

**Education and Formal Volunteering Delays Cognitive Decline among Hispanics:
Implications for Public Health Interventions**

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Abstract

This study examined the longitudinal associations of education and civic engagement with cognitive functioning among Hispanics in the United States. Methods included mixed effect growth curve models with Health and Retirement Study data on Hispanics in the United States (2006-2020, N = 2,437), controlling for economic, social, and health dimensions. Post-hoc analyses examined ages at which respondents met the threshold for cognitive impairment no dementia (CIND) status. Education and civic engagement resulted in a positive dose response with cognitive health benefits. The magnitude of health benefits, however, varied by educational attainment and civic intensity. Among Hispanics with less than a high school education, high intensity volunteering was positively associated with cognitive functioning at baseline and overtime, whereas any (low and high intensity) volunteering resulted in positive cognitive health at baseline and overtime among highly educated Hispanics. Post-hoc analyses reveal lower-educated respondents gained the greatest cognitive health benefits. High intensity volunteering delayed the onset of CIND status by 9 years among respondents with less than a high school education, in contrast to 5 years among college educated respondents. College completion and civic engagement are promising public health interventions to promote population health.

Limitations and implications for future research are discussed.

Keywords: Civic Engagement, Cognitive Health, Education, Equity, Hispanics

Introduction

The number of older adults living with Alzheimer’s Disease and Related Dementias (ADRD) is expected to grow worldwide, bringing challenges in daily life including loss of independence, increased caregiving, and economic costs to families and society (Murman, 2015). The Hispanic/Latine¹ population is the largest racial and ethnic group in the United States and the number of older Hispanics is expected to increase 391% within the next 30 years, more than any racial group (Mayeda et al., 2016). Hispanics are nearly twice as likely to develop ADRD when compared to Whites (CDC, 2018). Delaying the onset and severity of cognitive impairment is possible. Environmental factors, such as education, social isolation, obesity, hypertension, smoking and alcohol consumption ([Livingston et al., 2020](#)) can delay or hasten cognitive impairment. Whether and how education and volunteering can bolster cognitive health remains unknown among Hispanics.

In 2023, Gonzales and colleagues infused anti-racism and health equity lenses into the productive aging framework to promote population health (Gonzales, Morrow-Howell, Angel, et al., 2023). We argued racial and ethnic minorities were understudied in rigorous scientific research generally, and productive aging specifically. Nationally representative data of older adults in the United States reveal significant health, economic, social inequities across race and ethnicity. For example, in 2020, approximately three quarters (73%) of Hispanics did not volunteer with an organization, compared to 61% for Whites and 64% for Blacks . Hispanics reported significantly lower levels of education, income, and assets compared to Whites and

¹ The terms Hispanic and Latina/o/x/e are commonly interchanged. For purposes of this article, we use the term Hispanic to incorporate Latine populations – that is, individuals of Latin American Backgrounds such as Caribbean, Mexican, Central American. We also prefer the gender-neutral, nonbinary alternative to Latino/a.

Blacks. Depression, another risk factor to cognitive impairment, was also significantly higher among Hispanics when compared to Whites and Blacks. Hispanics reported lower cognitive functioning when compared to Whites.

The purpose of this study was to apply a productive aging-health equity lens (Gonzales, Morrow-Howell, Angel, et al., 2023) to explore how early life experience (education attainment) and later life productive engagement (formal volunteering) are associated with cognitive health within the diverse Hispanic population in the United States. Examining this heterogeneous population enables us to gain a clearer understanding of risk and protective factors across the lifespan among Hispanics to promote population health.

We focus on formal volunteering, as opposed to informal, because of the institutional arrangements that promote participation and health such as stipends, training, acknowledgement, support, and supervision (McBride et al., 2010; Shen et al., 2020; Wang et al., 2022). These institutional arrangements function as levers to increase recruitment, retention, the intensity and duration of engagement, as well as designing civic roles to stimulate cognitive, social, and physical activity. Social policies at the federal, state, local levels, and policies and practices within organizations, have the capacity to shape and craft volunteer roles to enhance health outcomes, as opposed to informal volunteering.

