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Cognition and Context: Rural–Urban Differences in Cognitive Aging Among Older Mexican Adults

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Abstract

Objective—To describe differences in cognitive functioning across rural and urban areas among older Mexican adults.

Method—We include respondents aged 50+ in the 2012 Mexican Health and Aging Study (MHAS). Cognitive functioning by domain is regressed as a function of community size. The role of educational attainment in explaining rural/urban differences in cognitive functioning is examined.

Results—Respondents residing in more rural areas performed worse across five cognitive domains. The majority, but not all, of the association between community size and cognitive functioning was explained by lower education in rural areas.

Discussion—Respondents residing in more rural areas were disadvantaged in terms of cognitive functioning compared with those residing in more urban areas. Poorer cognitive functioning in late life may be the result of historical educational disadvantage in rural areas or selection through migration from rural to urban regions for employment.

Keywords

Mexico; cognitive function; education; rural; MHAS

Background

With the rapid aging of the Mexican population, researchers have become increasingly interested in cognitive functioning in Mexico. Previous researchers have estimated the prevalence of dementia and cognitive impairment with no dementia (CIND) among older

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Authors' Note
The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. Data files and documentation are available for public use at www.MHASweb.org.

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Mexican adults to be 6.1% and 28.7%, respectively (Mejia-Arango & Gutierrez, 2011). Understanding the patterns and risk factors for cognitive impairment is of great importance as cognitive impairment may affect an individual's quality of life and ability to live independently, and may place considerable demands on family, caregivers, and the government (Langa et al., 2001). While cognitive research in Mexico has been increasing in recent years, Mexico is geographically diverse, with rural areas and one of the most populated urban areas in the world in Mexico City. Despite the urbanization of Mexico, as of 2010, approximately 23% of the general population and 24% of the population aged 50+ lived in communities with fewer than 2,500 residents. However, the percentage of the population inhabiting these communities increases to 29% for the population aged 80+ (Instituto Nacional de Estadística y Geografía [INEGI], 2010). Older adults living in rural areas of Mexico may differ from their urban dwelling counterparts in many ways including fewer educational opportunities and lower educational attainment (Wong & Palloni, 2009), less access to health care (Salinas, Al Snih, Markides, Ray, & Angel, 2010), less utilization of preventive care (Wong & Díaz, 2007), less exposure to air pollution (Secretaría de Medio Ambiente y Recursos Naturales, 2014), and fewer employment opportunities (Sanchez & Pacheco, 2012).

With such differences across rural and urban areas in Mexico, it is surprising that relatively few studies have explored disparities in cognitive functioning across rural/urban context considering rural Mexicans are disadvantaged in many markers of socioeconomic position throughout the life-course (Scott, 2010). At an international level, several studies have noted disproportionally higher levels of cognitive pathology in rural areas. For instance, older adults in rural areas of China demonstrated a higher prevalence of dementia when compared with their urban dwelling counterparts (Jia et al., 2014). In addition, research from Portugal has also reported a higher prevalence of cognitive impairment in rural populations compared with urban populations (Nunes et al., 2010). Furthermore, data from Mexico have suggested a higher incidence of dementia in a rural site (Morelos and Hidalgo) compared with an urban site (Mexico City) (Prince et al., 2012). However, research examining rural/urban differences in Alzheimer's disease and vascular dementia in developing countries has been inconsistent (Kalaria et al., 2008).

There are several reasons to believe that older Mexicans in rural areas may be disadvantaged in terms of cognitive functioning. First, educational attainment has demonstrated a robust relationship with cognitive function across many studies (Fors, Lennartsson, & Lundberg, 2009; Jefferson et al., 2011; Lee, Kawachi, Berkman, & Grodstein, 2003; Singh-Manoux, Richards, & Marmot, 2005). While educational attainment has increased steadily throughout the previous century in Mexico, educational opportunities and quality of education in rural areas have consistently lagged behind urban areas (Wong & Palloni, 2009). To the extent that educational attainment may protect against and/or delay cognitive impairment, rural areas may have a higher prevalence of cognitive impairment due to lower levels of education relative to urban areas throughout the life-course. This idea has found support in international research in which the higher prevalence of dementia and Alzheimer's disease among rural Chinese residents was largely explained by differences in educational attainment (Jia et al., 2014).

Second, Mexican adults in rural areas may be limited to less cognitively demanding occupations such as agricultural jobs, which may lead to poorer cognitive functioning. Previous research suggests that employment in complex, cognitively stimulating occupations may help preserve cognitive function throughout working years and into later life (Andel, Kåreholt, Parker, Thorslund, & Gatz, 2007). Third, health care facilities in rural Mexican areas are often scarce, undersupplied, and understaffed (Salinas et al., 2010), and older Mexicans in rural areas are less likely to be covered by health insurance (Wong & Palloni, 2009). For this reason, rural residents may be less likely to receive screening and diagnoses for chronic conditions and may patronize medical facilities that are ill-equipped to prevent, treat, or manage these chronic conditions. Certain chronic conditions including hypertension (Papademetriou, 2005) and diabetes (Deckers et al., 2015) have shown associations with poorer cognitive function, and failure to prevent, detect, or manage these conditions may be detrimental for cognitive health among older Mexican adults. Furthermore, of the general Mexican population in the year 2000, nearly 5 million could be considered to be isolated from roads and means of transportation to large urban areas and their health facilities (Hernández, 2004).

