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Research Article

The Association Between Spousal Education and Cognitive Ability Among Older Mexican Adults

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Abstract

Objectives: Education and cognition are closely associated, yet the role of spousal education is not well understood. We estimate the independent effects of own and spousal education on cognitive ability in late-life in Mexico, a developing country experiencing rapid aging.

Method: We analyzed 4,017 married dyads (age 50+) from the 2012 Mexican Health and Aging Study. Cognitive ability for married adults was a factor score from a single factor model. Using seemingly unrelated regression, we test whether spousal education influences older adults' cognitive ability, whether associations are explained by couple-level socioeconomic position, health and health behaviors, and social support, and whether associations differed by gender.

Results: Education and cognitive ability were correlated within couples. Higher spousal education was associated with better cognitive ability. Associations between spousal education and cognitive ability were independent of own education, did not differ by gender, and remained significant even after adjustment for couple-level socioeconomic position, health and health behaviors, and perceived social support.

Discussion: In addition to own education, spousal education was associated with better cognitive ability, even at relatively low levels of education. We discuss the possibility that spousal education may improve cognition via transmission of knowledge and mutually reinforcing cognitively stimulating environments.

Keywords: Aging, Cognition, Latin America, Marriage, Schooling

Education is related to intelligence and cognitive ability (Ritchie & Tucker-Drob, 2018). Higher education may improve cognition by building cognitive reserve allowing the brain to sustain more damage before experiencing cognitive deficits (Stern, 2002). Education may also shape cognition by providing access to cognitively stimulating occupations, which may aid in building cognitive reserve (Stern, 2002) and be beneficial for cognitive health (Andel, Kåreholt, Parker, Thorslund, & Gatz, 2007). Education also shapes health behaviors, income, wealth, and healthcare access (Ross & Wu, 1995). Together, these factors may affect risk for health conditions that may negatively impact cognition, including hypertension and diabetes (Deckers et al., 2015), and stroke (Al Hazzouri, Haan, Galea, & Aiello, 2011).

Although many have investigated effects of education on cognitive ability, research has typically considered education as an individual-level variable, ignoring how education may affect others. Research on *spousal* education and health has also tended to focus on high-income countries (United States, East Asia, and Europe) rather than low- and middle-income countries. The strength of correlation between own education (and presumably spousal education) and health differs across countries (Borgonovi & Pokropek, 2016). Further, older adults in Mexico had fewer than half

as many years of education (mean 5.7) than their counterparts in the United States (mean 13.2) in 2012 (Gateway to Global Aging, 2019). Investigating spousal education and cognitive ability in Mexico allows researchers to explore the effects of spousal education in a relatively low education context. Understanding factors that influence cognitive aging in Mexico is vital as the population aged 60+ is projected to increase from 9.9 to 36.2 million from 2010 to 2050 (Consejo Nacional de Población, 2004).

Spousal Education

Many adults age with a spouse and enter late-life after decades with their partner, yet many have ignored the role of partners in shaping health. Although there is a growing body of research on marriage and late-life well-being, researchers have also acknowledged the need to study late-life as many studies of marriage and well-being have historically focused on younger adults (Carr, Freedman, Cornman, & Schwarz, 2014). Marriage in late-life is a valuable context in which to study cognitive ability as marriage represents a lasting intimate relationship involving high levels of interaction, and shared resources and experiences. Through this lens, health of older married adults may be highly interdependent, affected by not only one's own resources but also by the resources of one's partner. Education may then serve as an *inter-individual* level resource. Spousal education has emerged as an important protective factor for one's own outcomes including cognition in the United States (Xu, 2019), cardiovascular health in Finland (Kilpi et al., 2018) and Norway (Egeland, Tverdal, Meyer, & Selmer, 2002), depressive symptoms in Korea (Jang & Kawachi, 2018), health risk factors in the Netherlands (Monden, van Lenthe, De Graaf, & Kraaykamp, 2003) and Norway (Egeland et al., 2002), mortality in Israel (Jaffe, Eisenbach, Neumark, & Manor, 2005; Jaffe, Eisenbach, Neumark, & Manor, 2006), and Norway (Egeland et al., 2002; Kravdal, 2008; Skalická & Kunst, 2008), and self-rated health in Europe (Huijts, Monden, & Kraaykamp, 2010), the Netherlands (Monden et al., 2003), Shanghai (Li, Fu, Zhao, Luo, & Kawachi, 2013), and the United States (Brown, Hummer, & Hayward, 2014).

