Effects of APOE Alleles and Productive Aging Activities on Cognitive Health among Older Hispanics in the United States: Implications for Social Policies and Practices

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Abstract

Background. This study examined the longitudinal associations of productive aging activities – formal education, employment, volunteering – with cognitive functioning in the context of genetic inheritance (APOE alleles) among older Hispanics in the United States.

Research Design and Methods. Mixed effect growth curve models tested associations with respondents in the Health and Retirement Study (8,558 observations longitudinally from 2010 to 2020), controlling for known health, economic, and social covariates.

Results. A fifth of respondents carried one or two ε4 alleles. Most respondents had less than a high school diploma (46%), nearly half worked for pay (45%), less than one quarter engaged in formal volunteering (24%), and roughly a little over one-sixth engaged in informal volunteering (36%). Respondents with ε4 alleles experienced lower levels of cognitive health at baseline, yet slower slopes of cognitive decline across models. Higher levels of education conferred greater cognitive health cross-sectionally and a slower cognitive decline rate. Although employed respondents reported lower levels of cognitive health at baseline, employment protected their cognitive health overtime. Formal volunteering resulted in higher levels of cognitive health, yet associations were unstable across models. Foreign born Hispanics experienced higher levels of cognitive health at baseline relative to US born Hispanics. Income, depression, and other social contexts influenced cognitive health at baseline and overtime in expected directions.

Discussion and Implications. Productive activities contributed to cognitive health, above and beyond genetic inheritance. Productive aging, income, and health policies and programs can bolster cognitive health. We also discuss areas for further research.

Keywords: APOEε4, Education, Employment, Healthy Aging, Volunteering

Background

Hispanics are projected to make up more than one-fifth of all older adults in the United States by 2060, with significant increases in the oldest old, 85+ years of age (Administration for Community Living, 2020). Age is a significant predictor of cognitive health, inclusive of Alzheimer's disease and related dementias (Alzheimer's Association, 2023). Public policies, such as the National Alzheimer's Project Act of 2011 and 2024, underscore the importance of healthy aging for the prevention of dementia and other chronic health conditions, a goal shared by policymakers, practitioners, advocates, and the public (Alzheimers.gov, n.d.). Seminal scientific reports continue to reveal possible pathways to achieve these shared goals: modifiable environmental factors, such as education and social connection, can bolster cognitive health and delay the onset and severity of cognitive impairment (Livingston et al., 2024). Nearly 45% of dementia cases can be prevented altogether with a focus on modifiable factors (Livingston et al., 2024).

The purpose of this study is to examine how genetic inheritance, specifically APOE alleles, and productive activities – formal education, employment, and volunteering – are associated with cognitive health trajectories among older Hispanics in the United States. Findings can help further advance gaps in science, guide public policies and practices, and inform public discourse on healthy aging.

Theory and Evidence

Cognitive health is influenced by a combination of genetic, behavioral, and modifiable environmental factors across the life course (National Institute on Aging 2024a, Global Council on Brain Health, 2022). Nearly 100 genes are associated with cognitive functioning, including Alzheimer's disease and related dementias (ADRD), with apolipoprotein E (APOE) being one of

the most well-known (Bellenguez et al., 2022; Chia-Chen et al., 2013; National Institute on Aging [NIA], 2023). It is thought to make a protein that helps to carry cholesterol and other types of fat into the bloodstream. Each biological parent contributes one APOE allele to their offspring, translating to each person having one of six possible combinations: 2/2, 2/3, 2/4, 3/3, 3/4, and 4/4. Among the APOE variants, ε4 is the strongest risk factor for cognitive impairment and Alzheimer's disease (Gharbi-Meliani et al., 2021; Griswold et al., 2021). According to NIA (2023), ε4 alleles are carried by approximately 15% to 25% of people and a subsample of approximately 2% to 5% of people carry two copies (4/4), which poses the highest risk. APOEε3 neither decreases or increases the risk of dementia, is thought to be neutral, and is the most common allele. APOEε2 protects against dementia and is carried by approximately 5% to 10% of the population. A recent analysis of older Hispanics, Blacks, and Whites in the Health and Retirement Study revealed the presence of at least one ε4 was related to poor cognitive functioning, and low-intensity volunteering protected their cognitive health (Lee et al., 2024).

