Permanente medical records. Place of birth was categorized as US census geographic region (Midwest, Northeast, South, West) or foreign born and having moved prior to high school age of entry. Parental education was reported as years of education or unknown and was categorized into a measure of (1) less than high school verses (2) high school degree or higher or (3) missing/unknown/no parental figure, considered separately for both maternal and paternal education.

### 2.3 Statistical Analysis

Linear regression models using generalized estimating equations with an identity link were used to estimate the effect of education on cognitive performance by race using weights to

account for the fractional assignment of racial/ethnic groups. Cognitive performance was assessed separately for each domain as a function of educational attainment. Pooled models including indicators for each racial/ethnic group and interactions between each race/ethnicity and education (as a categorical variable) were used to evaluate whether education-cognition associations differed significantly by race/ethnicity based on significance of an overall F-test for the interaction term. In the interest of transparency and fostering future meta-analyses, we report race/ethnic specific effect estimates for all outcomes but interpret differences as substantively important only if the F-test for racial/ethnic effect heterogeneity in educational categories overall was statistically significant ( $P < .05$ ) for each domain. All models were adjusted for age (linear), gender, maternal and paternal education, and place of birth (US Census region or foreign-born migrated prior to age 14). In sensitivity analyses, we estimated models (1) restricting only to the US born participants and (2) using the summary race/ethnicity variable rather than the fractional assignment of race/ethnicity.

### 3. Results

The average age of the sample was 75.8 years (standard deviation [SD]=6.9; Table 1). The majority of the sample was female (59.8%), with the highest percentage female participant distribution highest for Black (67.8%) participants. Maternal and paternal educational attainment of a high school degree or more were similar for Latino (maternal: 36.2%; paternal: 38.0%) and Asian participants (maternal: 48.6%; paternal: 49.8%), while Black (maternal: 45.8%; paternal: 30.0%) and White (maternal: 72.8%; paternal: 63.7%) participants on average reported a higher proportion of mothers compared to fathers with a high school degree.

Figure 1 shows the distribution of educational attainment among KHANDLE participants by race. Bachelor's degree completion or more was most common among Asian participants (65.7%), followed by White (59.4%), Latino (38.4%), and Black (34.7%) participants. Latino participants had the largest proportion reporting their education as high school degree or less (27.9%), followed by Black (22.3%), White (15.1%), and Asian (11.6%) participants.

We first evaluated whether the association of education with each cognitive domain differed by race/ethnicity (Supplementary Table A1). We found no evidence for racial/ethnic heterogeneities in associations between education and semantic memory ( $\chi^2(9)$  p-value: 0.42) or executive functioning (p-value=0.14), but did find evidence of effect heterogeneity for education and verbal episodic memory ( $\chi^2(9)$  p-value= 0.02). In race-stratified models for verbal episodic memory (fully-adjusted associations in Figure 2 and Supplementary Table A2), the association with Bachelor's degree completion (compared to HS only) was largest for Asian participants ( $\hat{B} = 0.58$  (95% CI: 0.23, 0.93;  $p < 0.01$ )) and similar for White ( $\hat{B} = 0.46$ ; 95% CI: 0.24, 0.69;  $p < 0.01$ ) and Black ( $\hat{B} = 0.44$ ; 95% CI: 0.22, 0.66;  $p < 0.01$ ) participants. For Latino participants, there was no association between completion of a Bachelor's degree and verbal episodic memory ( $\hat{B} = 0.11$ ; 95% CI: -0.17, 0.39;  $p = 0.55$ ). Patterns were similar for the associations of some college and Associate degree completion with verbal episodic memory: generally graded associations of more education with better scores except among Latino participants, for whom the association was flat.