Alternatively, certain characteristics and attributes of urban environments may be detrimental for cognitive functioning. First, urban residents of all ages are likely to be exposed to environmental outdoor air pollution to a greater extent than rural dwellers. Exposure to heavy air pollution has been negatively associated with brain health (Calderón-Garcidueñas et al., 2011) and cognitive function (Ranft, Schikowski, Sugiri, Krutmann, & Krämer, 2009). Residents in urban areas of Mexico may be exposed to air pollution throughout the life-course, which may manifest in poorer cognitive function in old age. Second, urban environments may be psychologically and socially demanding (Lederbogen et al., 2011) with many stressors including crowding and noise (Krupat, 1985). While mild and acute stress may facilitate cognitive function, chronic stressors in urban environments experienced throughout the life-course may negatively affect cognitive function in old age (Sandi, 2013). Third, negative health behaviors throughout the life-course including smoking (Smith & Goldman, 2007), sedentary lifestyles, and consumption of calorie rich foods (Uauy, Albala, & Kain, 2001) may be more prevalent in urban areas. In this way, urban dwellers may be more likely to develop noncommunicable diseases with cognitive consequences whereas rural dwellers may be at a higher risk for these conditions to go undetected or poorly managed.

Older Mexican adults living in rural and urban areas may differ significantly in their exposure to factors that may be beneficial (access to education, health care, and employment opportunities) or detrimental (long-term exposure to air pollution) for cognitive functioning throughout the life-course. Despite these differences, heterogeneity in cognitive function by domain according to rural/urban area has not been explored using representative samples of the older Mexican population. Thus, our first aim is to address this gap by documenting differentials in cognition across five cognitive domains across rural and urban areas of Mexico. Second, we seek to identify factors that help to explain potential differences in cognition across rural/urban contexts, using educational attainment, chronic conditions, and health insurance coverage. Given the educational disadvantages in rural areas and the strong association between education and cognitive functioning, we hypothesize that older Mexican adults in rural areas will have lower cognitive functioning, and that much of this association will be explained by lower educational achievement in rural areas. These questions are of great importance given the aging and urbanization processes in Mexico. The rapid expansion of the older Mexican population (Wong & Palloni, 2009) has made cognitive impairment among the elderly a major public health concern with the potential for large social and economic costs (Langa et al., 2001). Furthermore, understanding the patterns of cognitive functioning across rural and urban areas is important due to rural to urban population shifts in Mexico (Garza, 1999). The results of this analysis may help identify populations at risk for cognitive impairment in Mexico.

Method

Data for this analysis come from Wave 3 (2012) of the Mexican Health and Aging Study (MHAS; 2012). The MHAS is a large, longitudinal, nationally representative study of older Mexican adults (age 50+) and their spouses regardless of age. We restrict our sample to those who were age 50+ in 2012. Although others have considered only those age 60 and above to be “older adults,” we include those age 50 and above to get a more complete profile of cognition in the aged Mexican population. The MHAS is particularly suited for this study because it is representative of the Mexican population residing in both rural and urban areas. Wave 1 of the MHAS was collected in 2001, and follow-up interviews have been conducted in 2003, 2012, and 2015. The MHAS collects data across a variety of domains including demographics, physical and mental health, cognitive function, household characteristics, and economics. The MHAS is partly sponsored by the National Institutes of Health/National Institute on Aging (Grant NIH R01AG018016). Data files and documentation are available for public use at www.MHASweb.org.

Independent Variables

Rurality is categorized into four levels based on community size of residence. Communities are categorized as (a) 100,000+ residents, (b) between 15,000 and 99,999 residents, (c) between 2,500 and 14,999 residents, and (d) fewer than 2,500 residents. The cut points for community size are based on the standard values used by the Mexican statistical bureau (INEGI) and are the most detailed measure of rurality available in the MHAS public data. These categories have been used in previous research evaluating rural/urban differences in the MHAS (Salinas et al., 2010). Given the lower levels of educational attainment in rural areas and the well-established association between educational attainment and cognitive function, we treat the most urban areas (community size 100,000+) as the reference group. In the 2012 MHAS, of the 15,723 study participants, 9,123 (58%), 1,741 (11%), 1,738 (11%), and 3,121 (20%) resided in Categories 1 to 4, respectively.