Theoretical Framework

Although education is associated with cognitive reserve and better cognitive ability even at low levels of education (Farfel et al., 2013), whether spousal education relates with cognition in populations with limited education, including older Mexicans remains understudied. This context is unique as Mexico lacks strong institutional support for older adults (Wong, Michaels-Obregon, & Palloni, 2017), making older adults rely heavily on spouses and family (Peek, Perez, & Stimpson, 2012). This suggests family resources are integral for healthy aging. In Mexico, educational gradients in health and health behaviors may also differ from high-income countries (Smith & Goldman, 2007). In this unique context, spousal education may influence cognitive ability in several ways. First, a spouse's education may enhance one's socioeconomic environment as resources are often pooled within couples in Mexico and may be used by household members to promote health (Rojas, 2011). Enhanced socioeconomic resources may be a plausible mechanism connecting spousal education to cognition as higher income is associated with better cognitive ability among older adults in Mexico (Aguila & Casanova, 2019).

Second, a spouse's education may be beneficial through social support. Education is broadly useful, incorporating generalizable knowledge, mastery, and ability to control one's living situations (Mirowsky, 2003). Highly educated partners may use these skills to more effectively support a spouse. Spousal support may be particularly important in late-life because one's ability to mobilize social support may be limited among individuals with health problems, making others important agents in support mobilization (Huijts et al., 2010). Social support is associated with better cognition among older Mexican adults (Zamora-Macorra et al., 2017) and lacking spousal support is associated with depression (Gariépy, Honkaniemi, & Quesnel-Vallée, 2016), which is related to poorer cognition among older Mexican adults (Saenz, Garcia, & Downer, 2018).

Third, health and health behaviors of married adults are not independent. They are affected by transmission of health knowledge (Kravdal, 2008) and monitoring of health behaviors (Umberson, 1992). Although others hypothesized that spousal education may improve health by improving health behaviors, this pathway requires further attention in the Mexican context. For example, education may not exhibit clear associations with smoking and excessive alcohol consumption in Mexico (Smith & Goldman, 2007), as more smoking is observed among highly educated Mexicans (Christopoulou, Lillard, & Balmori, 2013). However, higher educated Mexican adults, particularly in urban areas, are less likely to have unhealthy biomarkers of several indicators of metabolic syndrome (Beltrán-Sánchez, Palloni, Riosmena, & Wong, 2016). Given these findings, it is unclear whether *spousal* education will be associated with health and health behaviors, and what implications this will have for cognition in Mexico. Fourth, living in a cognitively stimulating environment may help to preserve cognitive function (Hertzog, Kramer, Wilson, & Lindenberger, 2008). To the extent that couples share social environments and cognitive stimulation, spouses may also benefit from their partner's education.

Effect Heterogeneity

Effects of spousal education may differ by one's own education. Persons with less schooling may benefit more from other's resources. For example, having higher educated children was more strongly associated with better mental health among parents with low education (Yahirun, Sheehan, & Mossakowski, 2018). However, the wife's

education may be most protective against husband's coronary heart disease mortality among *highly* educated husbands (Egeland et al., 2002). Similarly, gradients in myocardial infarction incidence by wife's education were steepest for highly educated husbands (Kilpi et al., 2018), yet no significant interaction between own and spousal education was observed for depression in other work (Jang & Kawachi, 2018). Highly educated parents also benefit most from having an educated child in terms of mortality risk reduction (Zimmer, Martin, Ofstedal, & Chuang, 2007). Stronger spousal education effects among highly educated adults may be explained by individuals with more education being more aware of and better able to utilize the resources of others.