Complementary to the genetic perspective on cognitive aging, the National Institute on Aging's (NIA) Health Disparity Framework and productive aging perspectives emphasize environmental, sociocultural, institutional, and behavioral factors that contribute to health inequities (Hill et al., 2015), with ethnicity, education, and occupation as important areas for scientific inequity. The environmental complexity hypothesis (Schooler et al., 1999) and cognitive reserve hypothesis (Stern, 2002 and 2013) extend this line of logic and posit that cognitively challenging activities such as education, work, and volunteering, require individuals to learn, think, use abstract thinking, memory, executive functioning, and meta-cognition. Lifetime engagement in cognitively stimulating activities may delay cognitive decline by building cognitive reserve, even in the context of age-related changes to the brain (Aguilar et al.,

2024; Lenz Lock et al., 2023; Stern, 2013). Fundamental to these theories is the *use it or lose it* hypothesis or 'mental-exercise hypothesis' (Salthouse, 2006). Education, employment, and volunteering likely share common mechanisms associated with cognitive health and are influenced by social policies and practices. These activities are known as productive activities because they contribute to the development of goods and services for society and opportunities for meaningful and purposeful engagement for older adults themselves. These activities typically take place within institutions informed by federal, state, and local social policies and programs (Morrow-Howell et al., 2001; Gonzales et al., 2015).

Rarely do longitudinal population-based studies examine productive activities together, inclusive of genetic factors. The link between education and cognition is well established (Livingston et al., 2024; Lövdén et al., 2020; Ribeiro et al., 2021), yet it is important to examine how educational attainment varies among the Hispanic population in the United States, inclusive of foreign born Hispanics, and its longitudinal associations with cognition. Moreover, some research has supported aspects of the environmental complexity hypothesis by examining occupational demands, namely data, people, and things (work complexity), with cognitive health. Complex work is positively associated with cognitive functioning (Andel et al., 2019; Fujishero et al., 2019; Fisher et al., 2017; Hyun et al., 2020), yet findings become mixed when race and ethnicity are examined (Gonzales, 2022). The labor market is an integral part of social stratification (Ahonen et al., 2018) and a handful of studies suggest Hispanic workers are disproportionately concentrated in jobs that do not yield as many cognitive health benefits relative to Whites (Fujishiro et al., 2019; Sheftel, et al., 2025). U.S.-born Hispanics in the Health and Retirement Study reported to have had a lifetime exposure to low-status occupations and jobs incommensurate with their educational attainment, which was linked with lower cognitive

health (Sheftel et al., 2025). Sheftel et al., (2025) excluded foreign-born Hispanics, as well as depression and chronic health conditions from analyses, which we include in the present study.

Formal and informal volunteering have long been thought to be antidotes to many dimensions of health and cognitive health specifically (Fried et al., 2004; Morrow-Howell, 2010; Proulx et al., 2018). Theoretically, volunteering is similar to employment in that it involves complex mental, social, and physical tasks, which may bolster cognitive health in later life (Fried et al., 2004; Guiney & Machado, 2017; Gupta, 2018; Park et al., 2014; Proulx et al., 2018; Sharifi et al., 2024; Villalonga-Olives et al., 2023). Yet again, findings are mixed when race and ethnicity are examined (Wang et al., 2022). To our knowledge, only one study (Lee et al., 2024) used pooled data from the Health and Retirement Study to examine productive activities, genetics (APOE), and known economic, social, and other health predictors to assess cognitive health among Hispanics, Blacks, and Whites. The present study aims to confirm these findings with important methodological differences, which include examining the heterogeneity within the U.S. Hispanic population, and revealing how predictors shape cognitive health trajectories over time.