Because there was no evidence of racial/ethnic effect heterogeneity for executive function (Figure 3 and Supplementary Table A2) or semantic memory (Figure 4 and Supplementary Table A2), we consider the pooled results the best estimates (Supplementary Table A1). In pooled analyses, attainment of a college degree was associated in a graded fashion with semantic memory (some college  $\hat{B} = 0.27$ , 95% CI: 0.15, 0.39; associate degree  $\hat{B} = 0.33$ , 95% CI: 0.19, 0.46; college degree or higher  $\hat{B} = 0.44$ , 95% CI: 0.32, 0.55) and executive functioning (some college  $\hat{B} = 0.30$ , 95% CI: 0.18, 0.43; associate degree  $\hat{B} = 0.30$ , 95% CI: 0.15, 0.45; college degree or higher  $\hat{B} = 0.60$ , 95% CI: 0.48, 0.72). Evidence for heterogeneous effects of education by race remained unchanged in sensitivity analyses restricting to US born only (Supplementary Table A3) and using primary enrollment race only in place of fractional assignment (Supplementary Table A4).

#### 4. Discussion

In the first US study to date providing direct comparison of the US educational attainment gradient in cognitive test scores for Whites, Blacks, Asian-Americans, and Latino elderly adults, we found overall consistency for executive function and semantic memory. For verbal episodic memory, we found that among Latino adults more education was not associated with better performance. For Whites, Blacks, and Asian Americans, education level predicted verbal episodic memory in a graded fashion. Heterogeneities in effect estimates for semantic memory and executive function between racial/ethnic groups were generally small and consistent with chance, with a pattern of better performance with more education observed for all racial/ethnic groups.

Given the small heterogeneities in effects of educational degree attainment across racial/ethnic groups, our results fail to support both the opportunity constraint and resource substitution hypotheses as both imply substantial effect heterogeneity. Of note, the observed patterns of educational attainment offering lower benefit in Latinos for verbal episodic memory align with the opportunity constraint hypothesis, suggesting that at similar levels of attainment, Latinos benefit less than other racial/ethnic groups. However, this explanation is weak as it does not hold across the other SENAS domains. It is also possible that this domain is especially sensitive to linguistic differences for Latino participants as participants were given the option of completing the SENAS in Spanish language, but is not available in languages other than Spanish and English. Though further research is needed, we do not think foreign education prior to high school is a likely major driver of the difference in cognitive outcomes among Latinos as the percentage of participants foreign-born was low and adjusted for in analyses.

To our knowledge, this study is the first to compare the effects of educational degree attainment on late-life cognition across the four most common racial/ethnic groups in the US. Few studies have been able to formally examine potential modification of the effect of education on cognition by race/ethnicity.<sup>20</sup> The few available studies evaluating this relied on pooled methods combining multiple cohorts to increase diversity. This approach is an important strategy in the context of limited research diversity but between-study differences may bias results.<sup>21</sup> Our sample is recruited from long-term Kaiser Permanente Northern California health plan members. Health plan members are generally representative of the

catchment area, though with underrepresentation at extreme tails of the income distribution, and Kaiser members are likely to have similar residential stability and access to healthcare throughout adult life, regardless of race/ethnicity.<sup>22,23</sup> Furthermore, our study findings were strengthened by restriction to only participants who attended at minimum high school in the US, and the majority of individuals across all racial/ethnic groups were US born. Though this exclusion of foreign-educated individuals may affect generalizability of our findings to the population of the Kaiser catchment area, this restriction allowed us to maintain consistency in our exposure of US educational attainment between racial/ethnic groups.

Furthermore, this is the first study to evaluate cognitive outcomes in later life for individuals who completed some college or an associate degree but did not attain a bachelor's degree. Approximately one third (32.0%) of the KHANDLE sample reported their highest level of schooling as some college with no degree or as an associate degree, similar to Bureau of Labor Statistics reports that 27% of the US adult population overall had some college with no degree or had completed an associate degree only as of 2016.<sup>24</sup> Given the high prevalence of this educational category, it is important to evaluate the apparent cognitive benefits in later life. This is particularly pertinent in evidence on racial/ethnic disparities in cognitive aging considering previously shown evidence that racial/ethnic minorities are more likely than Whites to begin college but not complete a bachelor's degree.<sup>25,26</sup> Associate degrees are known to improve earnings,<sup>27,28</sup> but our results are the first evidence on whether they are associated with an advantage in cognitive function in late life. We found that associate degrees predicted higher cognitive outcomes for Asian American and Black respondents for most outcomes and for Latinos for semantic memory.

