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Stickel, Ariana M
Tarraf, Wassim
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Cognition and daily functioning: Results from the Hispanic Community Health Study/Study of Latinos (SOL) and Study of Latinos - Investigation of Neurocognitive Aging (SOL-INCA)

Ariana M. Stickel[a], **Wassim Tarraf**[b], **Benson Wu**[a], **Maria J. Marquine**[c], **Priscilla M. Vásquez**[d], **Martha Daviglus**[e], **Mayra L. Estrella**[e], **Krista M. Perreira**[f], **Linda C. Gallo**[g], **Richard B. Lipton**[h], **Carmen R. Isasi**[h], **Robert Kaplan**[h], **Donglin Zeng**[i], **Neil Schneiderman**[j], **Hector M. González**[a,*]

[a]Department of Neurosciences and Shiley-Marcos Alzheimer's Disease Research Center, UC San Diego

[b]Institute of Gerontology & Department of Healthcare Sciences, Wayne State University, Detroit, Michigan

[c]Department of Psychiatry, UC San Diego

[d]Department of Family Medicine and Public Health, UC San Diego

[e]Institute for Minority Health Research, University of Illinois at Chicago, College of Medicine, Chicago, Illinois

[f]Department of Social Medicine, UNC School of Medicine, Chapel Hill, North Carolina

[g]Department of Psychology, San Diego State University, San Diego, California

[h]Department of Epidemiology & Population Health, Albert Einstein College of Medicine

[i]Department of Biostatistics, University of North Carolina, Chapel Hill, North Carolina

[j]Department of Psychology, University of Miami, Miami, Florida

Abstract

Background: Among older adults, poorer cognitive functioning has been associated with impairments in instrumental activities of daily living (IADLs). However, IADL impairments among older Hispanics/Latinos is poorly understood.

Objective: To characterize the relationships between cognition and risk for IADL impairment among diverse Hispanics/Latinos.

Methods: Participants included 6,292 community-dwelling adults from the Study of Latinos - Investigation of Neurocognitive Aging, an ancillary study of 45+ year olds in the Hispanic Community Health Study/Study of Latinos. Cognitive data (learning, memory, executive

*Corresponding Author: Hector M. González, Ph.D.: University of California, San Diego, 9500 Gilman Dr., La Jolla, CA; Telephone: 858-534-5361; hmg002@health.ucsd.edu.

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functioning, processing speed, and a Global cognitive composite) were collected at Visit 1. IADL functioning was self-reported 7 years later, and treated as a categorical (i.e., risk) and continuous (i.e., degree) measures of impairment. Survey two-part models (mixture of logit and generalized linear model with Gaussian distribution) and ordered logistic regression tested the associations of cognitive performance (individual tests and composite z-score) with IADL impairment. Additionally, we investigated the moderating role of age, sex, and Hispanic/Latino background on the association between cognition and IADL impairment.

Results: Across all cognitive measures, poorer performance was associated with higher odds of IADL impairment 7 years later. Associations were generally stronger for the oldest group (70+ years) relative to the youngest group (50–59 years). Sex and Hispanic/Latino background did not modify the associations. Across the full sample, lower scores on learning, memory, and the Global cognitive composite were also associated with higher degree of IADL impairment.

Conclusion: Across diverse Hispanics/Latinos, cognitive health is an important predictor of everyday functioning 7-years later, especially in older adulthood.

Keywords

activities of daily living; cognition; Latinos; Hispanics; aging; sex

INTRODUCTION

In the United States, individuals with Alzheimer's disease and related disorders (ADRD) and their families lose an estimated $13,000 to $28,000 annually per person from time spent providing informal caregiving [1]. In 2017, informal ADRD caregivers provided 18.4 billion hours of care which equates to $232 billion dollars in care [2]. Among ADRD caregivers, Hispanics/Latinos spend more time (approximately 30 hours compared to 20 hours per week) caregiving than Whites [3]. Maintaining instrumental activities of daily living (IADLs) with age may help maintain quality of life and reduce the need for caregiver assistance and lost productivity [4]. Therefore, identifying factors that impact IADLs among older Hispanics/Latinos is critical to decreasing caregiver burden.

IADLs (e.g., managing finances) are daily functions that require more cognitive resources in order to be performed independently than do basic activities of daily living (e.g., toileting). Independence in basic activities of daily living tends to remain preserved longer than that of IADLs, in the presence cognitive impairment [5]. Cognitive impairment and deficits in IADLs are essential components of the criteria for diagnosing neurocognitive disorders, including those associated with ADRD [6]. Declines in cognition have been shown to precede declines in self-reported daily functioning [7]. Furthermore, among those with and without ADRD diagnosis, poorer episodic memory and executive functions are consistently associated with poorer subjective (self- and informant-reported) performance on IADLs [8]. Taken together, these findings indicate poor cognitive functioning may be a risk factor for developing difficulties in performing IADLs. However, some IADL measures (e.g., performance on a novel driving task) may differentiate cognitively healthy individuals with and without Alzheimer's biomarkers whereas cognitive testing may not, suggesting that cognitive impairment does not always precede functional declines [9, 10].