Background

The extant literature reveals very few studies that examine within-group differences in volunteering and cognitive health among Hispanics. Generally, however, formal volunteering among older adults is associated with improvements in psychological well-being (Gonzales, Suntai, & Abrams, [2019](#); Morrow-Howell et al. [2003](#); Ho [2017](#)), life satisfaction (Abu-Bader, Rogers & Barusch [2003](#); Van Willigen [2000](#)), positive affect (Greenfield & Marks [2004](#)), self-

efficacy (Li 2007), higher levels of happiness (Baker et al. [2005](#); Borgonovi [2008](#)), and lower risk of hypertension (Halvorsen, 2023). Civic engagement in later life provides purpose, social status, and social resources (Heo et al. [2016](#); Musick & Wilson [2003](#); Simon & Wang [2002](#)). Volunteering has demonstrated to be a protective factor to psychological well-being within the context of unplanned events, such as the death of a family member or friend (Jang et al., [2018](#)). Moreover, volunteers are more likely to be surrounded by a larger social network with access to greater resources, power, and prestige than non-volunteers (Hunter & Linn [1981](#); Lum & Lightfoot [2005](#); Morrow-Howell [2010](#)) which affect mental and emotional health. Finally, volunteering has demonstrated to be a long-term antidote for depression (Li & Ferraro, [2005](#)). While these are not necessarily mechanisms of volunteering, these psychosocial health outcomes are distal factors often associated with cognitive functioning (Anderson et al., 2014; Fried et al., 2004; Villalonga-Olives, et al., 2023).

Volunteering is associated with higher levels of cognitive functioning over time (Anderson et al., 2014; [Guiney & Machado, 2018](#); [Proulx, Curl, & Ermer, 2017](#); Villalonga-Olives, et al., 2023; [Wang et al., 2022](#)). Proulx, Curl and Ermer (2017) found that the positive association was stronger for individuals with low levels of education. Volunteers exhibited increased brain activity in the left prefrontal cortex and anterior cingulate cortex over the 6-month interval relative to matched controls in a wait-list control intervention with African American women with low education and low-income in a national intergenerational tutoring program, Experience Corps (Carlson, et al., [2009](#)). While the mechanisms of civic engagement associated with cognitive health remain unknown, it is hypothesized that volunteering has complex mental, social, and physical tasks that necessitate executive functioning, short and long term memory, verbal fluency, and application of crystallized and fluid intelligence (Park et al.,

2014; Proulx et al., 2018; Villalonga-Olives et al., 2023). Others suggest generativity, emotional and spiritual wellness are also important to protecting cognitive health, which are often benefits from civic engagement (Strout & Howard, 2015).

The salutary effect of education on cognitive health is consistent: Higher levels of education are associated with improved cognitive performance in later life (Lovden, et al., 2020; Opdebeeck, Martyr, & Clare, 2016). More years of education is also associated with slower declines in cognitive functioning (Sachdev, 2006), although this area of research is mixed. Importantly, these associations can sometimes function in non-linear associations, particularly among individuals who do not finish college (Montez, Hummer, & Hayward, 2012). Thus, it is important to examine linear and nonlinear associations between educational attainment with cognitive functioning.

This study fills many gaps of knowledge. First, we examine both early and later life opportunities to promote cognitive functioning: formal education and civic engagement – both modifiable factors. Second, we test dose effects by examining differences in educational attainment and the intensity of volunteering. Third, we utilize the best source of longitudinal data on the Hispanic population in the United States, the Health and Retirement Study, to examine cognitive health outcomes within the population. This is the first study, to our knowledge, that achieves these goals.

Methods

Data

This study utilized core and psychosocial leave-behind module data from 2006 through 2020 of the Health and Retirement Study (HRS). The HRS is a nationally representative longitudinal study of non-institutionalized older adults in the United States. It collects comprehensive data on

economic, psychosocial, and health. The HRS uses a multi-stage probability design that stratifies respondents based on geographic region and as of 2010 oversamples Hispanic older adults by about twice their national representation.

Inclusion Criteria

The sample was restricted to individuals 50 years of age and older, reported their primary ethnic identity as Hispanic, completed a cognition assessment at least four times between 2006 and 2020, and did not have a caregiving proxy at first observation. This produced a total sample of 2,437 Hispanic older adults.

Dependent Variable

Total cognition was operationalized using a modified version of the Telephone Interview for Cognitive Status (TICS-m). The TICS-m measures total cognition using a 27-point scale that combines measures of working memory (serial 7's), and immediate and delayed word recall (Ofstedal, Fisher, & Herzog, 2005). Lower scores indicate lower levels of total cognitive function and total scores range from 0 to 27.

Variables of Interest

Volunteering was operationalized into three categories: non-volunteers (0), moderate intensity volunteers if they engaged less than 100 hours in the last year (1), or high intensity volunteers if they volunteered more than 100 hours in the last year (2).

Education was constructed with four categories of attainment: Less than high school (0), high school (1), some college (2), and a college degree or more (3).