It is important to examine the longitudinal associations of genetic and productive activities with cognitive health, especially among Hispanics in the United States, because this ethnic group is large and heterogeneous. Social stratification processes may be reflected among older Hispanics in terms of life opportunities to education, labor force, and volunteering (Andel et al., 2023). Relative to non-Hispanic older adults in 2020, older Hispanics were less likely to have obtained a high school diploma, less likely to volunteer, live in poverty, and reported higher rates of disability status (Administration for Community Living, 2020; AmeriCorps Research and Evaluation, 2021). How these socio-ecological contexts elevate or reduce the risk for

cognitive impairment among Hispanics in the United States, a large, growing, and heterogeneous ethnic group, is an important line of scientific inquiry.

Research Design and Methods

Data and Sample

The present study utilized six waves (2010–2020) of the Health and Retirement Study (HRS), a study of nationally represented samples aged 51 and older from the United States. HRS core data has been collected biannually since 1992. For analysis, we utilized the longitudinal data file processed by RAND (The RAND HRS Longitudinal File 2020 (V2)), HRS core data, and the APOE and Serotonin Transporter Alleles sensitive health data.

From an initial sample in 2010 of 22,034 participants, our study sample was restricted to include those who responded without a proxy (1,382 observations deleted); who were not classified as demented (810 observations deleted, Crimmins et al., 2010; Langa et al., 2009); who were aged 51 or older (1,292 observations deleted); who were Hispanic (16,237 observations deleted); and who had APOE4 information (461 observations deleted). This yielded a final analytical sample of 1,731 participants at Time 1 (2010) who contributed a total of 8,558 observations for a longitudinal analysis over the ten-year period (Time 2=1,643, Time 3=1,508, Time 4=1,387, Time 5=1,179, Time 6=1,110). Among this sample, 58.75% were Mexican American/Chicano, 40.37% were Puerto Rican, and 0.98% were Cuban American. Sensitivity analyses revealed that there was no statistically significant difference in the distribution of APOE alleles among these ethnicities. Furthermore, there was no statistically significant difference in cognitive functioning among these groups at Time 1 nor overtime, while controlling for age, APOE, and education. There were significant differences in cognitive functioning among foreign and U.S. born Hispanics, for which we discuss in greater detail below.

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 (Brandt et al., 1988; Ofstedal et al., 2005). Higher scores indicate higher levels of total cognitive function, and total scores range from 0 to 27 (Langa et al., 2010). Sheftel et al. (2025, p. 67) and others, used mixed effects modeling with TICS-M for their primary analysis on cognitive functioning among U.S. born Hispanics, Blacks, and Whites in the HRS, and then validated findings with a subsample of respondents who underwent a full neuropsychiatric assessment with detailed medical, functioning, cognitive, and physical examines for dementia diagnosis in the ADAMS (Crimmins et al., 2011). The Langa-Weir vs. ADAMS analyses showed that the Langa-Weir classification provided a conservative estimate of dementia.

Major Independent Variables

APOE genes (ε2/ε2, ε2/ε3, ε2/ε4, ε3/ε3, ε3/ε4, and ε4/ε4) were categorized as 0 = no ε4 allele and 1 = one ε4 allele or two ε4 alleles. This variable was dichotomized rather than having three groups due to the small sample size for people with two ε4 alleles.

Education was constructed with three categories of attainment: lower education level (1), defined as less than high school education, medium education level (2), defined as GED/high school graduation, and higher education level (3), defined as some college and above.

Employment was constructed using a binary measure of engagement with the paid workforce. Participants were categorized as working full- or part-time, including partly-retired (0) or as fully retired, unemployed, disabled or not in the labor force (1). We examine current employment status because there is a general concern of underreporting of work histories for foreign-born

individuals (Sheftel et al., 2025), and we are not aware that the O*NET or DOT occupational codes have been validated in Central and South American economies.

Formal Volunteering was measured with the question 'Have you spent any time in the past 12 months doing volunteer work for religious, educational, health-related or other charitable organizations?' and if so, "how many hours?" Respondents were categorized into: non-volunteers (0), less than 100 hours in the last year (1, hereinafter moderate formal intensity), or more than 100 hours in the last year (2, hereinafter high formal volunteer intensity).

