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Offspring Educational Attainment and Older Parents' Cognition in Mexico

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ABSTRACT Population-level disparities in later-life cognitive health point to the importance of family resources. Although the bulk of prior work on the topic has established the directional flow of resources from parents to offspring, the linked lives perspective raises the question of how offspring resources could affect parental health as well. This study examines whether adult children's education influences older parents' (aged 50+) cognitive health in Mexico, where schooling reforms have contributed to significant gains in the educational achievements of recent birth cohorts. Harnessing a change in compulsory school laws and applying an instrumental variables approach, we found that each year of offspring schooling was associated with higher overall cognition among parents but was less predictive across different cognitive functioning domains. More offspring schooling improved parents' cognitive abilities in verbal learning, verbal fluency, and orientation, but not in visual scanning, visuospatial ability, or visual memory. The beneficial effects of offspring schooling on those cognitive domains are more salient for mothers than for fathers, suggesting potential gendered effects in the influence of offspring schooling. The results remained robust to controls for parent-child contact and geographic proximity, suggesting other avenues through which offspring education could affect parental health and a pathway for future research. Our findings contribute to growing research stressing the causal influence of familial educational attainment on population health.

KEYWORDS Cognition • Health • Education • Intergenerational relationships • Mexico

Introduction

An inadvertent consequence of the remarkable gains achieved in life expectancy throughout the twentieth century has been a dramatic increase in cognitive impairment and dementia across the globe (Riley 2005). Mexico, like many middle-income countries, experienced a rapid epidemiological transition that extended life expectancy and shifted mortality from communicable diseases to degenerative diseases, such as Alzheimer's disease (Stevens et al. 2008). Yet the risk of cognitive impairment is not equal across the Mexican population. Indeed, disparities in later-life cognitive health point to the importance of individual and family resources in shaping the onset and

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progression of cognitive decline (Jefferson et al. 2011; Lee et al. 2003). Although prior work has established the directional flow of resources from parents to offspring (Clouston et al. 2012; Fors et al. 2009; Singh-Manoux et al. 2005; Stern 2002, 2012), the "linked lives" perspective raises the question of whether offspring resources could also affect parental health and cognition in later life (Elder et al. 2003).

Recent research has indicated that having children with more schooling was negatively associated with dementia onset and overall cognitive decline among older adults in Asia (Lee 2018; Ma 2019). Findings from these studies echo results from a growing body of work highlighting the importance of children's resources, such as children's educational attainment, for parental mortality (De Neve and Harling 2017; Friedman and Mare 2014; Yahirun et al. 2017; Zimmer et al. 2007). Recent findings have also stressed that neither cognition nor cognitive decline is unidimensional, and have emphasized the importance of understanding factors that affect specific dimensions of cognitive health (Anstey and Christensen 2000; Guerra-Carrillo et al. 2017). Indeed, assessing separate elements of cognitive functioning could help to illuminate the particular pathways through which children's education may be most beneficial for later-life cognition. Although prior research has revealed possible associations between children's resources and parental health, this work is challenged by methodological constraints, including confounding factors that influence both offspring education and parental health (De Neve and Kawachi 2017). Several recent studies attempted to overcome these constraints through sibling fixed-effects models (Torssander 2013) and quasi-experimental data that used educational reform policies (De Neve and Fink 2018; Lundborg and Majlesi 2018; Ma 2019). Studies using exogenous educational reform policies to assess changes in offspring schooling and subsequent effects on parent mortality found that higher levels of offspring schooling were protective of older parents' longevity in South Africa and Tanzania (De Neve and Fink 2018; Lundborg and Majlesi 2018). However, few studies that have explicitly attempted to address questions of causality have assessed whether children's education plays a role in parents' cognitive health (for an exception, see Ma 2019).

The present study examines how children's education influences parents' cognitive health in Mexico, a middle-income, rapidly aging country where expansive educational reforms dramatically increased the levels of schooling of recent birth cohorts (Creighton and Park 2010; de Herrara 1996; Post 2001). Harnessing a 1993 policy change in compulsory schooling and applying an instrumental variables approach, we examine how increased compulsory schooling differentially shaped access to schooling for cohorts of offspring; and consequently, whether these increases were associated with parents' cognitive health. We expand upon recent work that has documented the association between children's education and parents' overall cognition (Lee 2018; Ma 2019) by examining specific cognitive domains (e.g., memory and visuospatial ability) that may elucidate concrete mechanisms through which children's education influences parental cognition. We also systematically assess what role such support from children, measured by child's contact with parents and geographic proximity to parents, acts as potential mechanisms. Finally, we assess whether children's education matters more for mothers than for fathers, given the central role of mothers in Mexico and findings that have emphasized the greater importance of children's schooling for women's than for men's longevity (Yahirun et al. 2017). Understanding how offspring education influences later-life cognitive ability in Mexico is critical because the number of adults living with dementia in Mexico and Latin America is projected to quadruple over the first half of the twenty-first century (Parra et al. 2018). Resources of children may be of particular importance for older adults in Mexico because the vast majority rely on support from adult children (Angel et al. 2016; Angel et al. 2017) as the development of institutional support systems for older adults continues to lag behind population aging (Gutiérrez Robledo et al. 2012).

Background

Intergenerational Pathways to Cognitive Health

A vast body of research on the intergenerational pathways to cognitive health has focused on the role of early-life conditions (Al Hazzouri et al. 2011; Fors et al. 2009; Glymour and Manly 2008; Heckman and Feng 2018; Luo and Waite 2005; Zhang et al. 2008; Zhang et al. 2016). This work underscores how early-life contexts influence both biological and social pathways to cognitive functioning in later life. Biologically, parents establish the early childhood environment for learning that shapes children's cognitive reserve, a concept which neuroscientists refer to as "differences between individuals in susceptibility to age-related brain changes . . . whereby some people can tolerate more of these changes than others and maintain function" (Stern 2012:1006). Cognitive reserve increases when education and cognitively stimulating environments in early childhood modify the brain's ability to function efficiently and effectively (Langa et al. 2017). More indirectly, parental resources also influence the socioeconomic pathways to cognitive functioning in later life. Highly educated parents tend to raise children who also complete higher levels of schooling (Chen et al. 2020), and more schooling leads to cognitively stimulating occupations, higher incomes, and careers with benefits, such as health insurance and premium health care. Together, this leads to better health outcomes in midlife that subsequently shapes later-life cognitive health (Greenfield and Moorman 2018; Luo and Waite 2005; Zhang et al. 2016). Thus, understanding cognition in older ages requires understanding early-life conditions as well.

One perspective that is largely absent from research on the life course determinants of cognition is whether adult children may also act as important agents of change for parents' cognitive health in later life. Aging alters the composition of social networks as older adults leave the labor force and the roles of family members become more salient (Antonucci 2001; Offer and Fischer 2018). In later life, Mexican older adults are significantly more likely than young adults to have kin in their close social network (Fuller-Iglesias and Antonucci 2016). Offspring, who earlier in the life course were frequently the recipients of resources and support, emerge as providers of support and care, a pattern that is especially pronounced in Mexico (Angel et al. 2016; Angel et al. 2017).

Adult Children's Education and Parents' Cognitive Health

Assessing the potential influence of one family member's education on the health outcome of others underscores the linked lives of parents and children, whereby events in one family member's life shape the lives of other members (Elder et al. 2003).

Recent research has analyzed how children's educational attainment affects parents' well-being. Across a variety of contexts, parents with more-educated children experience delayed mortality compared with parents whose children have fewer years of schooling (De Neve and Harling 2017; Friedman and Mare 2014; Torssander 2013; Zimmer et al. 2016; Zimmer et al. 2007). In Mexico, studies have found that parents with more children who completed upper secondary school had fewer functional limitations and lived longer than parents with less-educated children (Yahirun et al. 2016, 2017). In addition, research has demonstrated a positive association between children's education and parents' general cognitive health in East Asia (Lee 2018; Ma 2019). However, what remains less clear is the extent to which children's educational attainment may influence parental cognition in Mexico, which may have different etiologies than physical health (Hertzog et al. 2008), and whether children's education matters across different domains of cognitive functioning, including general cognitive ability.

Understanding cognitive aging using various domains of cognitive ability is essential because rates of change and risk factors for decline may differ across cognitive domains (Blazer et al. 2015). Indeed, results of previous work suggest that the variance explained by one's own educational attainment may differ across cognitive dimensions (Alley et al. 2000; Guerra-Carrillo 2017; Leibovici 1996; Scarmeas 2006), including in Mexico (Ardila et al. 2000). For instance, some studies have reported education to be more closely related to crystalized abilities (involving) but less so with fluid abilities (Antsey 2000) or processing speed (Guerra-Carrillo 2017). Notably, other research has noted weaker associations between education and memory tasks in specific contexts—for example, among older Mexican-Americans (Matallana 2011) and in Brazil (Laks 2010)—compared with nonmemory tasks. Still other studies have found a clear relationship between some types of verbal tasks but not others (Rosselli et al. 2009).