Research has also noted gender differences in spousal education effects with some reporting larger effects of the husband's education on the wife's self-rated health (Brown et al., 2014) and depression (Jang & Kawachi, 2018) and others reporting larger effects of the wife's education on the husband's mortality (Jaffe et al., 2005; Jaffe et al., 2006; Skalická & Kunst, 2008). The manner in which spousal education influences health must be understood through the lens of gender. For example, Jaffe et al. (2006) hypothesized that effects of the husband's education on the wife's health may operate primarily through economic mechanisms as households have traditionally depended more on the husband's financial resources. This may be especially relevant given strong traditional gender roles in Mexico where older women are less likely to have worked in the formal labor sector (Bureau of Labor Statistics, 2013). However, the wife's education may associate strongly with home life and family health behavioral factors (Jaffe et al., 2006). The effects of wives on husbands in Mexico may also be pronounced given that husbands tend to rely more heavily on the wife in late-life (Peek et al., 2012). Given these patterns, we explore whether effects of spousal education differ by gender.

Current Study

The primary aim of this analysis is to estimate associations between spousal education and cognitive ability in Mexico. We also investigate potential mechanisms connecting spousal education to cognitive ability (couple-level SES, health and health behaviors, and social support) and test whether spousal education influences cognition in gendered ways.

Method

Participants

We analyzed husband-wife dyads from the 2012 Mexican Health and Aging Study (MHAS, 2012), a longitudinal, nationally representative, household-based sample of Mexican adults (age 50+) and their spouses. The MHAS began in 2001 with follow-up interviews in 2003, 2012, and 2015. We use the 2012 wave because a cohort of individuals born 1952–1962 was added in 2012, making this the most recent wave that was representative of the population age 50+. The MHAS is an ideal resource for our analysis as relevant information (education, cognitive ability, health, and socioeconomic variables) is collected for both spouses. The 2012 MHAS had an 88.1% response rate and is described in greater detail elsewhere (Wong et al., 2017). From the 4,146 married dyads in the 2012 MHAS in which neither spouse reported an age below 50, we analyzed 4,017 dyads (96.9%) in which cognitive information was available at the couple-level.

Measures

Cognitive ability

Cognitive ability was measured using the Cross-Cultural Cognitive Examination, which is especially useful in populations with limited literacy and mathematical abilities (Glosser et al., 1993; Wolfe et al., 1992). For Verbal Learning, respondents were read an eight-word list and asked to recall the words for three study/test trials, and the total number of words recalled correctly was calculated (range: 0–24). Respondents recalled the eight-word list after a delay (range: 0–8) in Verbal Recall. Visual Scanning was a 1-min task in which respondents identified a stimulus in a visual array of stimuli (range: 0–60). For Visuospatial Ability, respondents copied a figure, score range of 0–6. Visual Memory required respondents to recall the copied figure after a delay (range: 0–6). The MHAS also assessed Verbal Fluency using a 1-min animal naming task (range: 0–60). Orientation consisted of correct identification of the day, month, and year (range: 0–3). Delays for Verbal Recall and Visual Memory were spent completing tasks, including Verbal Fluency, Visual Scanning, and Orientation.

We estimated a general cognitive ability (*g*) factor score for each respondent based on the cognitive tasks described above (Carroll, 2003; Plomin & Spinath, 2002; Spearman, 1904). It was estimated in M*plus* 8.0 as a single factor using maximum likelihood estimation with robust standard errors to ensure unbiased parameter estimates and standard errors under violations of multivariate normality. Separate scores were estimated for husbands and wives in the same model, and the correlation between their *g* values was estimated to quantify dependence between scores. Factor loadings were freely estimated across husbands and wives (Supplementary Table 1), and latent *g* factor means were fixed to zero and variances fixed to one to scale the factors with higher scores indicating better cognitive ability. Although 82.8% and 87.4% of husbands and wives, respectively, had no missing data on any cognitive tasks in our analytic sample, full information maximum likelihood (FIML) was used to include all available data either one or both spouses provided. Although FIML assumes that missing data were missing at random (MAR),

FIML is preferred over pairwise deletion, even in cases where data is not MAR (Enders, 2010).