Basic demographic covariates in the analysis included age, sex, and years of formal education. Education is included given its strong association with cognitive functioning. We also include a binary variable indicating whether the respondent has any health insurance as health insurance and health care vary by rural and urban context (Wong & Palloni, 2009). Household wealth is included as a measure of financial well-being in late life. We also include a count of chronic conditions to capture the respondent’s health status. Chronic conditions included self-reported hypertension, diabetes, cancer, pulmonary conditions, heart attack, and stroke. Financial well-being in late life is assessed using household wealth which is calculated as the sum of the value of all assets including real estate, businesses, money in stocks and accounts, and vehicles. Missing information on household wealth was imputed by the MHAS (Wong, Orozco-Rocha, Zhang, Michaels-Obregon, & Gonzalez-Gonzalez, 2016). Due to the highly skewed distribution of household wealth, we categorize wealth into quartiles with the first quartile reporting the lowest level of wealth and the fourth quartile reporting the highest level of wealth.

Cognitive Functioning

We assess cognitive function across five domains including verbal learning, verbal memory, verbal fluency, orientation, and attention using the Cross Cultural Cognitive Examination (CCCE; Glosser et al., 1993; Mejía-Arango, Wong, & Michaels-Obregón, 2015). The CCCE is especially useful in samples with low education and limited literacy or mathematical ability (Wolfe et al., 1992). While we evaluate cognitive functioning as a continuous variable, the CCCE has demonstrated high sensitivity and specificity for detecting dementia in the United States and Guam (Glosser et al., 1993), and in a sample of 173 participants from a memory clinic in Mexico City (Mejia-Arango & Gutierrez, 2011). Verbal learning is measured by having respondents immediately recall a list of eight words. Respondents are asked to recall the word list a total of three times and the average number of words recalled across the trials is calculated (score 0–8 points). Verbal memory is measured by having respondents recall the eight-word list after a delay (score 0–8 points). Verbal fluency is measured by having respondents name as many animals as he or she can in 1 minute (0–60 points). Orientation is measured by asking respondents to correctly recall the current day, month, and year (0–3 points). Attention is measured by having respondents identify a stimulus in a visual array of different stimuli in 1 minute (0–60 points). As the range of scales differs by cognitive domain, we standardize each domain score.

While the 2012 Wave of the MHAS begins with 15,723 respondents, the sample size for our models range from 12,099 to 13,086 due to proxy interviews, age-ineligible respondents, and missing data (the sample size differs as respondents may be missing in one cognitive domain but not others). Because the cognitive domain of attention had the largest amount of missing data, we explain our analytic sample size calculation for this domain. Starting with 15,723, we omit 851 age-ineligible participants (age <50), 1,235 proxy interviews, 220 respondents missing data on covariates, and 1,318 respondents with missing data on the attention domain (attention excluded 510 respondents who could not perform the task for vision reasons and 301 who could not or refused to hold a pen; these conditions were not required for other cognitive domains) resulting in a final sample size of $n = 12{,}099$. Sensitivity analyses (described below) were conducted for the missing data.

Statistical Method

We model each cognitive domain separately using ordinary least squares (OLS) regression as each domain may represent a particular aspect of the cognitive profile of older adults (McArdle, Ferrer-Caja, Hamagami, & Woodcock, 2002). Furthermore, by testing the rural/urban gradients across domains, we can be more confident that the factors contributing to rural/urban gradients in cognition affect cognitive functioning broadly and not only in specific domains and tasks. In the first model, we regress each cognitive domain as a function of age, sex, and community size. In the second model, we add years of education to determine whether the rural/urban differences observed in Model 1 are attenuated once educational attainment is included. In Model 3, we add chronic condition count as a measure of health status. In Model 4, we add quartiles of household wealth and health insurance coverage as measures of financial well-being.

We also conduct formal tests of statistical mediation using the Karlson, Holm, and Breen (KHB) method which decomposes the effect of an independent variable on a dependent variable into direct (unexplained by mediating variables) and indirect (explained by mediating variables) components. This method can also be used to estimate the percent of the indirect effect that is explained by individual variables in models with multiple mediating variables. The method has been described in greater detail elsewhere (Kohler, Karlson, & Holm, 2011) and has been used in previous research to assess mediation in the MHAS (Saenz & Wong, 2016; Torres & Wong, 2013). In this analysis, we assess what percent of the rural/urban differences in cognitive function (by domain) are explained by mediating variables including educational attainment, chronic condition count, and health insurance. All statistical models are estimated using Stata 14.