Covariates

Demographic and known predictors to cognitive functioning were included as covariates (Livingston, et al., 2020). *Participants' age* was measured in years and taken from the mid-

month of the scheduled interview period. We centered age on the minimum value for this sample (50 years old) and measured age in decades in regression models to improve interpretation. Respondents were coded as married/partnered (0) or unpartnered (1, inclusive of widowed, never married, single). Gender was coded using a two-item response for male (0) or female (1). *US born* reports whether a respondent was born outside the United States (0) or born in the United States (1). *Low-income* denotes whether a respondent's self-reported income over the last 12 months fell in the lowest quartile of the sample (1) or not (0). An indicator for whether respondents currently smoke (1) or not (0). An indicator that reports whether the respondent reported having consumed an average of 21+ alcoholic drinks per week over the past three weeks (1) or less than 21 drinks across that period (0). Physical activity measures respondents' engagement in light, moderate, or vigorous intensity at least once per week (0), or no physical activity (1). High blood pressure and diabetes measure whether the respondent reported a diagnosis (1) or not (0). *Obesity* measures whether the respondent had an interviewer-recorded body mass index of 30% or greater at time of interview. This measure was not recorded in 2020 due to a shift to phone interviews during the COVID-19 pandemic. *Psychiatric diagnoses* reports whether a respondent indicated that a doctor had previously told them that they had a diagnosis of any mental, emotional, or psychiatric condition (1) or not (0). *Depression* was measured using the eight-item CESD depression measure. Respondents' scores can range from 0 to 8 with higher scores indicating more depressive symptomatology ($\alpha = 0.84$).

Analytic Approach

Bivariate statistics (t-test and chi-squared, correlation coefficients) examined differences between educational attainment, volunteering, and covariates at Time 1. We then estimated mixed effect growth curves for all participants and then estimated with education-stratified

mixed effect growth curve models with quadratic age terms to explore the relationship between volunteering with cognition across levels of educational attainment with covariates. Mixed effect models are a preferred statistical method for exploring changes in total cognition over time and the trajectories influenced by individual and group characteristics (Finkel, Reynolds, McArdle, Gatz, & Pedersen, 2003).

We first estimated mixed-effects models including educational attainment and formal volunteering with quadratic age terms. We then included additional predictors of cognitive impairment in later life and explored interaction terms between educational attainment and formal volunteering. Following this interaction model, we estimated models stratified by education attainment. Model fit was iteratively assessed by manual inspection of residuals and inter-model comparison of Akaike and Bayesian Information Criterion values (A/BIC) to identify changes in prediction error as the number of covariates included in models increased. Mixed models combined individual-specific parameters (random effects) with average parameters for the sample (fixed effects). All mixed models in this study used unstructured covariance matrices and included a random effect for participant's age. As a post-hoc analysis, we estimated marginal effects to identify the mean age at which participants at different levels of educational attainment and volunteering intensity crossed the threshold for cognitive impairment with no dementias (CIND) using Crimmins, Kim, Langa, and Weir's cutoff (2011).

Descriptive Results

Table 1 provides basic results of the sample, stratified by education. Most of the sample were female (59%). Approximately three out of ten (27%) were unpartnered. Inequities in income across education are evident in this sample. Those with less than a high school education earned about one-fourth the amount that those with a college education or more in the previous

year on average (~\$24,000 vs. ~\$86,000, $p < 0.001$). With regards to health behaviors, approximately 15% smoke, less than 3% reported heavy alcohol consumption, 8% reported physical inactivity, nearly half (49%) reported high blood pressure, 27% were diabetic, 40% were obese, 17% reported any psychiatric diagnosis, and 2% reported depression. Most of the sample was born outside the United States (63%).

Education was associated with higher levels of civic engagement and the intensity of volunteering (Table 1; $\chi^2 = 175.54$, $p < 0.001$). Individuals with less than a high school education reported the lowest rates of high-intensity volunteering (100 or more hours per year) and the lowest rates of any formal volunteering in the last year (13%). Among respondents with some college education, just over one-third reported any formal volunteering activities. Nearly half of college graduates (47%) reported engaging in formal volunteering activities in the last year.

Baseline total cognition scores were significantly different among respondents with less education when compared to higher educated respondents ($p < 0.001$). Respondents with less than a high school education had the lowest total cognition scores at baseline ($\mu = 12.43$, $SD = 4.08$), and respondents with a college education or greater had the highest ($\mu = 16.83$, $SD = 3.66$). Importantly, there were no statistically significant differences in the proportion of being unpartnered, heavy alcohol consumption, physical inactivity, or obesity across levels of education.

