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Associations Between Country where Education is Obtained and Cognitive Functioning Among South American and Caribbean Older Adults Living in the U.S

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Abstract

The increasing prevalence of AD among Hispanics calls for a need for examining factors that affect cognitive functioning and risk of AD among Hispanic older adults. The current study examined cognitive functioning among older Hispanic adults living in the U.S. from two Hispanic regions, South America and the Caribbean, in relation to the country where education was obtained. Participants (n = 139) were stratified into groups based on Hispanic education region and diagnostic categories: cognitively normal and amnestic MCI (aMCI). Results of Pearson correlations showed that among Hispanic Americans in general, there were significant positive correlations between the country of education to performance on measures of episodic, verbal, and word list tests. When examined separately by region and diagnosis, only cognitively normal (CN) South Americans showed significant relationships between country of education and cognitive functioning in these areas. Results of general linear models controlling for education identified differences in neuropsychological performance between groups with the CN groups demonstrating better performance than the aMCI groups within each region. Overall, it was evident that relationships between years of education obtained outside of the U.S. and cognitive functioning were not similar among individuals from these two disparate Spanish speaking regions. This

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The data that support the findings of this study are available from the corresponding author upon request.

is the first study to examine the country where education was obtained among individuals from countries located in different regions with different cultures that may influence their education and cognitive development throughout life. Findings contribute to the cross-cultural neuropsychological literature in understanding factors that are unique to Hispanic older adults at risk for developing AD.

Keywords

Education; Cross-cultural neuropsychology; Hispanic older adults; Alzheimer's disease; Mild Cognitive Impairment

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With the growing population of minority groups and the increasing prevalence of Alzheimer's disease (AD) among Hispanics (U.S.Census Bureau, 2017, Alzheimer's Association, 2021), there is a need for understanding factors that contribute to cognitive functioning among this population. Previously observed variability across cognitive domains may be due to the influence of different factors, such as demographics and other life experiences (Ardila et al., 2000; Rosselli & Ardila, 2003). Important factors include linguistic, ethnicity, education, migration, and linguistic backgrounds, amongst others (Nielsen & Waldemar, 2016; Mungas et al., 2005, Babulal, Quiroz, Albensi, Arenaza-Urguijo, Astel, Babilone et al., 2019). As a result, this has led to demonstrated differences amongst racial/ethnic groups when comparing cognitive test scores and affect the ability to accurately identify cognitive decline among Hispanic cohorts (Casaletto et al., 2015; Flores et al., 2017;).

There has been a growing body of literature examining cultural factors among Hispanic older adults that affect cognitive functioning and the risk of dementia. This is partly due to the fact that Hispanic elderly are one of the fastest-growing minority groups found in the U.S. (Berastein, 2005). An important variable that has not often been considered in previous studies are the patterns of migration, including especially, the country of origin and educational attainment in that country. These are potentially important factors to consider when studying and comparing the differences between Hispanic groups on different cognitive test scores. The Alzheimer's Association (2021) has identified a need for more targeted measurements among Hispanic populations. Many Hispanic individuals currently living in the U.S. are a product of various migration waves that have occurred throughout history. Therefore, these individuals may have received the majority of their education outside of the U.S., which may influence cognitive performance during the acculturation process and in older age.

Rates of cognitive decline are highly variable, even among individuals with similar levels of brain injury and pathology (Mungas et al., 2018, Babulal, Quiroz, Albensi, et al., 2019). One prominent hypothesis that provides a foundation for further understanding of cognitive decline is cognitive reserve. Cognitive reserve can be viewed as an active capacity to mitigate cognitive and dementia symptomatology despite prevailing brain pathology (Rodriguez et al., 2019; Stern, 2009; Parra, Butler, McGeown, Nichols & Robertson, 2019). High cognitive reserve is associated with one's resilience towards disease-related cognitive decline (Reed et al., 2010, 2011). Education and bilingualism have been regarded as protective factors against cognitive decline (Freedman et al., 2014; Gollan et al., 2011) by promoting cognitive reserve (Stern, 2009).