Research is also needed to identify the underlying mechanisms linking children's education to parental cognitive health. Prior work on intergenerational relationships outlined multiple ways in which offspring support older parents in later life, including maintaining affective ties through emotional support and contact with parents, and providing instrumental forms of assistance and support ranging from financial assistance to housework (Seltzer and Bianchi 2013; Swartz 2009). Within the broader concept of intergenerational support, prior scholars have also highlighted the importance of social support that includes instrumental aid, emotional caregiving, and information that has positive, potentially health-promoting or stress-buffering effects on individual-level health outcomes (House et al. 1988:302). For example, a strong link between emotional support from kin (among others) and high cognitive functioning among older adults has been established (Seeman et al. 2001). Frequent contact with children and other family members has also been linked to fewer cognitive limitations and a lower likelihood of experiencing decline over time (Barnes et al. 2004) as well as slower memory decline (Ertel et al. 2008). Studies from Mexico have also found similar inverse correlations between indicators of social ties and cognitive functioning (Zamora-Macorra et al. 2017). Further, different types of support may be related with cognitive domains in unique ways. For example, emotional support has been shown to be associated with global cognition, reasoning, and processing speed but not episodic memory; comparatively, social activity (which includes not only contact with kin and friends but also membership in clubs and associations and the like) was tied to higher global cognition, working memory, and verbal fluency (for a systematic review, see Kelly et al. 2017). This evidence points to the possibility that the influence of children's education on parental cognitive health might be through intergenerational support and differs across cognitive domains.

However, the relationship between children's education and children's support of parents is complex. In Mexico, recent studies found that after controlling for labor force participation, education plays little role in determining which children are the primary caregivers to parents (Angst et al. 2019). However, labor force participation was associated with a lower overall probability of being selected as the primary caregiver. The same study found that even among children who were not the primary caregivers, noncaregiver offspring tended to provide more money and in-kind support to parents than caregivers, suggesting that offspring play different roles in providing care to parents, depending on their own socioeconomic resources. These factors underscore how highly educated children may be better positioned to provide certain types of support that particularly matter for health outcomes. In our own analyses of the Mexican Health and Aging Study (MHAS) data, we found that highly educated children are more likely to live with parents and have more frequent contact with parents than their peers with less education (analysis not shown here). Furthermore, the quality of the support provided by children could differ according to offspring education. For example, highly educated children may have better abilities to provide information to parents on management of chronic conditions, such as diabetes (De León 2018), as well as the mental and physical exercises that older individuals need to remain cognitively healthy (Sanders et al. 2019). In one study, better-educated children provided more financial transfers, instrumental support, and "knowledge" support that helped parents navigate healthcare in their last year of life (Jiang and Kaushal 2020). In ways that parallel the effect of one's own education on verbal fluency, highly educated children may also provide more opportunities for parents to engage in cognitively stimulating salubrious environments and rich diffuse conversations compared with children who have less education, leading to better cognitive health, especially in verbal domains (Rosselli et al. 2009). Thus, whereas the evidence of the positive effects of intergenerational support on older adults' cognitive health is clear, we know less about whether the socioeconomic characteristics of children matter for parents' cognition, how this could be explained by offspring support of parents, and whether this is patterned by cognitive domain.

Gender Differences

Furthermore, the relationship between children's education and parents' cognitive functioning likely differs for mothers versus fathers. First, mothers, as family kinkeepers, occupy a more central role in family life in Mexico compared with fathers. Social and cultural norms emphasize women's roles as homemakers and caregivers, whereas men have typically taken the role of breadwinners (Sana and Massey 2005). Gendered norms of socialization emphasize mother-child bonds that may enhance possibilities for children to influence a mother's later-life cognition rather than a father's. Second, *resource substitution* theory contends that educational resources are more important among individuals who are otherwise disadvantaged (Mirowsky and Ross 2003), whereby individuals with fewer social or economic resources can use education, as an attained resource, to substitute for social or economic resources they may lack. Women in Mexico have historically received fewer years of schooling than men (Creighton and Park 2010) and thus have experienced a relatively loose attachment to the labor force, translating to greater economic vulnerability in later life compared with men (Kanaiaupuni 2000). Although a large share of the Mexican population receives no formal retirement income (including formal pensions), given the large share of workers in the informal economy (Angel et al. 2017; Sheehan and Riosmena 2013), the gender disparity in pension income in Mexico is one of the largest in Latin America: only 25% of women ages 65 and older receive a pension, compared with 48% of men of the same age group (Arza 2012). Therefore, a reliance on the informal economy and lack of pensions for women increases their reliance on support from children in older ages. Studies have shown that because of a variety of conditions, older women receive more care from family members than men in later life (Angst et al. 2019). Together, these factors suggest that older mothers may be more sensitive to the resources of offspring than older fathers.

Past work has also pointed to the differential health benefits of children's education on mothers' versus fathers' health (De Neve and Fink 2018; Lundborg and Majlesi 2018). One study found that daughters' schooling was more important in extending the longevity of fathers with low socioeconomic status but had no bearing on mothers' mortality (Lundborg and Majlesi 2018). Still, others found no evidence that parents' gender moderated the link between the eldest child's education and parents' cognitive decline (Lee 2018). In Mexico specifically, offspring schooling was more likely to extend longevity for mothers than for fathers (Yahirun et al. 2017).

Educational Expansion in Mexico and the 1993 School Reforms

Challenges to previous studies that examine the upstream influence of children's education on parental health stem from problems of potential endogeneity and omitted variable bias (De Neve and Kawachi 2017). Compulsory schooling laws provide quasi-experiments that influence education but would not otherwise influence individual health outcomes (Glymour et al. 2008). Three recent studies used children's exposure to educational reforms as a source of exogenous variation in their education to examine the effect of children's schooling on parental mortality. Lundborg and Majlesi (2018) exploited a 1948 educational policy reform in Sweden, which increased compulsory education levels from seven to nine years of schooling. They found that increasing years of education of daughters was protective of fathers' mortality among men with low levels of education, although they found no significant effects of children's years of schooling on parental mortality on average. De Neve and Fink (2018) studied the Tanzanian compulsory education reform in 1974, mandating that all children start primary school by age 7, and found that sons' education was also protective of parental mortality. Ma (2019) also exploited a change in compulsory education from 1985 to 1991 in China and found offspring education to be positively associated with cognitive and physical functions and higher survival expectations among older Chinese parents.

In Mexico, educational reform policy occurred throughout the twentieth century and was marked by a series of restructurings (Creighton and Park 2010). Policies that increased student enrollment began in the latter half of the century under the

Eleven-year Plan (1959–1975) and continued under the Education for Everyone campaign (1972–1992) and the Constitutional Amendment of 1993 (1993–present) (Creighton and Park 2010). Whereas the economic downturn in the early 1990s stalled the progress of prior decades (Creighton and Park 2010; Post 2001), the 1993 Constitutional Amendment attempted to reverse this by increasing mandatory schooling from elementary school (grade 6) to lower secondary school (grade 9). Thus, younger birth year cohorts born 1979 or later were exposed to the reform. Estimates from prior research found that individuals exposed to changes from the 1993 Constitutional Amendment were more than twice as likely to transition from primary school to lower secondary school, demonstrating that the reform was effective at raising population-level educational attainment (Creighton and Park 2010:528).[1] In addition, one recent study found that the probability of completing lower secondary school, conditional on having entered that level, was also higher for individuals born in the birth cohort affected by the reform (1979–1986) compared with earlier birth cohorts, although the completion of lower secondary school was increasing gradually among prior birth cohorts as well (Urbina 2018:379–381).

Current Study

Our study uses the 1993 Constitutional Amendment reform, which increased compulsory schooling from grade 6 to grade 9, to estimate the effects of children's education on parental cognitive health. Given that childhood conditions have been shown to be critical for cognition among older adults in Mexico (Al Hazzouri et al. 2011), we control for early-life conditions of parents, factors that could influence their cognition and children's educational attainment. We also assess whether offspring education is predictive across different dimensions of parents' cognitive health in addition to a composite measure of cognition. Next, we examine measures of intergenerational support—the frequency of a child's contact with parents and their geographic proximity—to determine whether they explain associations between children's schooling and parents' cognitive health. Last, we test whether these relationships differ for mothers versus fathers.

Data

We used data from the Mexican Health and Aging Study (MHAS), an ongoing longitudinal, nationally representative study of health and aging among Mexican older adults born 1951 or earlier and their spouses/partners of any age. The first MHAS wave was collected in 2001, and three subsequent waves of data were collected in 2003, 2012, and 2015. In 2012, 15,723 interviews were conducted with original respondents as well as a refresher cohort of individuals born between 1952 and 1962 that was included to maintain representation of the Mexican population aged 50 and older.

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[1] *Oportunidades*, a national cash transfer program that was implemented in 2002, also encouraged children's school enrollment because cash transfers were conditional on children's continued attendance in school and clinic visits. *Oportunidades* now covers approximately 5 million Mexican families (Behrman et al. 2011).

MHAS is comparable with the United States Health and Retirement Study (see Wong et al. 2017). The richness of the MHAS data provides an excellent opportunity to examine how offspring influence the health of aging adults as detailed information is collected not only of older adult respondents but also of their children at each wave.

Although the MHAS began surveying older Mexicans in 2001, our analysis used data from only the 2012 wave due to variation in representativeness and cognition variables of different waves. Although the 2012 wave provides representative data on Mexico's population aged 50 and older, the 2015 wave is representative of only the population aged 53 and older because no refresher sample was added in 2015. In addition, by 2012 (Wave 3), the MHAS had added measures of verbal fluency and orientation (Mejía-Arango et al. 2015). Furthermore, a large time gap between the 2003 and 2012 surveys precludes finer longitudinal analysis of cognitive change before 2012, but the gap between the 2012 and 2015 surveys may not allow sufficient time to detect differences in rates of cognitive decline.