Longitudinal Analysis

Results for the fully adjusted mixed effect regression model are presented in Table 2. We found that completing a high school education ($\beta_0 = 1.90$, $SE = 0.24$, $p < 0.001$), some college ($\beta_0 = 2.76$, $SE = 0.26$, $p < 0.001$), and obtaining a college degree ($\beta_0 = 3.60$, $SE = 0.32$, $p < 0.001$) was significantly associated with higher cognition scores at baseline but not with cognitive change

over time. Older adults who volunteered for less than 100 hours in the previous year had slightly higher cognition scores at baseline than those who did not volunteer ($\beta_0 = 0.37$, $SE = 0.17$, $p < 0.05$) but their cognition did not change at a different rate as they aged. Marginal estimates of total cognition scores by educational attainment (Figure 1) suggested positive associations between higher intensities of formal volunteering and total cognition among Hispanic older adults who had less than a college degree.

To further explore this relationship, we estimated mixed effects models stratified by educational attainment (Table 3). Among respondents with less than a high school degree, volunteering 100 hours or more in the last year was associated with higher baseline cognition scores ($\beta_0 = 0.57$, $SE = 0.24$, $p < 0.05$) and slower rates of decline ($b = 0.44$, $SE = 0.14$, $p < 0.01$) relative to Hispanics who did not volunteer. Respondents who had a high school degree and volunteered less than 100 hours ($\beta_0 = 0.50$, $SE = 0.21$, $p < 0.05$) and 100 hours or more ($\beta_0 = 0.74$, $SE = 0.32$, $p < 0.05$) had significantly higher baseline cognition scores than those who did not volunteer in the previous year. Among those who had completed some college, only engaging in the highest level of volunteering intensity was associated with higher baseline cognition scores ($\beta_0 = 0.73$, $SE = 0.29$, $p < 0.05$). Hispanic older adults who completed at least a college degree did not have significantly different baseline cognition scores across levels of volunteering intensity, but did decline significantly slower if they engaged in civic activities at low or high intensity levels, respectively ($b = 0.43$, $SE = 0.20$, $p < 0.05$; $b = 0.56$, $SE = 0.24$, $p < 0.05$). Figure 2 presents the cognitive trajectories of Hispanic older adults who had less than a high school degree, and a high school degree. These trajectories illustrate a relatively large difference in predicted cognition scores between high intensity volunteers and non-volunteers, but very little difference

between low-intensity volunteers and non-volunteers. As these models approach the upper bounds of age, our estimates converge across all levels of volunteerism.

Finally, post-hoc analysis of marginal effects revealed that volunteering intensity was associated with differences in CIND threshold ages across educational attainment (Table 4). Hispanic older adults who had less than a high school degree and did not volunteer fell below 11 points on the TICS-M scale two years earlier than peers who did any volunteering, and nine years earlier than high intensity volunteers ($p < 0.001$). This group also crossed the CIND threshold earlier in life than those with higher levels of educational attainment regardless of volunteering intensity. A similar pattern emerged among individuals who completed high school. Among this more educated group, those with no volunteer activity crossed the CIND threshold two years earlier than those with low intensity volunteering, and eight years earlier than those who did 100 or more hours of volunteering ($p < 0.001$). Hispanic older adults who had some college education all crossed the CIND threshold between 90 and 91 years of age regardless of volunteering intensity. Among the most educated group, those with a college degree or more, non-volunteers crossed the CIND threshold four (4) years earlier than those with low intensity volunteering, and five (5) years earlier than those who did 100 or more hours of volunteering ($p < 0.001$).

Several theoretically and empirically informed covariates included in this analysis were associated with cognition among Hispanic older adults. Hispanic older adults who were not married or partnered had significantly lower cognition scores at baseline relative to those who were married ($\beta_0 = -0.37$, $SE = 0.18$, $p < 0.05$), and those who fell into the lowest income quartile had lower baseline cognition scores ($\beta_0 = -0.45$, $SE = 0.14$, $p < 0.01$) but declined at a slower rate relative to those in higher income quartiles ($b = 0.28$, $SE = 0.08$, $p < 0.001$). Hispanic older adults

who were born in the United States had significantly lower baseline cognition scores relative to those born outside the United States ($\beta_0 = -0.34$, $SE = 0.13$, $p < 0.01$). Among physical and mental health conditions, a diagnosis of diabetes was associated with lower baseline cognition scores ($\beta_0 = -0.19$, $SE = 0.09$, $p < 0.05$). Higher depression scores were also associated with lower baseline cognition ($\beta_0 = -0.09$, $SE = 0.03$, $p < 0.001$), but not differences in cognitive change over time.