There is evidence that culture has observable effects on the brain and behavior (Park & Huang, 2010). Sustained exposure to cultural experiences has been shown to affect neural structure and function (Park & Huang, 2010). Han & Ma (2015) have proposed a model of brain development that integrates cultural environments into the contextualization of human behaviors and modification of the functional organization of the brain. They argue that cultural beliefs and behaviors are directly related to how the brain develops. Thus, culture including language and education influences many aspects of society.

Language is integrated into culture and has been shown to have significant associations with cognitive functioning. Previous studies have identified positive associations between bilingualism and cognition, with positive effects on brain structure and connectivity (Grady et al., 2015). Hispanic bilinguals have been shown to display advantages in executive functioning and control (Salvatierra & Rosselli, 2011). Other studies have shown evidence supporting better cognitive flexibility in tasks involving inhibition (Bialystok et al., 2008; Soveri et al., 2011), and in cross-sectional studies, bilinguals demonstrate better cognitive test scores than monolinguals (Bialystok et al., 2004, 2007; Kave et al., 2008; Rosselli et al., 2019).

Studies indicate that education may serve as a protective factor that may delay the onset of dementia (Sharp, 2011; Mortimer, 1988). Education has been previously identified as a significant modifiable risk factor according to the 2020 report of the Lancet Commission (2020) who has stated that modifying 12 risk factors may prevent or delay up to 40% of dementias. Therefore, studies examining how education level and quality play a role in developing pathognomonic symptoms of AD such as cognitive decline can assist in identifying how best to modify them and ultimately decrease risk. Lower levels of education are associated with lower cognitive reserve, such that relatively minor occurrence of brain pathology could result in an individual with low cognitive reserve crossing the threshold into a cognitively impaired state (Babulal, Quiroz, Albensi, et al., 2019; Parra, Butler, McGeown, Nichols & Robertson, 2019, Livingston et al., 2020). Education demands adequate mental stimulation necessary to promote neuronal growth, which is important when considering an individual's history in relation to the onset of their cognitive decline (Mortimer & Graves, 1993). The association between cognitive health and education has been frequently observed. Higher levels of education can positively influence an individual's cognitive functioning by delaying the onset of cognitive decline. (Bosma et al., 2003; Butler et al., 1996; Lyketsos et al., 1999) This often results in higher cognitive test scores in comparison to those with lower levels of education (Glymour et al., 2005; Karlamangla et al., 2009; Tucker-Drob et al., 2009; Zahodne et al., 2011; Wilson et al., 2009). Among ethnic groups, it has been shown that the birth year of a cohort can have differential effects on education. A study conducted by Vonk and colleagues (2019) demonstrated that later birth year is associated with a less rapid rate of decline among whites, blacks, and Hispanics, especially among cohorts with high socioeconomic status and high education levels.

Currently, there is a gap in the literature examining the association between performance in neuropsychological tests and the quality of education among Hispanic older adults who have obtained the majority of their education outside of the U.S. The quality of schooling could relate to acquired learning strategies and strengths in specific domains of cognition (Chin et al., 2012). Educational quality has been found to have a greater influence on certain aspects of neuropsychological test performance than age and may also delay the onset of identifiable cognitive deficits among those with brain diseases (Ardila, 2007; Schoenhofen-Sharp & Gatz, 2011, Babulal, Quiroz, Albensi, et al., 2019). The quality of education for many in some Spanish-speaking countries may be poor due to low socioeconomic status. It has been found that there exists an increase in modifiable risk factors in low and middle income countries, including low quality of education (Livingston et al., 2020). For example, in South America, 184million people (30.2% of the population) live in poverty (Economic Commission for Latin America and the Caribbean, 2019), In the USA, the percentage of people living in poverty is 12.3% (U.S.Census Bureau, 2019). Despite the linguistic and partial cultural commonality across Spanish-speaking countries, there is diversity in economic and educational levels (Ardila, 2020). Additionally, there are marked differences between the educational structure in the U.S. when compared to other countries. For example, Upper secondary education in Latin America is approximately the equivalent of high school in the United States, and in 2015, 33% of children in Latin America reached this educational level, and only about 50% graduated. In 2017, enrollment rates in higher education for the Caribbean and Central American students were around 30%, though higher levels of secondary education completion are leading to a growth in enrollment in higher education, especially in Brazil, Chile, Colombia, and Venezuela. While access to higher education is tightly tied to socioeconomic status, many Latin American public universities are now tuition-free (Fiszbein & Stanton, 2018). Therefore, it seems reasonable to explore whether the type and quality of education received in the native country influences cognitive test performance in Hispanic immigrants to the US.