The analytic sample was derived from the 15,723 respondents who were interviewed in 2012. The sample decreased when proxies were omitted ($n=1{,}275$). We then excluded spouses/partners under age 50 ($n=794$) because the MHAS was not designed to be nationally representative of that segment of the Mexican population. Individuals who were not parents in 2012, or whose highest-educated child was younger than 20 or older than 70, were also dropped from our sample ($n=1{,}225$), such that the children were neither too young to have completed secondary school nor too old to have living parents (Ma 2019). We also restricted children to this age range to reduce the possibility that our results are driven by comparing children and hence their parents from cohorts that were affected by substantially different social policies. Last, we excluded individuals who were missing information on all cognitive tasks ($n=286$) or any control variables ($n=3{,}175$). Our final analytic sample consisted of 8,968 older adult Mexican parents aged 50 and older in 2012. In the Robustness Checks section, we further tested the representativeness of our sample and the sensitivity of our results to different sampling criteria.

Measures

Cognitive Functioning

Cognitive functioning in the MHAS was measured using the Cross Cultural Cognitive Examination (CCCE) (Glosser et al. 1993) and several tasks that have been added across waves. The CCCE is especially useful in populations with limited literacy and mathematical ability (Wolfe et al. 1992). The MHAS used cognitive tasks to collect cognitive data spanning several domains: verbal learning, verbal recall, visual scanning, verbal fluency, orientation, visuospatial ability, and visual memory. To assess *verbal learning*, respondents were read a list of eight words and asked to restate as many of the words as possible. This task was repeated two more times, and the average number of words restated correctly across three trials was calculated as a measure of verbal learning (range: 0–8). *Verbal recall* was assessed as the number of words from the eight-word list that are recalled correctly after a delay. To measure *visual scanning*, respondents completed a one-minute task in which they identify a visual stimulus in an array of stimuli (range: 0–60). *Verbal fluency* was assessed using a one-minute animal naming exercise, and the total number of uniquely named animals was calculated (range: 0–60). *Orientation* was measured by correctly identifying the day, month, and year (range: 0–3). Two visuospatial exercises were also conducted involving the drawing of a figure (*visuospatial ability*, range: 0–6) and delayed figure recall (*visual memory*, range: 0–6).

In addition to analyzing scores across individual cognitive tasks, we also constructed a composite cognitive score using the standardized cognitive scores across tasks. The composite cognitive score was constructed as the average *z* score across any of the cognitive tasks with nonmissing scores. This approach allowed each nonmissing task to have equal weight in the final composite score because each task score was converted into *z* scores rather than summed across tasks, which would allow tasks with greater ranges to have more influence on composite scores.

Offspring Characteristics

In this analysis, we limited our offspring sample to the respondent's highest-educated child, which parallels prior research (see Zimmer et al. 2002; Zimmer et al. 2007). In supplemental analyses, we tested other measures of offspring education (see the Robustness Checks section). Thus, the main independent variable of interest is the education of the highest-educated offspring, continuously coded in years (0–24 years). When children tie for highest level of education, we chose the oldest child. In the event that tied children are the same age, we selected a child at random. We focus on children who were adults, defined as those between ages 20 and 70 in 2012 (born from 1942 to 1992). We also accounted for that child's gender (son = 1, daughter = 0) and age in 2012, including a linear and quadratic term to control for complex age cohort trends in educational attainment.

Respondent Characteristics

We included respondent characteristics that are correlates of cognitive health as well as children's educational attainment. Specifically, we accounted for the parent's own years of schooling (coded continuously as years of formal education). To account for the respondent's age and nonlinear associations between age and cognition, we included both age and age squared. In our sample, respondents were born between 1910 and 1962 (mean 1947, age: 65). We coded gender as a dummy variable (1 = male, 0 = female) and included marital status as the following categorical variable: (0) married/partnered (referent), (1) widowed, and (2) other (never married/divorced/separated). We also controlled for the total number of living children. Because Mexico has an extremely heterogeneous population, we included an indicator of indigenous status measured as whether the respondent speaks an indigenous dialect (= 1 if speaks dialect, = 0 if not). We incorporated a measure of locality size to account for differences in cognition across rural/urban areas (Saenz et al. 2020). Locality size was categorized (in order from most urban to most rural) as (0) 100,000 or more persons (referent); (1) 15,000–99,000 persons; (2) 2,500–14,999 persons; or (3) fewer than 2,500 persons.

Finally, given prior research citing the importance of early-life indicators for later-life cognitive functioning, we included a set of childhood conditions that potentially affect both respondent's own cognitive health outcomes and offspring education. We included a measure of height in centimeters at the time of survey. Height in adulthood is a well-established correlate of childhood nutritional, inflammation, and health context (Crimmins and Finch 2006). Categorical variables measuring the educational attainment of the respondent's mother and father were coded identically, and are added in as (0) no formal schooling (referent), (1) less than six years of schooling, (2) six years of schooling (elementary school education), and (3) more than six years of schooling. Finally, we accounted for early childhood environment before age 10 through a series of dummy variables (=1 if condition was met): no toilet in the household, often went to bed hungry, did not wear shoes regularly, self/siblings had to drop out of school to support family, self/family member slept in same room that was used to prepare food, and family received financial assistance. Because our sample may be selective on cognitive health by excluding respondents who were not able to recall their childhood conditions, we also tested how our results changed without the inclusion of early-life control variables (see the Robustness Checks section).

Intergenerational Support Measures

We examined two mediators that quantify the amount of intergenerational support from the highest-educated child to parents: geographical proximity and frequency of contacts. We measured geographic proximity using a binary variable for coresidence with the highest-educated child; we measured frequency of contact as the number of contacts per year from the highest-educated children, assigning 365 to coresident children. These two measures are widely used as indicators for intergenerational support received by older adults (Silverstein et al. 1997). In ancillary analyses, as expected, we found a strong correlation between coresidency and frequency of contact ($r = .71$). We also tested the mediating effects of emotional support from children (scale: 1–8), which was weakly correlated with coresidency and frequency of contact ($r = .03$ and $r = .09$, respectively). However, the amount of emotional support received was measured at the respondent level and referred to all children rather than a specific child. Because of the different way that emotional support was assessed and because this measure was not a significant mediator in our analysis, we do not present the results for emotional support in this study.

Methods

To investigate the effects of children's schooling on the cognitive functioning of older adults, we estimated two sets of models. First, we used ordinary least squares (OLS) to regress both the composite score and the seven scores across cognitive tasks separately for men and women:

$$y_i = \alpha + \beta child\_edu_i + \Phi \mathbf{Control}_i + \varepsilon_i. \tag{1}$$

In Eq. (1), y_i is the cognitive function measure of interest of respondent i; $child\_edu_i$ is the educational attainment of the highest-educated child, measured in years of schooling. $\mathbf{Control}_i$ is the vector of child and respondent characteristics, described in the Measures section. ε_i is the error term, and all standard errors are adjusted for heteroskedasticity. We used a progressive adjustment strategy with nested models to assess how the addition of controls changes the association between children's education and parents' cognitive functioning. Model 1 includes year of education of the highest-educated child, parents' demographic characteristics, and children's age and gender. Model 2 adds controls for locality size to account for urban/rural differences. Early-life conditions are included in Model 3.

Although the OLS regression models shed light on the potential impact of offspring education on later-life cognitive abilities, omitted variables—unobserved individual or familial characteristics that correlate with both the cognitive abilities of older adults and the education of their children—could bias our results. In addition, reverse causality bias might also be present in our OLS analysis, such that parents with greater cognitive reserves are more likely to invest in children's education. To improve the causal interpretation of our study, our second analysis used an instrumental variables (IV) regression/two-stage least squares approach. We exploited the 1993 educational policy change in Mexico, which raised compulsory education from six to nine years of schooling. This policy change implied that in 1993, children aged 14 and younger would be required to finish lower secondary school, whereas children of older ages would not be required to do so.

Figure 1 shows the average years of schooling for cohorts born between 1942 and 1992 for all children and the highest-educated children of respondents in the MHAS 2012. Quadratic fitted lines are drawn separately for children born before 1979 and those born in 1979 or later. Consistent with past research (Creighton and Park 2010; Urbina 2018), the figure implies a jump in years of schooling for the 1979 cohort among all children and among the highest-educated children; therefore, we used 1979 as the cutoff birth cohort to identify the policy exposure of children. We also analyzed the 2010 Mexican census for the distribution of completed years of schooling among birth cohorts born between 1976 and 1984. Figure A1 of the online appendix illustrates that the completion of at least nine years of schooling among the 1979 cohort increased by 4 percentage points (or 8.0%), compared with the 1976–1978 average.[2] The findings of past research (Creighton and Park 2010; Urbina 2018), census data, and data from the children in the MHAS support our empirical strategy of using the change in compulsory education policy as a natural experiment.

Children's exposure to the 1993 educational reform, csl_i, was used as the instrument for years of schooling, which identified the effects of children's education on parents' old-age cognition. In our sample, 44.67% of parents had at least one child

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[2] In addition, educational attainment declined among the 1980 cohort, possibly because of the peso crisis of 1994. The crisis would have affected school enrollment among the 1980 birth cohort of adults, who would have transitioned to lower secondary school during this time. Although studies have generally found a negligible effect of the peso crisis on increasing child labor, prior studies did find a significant effect on decreasing school attendance, particularly among girls (Skoufias and Parker 2006). However, the completion rate recovered and increased gradually (at 2 percentage points) among post-1980 cohorts.

who was exposed to the 1993 reform. The first stage is given by Eq. (2), where csl_i equals 1 if the highest-educated child of respondent i was born in or after 1979 and was affected by the policy reform, and 0 if the child was born before 1979:

$$child\_edu_i = \gamma + \varphi csl_i + \eta \mathbf{Control}_i + \nu_i. \tag{2}$$

φ measures the increase in years of schooling due to the policy change, everything else equal. Equation (1) then becomes Eq. (3), the second-stage equation with $child\_edu_i$ replaced by its prediction from the first stage:

$$y_i = \alpha + \beta \widehat{child\_edu_i} + \Phi \mathbf{Control}_i + \varepsilon_i. \tag{3}$$

β then can be interpreted as the increase in cognition score as a result of a one-year increase in years of schooling of the highest-educated child. We used a similar progressive adjustment strategy for the IV estimates as described earlier for the OLS models.