Although the existing literature is limited among Hispanics/Latinos, cognition also seems to be linked to everyday functioning in this group [11–13]. Among Brazilians, those who maintained self-reported IADL independence over a 6-year period had higher baseline scores on the modified Mini Mental State Exam (a measure of global cognition) than those that developed IADL disability [11]. With regard to specific cognitive domains, Farias and colleagues found that poor object naming and verbal episodic memory were associated with lower informant-reported IADL performance in a bi-ethnic group of older adults [13], with similar associations by ethnicity (Hispanics/Latino, non-Hispanic/Latino) and preferred language (Spanish/English). Similarly, Stickel et al. (Stickel, McKinnon, Ruiz, Grilli, & Ryan, unpublished) found that lower scores on a verbal measure of episodic memory were associated with poorer informant-reported IADLs among Hispanics/Latinos.

Demographics, such as age and sex may also influence daily functioning. Older age has consistently been associated with increased impairment in reported IADLs [14–16]. In contrast, there are mixed findings for the effects of sex on everyday functioning. Most studies have detected male-advantages in maintaining daily functioning [14, 17–20] or no sex differences [16, 21, 22]. In some cases, female advantages are observed on specific IADL items (e.g., meal preparation) [14, 15]. With regard to Hispanics/Latinos, Alexandre et al. [11] found that older age and female sex were associated with impairments in self-reported IADLs over a six-year period. In contrast, Stickel et al. (unpublished) did not observe differences in informant-reported IADL functioning between sexes within their cross-sectional sample of Hispanics/Latinos of unspecified heritage backgrounds. It is unclear whether sex differences in IADL functioning would be evident among diverse groups of Hispanics/Latinos.

Furthermore, the relationships between cognition and IADL functioning have not been compared across different Hispanic/Latino backgrounds (e.g., Mexicans, Puerto Ricans).Hispanics/Latinos are one of the fastest growing ethnoracial groups in the United States [23] and are projected to account for 21% of the older adult population by 2060 [24]. ADRD prevalence estimates for Hispanics/Latinos vary widely [25–27]. Existing evidence suggests that individuals of Mexican background may be at similar risk of ADRD as non-Hispanic/Latino Whites [27] whereas Hispanics/Latinos of Caribbean background are at higher risk [25]. Characterizing the relationships between cognition and IADLs among Hispanics/Latinos without dementia may help elucidate patterns of differential ADRD risk. The purpose of this study is to examine associations between cognition and IADL impairment among diverse middle-aged and older Hispanics/Latinos and to what extent those relationships are moderated by age, sex, and Hispanic/Latino background. We hypothesized that across a diverse and large sample of middle-age and older Hispanics/Latinos from the Hispanic Community Health Study/Study of Latinos (HCHS/SOL) and its ancillary study, SOL-Investigation of Neurocognitive Aging (SOL-INCA), poorer cognition at Visit 1 (baseline) would be associated with self-reported IADL impairment at Visit 2, an average of 7-years later. We expected these associations would be stronger amongst older individuals and females.

MATERIALS AND METHODS

Data

The HCHS/SOL is a multisite, prospective cohort study of 16,415 community-dwelling Hispanic/Latino adults (18–74-years old) from diverse background groups. The HCHS/SOL was designed to estimate representative baseline risk factors for overall Hispanics/Latinos as well as for specific backgrounds including Central Americans, Cubans, Dominicans, Mexicans, Puerto Ricans, and South Americans. Data were collected from Field Centers in four U.S. metropolitan areas with substantial Hispanic/Latino population concentrations (Bronx, NY; Chicago, IL; Miami, FL; and San Diego, CA). Institutional review boards at each participating site approved the study protocol. Participants provided informed consent. Research complied with the Helsinki Declaration of 1975. Each Field Center recruited about 4,000 eligible, self-identified Hispanic/Latino adults. Detailed HCHS/SOL sampling methods have been previously published [28]. Neurocognitive function was obtained at Visit 1 (n=9,623) in participants 45–74 years of age. The HCHS/SOL ancillary study, the Study of Latinos - Investigation of Neurocognitive Aging (SOL-INCA), studied the prevalence and determinants of neurocognitive decline and disorders in HCHS/SOL. SOL-INCA occurred concurrent to HCHS/SOL Visit 2 (years 2014 to 2017) at which point participants were 50+ years old [29]. SOL-INCA uses the complex design features of HCHS/SOL, which include a multistage sampling strategy with stratification and clustering, and probability weights that account for non-response and attrition, used to ensure valid generalizations to the HCHS/SOL targeted populations.

Analytic Subpopulation

SOL-INCA enrolled 6,377 eligible HCHS/SOL participants. For the current study, we excluded n=85 participants with missing values on any of the covariates of interest. The analytic sample size was 6,292. Excluded participants had similar age and sex distributions but were less educated (38.4% vs. 45.9% less than high school education) than those in the analytic sample.

Outcomes

Participants completed all measures in their preferred language (Spanish/English) [29]. The primary outcome is daily functioning, measured using the Instrumental Activities of Daily Living (IADL) self-report questionnaire [30, 31] administered at Visit 2 (SOL-INCA). Daily functioning was operationalized as a continuous variable derived from the sum of 7 component questions that ask about the following tasks: (1) ability to use a telephone, (2) ability to get to places out of walking distance, (3) ability to go shopping for groceries or clothes, (4) ability to prepare own meals, (5) ability to do housework, (6) ability to take own medicine, and (7) ability to handle own money. Each question was coded trichotomously with 0 = Without help, 1 = With some help, and 2 = Completely unable to perform the task at all. We also considered, a three-category operationalization of this variable. For this, the 7 component questions were dichotomized with 0 = without help and 1 = With some help/ Completely unable to perform the task at all. Then, the 7 component questions were summed and then categorized as 0 = No IADL disabilities, 1 = one or two IADL disabilities, and 2 = more than two IADL disabilities.