Discussion

This study contributes to the growing body of evidence that environmental factors, many of which are malleable, are associated with cognitive health across the lifespan (Livingston, et al., 2020). Importantly, this study on older Hispanics underscores the importance of formal education and volunteering as protective factors to cognitive functioning in later life. The finding that more than half of older Hispanics have less than a high school education, yet their cognitive health can be protected with civic engagement has clear implications for interventions that respond directly to the needs of Hispanic communities. Delaying the onset of CIND by nearly a decade means every day and every year is an opportunity to live in good cognitive health, thwarting the economic, social, and psychological consequences of cognitive impairment for older adults themselves, their families and friends, and society. Nonetheless, these generative years are also lived building community and giving back to society, an important psychosocial developmental milestone in later life. The economic benefits clearly need to be calculated for future research.

Research is needed to identify the mechanisms of volunteering to maximize health generally, and cognitive health specifically. It is likely volunteer roles are similar to that of paid work (Fried et al. 2004; Lee et al., 2020). Many occupations that require mental and social complexity are consistently and positively associated with cognitive functioning, while findings

with physical complexity of work are mixed (Gonzales et al., 2020). Work complexity is a hierarchical construct with three latent factors: mental, social, and physical demands. Mental demands of work include analyzing data or information, developing objectives and strategies, evaluating information to determine compliance with standards, organizing, planning, and prioritizing work, thinking creatively, and updating and using relevant knowledge. Both fluid and crystalized intelligence are utilized in mental demands of work, similar to volunteering. Furthermore, social complexity of work operationalizes interpersonal skills that require coordination, instructing, negotiating, persuasion, service orientation, and social perceptiveness, similar to volunteering. Finally, similar to volunteering, work requires physical exertion such as dynamic flexibility and strength, extent flexibility, stamina, static strength and truck strength. Volunteering shares many of these same mental, social, and physical demands of paid-work ([Guiney, Keall, & Machado, 2020](#)), yet such a construct has not been developed, implemented, and tested in community settings and interventions. Additional mechanisms may include generativity, altruism, role enhancement, self-efficacy, and institutional factors such as stipends ([Anderson, et al., 2014](#); McBride et al., [2010](#)). Future research is needed to develop these complexity constructs of volunteering and empirically examine the longitudinal associations with cognitive functioning.

The salutary effects of education and volunteering on cognitive performance is compelling and refutes an assumption that cognitive decline is “an inevitable aspect of aging” ([Gupta, 2018, p. 46](#)). Evidence from this study supports the notion that volunteering should be considered a public health intervention especially among Hispanics with low levels of education ([Fried, 2004](#); [Han, Roberts, Mutchler, & Burr, 2020](#); [Jenkinson, et al., 2013](#)). Programs such as America Corps Senior, AARP’s Experience Corps, and national, state, and local programs are

poised to ensure the overall health of older adults, inclusive of cognitive functioning, as well as those that they serve, especially for Hispanics with less than a college degree. Gerontologists have suggested medical doctors write a prescription for older adults who demonstrate symptoms of depression and other mental health issues, to volunteer in evidence-based programs, such as [AARP's Experience Corps](#).

These findings should be understood with limitations. First, it is unclear what aspects of volunteering are associated with global cognitive functioning and is left for future research. Second, this study on older Hispanics revealed important differences with nativity and future research should test the healthy immigrant paradox to examine similarities and differences between US born Hispanics and first, second, and third generation Hispanic immigrants. Some researchers also argue there might be genetic differences by country of origin, which need further examination (González, Tarraf, Fornage, et al., 2019). Third, future research can also incorporate biological markers to clarify the relationship of genetic and environmental predictors to cognitive functioning. Fourth, future research can also disentangle which aspects of cognitive functioning are most affected by volunteering rather than relying on global cognitive functioning, which was utilized in this study. Finally, it is important to replicate these analyses across race, ethnicity, gender, and socioeconomic status to determine who benefits most by civic engagement.

Conclusion

This study contributes additional evidence to the argument that productive activities are an opportunity to maximize wellbeing and cognitive health. Education and formal volunteering are malleable factors associated with cognitive functioning. Social policies and practices can target populations with a high risk of developing cognitive impairment – such as racial and

ethnic minorities, populations with low levels of education, high rates of multimorbidity, and elevated levels of mental health issues – with educational and civic engagement opportunities and potentially delay the onset and severity of cognitive impairment. Further research is needed to identify the mechanisms of volunteering that are associated with these positive health outcomes, such as a complexity construct for civic engagement.

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Declaration of Interest Statement

The authors report there are no competing interests to declare.