To ensure that csl_i is a valid instrument, we assumed that the exposure to the 1993 educational policy is uncorrelated with the cognition outcomes of parents, except through its effect on the educational attainment of children. If other unaccounted-for policy changes or cohort trends also affect children's education as well as parents' cognition, the IV approach might not be valid.[3] Therefore, we accounted for complex cohort trends in children's educational attainment by controlling for a quadratic function of children's age in 2012. In addition, as important policy changes that could more directly affect health outcomes, cash transfer programs (*Oportuninades*/*Prospera*) and universal healthcare (*Seguro Popular*) were not adopted until 1997 and 2002, respectively. And even then, programs were phased in slowly across different parts of Mexico. We are also unaware of other concurrent health or social policies that would affect the cognition of parents in a manner that depends on the birth cohorts of children. Furthermore, we tested the sensitivity of our results to alternative control functions for children's age (cohort), ranges of children's ages, and parents' ages in the Robustness Checks section.

We examined both the composite cognitive functioning score and individual cognitive task scores. Additionally, we investigated the extent to which geographical proximity and contacts of children could explain the association and causal relationship between children's education and parents' cognitive health. We extended the fully adjusted OLS and IV regressions by adding either the binary indicator for coresidence or the frequency of contact variable as a control variable. Finally, to assess whether the relationships between children's education and different dimensions of parents' cognitive health differ for mothers versus fathers, we also conducted the same analysis for men and women separately.

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[3] The IV approach used in this paper is similar to the regression discontinuity design, wherein eligibility or treatment status is determined by an institutional rule that generally requires an assignment variable to fall above (or below) an exogenous threshold. Under the assumption that without the educational policy reform, children's education would be continuous against the assignment variable and some other premises, any discontinuity in children's education at the cutoff is due to the effects of the educational reform (Lee and Lemieux 2010).

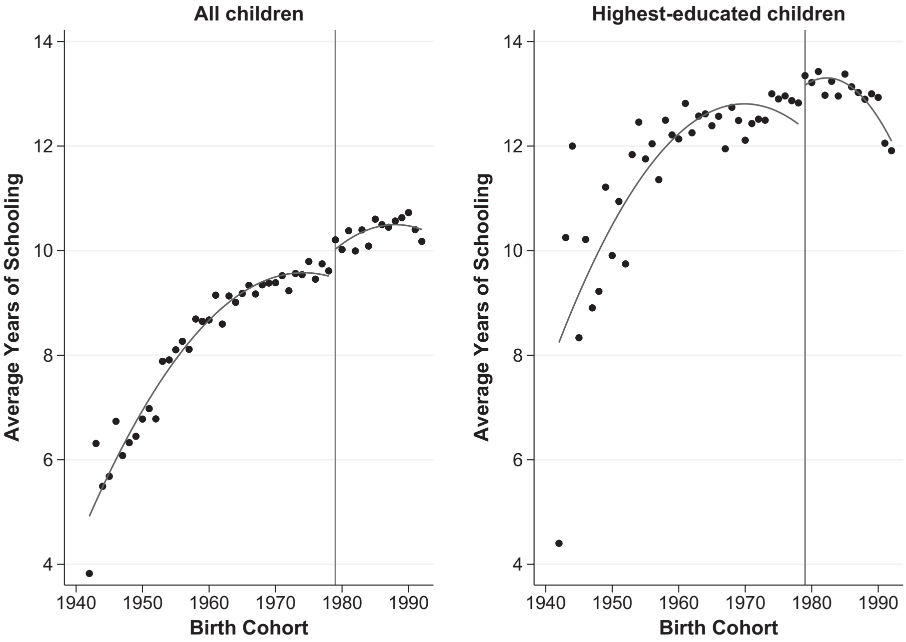

Fig. 1 Educational attainment of the children of Mexicans aged 50+. Average years of schooling by cohort are calculated for all children and highest-educated children, respectively. Quadratic fitted lines are drawn separately for children born before 1979 and in 1979 or later.

Results

Descriptive Statistics

Table 1 presents descriptive characteristics of our sample. Note that sample sizes for outcome variables differ given variation in missingness across the different cognitive tasks.[4] However, the substantive results for our main analyses were similar for an analytic sample that was held to be the same across measures (see the Robustness Checks section). In general, mean cognitive scores across the different tasks suggest that the average respondent was able to complete many of the assigned tasks. The average respondent in the sample scored 5.569 for visuospatial ability and 4.864 for visual memory (on a scale of 0 to 6). Orientation scores also indicate that, on average, respondents correctly listed at least two components of the day, month, or year (2.531 of 3). The average respondent named a little more than 15 animals on the verbal fluency assessment. Pearson correlations between each of the cognitive domains ranged from moderate (verbal learning and verbal learning $r = .613$) to weak (verbal learning

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[4] Specifically, among all respondents aged 50 and older who are not proxies, the frequency of missing values is higher in visual scanning (9.9%), visuospatial abilities (9.5%), and visual memory (10.8%) than for verbal learning (2.8%), verbal recall (3.3%), verbal fluency (3.0%), and orientation (2.5%). There is no gender difference in the likelihood of missing data in any of the domains.

Table 1 Descriptive statistics, Mexicans aged 50+

	Entire Sample		Men		Women	
	Mean	SD	Mean	SD	Mean	SD
Cognitive Batteries						
Composite cognition score	–0.026	0.702	–0.034	0.680	–0.021	0.719
Verbal learning score (0–8)	4.847	1.213	4.673	1.230	4.980	1.183
Verbal recall score (0–8)	4.497	2.007	4.162	2.038	4.755	1.945
Visual scanning score (0–60)	29.588	15.254	29.862	15.166	29.376	15.320
Verbal fluency score (0–60)	15.325	5.141	15.677	5.205	15.054	5.075
Orientation score (0–3)	2.531	0.779	2.559	0.748	2.509	0.800
Visuospatial ability score (0–6)	5.569	1.023	5.641	0.927	5.514	1.089
Visual memory score (0–6)	4.864	1.594	4.950	1.587	4.798	1.596
Child's Characteristics						
Years of schooling of the highest-educated child	13.189	3.827	13.139	3.838	13.228	3.819
Son (%)	50.357		50.179		50.493	
Child's age in 2012	35.799	9.479	34.715	9.172	36.634	9.628
Demographic Characteristics						
Own years of schooling	6.015	4.748	6.530	5.117	5.619	4.402
Number of children	5.023	2.820	5.041	2.800	5.008	2.835
Own age in 2012	64.589	9.170	65.478	9.131	63.906	9.142
Male (%)	43.488					
Marital status (%)						
Married	71.822		85.692		61.148	
Widowed	17.841		8.718		24.862	
Divorced, separated, never married	10.337		5.590		13.990	
Speaks an indigenous dialect (%)	7.070		7.949		6.393	
Locality size (%)						
100,000+	61.987		59.897		63.595	
15,000–99,999	11.229		11.231		11.227	
2,500–14,999	9.880		10.359		9.511	
<2,500	16.905		18.513		15.667	
Early-Life Characteristics						
Height in cm	159.824	9.681	166.301	8.041	154.840	7.679
Mother's education (%)						
No education	48.272		49.513		47.316	
Incomplete elementary education	35.281		33.872		36.365	
Elementary education	11.407		11.641		11.227	
Beyond elementary education	5.040		4.974		5.091	
Father's education (%)						
No education	41.503		43.077		40.292	
Incomplete elementary education	37.745		36.872		38.418	
Elementary education	12.924		12.462		13.279	
Beyond elementary education	7.828		7.590		8.011	
No toilet in household prior to age 10 (%)	67.328		68.692		66.279	
Often went to bed hungry prior to age 10 (%)	28.869		31.308		26.993	
Did not wear shoes regularly prior to age 10 (%)	20.473		21.026		20.047	
Self/siblings had to drop out of school to support family prior to age 10 (%)	40.812		43.000		39.128	

Table 1 (continued)

	Entire Sample		Men		Women	
	Mean	SD	Mean	SD	Mean	SD
Self/family member slept in the same room used to prepare food prior to age 10 (%)	22.346		23.256		21.646	
Family received financial assistance prior to age 10 (%)	9.935		10.179		9.747	
Intergenerational Support Measures						
Coresidence with highest educated child (%)	49.690		50.602		49.031	
Frequency of contact per year with highest educated child (0–365)[a]	257.934	150.885	257.063	151.537	258.5631	150.427
Number of Observations	8,968		3,900		5,068	

Source: Mexican Health and Aging Study, 2012.

[a] Total number of observations for social support variables is 6,931.

and visuospatial ability $r = .212$). Pearson correlations between each of the cognitive domains are presented in Table A1 of the online appendix.

The respondents were born between 1910 and 1962 (mean 1947) and, on average, were age 65, had five children, and were married in 2012. Children were born between 1942 and 1992 (mean 1976) and were, on average, 36 years old in 2012. Respondents themselves had an average of six years of schooling (an elementary school education), which is reflective of the older birth cohorts in the sample. Children in the sample were more educated than parents, with the average highest-educated child having completed more than 13 years of schooling, the equivalent of more than an upper secondary school education in Mexico. The sample of highest-educated children in our sample is evenly split between sons and daughters.