Results

We begin by presenting descriptive results for respondents with information on at least one cognitive domain. The average scores for verbal learning, verbal memory, verbal fluency, orientation, and attention in the full sample were 4.76, 4.40, 14.94, 2.47, and 28.54, respectively. The average age (range 50–112) in the full analytic sample was 65.44, and the average years of education (range 0–22) was 5.55. The full sample was 57.31% female, and only 11.98% reported no health insurance coverage. Mean scores and standard deviations by cognitive domain and by community size are presented in Table 1. Across cognitive domains, clear gradients are observed with those residing in a community with 100,000 or more inhabitants scoring the highest, followed by residents in communities with 15,000–99,999 residents, followed by those in communities with 2,500–14,999 residents. The most rural dwellers (fewer than 2,500 residents) scored the lowest across all five cognitive domains. For example, the mean cognitive scores for respondents in the most urban communities (100,000+ residents) versus the most rural communities (fewer than 2,500 residents) were 4.95 versus 4.38 for verbal learning, 4.59 versus 4.00 for verbal memory, 15.70 versus 13.49 for verbal fluency, 2.56 versus 2.26 for orientation, and 31.55 versus 22.06 for attention, respectively. The average age across community size ranged from 64.51 in communities size 100,000+ to 65.81 in communities size 2,500 to 14,999. Mean years of education varied considerably by community size with increasing educational disadvantage in smaller communities. Respondents residing in more rural areas also reported fewer chronic conditions and lower rates of health insurance coverage than respondents in more urban areas.

Regression Results

Regression results for verbal learning are shown in Table 2. In Model 1, we regressed verbal learning as a function of age, sex, and community size. Respondents who were younger or female tended to score higher on the verbal learning instrument. Verbal learning performance differed substantially by community size with lower verbal learning performance in communities with fewer residents. When we added years of formal education in Model 2, the rurality–verbal learning association decreased dramatically (suggesting that lower educational attainment in rural areas explained a large part of the differences across levels of community size) but remained statistically significant. The addition of chronic condition count in Model 3 or household wealth and lack of health insurance in Model 4 did not alter the rurality– verbal learning association. In the full model, being older, being male, residing in a more rural area, having fewer years of education, lacking health insurance, and having lower wealth were associated with lower verbal learning performance.

Results for verbal memory are shown in Table 3. In Model 1, verbal memory is regressed as a function of age, sex, and levels of rurality. Similar to verbal learning, being older, male, and residing in a more rural area were associated with poorer verbal memory. However, when educational attainment is added in Model 2, the rural/urban gradients in verbal memory were reduced to nonsignificance for two categories. After accounting for education, only residing in a community with fewer than 2,500 residents compared with more than 100,000 residents was associated with poorer verbal memory. The inclusion of chronic condition count in Model 3 or lack of health insurance and household wealth in Model 4 did not change the interpretation of other parameters. In the full model, being older, being male, living in a community with fewer than 2,500 compared with 100,000+ residents, fewer years of education, and having lower wealth were associated with poorer performance on the verbal memory measure.

Results for verbal fluency are shown in Table 4. In Model 1, respondents who were older, female, and resided in a less populated community named fewer animals. Similar to other cognitive domains, a large portion of the rural/urban gradient in verbal fluency could be attributed to lower educational attainment in rural areas. The inclusion of years of education in Model 2 reduced the size of the rural/urban gradient yet it retained statistical significance. Furthermore, the inclusion of chronic condition count, household wealth, and lack of health insurance did not reduce the rural/urban gradient, which remained significant in fully adjusted models. In the full model, being younger, being male, residing in a more urban area, having more years of education, and reporting greater levels of wealth were associated with better performance on the verbal fluency exercise.

We report results for orientation in Table 5. In the first model, being older, female, and residing in a more rural area were associated with poorer orientation. The addition of education reduced the rural/urban gradient in cognitive function to the extent that only residing in a community with fewer than 2,500 residents compared with 100,000+ residents was associated with poorer orientation. While chronic condition count (only in Model 3), household wealth, and health insurance (in Model 4) were associated with orientation, the inclusion of these variables did not affect the rural/urban gradient. In the full model, being older, being female, residing in a community with fewer than 2,500 residents compared with 100,000+ residents, lacking health insurance, and lower household wealth were associated with poorer performance on the orientation task.

We report results for attention in Table 6. Significant predictors of worse attention performance in Model 1 included being older, female, and living in less urban communities. The association between rurality and attention appeared to be driven to a large extent by educational disadvantage in rural areas. Similar to other domains, the association between rurality and poorer cognitive function was reduced substantially when educational attainment was added in Model 2, but remained statistically significant. The addition of chronic condition count in Model 3 or household wealth and lack of health insurance in Model 4 did not affect the estimated associations between community size and attention. However, sex was no longer significant after the addition of count of chronic conditions in Model 3. In the full model, being older, residing in a more rural community, having fewer years of education, reporting more chronic conditions, and having lower wealth were associated with lower performance on the attention exercise.