In the current study, the relationship between education obtained outside of the U.S. and cognitive performance at baseline was investigated among older Hispanic individuals at risk of developing AD. Given that significant associations have been identified in the literature between the level of education and cognitive functioning in the elderly population (Contador et al., 2017), it was hypothesized that significant relationships would be found between years of education obtained outside of the U.S. and cognitive functioning. These relationships were examined and compared among two Spanish-speaking regions: South America and Caribbean countries. Differences in the relationships between cognitive functioning and country of education were expected between these two disparate regions.

Methods

De-identified data obtained from the 1Florida Alzheimer's Disease Research Center (1Florida ADRC), Clinical Core were analyzed. This research was approved by the Institutional Review Board at Mt. Sinai Medical Center, Miami Beach, FL. Participants included Hispanic Spanish speakers evaluated at baseline in their primary language.

Participants

Participants included 139 Hispanic individuals who were cognitively normal (CN, n = 58) or diagnosed with amnestic mild cognitive impairment (aMCI, n = 81). Hispanic Individuals were identified according to self-report. In order to examine possible differences in cognitive performance related to educational quality among participants from different regions of origin, these regions were divided into a Caribbean group (i.e., Cuba, Puerto Rico, and the Dominican Republic) and a South American group (i.e., Venezuela, Colombia, Ecuador, Argentina, Peru, and Chile). The rationale for these group-wise divisions was the assumption that within these two main regions, there are similarities in cultural and educational environments. Table 1 displays the demographic statistics for these two main regions, for CN and aMCI subjects, namely: 1) Caribbean CN (n = 28), Caribbean aMCI (n = 55), South American CN (n = 30), and South American aMCI (n = 26). Information on the participants' number of years of education obtained in the U.S. and outside of the U.S. was obtained based on self-report.

Diagnostic Procedures

Participants were part of the 1Florida Alzheimer's Disease Research Center (1Florida ADRC), a 5-year longitudinal study that began in 2015 at the Mount Sinai Medical Center in Miami Beach, Florida. The study was funded by NIA as one of over 30 Alzheimer's Disease Research Centers. The focus of the 1FloridaADRC was the study of older participants with normal cognition, MCI, and mild dementia, and those in the gap between CN and MCI - categorized as pre-MCI by some (Loewenstein et al., 2012). This cohort is unique due to its ethnic and cultural diversity, as over 50% identify as Hispanic and report Spanish as their primary language.

Participants in this study completed an extensive medical, neurological, psychiatric, and neuropsychological evaluation, including all the elements required by the National Alzheimer's Coordinating Center (NACC) Uniform Data Set, version 3.0 (Besser et al., 2018). The Clinical Dementia Rating Scale (CDR) (Morris, 1997) was administered by an experienced geriatric psychiatrist (MTG) who was fully bilingual, and was blinded to the neuropsychological test results. The CDR Sum of Boxes (CDR-SB) score was used as a global cognitive/functional measure since it has been shown to accurately stage the severity of AD in the spectrum from MCI to severe dementia (O'Bryant 2010). No interpreter was needed for clinical diagnosis due to clinician being able to speak Spanish fluently.

All of the 5 sub-criteria listed for aMCI consistent with Petersen's criteria had to be provided including (a) a memory complaint by the participant or reliable informant; (b) obtained a global CDR of 0.5; (c) had no significant functional deficits that interfere with independent activities of daily living; (d) does not meet DSM-V criteria for a Major Neurocognitive Disorder (dementia) and (e) the participant scored 1.5 SD or below expected limits on at least one memory subtests using appropriate norms. Similarly, CN individuals had to meet all of the specified criteria for non-impairment to acquire this designation.