Ordinary Least Squares Results

Table 2 presents the OLS models, with nested models predicting the composite cognitive functioning score. In Model 1, the years of schooling of the highest-educated child was positively and significantly associated with higher scores for parents' overall cognition even after we accounted for the parent's own years of education. However, the effect size was small: each additional year of schooling for the highest-educated child equated to a 0.024 standard deviation increase in the composite cognition score for the respondent. Not surprisingly, more-educated parents also tended to have higher overall cognitive scores. Here, the magnitude was greater: each year of respondent schooling was associated with a 0.053 standard deviation increase in the composite cognitive score after we accounted for years of education of the highest-educated child. Fathers had worse cognitive health than mothers, although the difference was not significant in Model 1, and having more children was associated with worse parental cognitive functioning. Model 2 added controls for locality size, but the main results

Table 2 Regression coefficients from models predicting standardized cognitive composite score, Mexicans aged 50+

	Composite Cognition Score		
	Model 1	Model 2	Model 3
Child's Characteristics			
Years of schooling of the highest-educated child	0.024***	0.023***	0.021***
	(0.002)	(0.002)	(0.002)
Child's age in 2012	0.014**	0.013**	0.012**
	(0.005)	(0.005)	(0.005)
Child's age in 2012, squared	–0.000*	–0.000*	–0.000*
	(0.000)	(0.000)	(0.000)
Son	0.012	0.014	0.013
	(0.011)	(0.011)	(0.011)
Demographic Characteristics			
Own years of schooling	0.053***	0.052***	0.046***
	(0.001)	(0.001)	(0.002)
Number of children	–0.011***	–0.009***	–0.008***
	(0.002)	(0.002)	(0.002)
Own age in 2012	0.044***	0.043***	0.043***
	(0.010)	(0.010)	(0.010)
Own age in 2012, squared	–0.001***	–0.001***	–0.001***
	(0.000)	(0.000)	(0.000)
Male	–0.018	–0.017	–0.049***
	(0.012)	(0.012)	(0.015)
Marital status (ref. = married)			
Widowed	–0.022	–0.026	–0.022
	(0.018)	(0.018)	(0.018)
Divorced, separated, never married	–0.012	–0.017	–0.014
	(0.018)	(0.018)	(0.018)
Speaks an indigenous dialect	–0.156***	–0.146***	–0.112***
	(0.023)	(0.024)	(0.024)
Locality (ref. = 100,000+)			
15,000–99,999		–0.017	–0.008
		(0.018)	(0.018)
2,500–14,999		–0.049*	–0.038*
		(0.019)	(0.019)
<2,500		–0.068***	–0.057**
		(0.018)	(0.018)
Early-Life Characteristics			
Height in cm			0.004***
			(0.001)
Mother's education (ref. = no education)			
Incomplete elementary education			0.055***
			(0.014)
Elementary education			0.019
			(0.022)
Beyond elementary education			0.021
			(0.030)
Father's education (ref. = no education)			
Incomplete elementary education			0.045**
			(0.015)
Elementary education			0.066**
			(0.021)

Table 2 (continued)

	Composite Cognition Score		
	Model 1	Model 2	Model 3
Beyond elementary education			0.081** (0.026)
No toilet in household prior to age 10			–0.015 (0.013)
Often went to bed hungry prior to age 10			–0.003 (0.015)
Did not wear shoes regularly prior to age 10			–0.015 (0.015)
Self/siblings had to drop out of school to support family prior to age 10			–0.004 (0.013)
Self/family member slept in the same room used to prepare food prior to age 10			–0.018 (0.015)
Family received financial assistance prior to age 10			–0.021 (0.019)
Constant	–1.458*** (0.288)	–1.366*** (0.289)	–1.869*** (0.308)
Number of Observations	8,968	8,968	8,968

Note: Robust standard errors are shown in parentheses.

Source: Mexican Health and Aging Study, 2012.

$^{\dagger}p<.10$; $^{*}p<.05$; $^{**}p<.01$; $^{***}p<.001$

for children's education remain similar. The gender difference in the summary cognition score becomes significant in Model 3 when early-life conditions are accounted for, but very few of the early-life indicators are significant. The association between a child's schooling and parents' overall cognitive score remains positive, although the magnitude of the coefficient is slightly smaller than in Models 1 and 2.

Table 3 presents abbreviated OLS model results across all seven cognitive tasks. The coefficients for children's schooling suggest that similar to the composite score, more years of schooling is positively associated with parents' verbal learning and recall, visual scanning, verbal fluency, visuospatial ability, visual memory, and orientation. However, the strength of the association clearly varies across outcomes. For example, an extra year of schooling among children is associated with a 0.011 standard deviation increase on the visual memory task, compared with a 0.026 standard deviation increases on the orientation scale.

Instrumental Variable Results

Table 4 presents results from the first-stage regression using the instrumental variables (IV) approach. In Model 1, the results demonstrate a positive and significant effect of exposure to the compulsory schooling reform on children's years of schooling. Exposure to the 1993 reform increased the average years of schooling by 0.692 years for an average child in the sample. The size of the coefficient barely changes

Table 3 Regression coefficients from models predicting specific cognitive scores, Mexicans aged 50+

	Verbal Learning Score	Verbal Recall Score	Visual Scanning Score	Verbal Fluency Score	Orientation Score	Visuo-spatial Ability Score	Visual Memory Score
Years of Schooling of the Highest-Educated Child	0.024*** (0.003)	0.018*** (0.003)	0.025*** (0.002)	0.023*** (0.003)	0.026*** (0.003)	0.016*** (0.004)	0.011*** (0.003)
Own Years of Schooling	0.051*** (0.003)	0.033*** (0.003)	0.073*** (0.003)	0.054*** (0.003)	0.035*** (0.003)	0.034*** (0.003)	0.034*** (0.003)
Number of Observations	8,916	8,875	8,393	8,897	8,937	8,412	8,309

Notes: Results are from fully adjusted models. All models include controls for child characteristics, demographic characteristics of the respondent, locality size, and early-life conditions. Robust standard errors are shown in parentheses.

Source: Mexican Health and Aging Study, 2012.

***$p<.001$

when controls at the child or parent level, including early-life indicators, are added to the model. F statistics of the reform exposure variable from the first stage are well above 10, indicating the strength of the instrument (Staiger and Stock 1997).

Table 5 presents results for the second-stage regression. In Model 1, years of schooling of the highest-educated child are positively associated with parents' overall cognitive score. The magnitude of the coefficient for child's education in the IV model was also greater than in the OLS models. In Model 3, which includes the full set of controls, an increase in one year of schooling led to a 0.074 increase in the standard deviation of the composite cognitive score, compared with a 0.021 increase in the equivalent OLS model. Results for the controls are similar to the OLS models with the exception of respondents' own education. The magnitudes of the coefficients for respondents' own education are reduced in IV models and less salient than children's education. However, given that the estimate for respondents' own education is biased because of potential endogeneity, the two coefficients are not comparable. Indeed, it is also possible that respondents' own education matters less for cognitive health: prior research on mortality has found similar results with respect to the size of the coefficient for respondents versus children's schooling in later life (Zimmer et al. 2007).

The IV results across different cognitive tasks are presented in Table 6. Unlike the OLS estimates, the second-stage results suggest that only for verbal learning, verbal fluency, and orientation are children's years of schooling significant. Note that the effect sizes also vary across these outcomes: the effect from offspring education on parents' verbal fluency ($b=0.166$, $p<.01$) is stronger than the coefficient for verbal learning ($b=0.109$, $p<.05$). Similar to the composite score, the coefficients for children's education for these outcome measures suggest stronger effect sizes compared with the standard OLS approach.

Next, we investigated whether intergenerational support from children could explain

Table 4 Regression coefficients from first stage for instrumental variable models predicting standardized composite score, Mexicans aged 50+

	Years of Schooling of Highest-Educated Child		
	Model 1	Model 2	Model 3
Exposure to 1993 Compulsory School Reform	0.692*** (0.128)	0.694*** (0.127)	0.684*** (0.126)
Control: Child's Characteristics, Demographic Characteristics	Y	Y	Y
Control: Locality	N	Y	Y
Control: Early-Life Characteristics	N	N	Y
F Statistics	29.06	30.02	29.61
Number of Observations		8,968	

Note: Robust standard errors are shown in parentheses.

Source: Mexican Health and Aging Study, 2012.

***$p < .001$

the association and causal relationship between children's education and parental cognitive health. In Table 7, we present results for mediating effects of geographic proximity and frequency of contact between parents and children. Sample sizes are reduced because of missingness in the frequency of contact variable. However, neither the OLS nor the IV estimates are mediated by these two intergenerational support measures. This is true for the overall cognitive ability and for separate cognitive tasks.