Mediation Analysis

We present the results of our mediation analyses in Table 7. To facilitate interpretation of parameters, we analyze rural/urban as a binary variable (1 represents living in the most urban areas [community size 100,000+], all other categories are recoded as 0). The total, direct, and indirect effects are presented in Table 7. For each cognitive domain, the table presents the “total effect” of living in an urban area, which can be interpreted as the association between urban residence and cognitive functioning without accounting for mediating variables. The “indirect effect” represents the reduction in the coefficient estimate for urban residence after including mediating variables while the “direct effect” represents the coefficient estimate for urban residence after accounting for mediating variables. The “indirect” and “direct” effects then sum to the total effect. As expected, living in an urban area was associated with higher cognitive functioning across domains. Across cognitive domains, the mediating effects of education were significant and the majority of the association between rural/urban residence and cognitive function (between 55.5% and 64.4%) was explained by educational attainment. This process was repeated to test the mediating effects of other proposed mediators (chronic conditions and health insurance coverage), but neither mediation effect reached statistical significance. This implies that differences in the prevalence of chronic conditions and health insurance coverage did not explain differences in cognitive functioning across rural and urban areas in Mexico.

Sensitivity Analyses

Respondents who required proxy interviews did not receive the cognitive assessments used in our analyses. As proxies tend to be in worse health, we conducted various sensitivity analyses to determine whether the rural/urban gradient that we observed may be attributed to data that were not missing at random. First, we examined the number of proxy cases by community size and noted that proxy interviews were more common in more rural areas. As the size of the community decreased, the percentage of interviews that were proxies were 6.74%, 8.68%, 9.49%, and 11.03% (χ^2 significant at $p < .01$). As proxies tend to be in worse health and may be unable to take the interview due to cognitive impairment, the higher prevalence of proxy interviews in rural areas may imply that we are underestimating the extent of the cognitive disadvantage in rural areas. Second, we take advantage of the longitudinal nature of the MHAS by examining the 2003 cognitive scores of respondents who would become proxies in 2012. Using this retrospective method, we observed results that were similar to the 2012 complete case analysis. Average cognitive scores by domain and mean years of education decreased with each decrease in community size (results of sensitivity analyses are not shown, available upon request). These results suggest that excluded cases are behaving similar to the included cases and our results are not likely to be a consequence of missing data. In further sensitivity analyses (results available upon request), we tested each regression model in the population age 50–59 separately from the population 60+ and observed significant rural/urban gradients in each age group across cognitive domains.

Discussion

In this analysis, we assess differences in cognitive function by domain across rural and urban areas in Mexico. We found significant rural/urban gradients in cognitive function with rural residents performing worse across the five cognitive domains. Our results are consistent with previous research using smaller, nonrepresentative samples, suggesting cognitive disadvantages in rural compared with urban areas of Mexico (Prince et al., 2012). Importantly, much, but not all, of these differences in cognition observed in the present study were explained by lower levels of education among older respondents residing in rural areas. Across cognitive domains, approximately one half to two thirds of the association between rural/urban dwelling and cognitive function was explained by differences in educational attainment. In addition, reporting more chronic conditions and lacking health insurance were related to poorer cognitive functioning for specific domains. Furthermore, lower household wealth was associated with poorer cognitive functioning across domains. However, differences in these factors across community size did not explain rural/urban disparities in cognitive functioning. These results highlight the critical importance of education for cognitive functioning in old age and how this is patterned across rural and urban Mexico.

The important role of educational attainment in explaining rural/urban differences in cognitive performance likely reflects two demographic processes. First, the rural/urban gradients we observe in contemporary data are likely the result of the historical context of educational inequality. Rural areas have historically lagged behind urban areas in terms of literacy and educational opportunities (Wong & Palloni, 2009). It is also likely that many respondents may reside in the same community in which they received (or did not receive) schooling. To the extent that education may delay and/or prevent the onset of cognitive impairment, rural/urban cognitive gradients in old age may be a consequence of educational disadvantage in rural areas dating back to the beginning of the 20th century, suggesting a lasting impact of educational inequality. These results urge researchers to consider the importance of historical context when evaluating health in old age.

Second, the presence of rural/urban cognitive gradients in old age may be the result of the push and pull factors of internal migration throughout the life-course and must be understood within the process of urbanization in Mexico. Rural to urban migration intensified in the 1950s alongside the modernization and industrialization of Mexico (Sanchez & Pacheco, 2012). As a result, it is possible that rural residents with higher levels of education became dissatisfied with the occupational opportunities available in rural areas, which are often concentrated in the agricultural sector, and relocated to urban areas to pursue the growing demand for manufacturing and service labor (Lall, Selod, & Shalizi, 2006). This process may "select out" the most educated rural residents, leaving a lower educated rural population behind. These two processes are not mutually exclusive; rather, they likely work together in complementary ways resulting in rural/urban disparities in cognitive functioning in late life.

Although the examination of cognition across cognitive domains brought to light some minor differences with other predictors, the relationship between rurality and cognition was relatively homogeneous across cognitive domains. Furthermore, the role of educational attainment in explaining rural/urban differences was also present across cognitive domains. The consistent results across cognitive domains suggest that factors which contribute to rural/urban disparities in cognition broadly influence cognitive functioning. This includes educational attainment as well as characteristics closely related to education, including literacy, occupation status, and overall health status.