Primary Exposures -Neurocognitive Function

The neurocognitive tests administered at Visit 1 were the: (1 and 2) Brief-Spanish English Verbal Learning Test learning trials (sum of three trials; B-SEVLT Sum) and recall (post-interference trial; B-SEVLT Recall); verbal episodic learning and memory, respectively) [32]; (3) Controlled Oral Word Association (or Word Fluency; WF; verbal fluency) Test of the Multilingual Aphasia Examination [33]; and (4) Digit Symbol Subtest (DSS; processing speed) of the Wechsler Adult Intelligence Scale-Revised [34]; and (5) Six-Item Screener (SIS; mental status) [35]. Additionally, a (6) Global cognitive function measure was created by taking the average z-scores of B-SEVLT learning, B-SEVLT memory, Word Fluency, and Digit Symbol Subtest scores [29].

Covariates

Based on previous cognitive aging literature [15, 36], we adjusted for age in years at Visit 2; sex, education (less than high school, high school or equivalent, or greater than high school). We also adjusted for depressive symptoms using the Center for Epidemiologic Studies Depression scale (CESD-10) [37] measured at Visit 1. Lastly, we adjusted for a fixed effect of Field Center to account for potential unobserved and systematic site-specific differences, and time from Visit 1 to Visit 2 in days to control for individual differences between examination periods.

Statistical Analysis

First, we generated descriptive statistics to characterize the target population by the overall sample and by age (Table 1). See Supplemental Tables 1 and 2 for descriptive statistics on the overall sample by sex and Hispanic/Latino background, respectively. Descriptive characteristics of the excluded participants due to covariate missingness are presented in Supplemental Table 3. We used survey adjusted chi-squared tests (for categorical variables) and t-tests (for continuous variables) to examine and test for group differences. Additionally, we plotted the distribution of the IADL sum score by sex and age (Supplemental Figure 1).

Second, all Visit 1 cognitive outcomes were z-scored (generated using [Y_i-Mean Y_i]/ standard deviation) for analyses to facilitate comparison of the estimated associations across tests. To examine IADL performance at Visit 2, we fit survey two-part models (TPM) [38] to independently examine the associations of each cognitive outcome with IADL sum score. TPMs were used to account for the extreme right skew of the IADL sum-score. Detailed theoretical and applied treatments of TPM models and discussions of their statistical advantages relative to other techniques used to model zero-heavy outcomes are published elsewhere [39, 40]. The first part of the TPM was fit using logistic regression, and the second part of the TPM was fit using a generalized linear model (GLM) with a log link and a Gaussian family function. The two TPM models we fit for each IADL outcome were (1) age and sex, (2) model 1 with additional adjustments for education, CESD-10, Field Center, and time from Visit 1 to Visit 2. Odds ratios were reported for the first part of the TPM and beta coefficients were reported for the second part of the TPM, both with 95% confidence intervals (Table 2). The marginal IADL sum scores of demographically-adjusted and fully adjusted models were estimated and plotted with 95% confidence intervals over the

cognitive outcome exposure continua in order to facilitate interpretation of the associations (Figure 1).

Third, we used survey ordered logistical regression to in order to evaluate how well an individual's categorical IADL sum score can be predicted as a function of cognition at Visit 1 and multiple covariates. The ordered logistic regression was adjusted for the full set of covariates of interest as described above. A Wald test was used to test for violations of the proportional odds assumption (Table 3). A violation of this assumption indicates that an ordered logistic regression would not be appropriate for modeling the categorical outcome. Details on ordered logistic regression can be found elsewhere [41]. Ordered logistic regression marginal estimates with 95% confidence intervals over the cognitive outcome continua were plotted to facilitate interpretation (Figure 2).

Lastly, we tested for modification by sex, age (age groups 50–59 years, 60–69 years, and 70–86 years), and Hispanic/Latino background by repeating the primary fully adjusted models for each cognitive exposure, independently. Post-hoc ANOVA contrasts were used to test paired differences in slopes (Table 4). Average marginal effects with 95% confidence intervals over the cognitive outcome continua were estimated and plotted to facilitate interpretation (Figure 3).

RESULTS

The mean age at Visit 2 was 63.4±8.2 years. More than half of the target population was female (54.6%) and more than a third had less than a high school education (38.4%). Additionally, the mean CESD-10 score was 7.4±6.3. For the participants excluded due to covariate missingness (n=85), the mean age was relatively similar (63.9±8.6) years. However, excluded participants had an elevated CESD-10 score (8.7±5.6) and almost half had less than high school education (45.9%). Complete characteristics of the target population are presented in Table 1. The range of the IADL sum score was 0–14 with the mean being 0.62 ± 1.49 with a positive skew of 3.37. Descriptive statistics of the IADL sum score are presented in Supplemental Table 4, and visualization of the distributions of the IADL measures used in this study, overall and by sex and age groups, are presented in Supplemental Figure 1.