Neuropsychological Testing

All participants were administered a comprehensive neuropsychological evaluation which included measures of memory, executive function, processing speed, and verbal fluency. All tests were administered in Spanish, their preferred language, by fully bilingual psychometricians. The battery of tests included Spanish versions of the following: letter verbal fluency (FAS; Controlled Oral Word Association Test; Benton et al., 1994), category fluency (C-Flu; Benton, 1968), Hopkins Verbal Learning Test delayed (HVLT-II; Brandt 1991), Logical Memory delayed (LM-II) from the Wechsler Memory Scale, 3rd edition (WMS-III; Wechsler, 1997), the Trail Making Test-Part A and B (TMT-A and TMT-B; Corrigan & Hinkeldey, 1987; Reitan, 1958; Reitan & Wolfson, 1993), the Stroop color and word test (Trenerry et al., 1989), and the Mini-Mental State Examination (MMSE; Folstein, 1975). The MMSE is a commonly used cognitive screener which assesses five cognitive domains including attention, orientation, memory, language, and visual-spatial skills. Orientation is assessed by asking the patient questions about person, time, and place (i.e. what is today's date?, What city are we in?). Attention and memory are assessed by asking the patient to repeat the names of objects and remember them later. Language is assessed by tasks such as repeating and writing a sentence. Visual-spatial skills are assessed by asking the participant to copy an abstract design. All tests provided to the participants were validated Spanish versions of the test. For verbal fluency, participants were asked to provide Spanish words. The Spanish version of the Stroop color and word test were administered. Appropriate age, and education norms were utilized (Arango-Lasprilla, Rivera, Garza, et al., 2015; Arango-Lasprilla, Rivera, Aguayo, et al., 2015; Ardila et al., 1994; Benton et al., 2014; Golden 1999; Ostrosky-Solis et al., 2000; Pena-Casanova, Quinones-Ubeda, et al., 2009).

A diagnosis was determined by considering established diagnostic criteria (Petersen, 2004) and scores on the Clinical Dementia Rating (CDR; citation) sum of boxes. CN participants had no reported cognitive or functional decline after a comprehensive interview with the participant and a collateral informant and obtained a Clinical Dementia Rating (CDR) global score of 0). Further, there was no memory impairment (< 1.0 SD) below expected levels, based on age and education adjusted normative data for each cultural/language group, on the Hopkins Verbal Learning Test (HVLT-R, Brandt 1991) delayed recall or on the delayed paragraph recall of the National Alzheimer's Coordinating Center (NACC) delayed story passages.

Criteria for aMCI was determined using Petersen's guidelines (2004) and included (a) memory complaints, preferably confirmed by an informant, (b) a CDR score of 0.5, (c) no impairment in social and/or occupational functioning; (d) no evidence of DSM-5 criteria (American Psychiatric Association, 2013) for major neurocognitive disorder; (e) confirmation of memory impairment at 1.5 SD or greater, below expected levels, based on age and education adjusted normative data for each cultural/language group, on the Hopkins Verbal Learning Test (HVLT-R, Brandt 1991) delayed recall or on the delayed paragraph recall of NACC's delayed story passage.

Statistical Analysis

All data were analyzed using SPSS (version 26; IBM Corp, year). Partial correlations controlling for age, sex, and, education were conducted for each group, to examine relationships between years of education obtained in and outside of the U.S. to neuropsychological performance. A series of four One-Way Analyses of Variance (ANOVAs) were conducted to compare demographic information between the four cultural/ diagnostic groups with post hoc analyses using Tukey's post hoc tests of means. A multiple general linear model with education, age, and sex as covariates was conducted to compare neuropsychological test scores between the groups. Posthoc tests of means were conducted using Sidak's multiple comparisons test. For multiple correlation coefficients, and the increased probability of family-wise Type 1 errors Benjamini and Hochberg correction for multiple comparisons were applied (Hochberg, 1995). We only considered corrected p-values of $p < .05$ corrected for false discovery rate (FDR) using this method. Chi-Square analyses were conducted to compare differences in sex among the groups. All alpha levels for corrected and non-adjusted comparisons were set at $p < .05$.