The results of this analysis provide important policy and public health implications. First, previous efforts have been made to improve educational opportunities in rural areas in Mexico which have resulted in large improvements in educational attainment in rural areas (Wong & Palloni, 2009). However, educational inequality is still observed today. As of 2010, residents (age 12+) in communities with fewer than 2,500 residents were approximately 4.2 times more likely to have no education compared with those in communities with more than 100,000 residents (INEGI, 2010). Educational disadvantages in rural areas may carry into the future as children in primary schooling ages (age 6–15) in communities with fewer than 2,500 residents are almost twice as likely to not attend school compared with children in the same age group in communities with 100,000+ residents (INEGI, 2010). These educational disparities may have significant impacts on the patterns of cognitive impairment and dementia in future generations of older Mexican adults. Policy makers should continue educational initiatives that target rural areas.

Second, understanding the geographical patterns of cognitive functioning is important as this suggests where resources should be allocated. In an effort to use resources most efficiently, public health interventions designed to promote cognitive health should be targeted and designed for rural communities. In addition, programs meant to educate older adults about normative and pathological changes in cognitive functioning as well as resources for families providing care for someone with cognitive impairment or dementia should be allocated to rural communities in Mexico.

This analysis comes with several limitations. First, future work should evaluate the cognitive performance of proxies. While the MHAS conducts interviews of an informed respondent who evaluates the cognitive abilities of the target respondent in comparison with 2 years prior, we do not use this information as it is not comparable with the cognitive measures used in direct interviews. However, we conducted sensitivity analyses to demonstrate that our results are unlikely to be a consequence of excluding proxy interviews. Second, there are several community-level characteristics that may influence cognition including the historical availability of schools, health care services, and employment opportunities. While our levels of rurality likely serve as a proxy for some of this variance, future work should examine these community-level characteristics to identify community-level traits that may help explain rural/urban differences in cognitive functioning. Third, our analyses are based on community size in old age. Future work should examine the role that rural to urban migration plays in the rural/urban patterning of cognition in old age. Fourth, we explore differences in cognitive functioning across rural and urban areas because this has not been explored in previous studies. While these results are important, future work should take advantage of the longitudinal nature of the MHAS by evaluating whether rates of cognitive decline differ across rural and urban populations in Mexico. Last, although we include several cognitive domains to achieve a broad presentation of cognition, several domains including processing speed, working memory, and self-perceptions of memory are not included.

Notwithstanding these limitations, there are several strengths worth mentioning. First, the large sample size of the MHAS allowed for sufficient sample size to examine cognitive function across four levels of community size as opposed to a binary variable. Second, the collection of data across many domains allows for the inclusion of several covariates to test our hypothesized mediating variables while accounting for various confounding variables. Third, the collection of data across several cognitive domains allowed us to determine whether rurality affected cognitive domains in heterogeneous ways.

Educational attainment is closely linked to cognitive functioning. The historical context of educational disadvantage in rural Mexico dating back to the beginning of the 20th century, as well as rural to urban population shifts throughout the 20th century should be considered when investigating rural/urban patterns of cognitive functioning in Mexico. Our results have important implications for public health and educational policy. One existing program that may influence cognitive functioning in future cohorts of older Mexicans is PROGRESA/ Oportunidades. PROGRESA/Oportunidades is a conditional cash transfer program that began in rural communities in 1997 and provides cash payments to families. These payments are conditional on their children regularly attending school and visiting health clinics (Oportunidades, 2004). Policy makers should continue to support policies which may improve education in rural areas.

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Table 1

Descriptive Characteristics of Older Mexican Adults (Age 50+) in the Mexican Health and Aging Study by Rurality (n = 13,138).

	100,000+		15,000–99,999		2,500–14,999		<2,500		ANOVA/chi-square
Community size	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***p***
Mean cognitive score									
Verbal learning	4.95	1.21	4.66	1.20	4.52	1.27	4.38	1.24	***a
Verbal memory	4.59	2.00	4.31	2.02	4.15	2.10	4.00	2.12	***a
Verbal fluency	15.70	5.26	14.51	4.97	13.76	4.62	13.49	4.49	***a
Orientation	2.56	0.76	2.45	0.84	2.40	0.87	2.26	0.95	***a
Attention	31.55	15.48	26.59	14.89	24.72	14.34	22.06	13.05	***a
Demographics									
Age	64.51	9.21	65.76	9.50	65.81	9.78	64.57	9.75	***a
Years of education	6.84	4.95	5.07	4.38	4.30	3.92	3.22	3.30	***a
Female (%, *n*)	58.7	4,566	58.0	844	56.0	793	53.2	1,326	***b
Wealth									
1st quartile (%, *n*)	18.4	1,427	23.2	337	25.9	367	28.5	709	***b
2nd quartile (%, *n*)	23.7	1,844	28.7	417	25.8	366	27.9	694	
3rd quartile (%, *n*)	27.8	2,160	26.4	384	26.0	368	21.1	525	
4th quartile (%, *n*)	30.2	2,344	21.8	317	22.3	316	22.6	563	
Health variables									
Chronic condition count	0.84	0.86	0.82	0.86	0.78	0.85	0.74	0.83	***a
Uninsured (%,*n*)	10.4	805	14.3	208	13.5	192	14.8	369	***b
Sample size									
n	7,775		1,455		1,417		2,491		

Source. Authors' own calculation using data from the Mexican Health and Aging Study (2012).