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Table 1. Descriptive Statistics

	Total N = 2,437 (100%) Mean or % (SD)	Less than High School N = 1,294 (52.47%) Mean or % (SD)	High School N = 488 (20.13%) Mean or % (SD)	Some College N = 420 (17.41%) Mean or % (SD)	College or More N = 235 (9.98%) Mean or % (SD)
Age***	59.82 (8.20)	61.09 (8.76)	59.34 (8.15)	57.87 (6.45)	57.37 (6.57)
Female***	59.00%	59.97%	59.43%	58.10%	54.47%
US Born	36.32%	25.95%	46.11%	53.10%	36.32%
Formal Volunteering***					
None	77.50%	86.03%	78.10%	65.21%	52.79%
<100 Hours per Year	14.78%	9.79%	14.67%	22.14%	28.33%
100+ Hours per Year	7.72%	4.18%	7.23%	12.65%	18.88%
Unpartnered	27.66%	27.82%	23.57%	31.67%	28.09%
Lowest Income***	21.09%	29.06%	12.70%	13.33%	9.36%
Current Smoker*	14.65%	15.61%	14.75%	15.00%	7.66%
Heavy Alcohol Use	2.42%	2.17%	2.90%	3.34%	1.28%
Physical Inactivity	8.08%	8.82%	7.38%	7.14%	7.23%
High Blood Pressure***	49.73%	52.78%	50.61%	46.67%	37.87%
Diabetes***	27.01%	30.53%	24.59%	24.52%	16.60%
Psychiatric Diagnosis**	17.18%	19.01%	15.37%	17.62%	10.64%
CESD Depression Index***	2.14 (2.42)	2.44 (2.52)	1.96 (2.34)	1.91 (2.37)	1.37 (1.89)
Total Cognition***	13.83 (4.24)	12.43 (4.08)	14.70 (3.78)	15.41 (3.79)	16.83 (3.66)

Bivariate analysis compared covariates across educational attainment using ANOVA and chi-square analyses.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

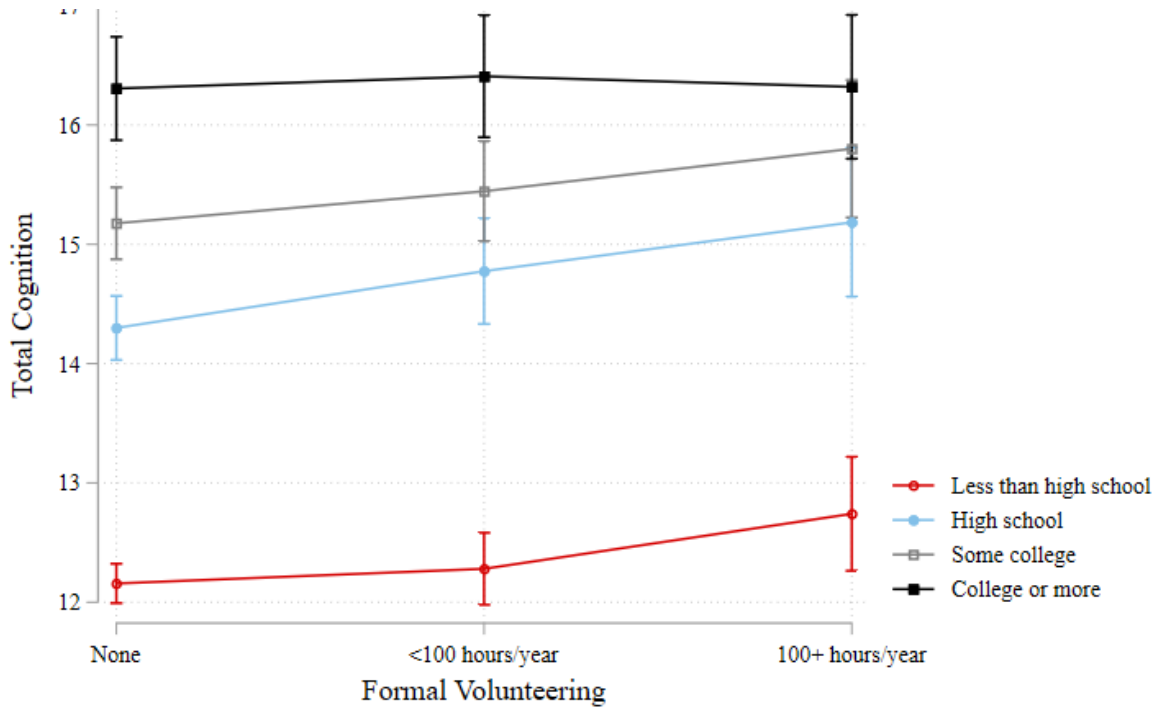
Table 2. Adjusted Mixed Effect Estimates