Results

Chi-square analysis revealed no significant differences in age and sex between groups (Table 1). The results of one-way ANOVAs are displayed in Table 1. With regard to demographic factors, there were no observed significant differences between the four groups for age or years of education obtained in and outside of the U.S. Significant differences were found for years of education [F (3, 148) = 3.595, $p < .05$], with the Caribbean CN group having higher mean years of education (M = 16.32) than the Caribbean MCI group (M = 14.03; $p = .020$). Therefore, years of education was used as a covariate in subsequent general linear models comparing neuropsychological performance among the groups.

The results of partial correlations controlling for age and education among the entire CN sample (both Caribbean and South American combined) revealed significant positive relationships between the years of education obtained outside of the U.S. and performance on Category Fluency [r (35) = 0.335, $p = .043$]. Among the entire MCI sample, a significant negative relationship was identified between years of education obtained in the U.S. and performance on LM-II delayed [r (52) = −0.357, $p = .008$], and a positive relationship between education obtained outside of the U.S. and LM-II[r (52) = 0.308, $p = .023$]. Results of partial correlations by country and diagnostic groups are displayed in Table 2. After applying Benjamin and Hochberg correction for multiple comparisons, only the CN South American group showed significant associations between level and education and performance on LM-II [r(21) = 0.483, $p < .05$] HVLT delayed [r(21) = 0.550, $p < .05$], and FAS [r (21) = 0.607, $p < .05$]. The other three groups showed non-significant associations after the correction for multiple comparisons.

Table 3 summarizes general linear model results. Significant differences between groups were found for the neuropsychological measures [F(3,134) = 3.171, $p < .001$]. Group differences were found for total MMSE scores [F(3,134) = 5.953, $p < .01$], Logical Memory Delayed [F(3,134) = 5.754, $p < .01$], Hopkins Verbal Learning Test delayed [F(3,134) = 18.271, $p < .001$], Trail Making Test B [F(3,134) = 5.464, $p < .01$], Stroop Color and Word

Test [$F(3,134) = 5.229$, $p < .01$], FAS total [$F(3,134) = 3.742$, $p < .05$] and Category Fluency [$F(3,134) = 8.365$, $p < .001$].

Tukey's HSD post hoc analysis revealed that the Caribbean CN and South American CN groups performed better than the Caribbean MCI and South American MCI groups ($p < .05$) on the MMSE, LM-II, HVLT-II, TMT-B, and the Stroop Color and Word Test. Groups performed similarly on the TMT-A. Comparisons conducted for individual neuropsychological tests by diagnostic group and region of origin revealed that there were significant differences for (1) performance on the FAS verbal fluency test, in which the South American CN group performed significantly better than the Caribbean MCI group ($p < .05$), and (2) for performance on Category Fluency test, in which the South American CN group performed better than the Caribbean MCI and the South American MCI group ($p < .001$). Within the Hispanic groups, no significant differences were found within the same diagnostic categories.

Discussion

Our findings revealed that among Hispanic Americans in general, there are significant positive associations between the number of years of education obtained outside of the U.S. and performance on cognitive tests, specifically for performance on category verbal fluency and delayed episodic memory. It should be noted that these measures are both heavily influenced by language, and in our sample, they were administered in Spanish. We compared relationships between these variables among Caribbeans and South Americans separately. Overall, it was evident that relationships between years of education obtained outside of the U.S. and cognitive functioning were not similar among individuals from these two disparate Spanish-speaking regions. These associations were present among cognitively normal South Americans, but not Caribbean participants. Greater number of years of education obtained outside of the U.S. among Hispanic American participants was associated with better performance on measures of delayed episodic and word list memory, and verbal fluency. These measures are heavily influenced by language. While Spanish has been characterized as a unified language, in fact, its usage is spread widely across countries and continents with diverse subcultures groups (Ardila, 2020). Researchers have noted differences in neurocognitive screening outcomes and have sought to generate country-specific normative data. Validation studies of the Logical Memory Delayed and Hopkins Verbal Learning Test delayed (Arango-Lasprilla et al., 2015), semantic and letter category verbal fluency (Olabarrieta-Landa et al., 2015; Diego Rivera et al., 2019), Trail Making Tests (A&B), and Stroop Color and Word Interference Test (Rivera et al., 2015) have produced normative data with differing influences of age, sex, and education. Olabarrieta-Landa and colleagues (2015) found that education explained eight (Cuba) to 32% (Chile) of the variance in the S letter category fluency, and 16% (Cuba) to 43% (Paraguay) of the variance in the animal category test. They attributed this variance to differences in the level of education across the countries.