Note. First quartile of wealth is lowest wealth.

[a] Indicates differences are tested by ANOVA.

[b] Indicates differences are tested by chi-square.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 2

Ordinary Least Squares (OLS) Regression of Standardized *Verbal Learning* Scores Among Older Mexicans in the Mexican Health and Aging Study (n = 13,039).

	Model 1		Model 2		Model 3		Model 4	
	β	*SE*	β	*SE*	β	*SE*	β	*SE*
Demographics								
Age	−0.04***	(0.00)	−0.03***	(0.00)	−0.03***	(0.00)	−0.03***	(0.00)
Female	0.15***	(0.02)	0.24***	(0.02)	0.24***	(0.02)	0.24***	(0.02)
Community size[a]								
15,000–99,999	−0.18***	(0.03)	−0.07**	(0.02)	−0.07**	(0.02)	−0.06*	(0.02)
2,500–14,999	−0.29***	(0.03)	−0.13***	(0.03)	−0.13***	(0.03)	−0.12***	(0.03)
<2,500	−0.44***	(0.02)	−0.20***	(0.02)	−0.20***	(0.02)	−0.19***	(0.02)
Education								
Years of education			0.07***	(0.00)	0.07***	(0.00)	0.07***	(0.00)
Health variables								
Chronic condition count					0.01	(0.01)	0.00	(0.01)
Uninsured							−0.09***	(0.02)
Household wealth[b]								
2nd quartile							0.04*	(0.02)
3rd quartile							0.08***	(0.02)
4th quartile							0.08***	(0.02)

Source. Authors' own calculation using data from the Mexican Health and Aging Study (2012).

Note. β indicates parameter estimate.

[a]Reference category is community size 100,000+.

[b]Reference category is first quartile (lowest quartile of household wealth).

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 3

Ordinary Least Squares (OLS) Regression of Standardized *Verbal Memory* Scores Among Older Mexicans in the Mexican Health and Aging Study (n = 12,972).

	Model 1		Model 2		Model 3		Model 4	
	β	*SE*	β	*SE*	β	*SE*	β	*SE*
Demographics								
Age	−0.04***	(0.00)	−0.03***	(0.00)	−0.03***	(0.00)	−0.03***	(0.00)
Female	0.20***	(0.02)	0.26***	(0.02)	0.26***	(0.02)	0.26***	(0.02)
Community size[a]								
15,000–99,999	−0.08**	(0.03)	−0.01	(0.03)	−0.01	(0.03)	−0.01	(0.03)
2,500–14,999	−0.16***	(0.03)	−0.05	(0.03)	−0.05	(0.03)	−0.05	(0.03)
<2,500	−0.27***	(0.02)	−0.11***	(0.02)	−0.11***	(0.02)	−0.11***	(0.02)
Education								
Years of education			0.04***	(0.00)	0.04***	(0.00)	0.04***	(0.00)
Health variables								
Chronic condition count					−0.01	(0.01)	−0.01	(0.01)
Uninsured							−0.04	(0.02)
Household wealth[b]								
2nd quartile							0.03	(0.02)
3rd quartile							0.05*	(0.02)
4th quartile							0.02	(0.02)

Source. Authors' own calculation using data from the Mexican Health and Aging Study (2012).

Note. β indicates parameter estimate.

[a]Reference category is community size 100,000+.

[b]Reference category is first quartile (lowest quartile of household wealth).

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 4

Ordinary Least Squares (OLS) Regression of Standardized *Verbal Fluency* Among Older Mexicans in the Mexican Health and Aging Study (n = 13,013).

	Model 1		Model 2		Model 3		Model 4	
	β	*SE*	β	*SE*	β	*SE*	β	*SE*
Demographics								
Age	−0.03***	(0.00)	−0.02***	(0.00)	−0.02***	(0.00)	−0.02***	(0.00)
Female	−0.20***	(0.02)	−0.10***	(0.02)	−0.10***	(0.02)	−0.10***	(0.02)
Community size[a]								
15,000–99,999	−0.19***	(0.03)	−0.07**	(0.02)	−0.07**	(0.02)	−0.07**	(0.02)
2,500–14,999	−0.34***	(0.03)	−0.17***	(0.03)	−0.17***	(0.03)	−0.16***	(0.03)
<2,500	−0.44***	(0.02)	−0.17***	(0.02)	−0.17***	(0.02)	−0.17***	(0.02)
Education								
Years of education			0.07***	(0.00)	0.07***	(0.00)	0.07***	(0.00)
Health variables								
Chronic condition count					−0.00	(0.01)	−0.00	(0.01)
Uninsured							−0.04	(0.02)
Household wealth[b]								
2nd quartile							0.04	(0.02)
3rd quartile							0.04	(0.02)
4th quartile							0.09***	(0.02)

Source. Authors' own calculation using data from the Mexican Health and Aging Study (2012).