Cognition and IADL impairment

The parameter estimates from the two-part models are shown in Table 2 and marginal IADL sum scores are plotted in Figure 1. We found significant associations between all six cognitive performance measures, individually, and the IADL sum score for the logistic portion of the two-part models after adjusting for covariates. Higher performance on B-SEVLT Sum, B-SEVLT Recall, WF, DSS, and Global cognitive performance at Visit 1 were associated with lower odds ratios of having any IADL impairment at Visit 2. Impaired mental status (SIS 4) was associated with higher odds ratios of IADL limitations. We also found significant associations between the IADL sum score and B-SEVLT-Sum ($\exp(\beta)$ = 0.86 [0.80; 0.93]; $p < 0.001$), B-SEVLT-Recall ($\exp(\beta)$ = 0.88 [0.83; 0.94]; $p < 0.001$), and Global cognitive performance ($\exp(\beta)$ = 0.81 [0.73; 0.91]; $p < 0.001$), independently, in the GLM portion of the two-part models after adjusting for covariates. Exponentiated values

below 1.0 indicate a lower risk for IADL impairment. This suggests that among those with evidence of limitations (i.e. IADL more than 0), higher cognitive scores on these tests are associated with lower likelihood of IADL severity. There were significant associations between the IADL sum score and WF, DSS, and dichotomous SIS, but results were fully attenuated after adjusting for covariates.

Cognition and IADL classification

The estimated odds ratios and their 95% confidence intervals are summarized in Table 3 and marginal probabilities are plotted in Figure 2. None of the p-values from the Wald Tests used to test the proportional odds assumptions were significant, indicating that the ordered logistic regression was appropriate for modeling the categorical IADL outcome. Higher performance on the cognitive outcomes led to lowered odds of having poor IADL classification relative to the combined good and moderate IADL groups across cognitive measures for B-SEVLT-Sum, B-SEVLT-Recall, WF, DSS, and Global cognitive performance. Additionally, being in the impaired category by the SIS standards led to increased odds ratios of having poor IADL classification relative to the combined good and moderate groups.

Cognition interactions with demographics

We found that age significantly or borderline-significantly modified the associations of B-SEVLT Sum ($p < 0.01$), B-SEVLT Recall ($p < 0.01$), DSS ($p = 0.056$), dichotomous SIS ($p < 0.001$), and Global cognitive performance score ($p < 0.01$) with IADL sum score. The estimated contrasts of age-groups specific marginal slopes and their standard errors are presented in Table 4 and marginal IADL sum scores are visualized in Figure 3. The associations were strongest for the oldest group (70+ years) relative to the youngest group (50–59 years) for all cognitive measures except for Word Fluency. Neither sex or Hispanic/Latino background modified the relationships between cognitive outcomes and the IADL sum score (see Supplemental Tables 5 and 6, respectively).

DISCUSSION

We found that lower cognitive performance at Visit 1 was associated with self-reported IADL impairment 7-years later in our population-based prospective study of diverse middle-aged and older Hispanics/Latinos. Each individual cognitive measure and the Global cognitive function at Visit 1 were associated with increased risk of IADL impairment at Visit 2. Second, lower learning, memory, and Global cognitive function were each related to greater degree of IADL impairment. Third, as expected, age exacerbated the links between cognitive measures at Visit 1 and IADL impairment at Visit 2. That is, the associations between cognition and IADL impairment were more prominent among Hispanics/Latinos 70-years and older relative to middle-aged Hispanics/Latinos. Finally, sex and Hispanic/Latino background did not moderate the relationships between cognition and IADL impairment.

Our primary results were largely consistent with previous studies [8], despite having a relatively young cohort with relatively low impairment (76.19% denied any impairments).

For example, Farias and colleagues also found that poorer cognitive performance was associated with worse informant-reported daily functioning using a cross-sectional design [13], among Hispanics/Latinos of predominantly Mexican background. Thus, our results extend to diverse Hispanics/Latinos. Similar to findings from an older Brazilian sample, risk for self-reported IADL impairment was also detectable using a global cognitive screener (i.e., the Six-Item Screener in the present study) [11]. Importantly, learning, memory, and our cognitive composite were also associated with degree of IADL impairment. Memory, in particular, has consistently been linked to IADL outcomes [8, 13]. In fact, in Farias et al.'s [13] sample of Mexican Americans, memory was independently associated with IADL functioning, over and above other cognitive measures.

Existing cross-sectional and longitudinal evidence suggest that older age is associated with increased difficulty in reported daily functions [11, 14–16]. Our findings expand on this literature by suggesting that adults 70+ years of age are particularly susceptible to difficulties with IADLs in the presence of lower cognitive performance. The age modifications also suggest that maintaining cognitive functioning may reduce the risk of IADL impairment into older adulthood. However, other factors (e.g., mental health, mobility limitations, sensory issues) may have a differential impact on IADL impairment based on age group. Further, in older age certain limitations (e.g., sensory limitations) may be more prevalent and/or have a stronger impact on both cognitive performance and IADLs [42]. Therefore, longitudinal data are needed to disentangle potential physical and mental health limitation confounds.