Informal Formal Volunteering was measured with the question 'Altogether, about how many hours did you spend in the last 12 months helping friends, neighbors or relatives who did not live with you and did not pay you for the help? The variable was trichotomized: non-volunteers (0), less than 100 hours in the last year (1, hereinafter moderate informal volunteer intensity), or more than 100 hours in the last year (2, hereinafter high informal volunteer intensity).

Covariates

Demographic and known predictors of cognitive functioning were included as covariates (Aguilar et al., 2024; Livingston et al., 2024; Proulx et al., 2018). We centered age using participants' age in 2010. A time variable, measured as years since baseline, was included in the model. We included measures of sex (1=female, 0=male), place of birth (1=born in the U.S., 0=not born in the U.S.), marital status (1=married/partnered, 0=not married/partnered), household income (logged transformed), depressive symptoms (Center for Epidemiological Studies Depression (CESD) scale using eight items, Radloff, 1977), and the number of chronic health conditions reported at each wave (eight conditions including high blood pressure, diabetes, cancer, lung disease, heart disease, stroke, psychiatric problems, and arthritis).

Analytic Approach

Prior to longitudinal analysis, we computed descriptive statistics for all participants at each time point. We then estimated unweighted mixed-effect growth curves for all participants. Mixed effect models are a preferred statistical method for exploring changes in total cognition over time and exploring how trajectories are influenced by individual and group characteristics (Finkel, Reynolds, McArdle, Gatz, & Pedersen, 2003).

We estimated mixed-effects models, including age, time, APOE, and education (Model 1). We then examined additional models with added predictors of cognitive health: Model 2 added employment (i.e., Model 1 + employment). Model 3 added formal volunteering (i.e., Model 1 + formal volunteering). Model 4 added informal volunteering (i.e., Model 1 + informal volunteering). Model 5 included age, APOE, education, and all productive activities. The final model added empirically informed covariates to Model 6 (Aguilar, et al., 2024; Livingston et al., 2024; Proulx et al., 2018). 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. All mixed models in this study used unstructured covariance matrices and included a person-level random intercept.

Descriptive Results

Table 1 provides the basic results of the sample. On average Hispanics' cognitive function score 13.88 at baseline (*SD*=3.81). A fifth of respondents carried one or two ε4 alleles. On average, respondents were 62 years of age. Most respondents reported less than a high school education (47%), almost half were older workers engaged in full or part-time employment (45%), and most were not engaged in formal or informal volunteering (75% and 64%, respectively). The majority of respondents were female (58%) and born outside the United States

(61%). Most were married or partnered (69%), reported an average income of ~$41,000, and reported relatively few depressive symptoms (μ=2.07, SD=2.38) and chronic health conditions (μ=1.67, SD=1.41).

Longitudinal Analysis

Table 2 presents mixed-effect models predicting cognitive functioning longitudinally. In Model 1, increased years since baseline and age were associated with lower cognitive functioning. The presence of ApoE4 was associated with lower levels of cognitive functioning. Relative to respondents with less than high school educational attainment, respondents with GED/high school degrees and some college and above were associated with significantly higher levels of cognitive functioning. Interestingly, the presence of ApoE4 was associated with slower cognitive decline (β=0.052, $p < 0.05$). Medium and high levels of education were associated with a slower cognitive decline rate (β=0.050, $p < 0.05$; β=0.064, $p < 0.01$ respectively). In Model 2, respondents who worked had a marginally significant lower cognitive functioning (β=-0.232, $p < 0.10$), and had a significantly slower decline over time in the total cognition score (β=0.132, $p < 0.001$). In Model 3, higher-intensity formal volunteering was associated with higher levels of cognitive functioning (β=0.618, $p < 0.01$). Compared with non-volunteers, volunteers engaged in lower intensity (β=0.050, $p < 0.10$) had a significantly slower cognitive decline over time. In Model 4, informal volunteering was not significantly associated with cognition cross-sectionally and longitudinally with covariates. In Model 5, when work, formal volunteering, and informal volunteering were all included in the model, high-intensity formal volunteering was positively associated with cognition (β=0.57, $p < 0.05$) and moderate informal volunteering was marginally significant with better cognition (β=0.24, $p < .10$). Engagement in work was associated with a slower cognitive decline (β=0.13, $p < 0.001$). In Model 6, accounting