The relationship between education and dementia varies between studies,<sup>1</sup> likely driven by inconsistencies in the educational experience of individuals. Such differential returns have been studied extensively in relation to economic outcomes such as lifecourse earnings and selection into higher education.<sup>8,29</sup> However, racial differences in the beneficial effects of education have received little attention in the health literature, with most investigations focusing on mortality or risk behaviors such as smoking.<sup>5,6,30</sup> Numerous mechanisms have been proposed for the health benefits of education, including labor market benefits of additional credential (degree) attainment, increased time in formal education leading to increased cognitive skills and engagement, access to more advantageous social networks, and beneficial delayed entry into the workforce.<sup>31–33</sup> Further complicating our understanding of the relationship are differences in the individual educational experience, such as those arising from school quality. School quality has been linked to racial/ethnic disparities in a number of health outcomes including late-life cognitive performance and current older adults were likely to have attended a large portion of their schooling during a time when segregated schools were standard, directly affecting the quality of their schooling.<sup>34–36</sup>

Our findings come with a number of limitations. While fractional assignment allowed for the contribution of individuals to multiple racial categories, it allocates equal proportions to each race which may not accurately reflect an individual's racial/ethnic identity and lived experiences. However, this allocation of racial categorization also allowed us to consider participants' full racial/ethnic identity without assuming an individual's primary identified

race, and the inclusion of an indicator for mixed race individuals was used to account for the experiences of multiracial individuals as being distinct from single-race individuals.<sup>37,38</sup> We could not examine cognitive decline or dementia in this baseline sample, as KHANDLE participants were required to be free of prior diagnoses of dementia at baseline. Wave 2 of data collection is currently ongoing, and future research will be able to examine these outcomes longitudinally as well as leverage KPNC MHC and medical record data from midlife for the investigation of potential mediating pathways. Our results should be interpreted considering the potential issues of unmeasured confounding present in observational data, as this study utilizes self-reported measures of education and other covariates. However we do not feel that this is a major concern, as previous research has shown that the effects of education in observational studies are similar to the estimated effects in quasi-experimental studies.<sup>39,40</sup>

To our knowledge, this is the first ever study including the four largest racial/ethnic groups in the US allowing for direct comparisons of educational attainment in the US. Investigations on potential effect heterogeneity in cognition and subsequent dementia risk between racial/ethnic subgroups in diverse cohorts is crucial for understanding drivers of health disparities. We found evidence that the effect of education for late-life memory differed across racial/ethnic groups in only one comparison: performance of Latino participants on verbal episodic memory. It remains unclear whether these differences result from differences in the classroom experience and educational quality or subsequent opportunities resulting from degree attainment. The degree of consistency between effects is somewhat surprising but encouraging news for generalizing results across racial/ethnic groups. Important next steps include evaluating these associations longitudinally and in larger samples and disentangling why education has such robust associations with cognition across racial/ethnic groups with heterogeneous educational and social experiences.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