Few studies have examined the sex-specific associations of cognition and daily functioning. Both Alexandre et al. [11] and the present study found that poorer performance on brief cognitive screenings was associated with increased risk of difficulties in self-reported IADLs similarly in males and females. Further, we did not detect differential associations based on sex when using more specific cognitive measures. It remains unclear if there are differences in ADRD in male versus female Hispanics/Latinos [43]. Our findings as well as similar prevalence of Mild Cognitive Impairment observed between sexes in this cohort (see González et al. [44]) suggest similar risk but more research is needed to confirm [45]. Furthermore, female Hispanics/Latinas may be more susceptible than their male counterparts to ADRD via other risk factors not included in our study, such as cardiovascular disease risk [46].

Hispanic/Latino background did not significantly influence the relationships between cognition and IADLs. Given that ADRD incidence rates vary among Hispanics/Latinos by background [26], future research is needed to elucidate potential mechanisms. Although our findings suggest that cognition is equally important in predicting self-reported IADL impairment across Hispanic/Latino groups, future research is needed to determine whether *declines* in cognition may have a differential impact on IADL impairment based on background. Alternatively, other factors (e.g., genetic, cultural) may play a role in Hispanic/ Latino group differences in risk for ADRD.

Given our observations of a largely uniform association between cognition and 7-year IADL functioning, interventions to improve cognition among Hispanics/Latinos may have

additional benefits of maintaining IADLs with age. Previous findings from the HCHS/SOL suggest that certain factors, such as established family connections, are associated with enhanced cognitive stimulation [47]. Physical health interventions (e.g., Latin dance [48]) have been associated with cognitive improvements among Hispanics/Latinos and may help maintain IADLs through multiple pathways (e.g., via mental and physical health). Interventions aimed at reducing risk for ADRD through maintenance of cognitive functions and IADLs among Hispanics/Latinos are critical to public health, in particular because Hispanics/Latinos are projected to have the highest increase in ADRD cases in the United States from 2015 to 2060 [49].

Our study includes some limitations. First, we only include a self-reported measure of IADLs. Previous research has found that self-reported IADL functioning is uniquely associated with directly observed behavior beyond variance accounted for by tests of everyday problem-solving [50]. However, it is possible that participants may be under- or over-reporting IADL impairments, and future studies should attempt to corroborate self-reported data with informant reports. Additionally, future studies should consider supplementing daily functioning questionnaires with performance-based measures. Performance-based measures may be better able to detect differences in daily functioning between individuals who are cognitively healthy versus those with mild cognitive impairment [51] (see [52]). Performance-based measures of daily functioning may also be more accurate [53] and sensitive to cognitive abilities than report-based measures [54, 55]. Second, we did not measure the extent to which IADL impairments were related to physical versus cognitive limitations. As noted above, sensory and motor/physical deficits are more common in older age. If such deficits influence cognitive performance and IADLs in parallel this may explain the exacerbated link between poorer cognition and worse IADL functioning among individuals 70 years and older. Further, aspects specific to the Hispanic/Latino community (e.g., high prevalence of cardiovascular risk factors, high rates of poverty [56, 57]) may also play a role in the associations between cognition and daily functioning. Future studies are needed to clarify independent versus mediated associations between cognition and IADLs.

Third, although we attempted to predict future IADL impairment, we only included IADL information at one timepoint (Visit 2). Therefore, it is possible that IADL impairments already existed at the time of cognitive testing (Visit 1). Notably, participants were healthy and functional enough to provide informed consent and complete an in-person cognitive examination at Visit 1. Finally, future studies should examine how limitations in IADLs may influence psychosocial functioning (e.g., social engagement, quality of life). Furthermore, there may be multidirectional relationships between IADL impairment, psychosocial functioning, and cognition that influence risk for ADRD.

Conclusion

We found that lower cognition was associated with both increased prevalence and severity of IADL impairment 7-years later in a diverse, population-based cohort of Hispanics/Latinos. These relationships were stronger among Hispanics/Latinos 70 years and older. Our findings

highlight the relevance of cognitive health in maintaining independent everyday functioning for aging Hispanics/Latinos.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