for other covariates, work was negatively associated with cognition (β=-0.30, $p < 0.05$), high-intensity formal volunteering was associated with higher cognition (β=0.54, $p < 0.05$), and engagement in work was associated with a slower decline in cognition over time (β=0.11, $p < 0.001$). Across all models, time, age, and presence of ApoE4 were negatively associated with cognitive functioning, and the presence of ApoE4 and higher education levels were associated with a slower cognitive decline rate. In all models, education was a strong predictor of cognitive functioning and a slower cognitive decline. Being born in the U.S., having higher CESD levels, and having more chronic health conditions were associated with lower cognitive function (Model 6). On the other hand, higher levels of logged income were associated with better cognitive functioning. Being female and married was associated with a slower cognitive function decline over time (Model 6). As a supplement to our primary analyses, we replicated our model using dichotomized formal and informal volunteering. We observed similar results compared to the models using three-category volunteering variables (data available upon request). Model Fit indicated by AIC and BIC were better in Model 6 with the covariates than other models. Marginal estimates of total cognition scores by education, work status, formal volunteer intensity, and birthplace are presented in Figures 1-4, respectively, while controlling for covariates (Model 6).

Discussion and Implications

This study underscores the importance of productive aging activities linked with cognitive functioning, within the context of inheritable genetic factors. Older adults are an important resource to society as they contribute their talents, experience, skills, and time in the labor force and civic sectors, translating to trillions of dollars in contributions to the gross domestic product and millions of dollars saved through civic activities (AARP, 2022). This study

further reveals how older Hispanics, foreign and U.S. born, are an integral part of the workforce and civic sectors (AmeriCorps, n.d.) and points for further development of policies and practices, which we discuss below, to improve their cognitive health.

Developing person-centered interventions to promote cognitive health is a top priority. Findings of this study align with the extant literature which suggests APOE provides unique contributions to cognitive health (Andrade-Guerrero, et al., 2023; Bellenguez et al., 2022; Griswold et al., 2021) and there is great variability in the effect of APOE across ancestry and country of origin (González et al., 2018; Granot-Hershkovitz et al., 2021; Granot-Hershkovitz et al., 2023; Suchy-Dicey et al., 2022). We did not find differences in the effects of APOE e4 across ancestry among the Mexican American, Puerto Rican, and Cuban older adults in this study, but more work is clearly needed in exploring heterogeneity across ethnic origin in Hispanic samples. Replicating and validating these findings with different datasets, such as Hispanic Community Health Study / Study of Latinos (HCHS/SOL) with greater specificity of ancestry and country of origin is suggested.

The value of higher education is emphasized with these findings. Policies and programs that enable everyone to achieve higher education is an important prevention strategy to cognitive decline (Livingston et al., 2024; Lövdén et al., 2020; National Academy of Medicine, 2022). Strategies such as ensuring higher education affordability, mentorship throughout the academic journey for Hispanic populations, service learning courses in targeted health promotion areas, and loan forgiveness are all promising social policies likely to reduce the barriers to obtaining higher education. Intergenerational tutoring programs have been effective strategies with African Americans and Whites with significant improvements in cognitive, mental, physical and social wellbeing for older adults and improved reading, socioemotional health, and behavioral among

young African American and white children (AARP Foundation, 2023; Carlson et al., 2009; George & Singer, 2011). Given that intergenerational co-residence and cultural norms of respect for elders in many Hispanic communities, it is likely that intergenerational support is occurring informally and often but rarely captured in datasets, such as the HRS. The expansion of formal opportunities for intergenerational connection via program development and expansion is important for the equitable distribution of resources to support the cognitive, physical, mental and social health of older Hispanics.