Gender Differences

To assess whether mothers or fathers differentially benefited from the education of their children, we estimated the effects of children's years of schooling on both the composite measure and across the various cognitive tasks using the IV models separately for men and women. The results underscore gender differences for the composite score, verbal fluency, and orientation. We present the predicted scores for mothers versus fathers in Figure 2, controlling for the full set of covariates in Model 3; the regression coefficients are reported in the online appendix, Table A2. Table A2 and panel a of Figure 2 show that for the composite score, the effect of children's education is more salient for mothers than for fathers ($p < .10$). Similar to the results for the sample of women and men together (Table 5), having highly educated children translated to higher composite scores among mothers. For instance, mothers whose child attained 16 years of schooling had cognition scores that were nearly 1 standard deviation above the average, whereas mothers whose highest-educated child completed eight years of schooling scored 1 standard deviation below the average. However, the confidence intervals surrounding the predicted estimates suggest that the difference is clearly demarcated by those offspring with more than a high school education (14 years of schooling or more) versus those with a high school education or less. Panels b and c of Figure 2 present similar results for mothers' versus fathers' differences in verbal fluency and orientation. Although fathers also benefitted from

Table 5 Regression coefficients from instrumental variable models predicting standardized composite score, Mexicans aged 50+

	Composite Cognition Score		
	Model 1	Model 2	Model 3
Child's Characteristics			
Years of schooling of the highest-educated child	0.076*	0.076*	0.074*
	(0.031)	(0.031)	(0.032)
Child's age in 2012	0.010†	0.010†	0.010†
	(0.006)	(0.005)	(0.005)
Child's age in 2012, squared	–0.000	–0.000	–0.000
	(0.000)	(0.000)	(0.000)
Son	0.012	0.011	0.010
	(0.012)	(0.012)	(0.012)
Demographic Characteristics			
Own years of schooling	0.033**	0.033**	0.030**
	(0.012)	(0.011)	(0.009)
Number of children	–0.012***	–0.012***	–0.011***
	(0.003)	(0.003)	(0.003)
Own age in 2012	0.027†	0.027†	0.027*
	(0.015)	(0.014)	(0.014)
Own age in 2012, squared	–0.000***	–0.000***	–0.000***
	(0.000)	(0.000)	(0.000)
Male	0.013	0.013	–0.006
	(0.023)	(0.022)	(0.030)
Marital status (ref. = married)			
Widowed	–0.001	0.001	0.002
	(0.022)	(0.024)	(0.023)
Divorced, separated, never married	0.012	0.014	0.015
	(0.024)	(0.026)	(0.025)
Speaks an indigenous dialect	–0.129***	–0.131***	–0.115***
	(0.029)	(0.026)	(0.025)
Locality (ref. = 100,000+)			
15,000–99,999		–0.003	0.001
		(0.021)	(0.020)
2,500–14,999		–0.013	–0.009
		(0.028)	(0.026)
<2,500		0.028	0.031
		(0.059)	(0.055)
Early-Life Characteristics			
Height in cm			0.002†
			(0.001)
Mother's education (ref. = no education)			
Incomplete elementary education			0.039*
			(0.018)
Elementary education			–0.009
			(0.028)
Beyond elementary education			–0.007
			(0.035)
Father's education (ref. = no education)			
Incomplete elementary education			0.024
			(0.020)
Elementary education			0.049*
			(0.025)

Table 5 (continued)

	Composite Cognition Score		
	Model 1	Model 2	Model 3
Beyond elementary education			0.060*
			(0.030)
No toilet in household prior to age 10			–0.013
			(0.014)
Often went to bed hungry prior to age 10			0.016
			(0.019)
Did not wear shoes regularly prior to age 10			–0.007
			(0.017)
Self/siblings had to drop out of school to support family prior to age 10			–0.012 (0.014)
Self/family member slept in the same room used to prepare food prior to age 10			0.000 (0.020)
Family received financial assistance prior to age 10			–0.019
			(0.020)
Constant	–1.334***	–1.364***	–1.655***
	(0.310)	(0.303)	(0.347)
Number of Observations	8,968	8,968	8,968

Notes: Robust standard errors are shown in parentheses.

Source: Mexican Health and Aging Study, 2012.

$^\dagger p<.10$; $*p<.05$; $**p<.01$; $***p<.001$

having more-educated children with respect to their verbal fluency outcome, mothers' verbal fluency was more sensitive to each level of children's schooling.

Robustness Checks

We conducted several additional checks to further investigate the robustness of our results, including testing (1) different measures of children's educational attainment, (2) alternative specifications, and (3) the sensitivity of our results to sample selection issues.

Measure of Children's Education

In the main analysis, we specified children's education as years of schooling of the highest-educated child. We are aware that findings for the highest-educated children might not be valid for other children. Therefore, we analyzed the least-educated child and the education of all children pooled together, as in Lundborg and Majlesi (2018). Table A3 of the online appendix shows that alternative measures of children's education render similar associations with parental cognitive functioning in OLS estimations. However, IV regression results suggest that the specification of children's education *does* matter; in other words, some children matter more than others for

Table 6 Regression coefficients from instrumental variable models predicting specific cognitive scores, Mexicans aged 50+

	Verbal Learning Score	Verbal Recall Score	Visual Scanning Score	Verbal Fluency Score	Orientation Score	Visuospatial Ability Score	Visual Memory Score
Years of Schooling of the Highest-Educated Child	0.109*	0.073	0.009	0.166**	0.107*	0.012	0.028
	(0.052)	(0.053)	(0.048)	(0.058)	(0.054)	(0.054)	(0.055)
Own Years of Schooling	0.026†	0.017	0.077***	0.012	0.011	0.035*	0.029†
	(0.016)	(0.016)	(0.014)	(0.017)	(0.016)	(0.016)	(0.016)
First Stage							
Exposure to 1993 compulsory school reform	0.675***	0.686***	0.662***	0.700***	0.684***	0.678***	0.683***
	(0.126)	(0.126)	(0.128)	(0.126)	(0.126)	(0.128)	(0.128)
F Statistics	28.69	29.62	26.63	30.81	29.5	28.11	28.48
Number of Observations	8,916	8,875	8,393	8,897	8,937	8,412	8,309

Notes: Results are from fully adjusted models. All models include controls for child characteristics, demographic characteristics of the respondent, locality size, and early-life conditions. Robust standard errors are shown in parentheses.

Source: Mexican Health and Aging Study, 2012.

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

parental cognition. The IV estimates were not significant when we coded children's education based on the parent's *least*-educated child. When we pooled all parent-child pairs in the regressions, the IV estimates for children's education remained significant for verbal fluency and orientation of women, but the size of effects were reduced compared with the results for highest-educated children. These findings indicate that children with different levels of educational attainment may have different roles in preserving parental cognitive abilities in old age. Given that past work has found that the influence on health is strongest from those offspring with the highest level of education and hence more resources (e.g., Zimmer et al. 2007), we believe it is reasonable to measure children's education as the highest amount among all children, at least in this context. We return to this finding in the Discussion section.

Specification

Another concern regarding the validity of our results is whether exposure to the compulsory education reform satisfies the exclusion restriction and is relevant in changing children's educational attainment in Mexico. In the main analysis, we analyzed parents aged 50 and older with children aged 20–70 and included a quadratic function of children's age to control for the cohort trend in children's education and parental cognitive health. We therefore assumed that conditional on the continuous cohort trend, the

Table 7 Tests of mechanism: Coresidency and frequency of contact, Mexicans aged 50+

	No Mediators	Coresi-dency	Frequency of Contact
Composite Cognition Score			
OLS, all			
Years of schooling of children	0.020***	0.020***	0.020***
	(0.002)	(0.002)	(0.002)
IV, all			
Years of schooling of children	0.080*	0.091†	0.081†
	(0.039)	(0.047)	(0.043)
Number of observations	6,931	6,931	6,931
Standardized Verbal Learning Score			
OLS, all			
Years of schooling of children	0.022***	0.022***	0.021***
	(0.003)	(0.003)	(0.003)
IV, all			
Years of schooling of children	0.127†	0.140†	0.126†
	(0.065)	(0.077)	(0.071)
Number of observations	6,887	6,887	6,887
Standardized Verbal Recall Score			
OLS, all			
Years of schooling of children	0.019***	0.018***	0.018***
	(0.003)	(0.003)	(0.003)
IV, all			
Years of schooling of children	0.110†	0.119	0.112
	(0.066)	(0.078)	(0.072)
Number of observations	6,854	6,854	6,854
Standardized Visual Scanning Score			
OLS, all			
Years of schooling of children	0.026***	0.026***	0.025***
	(0.003)	(0.003)	(0.003)
IV, all			
Years of schooling of children	–0.038	–0.055	–0.056
	(0.062)	(0.076)	(0.070)
Number of observations	6,428	6,428	6,428
Standardized Verbal Fluency Score			
OLS, all			
Years of schooling of children	0.023***	0.023***	0.023***
	(0.003)	(0.003)	(0.003)
IV, all			
Years of schooling of children	0.174*	0.200*	0.185*
	(0.073)	(0.087)	(0.080)
Number of observations	6,872	6,872	6,872
Standardized Orientation Score			
OLS, all			
Years of schooling of children	0.025***	0.025***	0.025***
	(0.004)	(0.004)	(0.004)
IV, all			
Years of schooling of children	0.073	0.087	0.079
	(0.063)	(0.074)	(0.069)
Number of observations	6,907	6,907	6,907
Standardized Visuospatial Ability Score			
OLS, all			
Years of schooling of children	0.019***	0.019***	0.019***
	(0.004)	(0.004)	(0.004)

Table 7 (continued)

	No Mediators	Coresidency	Frequency of Contact
IV, all			
Years of schooling of children	0.032	0.055	0.039
	(0.070)	(0.087)	(0.078)
Number of observations	6,456	6,456	6,456
Standardized Visual Memory Score			
OLS, all			
Years of schooling of children	0.012**	0.011**	0.011**
	(0.004)	(0.004)	(0.004)
IV, all			
Years of schooling of children	0.021	0.014	0.017
	(0.071)	(0.086)	(0.079)
Number of observations	6,368	6,368	6,368

Notes: Results from fully adjusted models. The first column reports results from Model 3 on sample with nonmissing intergenerational support variables. All models include controls for: child characteristics, demographic characteristics of respondent, locality size, and early-life conditions. Robust standard errors in parentheses.

Source: Mexican Health and Aging Study, 2012.