## Acknowledgements and Conflicts of Interest:

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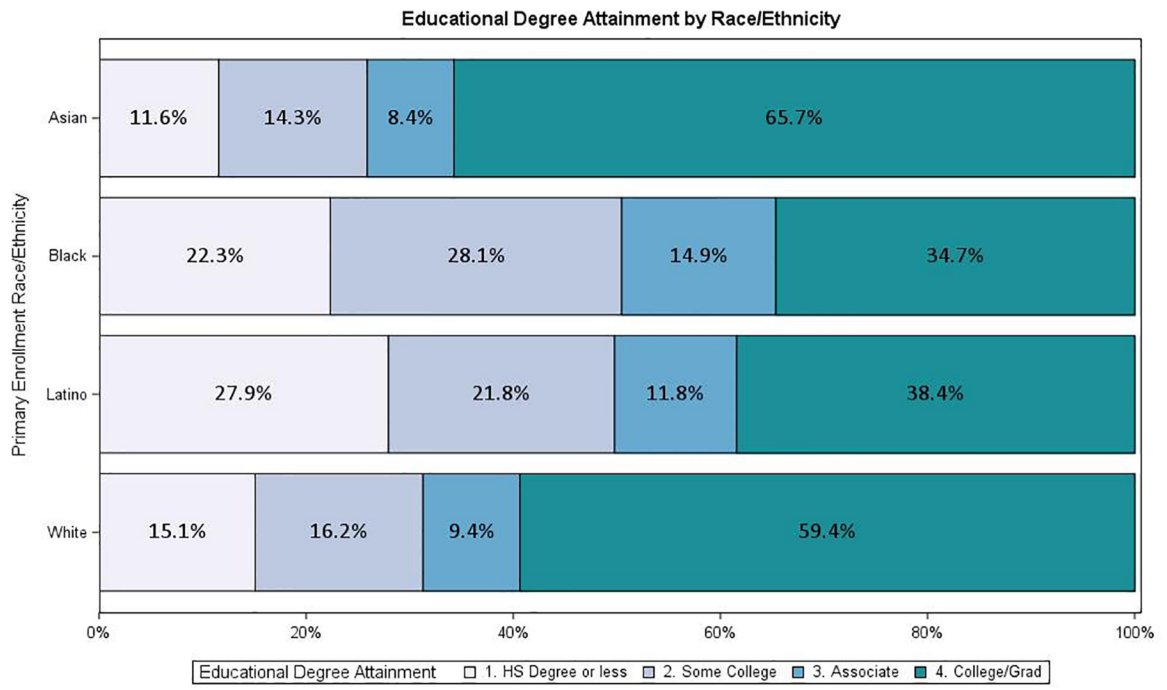
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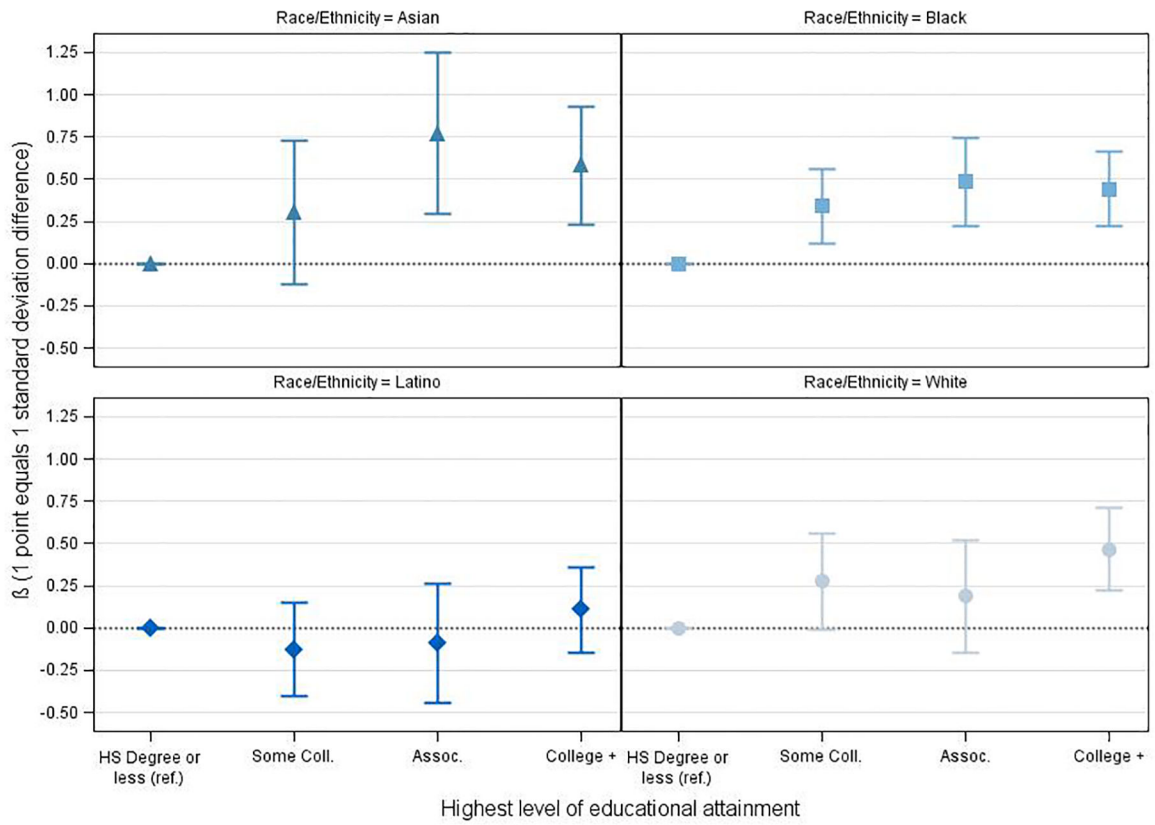