	Model 1				Model 2			
	<i>Estimate (SE)</i>				<i>Estimate (SE)</i>			
Age	1.01***	(0.18)			1.01***	(0.18)		
Age ²	-0.55***	(0.04)			-0.55***	(0.04)		
	Initial Level		Change over time		Initial Level		Change over time	
Intercept	12.86***	(0.22)			12.87***	(0.22)		
Female (ref. = Male)	0.35	(0.20)	-0.14	(0.11)	0.35	(0.20)	-0.14	(0.11)
Education (ref. = Less than High School)								
High School	1.90***	(0.24)	0.26	(0.14)	1.81***	(0.25)	0.27*	(0.14)
Some College	2.76***	(0.26)	0.23	(0.16)	2.72***	(0.27)	0.24	(0.16)
College or More	3.60***	(0.32)	0.35	(0.20)	3.76***	(0.34)	0.33	(0.20)
Formal Volunteering (ref. = None)								
Less than 100 hours/year	0.37*	(0.17)	-0.09	(0.11)	0.28	(0.21)	-0.09	(0.11)
100 or more hours/year	0.22	(0.25)	0.14	(0.15)	0.25	(0.33)	0.10	(0.15)
Education x Formal Volunteering								
High School x <100 hours/year					0.30	(0.24)		
High School x 100+ hours/year					0.45	(0.37)		
Some College x <100 hours/year					0.10	(0.23)		
Some College x 100+ hours/year					0.21	(0.36)		
College or more x <100 hours/year					-0.07	(0.27)		
College or more x 100+ hours/year					-0.55	(0.38)		
Unmarried	-0.37*	(0.18)	0.06	(0.10)	-0.37*	(0.18)	0.06	(0.10)
Low Income	-0.45**	(0.14)	0.28***	(0.08)	-0.46**	(0.14)	0.28***	(0.08)
Current Smoker	-0.35	(0.22)	0.11	(0.15)	-0.35	(0.22)	0.11	(0.15)
Heavy Alcohol Use	0.57	(0.42)	-0.15	(0.28)	0.56	(0.42)	-0.14	(0.28)
Physically Inactive	-0.19	(0.19)	-0.12	(0.09)	-0.18	(0.19)	-0.13	(0.09)
High Blood Pressure	-0.16	(0.09)			-0.16	(0.09)		
Diabetes	-0.19*	(0.09)			-0.19*	(0.09)		
Any Psychiatric Diagnosis	-0.19	(0.20)	-0.11	(0.11)	-0.17	(0.20)	-0.12	(0.11)
Depression Symptoms	-0.09***	(0.03)	-0.00	(0.02)	-0.09**	(0.03)	-0.00	(0.02)
U.S. Born	-0.34**	(0.13)			-0.34**	(0.13)		
<i>Random Effects</i>								
Age	0.80	(0.12)			0.81	(0.12)		
Intercept	2.73***	(0.10)			2.73***	(0.10)		
Covariance	-0.20	(0.11)			-0.20	(0.11)		
Residual	2.73***	(0.02)			2.73***	(0.02)		
Observations	13471				13471			
AIC	70102.21				70106.89			
BIC	70372.50				70422.24			

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 1. Predictive Margins of Total Cognition Formal Volunteering Intensity and Educational Attainment



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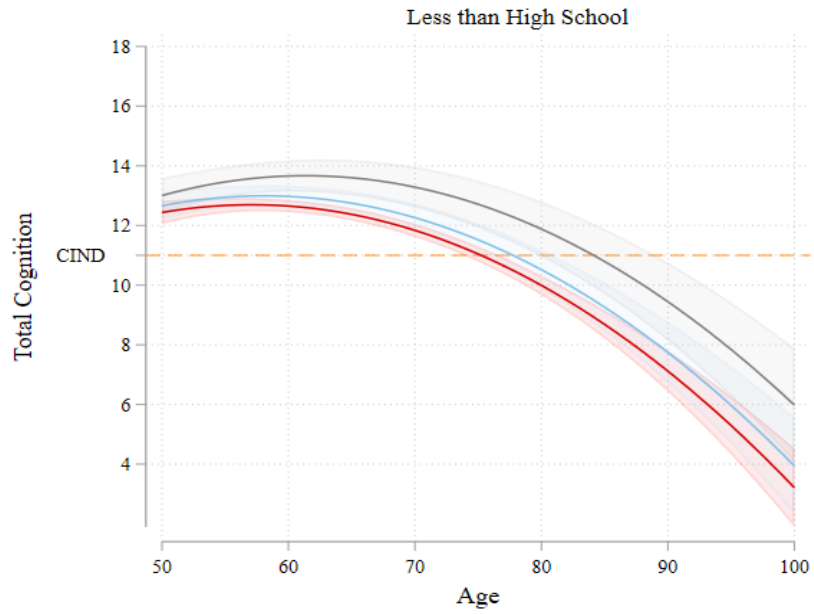
Table 3. Mixed Effect Estimates Stratified by Educational Attainment