It is unclear if working longer is a choice or obligation among this sample of older Hispanics. Nevertheless, working in later life had a significant impact on cognitive functioning above and beyond APOE, education, economic, social, and health status. This finding is similar to that found in other population-based samples and is further support of the use it or lose it hypothesis (National Academies of Medicine, 2022). Further analysis on the nature of work, whether their jobs are mentally and socially stimulating or rote and physically demanding, may provide greater insight on the dimensions of employment that are linked with cognitive performance. Future research also needs to identify lifetime occupational status and the cumulative exposure to complex jobs and work environments among foreign born Hispanics (Sheftel et al., 2025), a large and growing population. Federal programs, such as The Senior Community Service Employment Program (SCSEP) of Title V of The Older Americans Act, can be a vital resource for low-income Hispanics to obtain job training, interview coaching, and employer referrals should they need and or want to work longer (Carolan et al., 2020). SCSEP is the only federal program to help older adults, and specifically low-income older adults with job training and acquisition. Mixed methods research on its impact on participant's health, social, and employment outcomes are encouraging as participants report improved mental health,

reduced homelessness, greater economic and food security, and stronger motivations for unsubsidized work (Gonzales et al., 2019; Lai et al., 2024; Halvorsen et al., 2023).

The association between formal and informal volunteering and cognitive health were surprising, especially revealing that most older Hispanics were not engaged in either form. The literature in this area generally suggests more volunteering is beneficial for many health domains including cognition (Fried, et al., 2004; Guiney & Machado, 2019; Morrow-Howell, 2010). However, findings on volunteering, race or ethnicity, and cognitive health have shown mixed and unexpected results (Wang et al., 2022). It is possible that when older Hispanics do volunteer, they are not assigned to cognitively demanding roles, especially older Hispanics with low levels of formal education and lifetime occupations that were not generally mentally or socially complex. Supervisors and managers of volunteer organizations may assign low-educated Hispanic tasks that are cognitively simple. In our discussions with directors of national service programs, such as SeniorCorps and Foster Grandparents, supervisors first and foremost want older volunteers to gain a sense of confidence. They are more likely to assign highly educated volunteers to read with children, assist with course assignments, and review homework. Yet with other volunteers who may not have high levels of literacy, supervisors often assign them tasks such as talking with, and mentoring children, in turn facilitating a sense of self-esteem and self-concept. These types of practices reveal some social stratification of volunteer roles based on education levels. Practitioners need valid and reliable psychometric tools to measure many domains of health and wellbeing at intake, inclusive of cognition, and to match volunteers to mentally, socially, and physically tasks that strikes a balance between feeling a sense of contribution while also facilitating a cognitively stimulating environment. Furthermore, the nature and scope of the volunteer questions in this dataset may need further cultural

considerations (Reyes, 2023). The HRS variables used in this study may under specify the volunteer activities of older Hispanics and consequently its association with cognitive health. Nonetheless, AmeriCorps, Senior Corps, League of United Latin American Citizens (LULAC), AARP Experience Corps, and local volunteer programs can facilitate the recruitment and retention of older Hispanics to benefit communities and older adults themselves.

Covariates functioned in expected directions and have important social policy implications. Meals-on-wheels and other nutritional programs, Medicaid, and Supplemental Security Income designed to help low-income adults are important to economic security and cardiovascular health, two pathways linked with cognition among Hispanics in this study. Mental health interventions, specifically related to depression, are also important.