Buré-Reyes et al. (2013) examined neuropsychological test differences within Spanish-speaking subpopulations in Chile, Puerto Rico, Dominican Republic, and Spain. The findings identified differences in delayed recall and category fluency (phonetic) outcomes.

Compared to Puerto Rican, Dominican, and Spanish subgroups, the Chilean sample produced the lowest mean scores in both cognitive domains. No statistically significant differences were found with Trail Making tests (A&B), Stroop, and Rey–Osterrieth Complex Figure Test. Similarly, Buré-Reyes et al. (2013) reported that although samples were matched based on demographics, including years of education, that differing educational practices or the quality of education may have influenced results. In the current study, a positive correlation was observed between educational attainment and cognitive performance among South American participants as a group. Given that Chile represents only one country in South America, no conclusions about regional differences are within South America are possible, with regards to the findings documented in Chile by Buré-Reyes et al. (2013).

As would be expected, our findings revealed that Caribbean and South American individuals who are cognitively normal performed better than MCI groups on measures of cognitive performance, including global cognitive functioning, delayed episodic, word list memory, and executive functioning. Similar performances were identified across all four groups on measures of processing speed. This suggests that processing speed is relatively preserved among Hispanic older adults at risk for developing dementia and may not be affected by cultural factors. While the South American CN group performed significantly better than the South American MCI group on measures of verbal fluency, the Caribbean CN and MCI groups performed similarly, perhaps indicating verbal fluency performance in the Caribbean groups is not sensitive to detecting the differences between CN and MCI groups.

Normative data for Spanish-speaking older adults outside of the U.S. is limited, but both education and age predicted outcomes in Rivera et al.'s (2009) 11 country analysis, which includes countries located in both the Caribbean and South America. Younger and better-educated participants scored higher than those who were older and less educated. Among monolingual Spanish-speaking older adults, Ostrosky-Solis et al. (2007) found small education effects on 10 neurological measures among children, adolescents, and adults up to age 56, but significant effects on cognitive scores related to the level of education after this age.

Addressing differences in quality of education and their effects on cognitive decline among Hispanic individuals has been identified as a significant gap in the cross-cultural literature. It is important to note that various factors within each Spanish-speaking country can contribute towards quality of education such as location, socioeconomic status, and culturally mediated attitudes toward academic achievement. Previous studies conducted have examined geographic and situational factors within the U.S. utilizing available resources such as Census Bureau data and have identified factors such as whether older adult participants were born in Southern versus Northern regions and the effects of school segregation on cognitive functioning (Lamar et al., 2020). This type of data is not as easily accessible from Spanish-speaking countries such as countries in Latin and South America. The current study was the first step towards identifying that the relationship between quality of education from these counties and cognitive functioning in old age exist, and future studies should investigate effective ways of identifying differences in quality of education within each Spanish speaking country.

Our study was the first to examine cognitive functioning among older U.S. immigrants from Spanish speaking countries, and one of a few that have examined the effect of being from a Carribbean versus a South America country. We have demonstrated that there exist differences in factors that contribute to cognitive functioning among countries from different regions/areas. The culture among the Caribbean and South American countries are characteristic of different values, behaviors, and environments, which presumably affect brain development throughout the lifespan. These factors more than likely shape and heavily influence the education system in these countries. In addition, the provision of compulsory education, completion of primary and secondary education, and tuition-free higher education influence academic access. For example, while primary education is compulsory in most South American and Caribbean countries, and 93% of children obtain this level of education, there are some counties in the Caribbean, as well as South American countries, such as Bolivia and Paraguay, where enrollment in primary education is below 90%. A 2018 report found that the drop-out rate from primary school was 20% in El Salvador, Guatemala, Honduras, and the Dominican Republic, while this rate was around 50% in Nicaragua. There are several documented factors leading to the decision to unenroll, such as a need to contribute income to the family, violence at or on the way to school, low expectations for education, and repeating grades and aging out. While secondary school rates were below 50% in 2015 for children in Guatemala, Honduras, and Nicaragua, tremendous regional gains were reported between 2000 and 2015 when secondary school enrollment was reportedly below 50% in the DomMorris,inican Republic, Ecuador, El Salvador, Guatemala, Nicaragua, and Paraguay. In 2015, enrollment rates in secondary school in Antigua and Barbuda, Argentina, Barbados, Brazil, Chile, Cuba, Dominica, Ecuador, Grenada, Guyana, St. Kitts and Nevis, and St. Vincent and the Grenadines exceeded 80% (Fiszbein & Stanton, 2018).