	Less Than High School <i>Estimate (SE)</i>				High School <i>Estimate (SE)</i>				Some College <i>Estimate (SE)</i>				College or More <i>Estimate (SE)</i>			
	Initial Level		Change over time		Initial Level		Change over time		Initial Level		Change over time		Initial Level		Change over time	
Age	0.76**	(0.24)			1.27**	(0.39)			0.81	(0.46)			1.33*	(0.61)		
Age ²	-0.52***	(0.06)			-0.47***	(0.10)			-0.50***	(0.13)			-0.62***	(0.18)		
Intercept	13.31***	(0.28)			14.60***	(0.42)			15.87***	(0.44)			16.01***	(0.56)		
Female (ref. = Male)	0.14	(0.30)	-0.21	(0.16)	0.56	(0.43)	-0.22	(0.26)	0.51	(0.43)	-	(0.30)	1.09*	(0.56)	-0.52	(0.41)
Formal Volunteering (ref. = None)																
Less than 100 hours/year	0.22	(0.15)	0.10	(0.10)	0.50*	(0.21)	0.03	(0.15)	0.33	(0.20)	0.02	(0.15)	0.01	(0.25)	0.43*	(0.20)
100 or more hours/year	0.57*	(0.24)	0.44**	(0.14)	0.74*	(0.32)	0.36	(0.19)	0.73*	(0.29)	-	(0.22)	-0.16	(0.31)	0.56*	(0.24)
Unmarried	-0.44	(0.28)	0.18	(0.15)	-0.06	(0.43)	0.00	(0.25)	-1.15**	(0.42)	0.32	(0.28)	-0.27	(0.55)	-0.06	(0.39)
Low Income	-0.39*	(0.18)	0.13	(0.11)	-0.40	(0.37)	-0.06	(0.24)	-0.17	(0.50)	-	(0.34)	-0.80	(0.69)	0.75	(0.47)
Current Smoker	-0.26	(0.32)	0.00	(0.20)	-0.03	(0.51)	0.01	(0.39)	-0.59	(0.55)	0.48	(0.50)	-2.25*	(0.89)	1.34	(0.75)
Heavy Alcohol Use	1.03	(0.56)	-0.54	(0.38)	-1.07	(1.00)	1.34*	(0.66)	0.38	(1.05)	-	(0.75)	2.17	(1.95)	-1.71	(1.50)
Physically Inactive	-0.31	(0.26)	-0.02	(0.12)	-0.57	(0.49)	-0.13	(0.26)	0.30	(0.54)	-	(0.35)	-0.04	(0.73)	-0.22	(0.43)
High Blood Pressure	-0.10	(0.12)			-0.00	(0.21)			-0.45*	(0.22)			-0.25	(0.28)		
Diabetes	-0.19	(0.13)			-0.68**	(0.22)			-0.28	(0.23)			-0.31	(0.32)		
Any Psychiatric Diagnosis	-0.34	(0.29)	0.04	(0.15)	0.33	(0.49)	-0.35	(0.32)	-0.20	(0.46)	-	(0.32)	-0.05	(0.75)	-0.21	(0.50)
Depression Symptoms	-0.13***	(0.04)	0.00	(0.02)	0.00	(0.07)	-0.07	(0.04)	-0.17*	(0.07)	0.05	(0.05)	-0.07	(0.11)	0.06	(0.07)
U.S. Born	-0.56**	(0.21)			-0.76**	(0.26)			0.30	(0.27)			0.36	(0.34)		
<i>Random Effects</i>																
Age	0.42	(0.32)			0.77	(0.29)			0.22***	(0.04)			0.02	(0.18)		
Intercept	2.92***	(0.16)			2.65***	(0.22)			2.17***	(0.11)			2.14***	(0.24)		
Covariance	-0.03	(0.39)			-0.41	(0.19)			1.00	(0.00)			-1.00	(.)		
Residual	2.65***	(0.03)			2.79***	(0.05)			2.80***	(0.05)			2.74***	(0.07)		
Observations	6282				2400				2054				1127			
AIC	32663.34				12580.14				10758.13				5838.84			
BIC	32865.71				12753.64				10926.95				5984.63			

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 2. Cognitive Health Trajectories

by Formal Volunteering Intensity among Less than High School Educational Attainment



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Table 4. Predicted Margins of CIND Threshold Age by Educational Attainment and Volunteering Intensity

	Less than High School	High School	Some College	College or More
Formal Volunteering				
None	76***	89***	90***	91***
<100 Hours per Year	78***	91***	91***	95***
100+ Hours per Year	85***	97***	90***	96***

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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