Note. β indicates parameter estimate.

[a]Reference category is community size 100,000+.

[b]Reference category is first quartile (lowest quartile of household wealth).

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 5

Ordinary Least Squares (OLS) Regression of Standardized *Orientation* Among Older Mexicans in the Mexican Health and Aging Study (n = 13,086).

	Model 1		Model 2		Model 3		Model 4	
	β	*SE*	β	*SE*	β	*SE*	β	*SE*
Demographics								
Age	−0.03***	(0.00)	−0.02***	(0.00)	−0.02***	(0.00)	−0.02***	(0.00)
Female	−0.13***	(0.02)	−0.06***	(0.02)	−0.06***	(0.02)	−0.07***	(0.02)
Community size[a]								
15,000–99,999	−0.10***	(0.03)	−0.02	(0.03)	−0.02	(0.03)	−0.01	(0.03)
2,500–14,999	−0.16***	(0.03)	−0.04	(0.03)	−0.04	(0.03)	−0.03	(0.03)
<2,500	−0.37***	(0.02)	−0.18***	(0.02)	−0.18***	(0.02)	−0.17***	(0.02)
Education								
Years of education			0.05***	(0.00)	0.05***	(0.00)	0.05***	(0.00)
Health variables								
Chronic condition count					0.02*	(0.01)	0.02	(0.01)
Uninsured							−0.08**	(0.03)
Household wealth[b]								
2nd quartile							0.10***	(0.02)
3rd quartile							0.13***	(0.02)
4th quartile							0.10***	(0.02)

Source. Authors' own calculation using data from the Mexican Health and Aging Study (2012).

Note. β indicates parameter estimate.

[a] Reference category is community size 100,000+.

[b] Reference category is first quartile (lowest quartile of household wealth).

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 6

Ordinary Least Squares (OLS) Regression of Standardized *Attention* Among Older Mexicans in the Mexican Health and Aging Study (n = 12,099).

	Model 1		Model 2		Model 3		Model 4	
	β	*SE*	β	*SE*	β	*SE*	β	*SE*
Demographics								
Age	−0.05***	(0.00)	−0.03***	(0.00)	−0.03***	(0.00)	−0.03***	(0.00)
Female	−0.16***	(0.02)	−0.03*	(0.01)	−0.02	(0.01)	−0.02	(0.01)
Community size[a]								
15,000–99,999	−0.27***	(0.03)	−0.11***	(0.02)	−0.12***	(0.02)	−0.11***	(0.02)
2,500–14,999	−0.41***	(0.03)	−0.18***	(0.02)	−0.18***	(0.02)	−0.17***	(0.02)
<2,500	−0.63***	(0.02)	−0.27***	(0.02)	−0.27***	(0.02)	−0.27***	(0.02)
Education								
Years of education			0.10***	(0.00)	0.10***	(0.00)	0.09***	(0.00)
Health variables								
Chronic condition count					−0.04***	(0.01)	−0.04***	(0.01)
Uninsured							−0.01	(0.02)
Household wealth[b]								
2nd quartile							0.04*	(0.02)
3rd quartile							0.10***	(0.02)
4th quartile							0.10***	(0.02)

Source. Authors' own calculation using data from the Mexican Health and Aging Study (2012).

Note. β indicates parameter estimate.

[a]Reference category is community size 100,000+.

[b]Reference category is first quartile (lowest quartile of household wealth).

*p < .05.

**p < .01.

***p < .001.

Table 7

Decomposition of the Association Between Urban Dwelling and Cognitive Function in 2012 Into Direct and Indirect Components.

	Verbal learning			Verbal memory			Verbal fluency			Orientation			Attention		
	β	*p*	%	β	*p*	%	β	*p*	%	β	*p*	%	β	*p*	%
Decomposition of urban dwelling association with cognition with and without educational attainment															
Total effect	0.301	***		0.177	***		0.318	***		0.212	***		0.440	***	
Direct effect	0.134	***	44.5	0.063	***	35.6	0.137	***	43.1	0.084	***	39.4	0.197	***	44.8
Indirect effect	0.167	***	55.5	0.114	***	64.4	0.181	***	56.9	0.129	***	60.6	0.244	***	55.5

Source. Authors' own calculation using data from the Mexican Health and Aging Study (MHAS).

Note. Effects based on ordinary least squares (OLS) regression. Model accounts for all covariates. Sample sizes for verbal learning, verbal memory, verbal fluency, orientation, and attention are 13,039, 12,972, 13,013, 13,086, and 12,099 respectively. Urban = community size 100,000+.

* $p < .05$.

** $p < .01$.

*** $p < .001$.