$^{\dagger}p<.10$; $*p<.05$; $**p<.01$; $***p<.001$

exposure to the law introduced exogenous variation in children's years of education and did not have a direct impact on parental cognitive abilities. However, if the control function of age is misspecified, given the wide age range of children and hence the wide age range of parents, the validity of the instrument could be compromised, and IV estimates could be inconsistent. Therefore, we tested the sensitivity of our results to alternative specifications of ranges of children's ages and parents' ages. In Table A4 of the online appendix, columns 1–4, we find substantively similar OLS and IV estimates when we controlled for a third-order polynomial of children's age, and when we restricted the sample of three bandwidths relative to the 1979 cohort: [–20,10], [–15,10], and [–10,10]. In column 5, we kept only those parents aged 50–70 and found similar results. Notably, because age ranges were restricted, the IV coefficients were less precisely estimated and the first stage became weaker, as suggested by the *F* statistics; the size and sign of the effects, however, were similar to the main results.[5]

We also found that our IV estimates for children's education were larger than that for parental own education and its OLS estimate. To rule out the possibility that the large effects of children's education were due to the high correlation between education of parents and children, we tested whether our results changed when parent's own education was removed from the model. In Table A5 of the online appendix, we found that although OLS estimates for children's education increased as expected, the IV estimates were largely unchanged. Note that the causal estimates of children's education and noncausal estimates of parents' own education are not comparable because unlike the estimates for children's education, the estimates of parents' own

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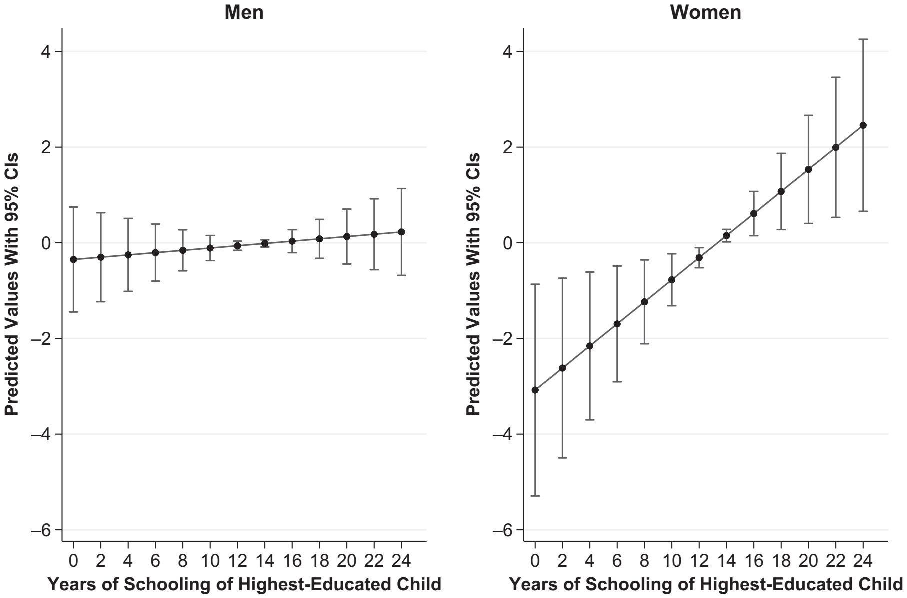
[5] Results by gender are available upon request.

a. Composite cognition score



b. Standardized verbal fluency

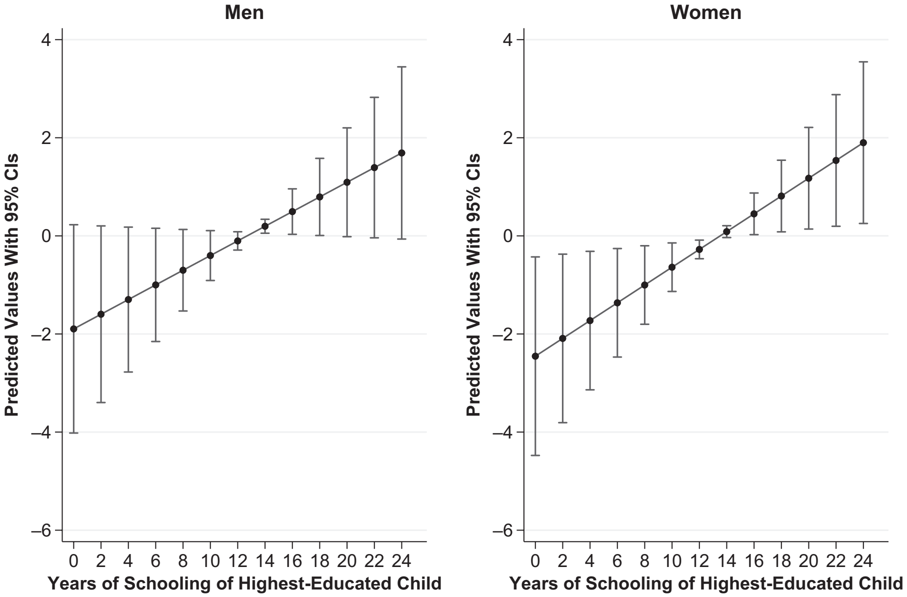


Fig. 2 Predicted cognition scores with 95% confidence intervals (CIs) of Mexicans aged 50+ from instrumental variable models with full set of controls by gender. All covariates are held at their means.

(continued)

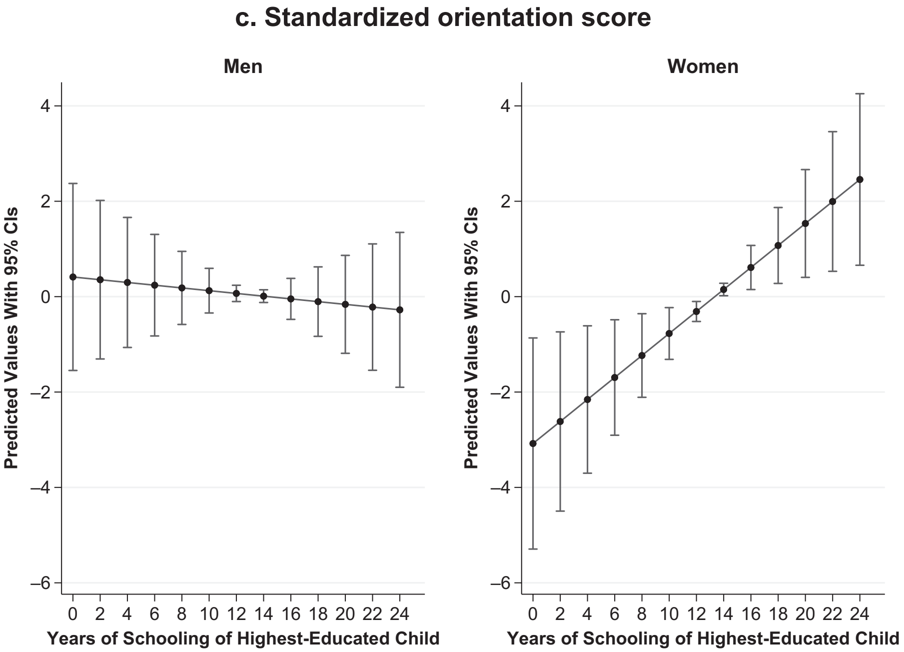


Fig. 2 (continued)

education are likely biased. It is also common to find that IV estimates appear larger than OLS estimates (e.g., De Neve and Fink 2018) because IV regressions estimate local average treatment effects, which place greater weight on those most affected by instruments. That is, children whose education was most directly affected by the change in compulsory schooling law might also be the same children whose families benefited more from educational resources.

Sample Selection

Our sample might be selective on cognitive health by including respondents of older ages who were subject to a higher mortality risk, excluding respondents who were proxies in the 2012 survey, or excluding those respondents who had missing information on control variables or all cognition tasks. Therefore, we tested the sensitivity of our results against different sampling criterion.

First, results shown in Table A6 of the online appendix confirm that the final analytic sample had higher cognitive scores in each domain compared with the average nonproxy Mexican parent aged 50 and older with no missing scores in that domain.

Second, the sample size was substantially reduced when we controlled for early-life conditions. In addition, we calculated the difference in each cognitive domain between respondents in our analytical sample and those excluded because of missingness in early-life variables and all nonproxy Mexican parents aged 50 and over with no missing scores in that domain. The differences were either insignificant or greatly reduced in size. We then reestimated the relation between children's education and parental cognitive health by adding back parents with missing information on early-life conditions and dropping the early-life variables as controls. As shown in panel A of Table A7 (online appendix), the results were substantively similar to the main analysis, although the size of the IV estimates was reduced.

Third, we tested whether the heterogeneous results for different cognitive domains were due to different sample selection criteria. We fit the models across all domains of cognitive functioning using the same sample of respondents who were not missing information on any of the cognitive tasks. Results of OLS and IV estimations, as presented in panel B of Table A7 (online appendix), are similar to those of the main analysis. Hence, we argue that allowing for different sample sizes is not driving the heterogenous results across cognitive domains.

Fourth, we gauged the implications of mortality selection on our results by limiting our sample to younger parents and found that the overall results were robust (see Table A4, column 5, online appendix). The patterns from OLS and IV estimations were similar to the main analysis.

Finally, because we excluded those who required proxies or had missing cognitive scores in all domains, we are likely to have excluded those with the worst cognitive abilities. We addressed this issue by testing whether adding back respondents with missing cognitive scores in 2012 using their 2003 values as approximations would change our results. We did so for verbal learning, verbal recall, visual scanning, and orientation, which have consistent coding across waves, as well as for the summary cognition score. To control for the fact that respondents might be healthier in 2003 and to adjust for potential wave-specific effects, we added a wave dummy variable for the year of cognitive tasks in the regression. Panel C of Table A7 (online appendix) shows both the OLS and IV results are substantively comparable with the main results, implying that our results are not largely biased by excluding respondents who were not able to complete the cognitive tasks in the 2012 survey.