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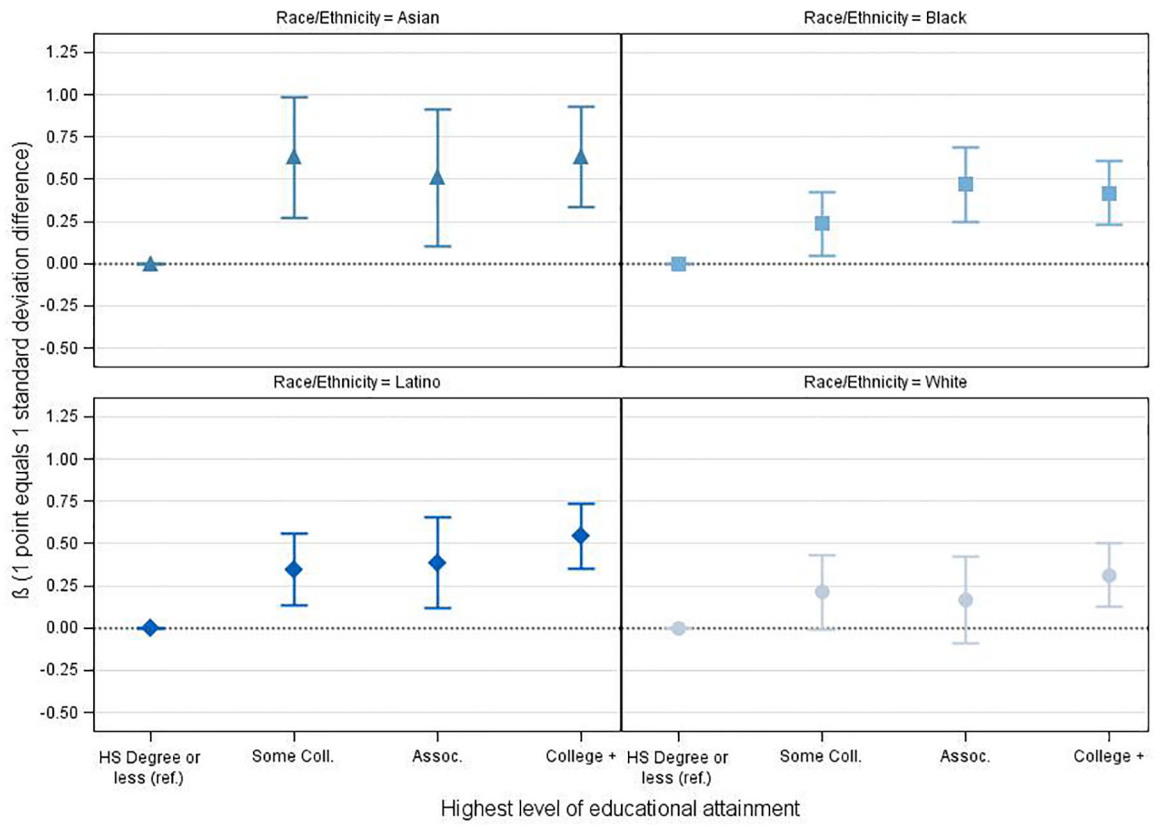
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