ACKNOWLEDGEMENTS

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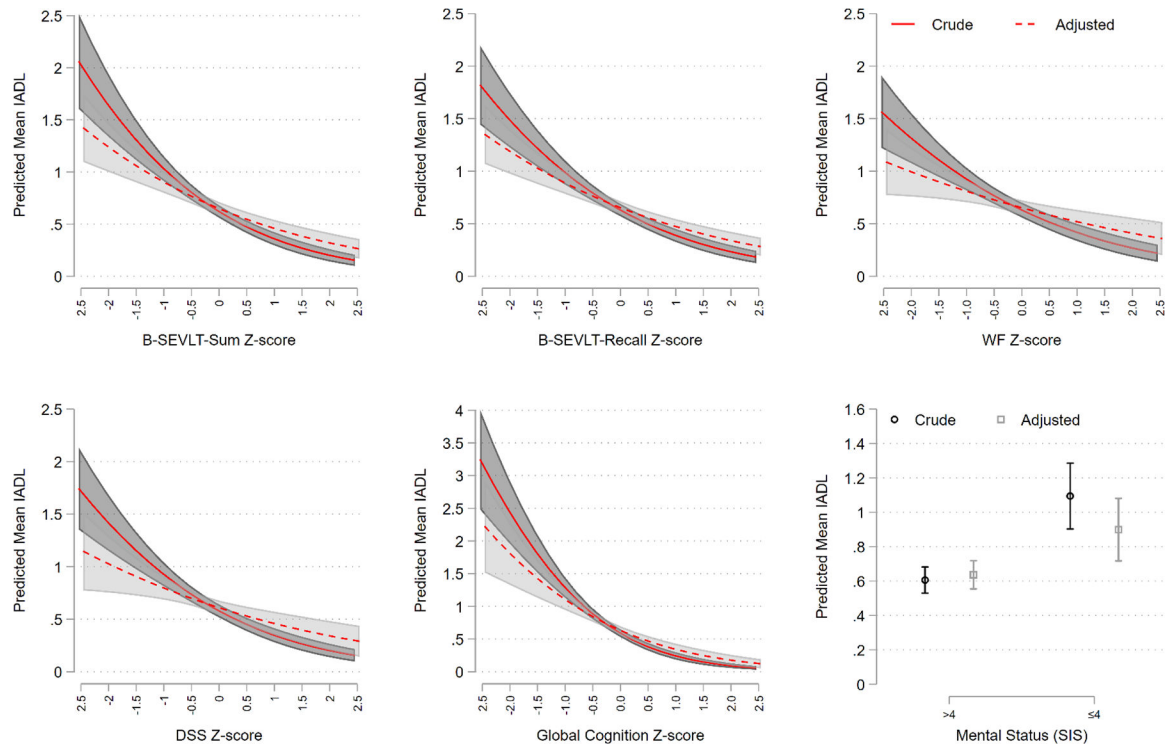
Figure 1.
Marginal IADL sum scores from two-part models examining associations between Visit 1 cognitive outcomes and IADL sum score. Crude (dark gray, solid line) models control for age and sex. Adjusted (light gray, dashed line) models control for age, sex, Center for Epidemiologic Studies Depression (CESD-10), time from Visit 1 to Visit 2 (days), education, and Field Center. B-SEVLT: Brief Spanish English Verbal Learning Test; WF: Word Fluency; DSS: Digit Symbol Subtest; SIS: Six-Item Screener; IADL: Instrumental activities of daily living.

Ordered Logistic Margins
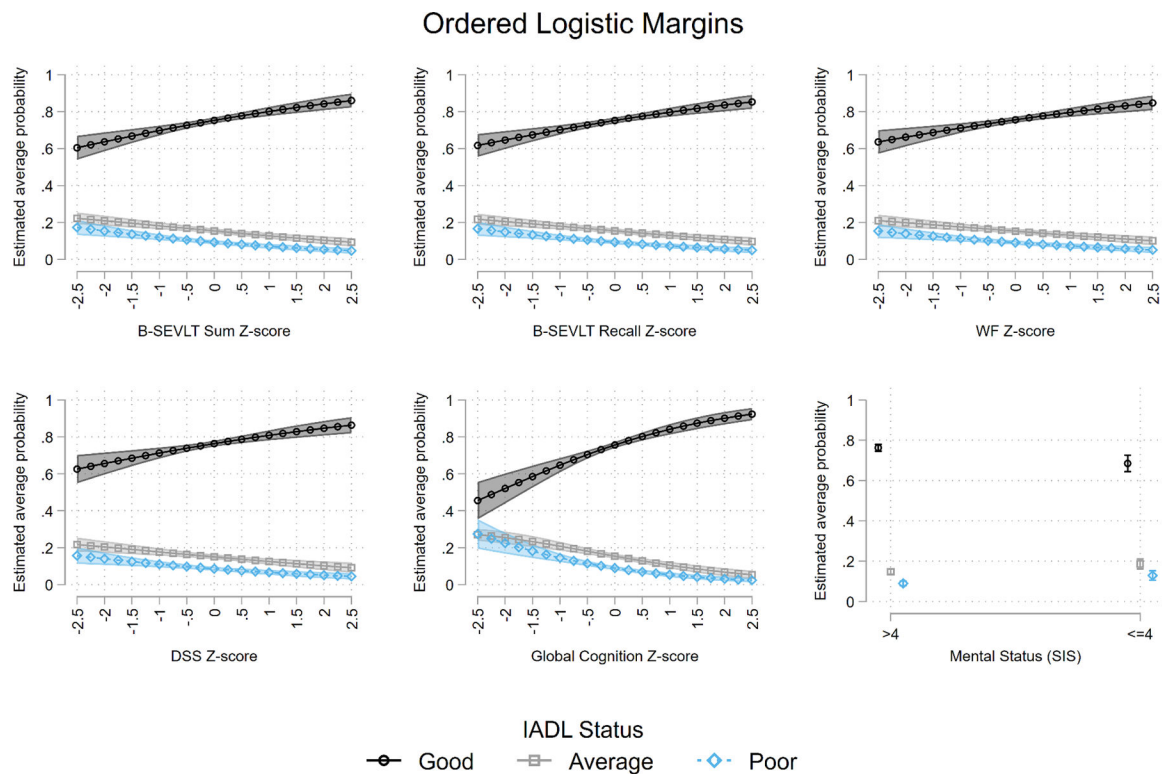
Figure 2.
Ordered logistic regression marginal estimates with 95% confidence intervals by level of IADL impairment. Levels of impairment were categorized as "Good"/ No IADL disabilities (black circles): IADL sum score = 0; "Average" (gray squares): IADL sum score = 1–2; and "Poor" (blue diamonds): IADL sum score > 2. Models adjusted for age, sex, Center for Epidemiologic Studies Depression (CESD-10), time from Visit 1 to Visit 2 (days), education, and Field Center. B-SEVLT: Brief Spanish English Verbal Learning Test; WF: Word Fluency; DSS: Digit Symbol Subtest; SIS: Six-Item Screener; IADL: Instrumental activities of daily living.