To our knowledge, only one other study has examined the effects of country of education on cognitive functioning among older adults. Mungas and colleagues (2018) examined bilingualism and the country where education was obtained and their cognitive trajectories. Significant results were reported at baseline, but not longitudinally. The cognitive measures they included were the modified Mini Mental Status Examination (MMSE) and a verbal learning test. Our study included a comprehensive battery of tests to examine associations across several areas of cognitive functioning. In their study, Mungas and colleagues examined country of education categorically based on when participants migrated to the U.S., whereas our study examined years of education obtained outside of the U.S. as a continuous variable. This allows for the examination of the effects of the quantity of education obtained outside of the U.S. on cognitive functioning. Moreover, in Mungas' study, the country of origin for all their participants was Mexico. In contrast, participants in the current study migrated to the US from two different regions, thereby allowing the examination of differences in cognitive functioning among individuals from culturally diverse backgrounds.

There are some limitations to the current study. One limitation is that our analyses were based on self-identified ethnicity based on self-report instead of an objective method. Secondly, our sample included variability with regards to age of immigration to the U.S., and this was a factor that was not controlled for in our results. SES and social determinants of health were not assessed in the current study and should be incorporated in future studies. The current study confirmed that the country where education was obtained has an effect on cognitive functioning in old age, but future studies should directly measure quality of education within these countries. Future studies should also examine other covariates that may influence cognitive functioning such as health comorbidities, medication, and mood disorders. Overall, there needs to be a global effort towards conducting strategies to increase participation of Hispanics in research and in understanding how cultural factors affect cognitive functioning among this cohort. Currently there are organization such as the Latin America and Caribbean Consortium on Dementia (LAC-AD) and the Global Dementia Prevention Program (GloDePP) who have gathered to create strategies to address this need in regards to management and treatment of Hispanic aging populations (Parra, Butler, McGeown, Nichols & Robertson, 2019). More work towards modifying risk factors can be accomplished by implementing programs in low income and middle income countries that can enrich educational quality and provide all children with primary and secondary education (Livingston et al., 2020).

Strengths of the current study include a well worked-up diagnostic groups from Caribbean versus South American countries, a thorough analyses of demographic factors and focus on the amount of education obtained outside of the United States. We also employed statistical correction procedures that adjusted for the number of group comparisons which can produce spurious errors of inference (family- wise Type 1 error rates). A weakness of the study is that there was not a sufficient number of participants to examine specific countries within each region of origin. Additionally, we did not take into account socioeconomical variations across countries.

The results of the current study highlight the importance of understanding the effect of the educational environment on cognitive functioning and of identifying factors that can protect against cognitive deficits that are characteristic of AD (i.e. cognitive reserve). Future studies should examine these associations in larger sample sizes, using additional measures, such as the quality of education in various countries and regions. Moreover, the effect of social-economic status on education should be examined, especially the differences between the public and private school systems in Spanish speaking countries. Future studies should also utilize biomarkers to better understand how the integration of culture and education affects brain and cognitive development, as well as decline in older age.

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Table 1.

Descriptive statistics and group comparison by diagnosis (control normal [CN} and Mild Cognitive Impirament (MCI) and country of origin (Caribbean and South American)

	Caribbean CN (n =28)		Caribbean aMCI (n =47)		S.A.CN(n = 30)		S.A. aMCI(n = 26)		Statistic	p-value
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	F	
Age	71.89	5.043	72.19	9.19	69.88	6.93	74.29	6.88	1.44	0.234
Education (total)	16.29^{ac}	2.57	13.85^{bc}	3.24	15.96^{ac}	3.84	14.79^{ac}	4.47	3.61	0.015
Education U.S.	7.04	5.93	5.06	5.92	3.88	6.08	4.54	5.75	1.43	0.238
Education Outside U.S	8.79	5.30	8.90	5.44	12.24	4.74	10.25	6.46	2.43	0.068
Sex	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	X^2	
									4.84	0.184
Male	7	25%	19	40%	7	26.9%	12	50%		
Female	21	75%	28	60%	19	73.1%	12	50%		