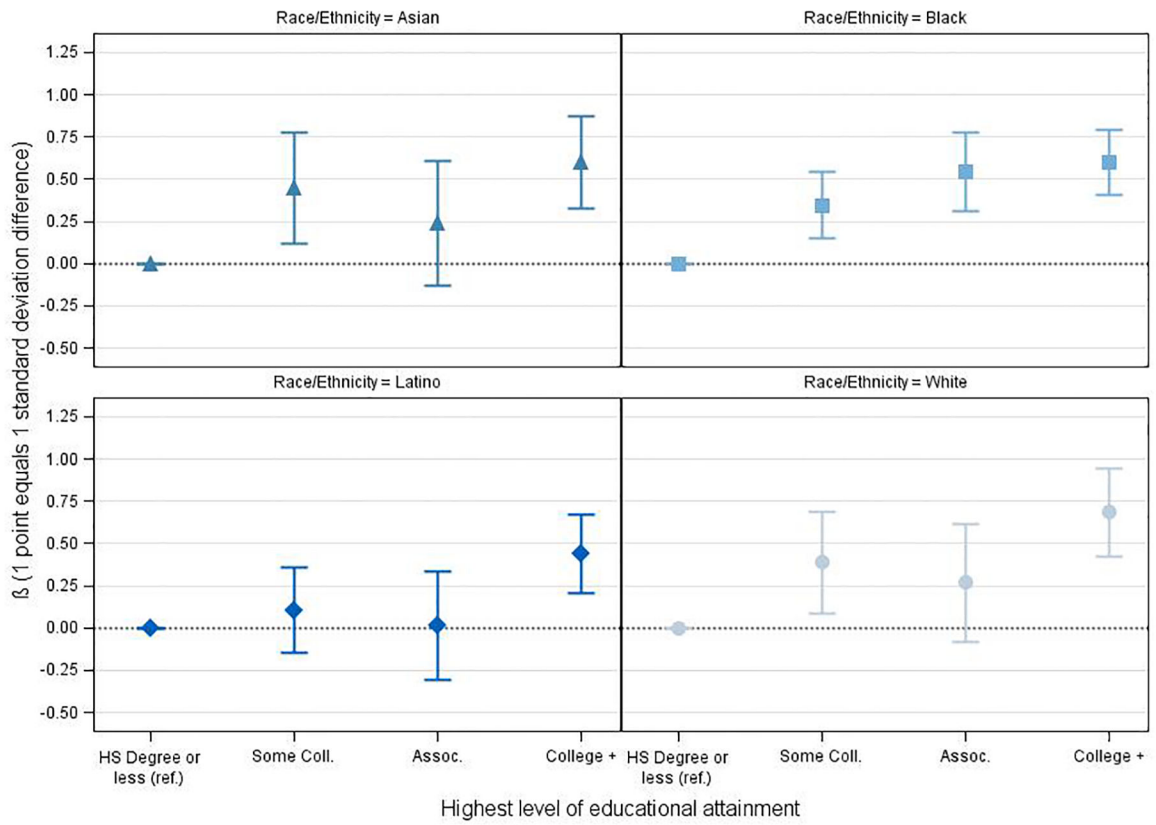
**Figure 1.** Educational degree attainment of KHANDLE participants, by race/ethnicity.