Age Interaction Margins

Figure 3.
Age modifications in the associations between Visit 1 cognitive outcomes and IADL sum score. Age groups were categorized as 50–59 years (black circles); 60–69 years (gray squares); and 70+ years (blue diamonds). Models adjusted for sex, Center for Epidemiologic Studies Depression (CESD-10), time from Visit 1 to Visit 2 (days), education, and Field Center. B-SEVLT: Brief Spanish English Verbal Learning Test; WF: Word Fluency; DSS: Digit Symbol Subtest; SIS: Six-Item Screener; IADL: Instrumental activities of daily living
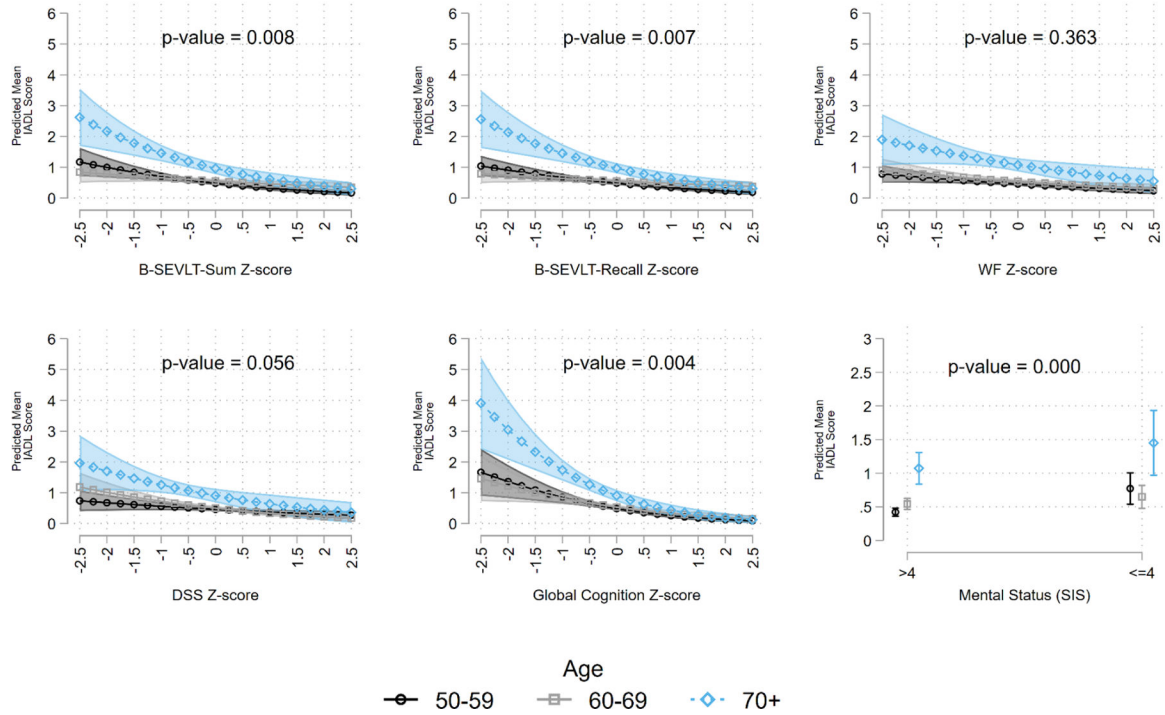
Table 1.

Characteristics of SOL-INCA Target Population (Unweighted n = 6,292) by Age.

	Ages 50–59	Ages 60–69	Ages 70+	Overall
Weighted %	38.70%	35.80%	25.50%	
	Mean (SD)			
Age at Visit 1 (years)	55.24 (2.55)	64.24 (3.09)	74.61 (2.66)	63.40 (8.15)
Time from Visit 1 to Visit 2 (days)	2507.20 (452.07)	2586.99 (446.96)	2590.88 (341.53)	2557.10 (426.27)
CESD-10 Depression Score	7.40 (6.59)	7.51 (6.89)	7.21 (4.86)	7.39 (6.28)
Sex	**%(SE)**			
Female	52.50 (1.29)	54.61 (1.44)	57.59 (1.97)	54.55 (0.85)
Education				
< High School	32.04 (1.46)	40.08 (1.51)	45.79 (2.20)	38.43 (1.07)
High School or equivalent	25.07 (1.25)	20.56 (1.13)	16.30 (1.57)	21.22 (0.76)
> High School	42.89 (1.58)	39.36 (1.41)	37.91 (2.30)	40.36 (1.01)
Center				
Bronx	27.80 (1.81)	27.03 (1.92)	25.59 (2.32)	26.96 (1.51)
Chicago	14.20 (1.04)	13.33 (1.12)	9.14 (1.07)	12.60 (0.86)
Miami	32.01 (2.56)	34.95 (2.62)	45.09 (3.18)	36.40 (2.31)
San Diego	25.98 (1.97)	24.69 (1.97)	20.18 (2.11)	24.04 (1.65)

Abbreviations:

CESD: Center for Epidemiologic Studies Depression; SD: standard deviation; SE: standard error

Table 2.