Note: S.A.: South American; CN: Cognitively Normal; aMCI: amnestic mild cognitive impairment; Means with different alphabetic superscripts are statistically significant using the Tukey's post-hoc test of means at $p \leq .05$

Table 2

Partial Correlations controlling for age and education among cultural clinical groups

CN Caribbean (n = 25)			**MCI Caribbean (n = 41)**	
US Edu	US Edu	Non-US Edu	US Edu	Non-US Edu
	-		-	
Non-US edu	−0.961*	-	−0.937*	-
LM II	0.039	0.025	**−0.325***	**0.354***
HVLT II	−0.022	0.025	−0.030	0.074
TMT-A	−0.361	0.378	−0.212	−0.183
TMT-B	0.208	0.092	**−0.336***	0.343
Stroop	0.226	−0.137	−0.124	0.180
FAS	0.328	−0.306	−0.062	0.121
Cat Flu	−0.113	0.203	0.099	−0.038
CN S.A. (n = 25)		MCI S.A. (n = 22)		
US Edu	US Edu	Non-US Edu	US Edu	Non-US Edu
	-		-	
Non-US edu	−0.809*	-	−0.930*	-
LM II	−0.253	**0.443***	−0.186	0.099
HVLT II	−0.281	**0.496***	0.011	−0.084
TMT-A	−0.018	0.224	−0.388	**0.581***
TMT-B	−0.080	−0.172	0.046	−0.040
Stroop	−0.228	0.360	−0.270	0.244
FAS	**−0.493***	**0.628***	−0.123	0.021
Cat Flu	0.033	0.210	−0.402	0.343

Note: LMII: Logical memory delayed, HVLT-II: Hopkins verbal learning test delayed, TMT A: Trail Making Test A; TMT B: Trail Making Test B, Stroop: Stroop color word test, FAS: verbal fluency, Cat Flu: Category Fluency

Table 3

Generalized linear model comparing neuropsychological performance with age, education, and sex as covariates

	Caribbean CN (n = 25)		Caribbean MCI (n = 43)		CN S.A. (n = 26)		MCI S.A. (n = 22)		Type III Sum of Squares	F-value	p-value
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*			
MMSE	29.40 [a]	0.76	27.70[b]	1.68	28.54 [a]	1.86	27.41 [b]	2.54	44.32	4.98	0.003
LM-II	11.76[a]	4.15	7.49[b]	3.39	10.92[a]	3.75	8.82[b]	5.37	297.69	5.95	< 0.001
HVLT- II	6.92 [a]	3.42	1.88 [b]	3.21	6.54 [a]	3.57	1.95 [b]	2.57	457.40	14.90	< 0.001
TMT A	38.84 [a]	14.23	50.86 [a]	28.97	43.33 [a]	17.33	56.91[a]	28.97	2396.78	1.92	0.130
TMT B	86.76 [a]	28.17	155.88[b]	87.56	109.57[a]	73.15	166.86[b]	96.31	56362.23	4.28	0.007
Stroop	37.36 [a]	7.75	29.26 [b]	11.17	34.88 [a]	9.13	26.95 [b]	9.05	955.67	4.03	0.009
FAS	36.96[a]	9.13	29.26[a]	10.54	37.65[a]	10.93	30.64[a]	12.21	823.32	2.57	0.058
Category Flu	43.40[ab]	7.37	36.26[a]	9.19	46.31[b]	9.39	37.27[a]	7.85	1243.07	5.99	< 0.001

Note: LMII: Logical memory delayed, HVLT-II: Hopkins verbal learning test delayed, TMT A: Trail Making Test A; TMT B: Trail Making Test B, Stroop: Stroop color word test, FAS: verbal fluency, Cat Flu: Category Fluency

[*] p < .05 after correcting for multiple comparisons via Benhamini and Hochberg method