**Figure 2.** Associations between educational degree attainment and verbal episodic memory in race/ethnicity stratified models. Each coefficient is for the specified level of education in that racial/ethnic group compared to HS degree or less for the same racial/ethnic group.



**Figure 3.** Associations between educational degree attainment and semantic memory in race/ethnicity stratified models. Each coefficient is for the specified level of education in that racial/ethnic group compared to HS degree or less for the same racial/ethnic group.



**Figure 4.** Associations between educational degree attainment and executive functioning in race/ethnicity stratified models. Each coefficient is for the specified level of education in that racial/ethnic group compared to HS degree or less for the same racial/ethnic group.

**Table 1.**

Baseline sociodemographic characteristics.

	Overall n=1,348		Primary Race							
	Mean/N	SD/%	Asian (n=251)	Black (n=430)	Latino (n=229)	White (n=438)	Mean/N	SD/%	Mean/N	SD/%
Age	75.80	6.86	76.04	75.34	75.43	76.31	75.43	6.43	76.31	7.11
Gender										
Female	806	59.79%	138	292	125	251	125	54.59%	251	57.31%
Male	543	40.28%	113	138	104	187	104	45.41%	187	42.69%
Education										
HS Degree or less	255	18.92%	29	96	64	66	64	27.95%	66	15.07%
Some college (no degree)	278	20.62%	36	121	50	71	50	21.83%	71	16.21%
Associate degree	153	11.35%	21	64	27	41	27	11.79%	41	9.36%
College degree or higher	662	49.11%	165	149	88	260	88	38.43%	260	59.36%
Birthplace										
US Born*	1247	92.51%	209	419	202	417	202	88.21%	417	95.21%
Midwest	129	9.57%	6	38	6	79	6	2.62%	79	18.04%
Northeast	85	6.31%	6	9	12	58	12	5.24%	58	13.24%
South	318	23.59%	6	257	15	40	15	6.55%	40	9.13%
West	714	52.97%	191	114	169	240	169	73.80%	240	54.79%
Foreign Born	102	7.57%	42	12	27	21	27	11.79%	21	4.79%
Maternal Education										
Less than HS	409	30.34%	70	154	111	73	111	48.47%	73	16.67%
HS or More	721	53.49%	122	197	83	319	83	36.24%	319	72.83%
Refused/Unknown	219	16.25%	59	79	35	46	35	15.28%	46	10.50%
Paternal Education										
Less than HS	388	28.78%	61	152	85	89	85	37.12%	89	20.32%
HS or More	620	45.96%	125	129	87	279	87	37.99%	279	63.70%
Refused/Unknown	341	25.28%	65	149	57	70	57	24.89%	70	15.98%
Mixed Race <sup>†</sup>	85	6.30%	8	18	59	0	59	25.76%	0	0.00%

	Primary Race											
	Overall n=1,348		Asian (n=251)		Black (n=430)		Latino (n=229)		White (n=438)		Mean/N	SD/%
	Mean/N	SD/%	Mean/N	SD/%	Mean/N	SD/%	Mean/N	SD/%	Mean/N	SD/%	Mean/N	SD/%
SENAS Scores <sup>‡</sup>												
Verbal Episodic Memory	0.03	0.99	0.16	1.03	-0.13	0.93	-0.09	0.91	0.18	1.02		
Semantic Memory	0.17	0.95	0.13	0.83	-0.48	0.87	0.37	0.75	0.73	0.76		
Executive Functioning	0.14	0.98	0.06	0.82	-0.24	0.87	0.02	0.85	0.62	1.05		

Abbreviation: N, number; SD, standard deviation.

\* US born includes Midwest, Northeast, South, and West

<sup>‡</sup> Self-reporting more than one category of Asian, Black, Latino, or White

<sup>‡</sup> In standard deviation units (z-standardized to full baseline sample)