The findings of this study should be understood with its limitations. Lifetime complexity constructs that are validated and sensitive to cohorts and economies, industries, and occupations in Central and South America is warranted. Future research can develop and apply a work complexity instrument that accurately reflects the nature of work in Northern, Central, and South Americas, and Western Europe where migration among Hispanics occurs. The Health and Retirement Study needs to further query ancestry, country of origin, timing and motivations for migration. Given the importance and magnitude of immigration, more data in this dataset is needed to characterize the timing, push/pull factors, social, political, and economic motivations for Hispanics to migrate to the United States. Furthermore, this study relied on a survey-based classification of cognitive functioning (TICS-M), which is the most widely translated and validated instrument (Castanho et al., 2014), rather than a formal diagnosis. One advantage is that the survey-based approach often yields greater participation among Hispanic and Black populations due to access barriers in healthcare (Lin et al., 2021). Sheftel et al., (2025) also note

that the Langa-Weir classification is likely conservative (Crimmins et al., 2011). Replicating these findings with other datasets, such as the Hispanic Community Health Study/Study of Latinos (HCHS/SOL), may provide greater clarity on genetic, ancestry, country of origin, and modifiable environmental factors across diverse Hispanics/Latinos in the US.

Conclusion

Engaging in productive activities can enhance cognitive health above and beyond APOE and other known factors for older Hispanics. Social policies and practices should focus on high-risk populations—such as Hispanics with low education, low-income, non-volunteers, high rates of multimorbidity, and elevated mental health concerns—by offering opportunities for education, paid work, and volunteering, and social policies that target economic security and social connection. Additional research is needed to pinpoint the specific aspects of work and volunteering that contribute to these positive health outcomes, including the complexity of productive tasks.

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Table 1. Descriptive statistics at baseline (N=1,731)

	Mean (SD) or %	Range
Age	62.23 (9.16)	51-96
One or two APOε4 alleles	20.45%	
Education		
Less than high school	46.85%	
High school diploma or GED	25.65%	
Some college or more	27.50%	
Currently working	44.54%	
Formal volunteering		
None	75.56%	
Less than 100 hours	16.64%	
100 hours or more	7.80%	
Informal volunteering		
None	64.41%	
Less than 100 hours	28.37%	
100 hours or more	7.22%	
Female	58.06 %	
Born in the United States	38.19%	
Married/partnered	69.04%	
Log household income	10.12 (1.04)	2.46-13.29
Depression	2.07 (2.38)	0-8
Chronic health conditions	1.67 (1.41)	0-7
Total cognitive function	13.88 (3.81)	7-27

Table 2. Mixed-effect models predicting total cognitive function

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	Intercept	**Slope**	**Intercept**	**Slope**	**Intercept**	**Slope**	**Intercept**	**Slope**	**Intercept**	**Slope**	**Intercept**	**Slope**
Time from baseline	12.60***	-0.07***	12.65***	-0.10***	12.55***	-0.07***	12.55***	-0.07***	12.54***	-0.09***	11.11***	-0.07***
Age at baseline	-0.11***		-0.11***		-0.11***		-0.11***		-0.10***		-0.09***	
One or two APOEe4 Alleles	-0.45*	0.05*	-0.44*	0.05*	-0.45*	0.05*	-0.46*	0.05*	-0.45*	0.05*	-0.45*	0.05*
Education (ref: <high school)												
High school diploma/GED	1.97***	0.05*	2.00***	0.03	1.92***	0.05*	1.92***	0.05*	1.90***	0.04	1.89***	0.04†
Some college or more	2.87***	0.06**	2.92***	0.04†	2.77***	0.06*	2.80***	0.06*	2.76***	0.03	2.69***	0.05*
Currently working			-0.23†	0.13***					-0.22	0.13***	-0.30*	0.11***
Formal volunteering (ref: none)												
<100 hours					0.22	0.05†			0.22	0.03	0.20	0.03
100+ hours					0.62**	0.06			0.57*	0.05	0.54*	0.05
Informal volunteering (ref: none)												
<100 hours							0.20	0.03	0.24†	0.01	0.20	0.01
100+ hours							0.35	0.00	0.29	-0.01	0.25	-0.01
Female											0.10	0.04*
Born in the U.S.											-0.40*	-0.03
Married/partnered											-0.07	0.06*
Logged income											0.20**	-0.00
Depression											-0.08**	0.00
Chronic health conditions											-0.15**	-0.02*

Notes: †$p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$.