Discussion

As social factors have become increasingly important for cognition in older ages, past research has underscored the positive relationship between education and cognitive health among older adults (Langa et al. 2008). Whereas most of this work has examined the effect of one's own education on cognitive functioning, recent research has pointed to the importance of considering the education of family members—both parents and offspring—as potential resources that also determine individual cognition in older adulthood (Al Hazzouri et al. 2011; Fors et al. 2009; Glymour and Manly 2008; Lee 2018; Ma 2019; Yahirun et al. 2020; Zhang et al. 2016). The resources of adult children may be an especially critical yet often overlooked factor for many older adults in contexts such as Mexico, where offspring are the primary caregivers for older parents (Angel et al. 2016; Angel et al. 2017). Nearly all (95%) adults aged 50 and older in Mexico have at least one child, making children and their resources a highly relevant topic to consider given the large number of older adults who benefit from their child's education. The importance of the resources that children provide are amplified by the ongoing role that intergenerational support plays in Mexico (Angel et al. 2016; Angel et al. 2017).

This study expanded on recent work assessing the relationship between offspring education and parents' cognitive health in East Asia (Lee 2018; Ma 2019) and the United States (Yahirun et al. 2020) in a number of important ways. First, we exploited the 1993 educational policy reforms in Mexico that raised compulsory schooling from grade 6 (completion of elementary school) to grade 9 (completion of lower secondary school). We used the exogenous policy changes to compulsory schooling in an IV approach (Glymour et al. 2008) and compare our results with findings from standard OLS regression models. Using policy reforms as an IV helps reduce the endogeneity bias frequently present in the growing body of work examining how children's education affects parental health (De Neve and Fink 2018; Lundborg and Majlesi 2018). We found that in the IV analyses, a child's educational attainment was significantly associated with better general cognitive ability among parents.

Second, we built on previous work by assessing different domains of cognitive health. Prior research has found that the variance explained by educational attainment may differ across cognitive domains (Guerra-Carrillo et al. 2017). Applying the standard OLS framework, we found that children's schooling was positively associated with parental health across all domains of cognitive functioning. However, only some of these findings were robust when the IV approach was applied. Based on the IV estimates, each year of children's schooling was associated with only verbal learning, verbal fluency, and orientation.

Pinpointing the cognitive health outcomes that are affected by children's education could help shed light on the mechanisms through which children influence parental cognitive functioning. To understand why children's education may matter for some domains but not others, we return to the aims of specific tasks used to measure cognitive health. Cognitive health researchers have argued that verbal learning and verbal fluency tasks measure underlying verbal ability (Shao et al. 2014), and verbal fluency is also linked to vocabulary size (Sauzéon et al. 2011). Prior work has highlighted how rich communication may help maintain and strengthen vocabulary size and verbal abilities in later life, and social interaction has been associated with better semantic memory (measured using a verbal fluency task among other items) and slower declines in semantic memory (James et al. 2011). Previous research has also found that a higher level of social engagement with children was associated with better cognitive functioning and slower cognitive decline using a measure that included orientation tasks (Béland et al. 2005; Zunzunegui et al. 2003). In contrast, engaging in social activities is not associated with constructional praxis or the ability to build or assemble objects (Sposito et al. 2015).

Specifically, we tested whether intergenerational support, measured by frequency of contact and coresidency with children, may help explain some of the association between offspring schooling and parents' cognitive health. We found that the effect of children's schooling on the specific cognitive domains remains robust to these measures. Although our own supplemental analyses (not shown) using MHAS data found that more-educated children are more likely to live with and have frequent contact with parents, our results imply that other aspects of intergenerational support may matter more in shaping the patterns of parental cognitive health against children's education. For example, highly educated children may be well-equipped to provide informational support to aid their parents in promoting better overall health, accessing healthcare benefits, and navigating a complex healthcare system (Jiang and Kaushal 2020). As others have suggested, highly educated children may also act as role models in better health behaviors for older parents (e.g., health and diet), thus allowing for important spillover effects that could also shape cognitive health outcomes (Friedman and Mare 2014).

We also suspect that one of the pathways through which better-educated children are able to strengthen the verbal abilities and orientation of older parents could be high-*quality* social contact, although these resources may be less effective at helping parents maintain other cognitive dimensions, such as visuospatial abilities or visual memory. It may not be enough to check in with a parent regularly; engaging parents in rich meaningful conversation or encouraging parents to maintain high levels of engagement with others may be necessary. However, the MHAS does not directly measure these aspects of intergenerational support and modeling behavior, which remain an important source of potential variation between more- and less-educated children. We believe this to be an avenue ripe for future research, especially given that much less attention has been paid to the mechanisms that affect the different domains of parents' cognitive health as opposed to parents' mortality. We recommend that such measures be included in future waves of the MHAS.

Finally, our results demonstrate that children's schooling was particularly effective for mothers but not fathers in our sample. These findings parallel prior work in Mexico that also found a stronger association between children's education and mothers' as opposed to fathers' mortality (Yahirun et al. 2017). These results also lend support to theories of *resource substitution*, which suggest that women are more effective at leveraging the resources of offspring in part due to their lower socioeconomic status than fathers (Mirowsky and Ross 2003).

One limitation of this study is that that our focus on the highest-educated child leaves open questions about the role of other children and how children potentially work together to shape parents' health outcomes (Matthews 2002; Pillemer and Suitor 2014). However, in additional robustness tests (shown in Table A3 of the online appendix), we found that the least-educated child's education was not predictive of parents' cognitive health in the IV estimates, although it was significant in the OLS models. These findings suggest that the highest-educated child may well be integral to parents' health in a way that other children are not. Our findings depart from recent work by Peng and colleagues (2019), who suggested that aggregate measures of children's schooling are more robust predictors of parental health. However, Peng et al. (2019) used data from the United States and looked at overall well-being, not cognitive health specifically. Given the rapid pace of educational mobility in Mexico, the schooling gap between parents and children and between siblings is substantial in Mexico (Creighton and Park 2010). Thus, parents in Mexico may rely more on certain children in later life rather than the resources of all their children, although future work is needed to understand these patterns more definitively.

Another important limitation is that we lack contextual information (region, state, and school quality) that may be related to children's exposure to the new policy and its effect on the broader community, which also shaped health behaviors and knowledge among parents. Other studies have found that the 1993 reform was successful at increasing the likelihood of lower secondary school enrollment and the completion of lower secondary school (Creighton and Park 2010; Urbina 2018). However, overall compliance with the 1993 reform was not universal: children's enrollment was tied to gender and birth order along with a host of other contextual factors (Post 2001). Educational reform, though, is unlikely to have a direct effect on the health of parents in the sample. At the time of the reform, respondents in our sample were aged 17–69 and would not have been exposed to the reform themselves. Two important policy changes that could more directly affect health outcomes, cash transfer programs (*Oportunidades*/*Prospera*) and universal healthcare (*Seguro Popular*), were not adopted until 1997 and 2002, respectively. However, we do not have information on children's health or actual income, so we were unable to test directly whether the educational reform improved child resources other than their education.

Third, although findings from this study suggest that women may benefit more from the schooling of adult children than men, these results may be due to gendered mortality selection. Given women's longer life spans and thus greater exposure to the risk of cognitive decline, women are better able to reap the benefits of their children's educational attainment compared with men. However, our results nonetheless highlight how even those select men who do survive into old age do not gain the same types of benefits from adult children's education than mothers. Beyond parents' gender, other important moderators, such as parents' own education or indigenous status, remain untested because of space constraints. Of course, another critical and unaddressed question is how the cognitive health of childless individuals compares with that of the older parents in our sample. Recent work in this area has found that older adults who have only one child or no children are a very select group of individuals for this cohort in Mexico, and overall they have worse cognitive health than parents of two to three children (Saenz et al. 2019). It is difficult to simultaneously disentangle the effects of parenthood selection and children's education on older adult cognitive health, and we leave this for future work.

Our study is also limited because we excluded proxy respondents, persons who are likely to have the poorest cognitive abilities. In the MHAS, proxy respondents did not complete the cognitive battery tests that we analyzed and thus cannot be included in the analysis. In addition, those with very low levels of cognition who are included in our sample may be more likely to misremember the educational attainment of their child(ren). However, we find it unlikely that they would be systematically more likely to remember educational attainments that did not occur rather than the opposite.

Our results indicate that population-level increases in educational attainment in more recent cohorts may have resulted in improvements in the cognitive health of parents of children affected by educational reforms. These findings highlight the far-reaching and complex effects of education and bring new insights into the ways in which offspring can shape the cognitive health outcomes of family members. In Mexico, as in other contexts, education is a fundamental cause of health (Link and Phelan 1995), and there has been growing interest in understanding how educational resources also shape the health outcomes of family members, whose lives are intertwined and interdependent (De Neve and Kawachi 2017). In particular, having highly educated children could be beneficial to parents throughout the life course in helping parents secure old-age benefits, obtain healthcare, and navigate new and unfamiliar healthcare and aging institutions. We argue that education represents an interindividual resource and that more attention should be paid to the implications of adult children's resources for the health and well-being of aging adults. In societies like Mexico, the stalled expansion of the higher-educated is preventing parents from reaping potentially greater health advantages from offspring education that goes beyond current levels of compulsory schooling (Yahirun et al. 2017). Hence, the effects of further governmental investment in human capital development may be profound in reducing health disparities among older adults. ■

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