Two-part model results showing the associations between standardized cognitive outcomes at baseline and IADL sum score (0–14)

		IADL Sum	
		M1	M2
		exp(β)/ 95% CI	exp(β)/ 95% CI
B-SEVLT Sum			
Logit		0.63***[0.56;0.71]	0.75***[0.66;0.85]
GLM		0.82***[0.76;0.89]	0.86***[0.80;0.93]
B-SEVLT Recall			
Logit		0.65***[0.58;0.74]	0.76***[0.67;0.86]
GLM		0.86***[0.81;0.91]	0.88***[0.83;0.94]
WF			
Logit		0.67***[0.60;0.75]	0.78***[0.69;0.88]
GLM		0.90**[0.83;0.96]	0.94 [0.85;1.05]
DSS			
Logit		0.62***[0.55;0.71]	0.75***[0.65;0.87]
GLM		0.87***[0.81;0.94]	0.92 [0.82;1.04]
SIS			
Logit	>4 (Not impaired)	ref	ref
	4 (Impaired)	2.06***[1.64;2.59]	1.57***[1.24;1.99]
GLM	>4 (Not impaired)	ref	ref
	4 (Impaired)	1.11 [0.93;1.34]	1.06 [0.86;1.31]
Global Cognition			
Logit		0.45***[0.39;0.53]	0.57***[0.47;0.69]
GLM		0.77***[0.70;0.85]	0.81***[0.73;0.91]

Abbreviations and Notes:

IADL: Instrumental activities of daily living

B-SEVLT: Brief Spanish English Verbal Learning Test; WF: Word Fluency; DSS: Digit Symbol Subtest; SIS: Six-Item Screener

GLM: generalized linear model; β: beta coefficient estimate; CI: confidence interval

M1: Age, sex; M2: M1 + Center for Epidemiologic Studies Depression (CESD-10), time from Visit 1 to Visit 2 (days), education, and Field Center

For the logistic portion, the exponentiated beta coefficients are the odds ratios. The GLM portion is fit among participants with any evidence of IADL limitation (IADL sum score more than 0). For the GLM portion, an exponentiated beta coefficient value above 1.0 indicates higher severity of IADL limitations while a value below 1.0 indicated lower severity of IADL limitations.

*** = $p < 0.001$

Table 3.

Ordered Logistic Regression results with Proportional Odds Assumption test results

	Adjusted (OR/95% CI)
B-SEVLT Sum	0.74 *** [0.65;0.83]
B-SEVLT Recall	0.76 *** [0.67;0.85]
WF	0.78 *** [0.69;0.88]
DSS	0.75 *** [0.65;0.87]
SIS	
4+ (Not impaired)	ref
4 (Impaired)	1.54 *** [1.22;1.94]
Global Cognition	0.56 *** [0.47;0.67]

Abbreviations and notes:

B-SEVLT: Brief Spanish English Verbal Learning Test; WF: Word Fluency; DSS: Digit Symbol Subtest; SIS: Six-Item Screener

OR: odds ratios; CI: confidence interval

None of the associations violated the proportional odds assumption based on Wald Tests. Model was adjusted for age, sex, Center for Epidemiologic Studies Depression (CESD-10), time from Visit 1 to Visit 2 (days), education, and Field Center.

*** $= p < 0.001$

Table 4.

Age modifications in the associations between cognitive outcomes at baseline and IADL sum score

Age x Cognitive Outcome Interaction		SE	p-value
B-SEVLT Sum			
60–69 vs 50–59	0.09	0.06	0.142
70 vs 50–59	−0.24	0.11	0.026
Overall p-value			0.008
B-SEVLT Recall			
60–69 vs 50–59	0.08	0.06	0.129
70 vs 50–59	−0.25	0.11	0.018
Overall p-value			0.007
WF			
60–69 vs 50–59	−0.01	0.05	0.875
70 vs 50–59	−0.16	0.11	0.156
Overall p-value			0.363
DSS			
60–69 vs 50–59	−0.10	0.06	0.070
70 vs 50–59	−0.22	0.11	0.044
Overall p-value			0.056
Dichotomous SIS			
60–69 vs 50–59 and >4 (Not impaired)	0.12	0.05	0.011
60–69 vs 50–59 and 4 (Impaired)	−0.12	0.15	0.402
70 vs 50–59 and >4 (Not impaired)	0.65	0.12	0.000
70 vs 50–59 and 4 (Impaired)	0.68	0.27	0.012
Overall p-value			0.000
Global Cognition			
60–69 vs 50–59	0.05	0.08	0.528
70 vs 50–59	−0.36	0.12	0.004
Overall p-value			0.004

Abbreviations and notes:

IADL: Instrumental activities of daily living; B-SEVLT: Brief Spanish English Verbal Learning Test; WF: Word Fluency; DSS: Digit Symbol Subtest; SIS: Six-Item Screener

: contrast of estimated marginal slopes; SE: standard error

Model was adjusted for sex, Center for Epidemiologic Studies Depression (CESD-10), time from Visit 1 to Visit 2 (days), education, and Field Center.