Education

We categorized education based on elementary education in Mexico as no education (reference group), incomplete elementary (1–5 years), elementary (6 years), and beyond elementary (7+ years). Classifications were based on elementary education both because we are interested in spousal education effects in a relatively low educational attainment context, and because the majority (approximately 70%) of our analytic sample had an elementary education or less.

Confounding variables

Confounding variables included locality size (based on the size of the couple's locality of residence, categorized as 100,000+, 15,000–99,999, 2,500–14,999, and <2,500 persons), employment history (currently working, retired, or having never worked for pay), own education, and own income (measured as the sum of income from various sources).

Potential mediating variables

To determine whether spousal education improves cognition through couple-level SES, we included spousal income and couple-level wealth (measured as the sum of the value of all assets including real estate, businesses, money in stocks and accounts, and vehicles). Income and wealth were assessed in pesos and categorized into deciles, which were treated as continuous variables.

We included several variables to capture respondents' health and health behaviors. Chronic condition count was the number of conditions endorsed by respondents (hypertension, diabetes, heart attack, respiratory conditions, cancer, and stroke). Functional limitations were assessed using activities of daily living (ADL) limitations (Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963) (dressing, bathing, eating, getting out of bed, and using the toilet) and Instrumental ADL (IADL) limitations (preparing meals, shopping, taking medications, and managing money). Classifications of (I)ADL limitations were based on Díaz-Venegas, De La Vega, and Wong (2015). Two binary variables were constructed, indicating the presence of ADL and IADL limitations.

Health behaviors included binge drinking, smoking, and exercise. Although the National Institute on Alcohol Abuse and Alcoholism (NIAAA) considers consuming 4+ drinks (females) or 5+ drinks (males) in 2 hr to be binge drinking (NIAAA, 2004), the MHAS only ascertained whether respondents had 4+ drinks in a single occasion in the past 3 months. We classify this as binge drinking but acknowledge that this is not entirely consistent with NIAAA. Smoking (current, former, or never smoker), and exercise (whether respondents exercised or did hard physical work 3+ times a week, on average, over the last 2 years) were also included.

We included perceived spousal social support (range 0–8) and depressive symptoms (range 0–9) ascertained using a modified Center for Epidemiologic Studies—Depression scale (Radloff, 1977). The items for these scales are provided in Supplementary Table 2. We tested models, including spousal chronic conditions and functional limitations as independent variables in equations for own cognitive ability, but these did not affect our findings and were not included in our final models.

Data Analysis

We present descriptive results and cross-spouse correlations demonstrating similarity in key independent and dependent variables between spouses. Following prior studies (Carr, Cornman, & Freedman, 2016; Carr et al., 2014), we estimate actor-partner interdependence models (APIM, Cook & Kenny, 2005) using seemingly unrelated regression. The APIM model accounts for nonindependence of spouses' cognitive ability and allows the estimation of "actor" (effects of own education on own cognitive ability) and "partner" effects (effects of spousal education on own cognitive ability) while estimating the covariance of spouse-specific error terms and accounting for individual and couple-level characteristics.

We designed models to evaluate mechanisms through which spousal education influences cognitive ability. In Model 1, we included spousal education and confounding variables (own education, both spouses' ages, locality size, own employment history, and own income). In Model 2, we added variables hypothesized to mediate associations between spousal education and cognition including couple-level wealth and spousal income (to determine whether spousal education improves cognition by enhancing couple-level SES), own chronic condition count, ADL/IADL limitations, and health behaviors (to determine whether spousal education improves cognition through one's health and health behaviors), and perceived spousal social support and depressive symptoms (to test whether associations between spousal education and own cognition were explained by these factors). We freely estimated spousal education parameters for husbands and wives in Models 1 and 2. To evaluate whether spousal education effects were gender-specific, we constrained spousal education parameters to be equal across gender and tested whether the constrained model fit more poorly than the model with parameters estimated freely by gender. Models were fit using FIML with robust standard errors using R lavaan.

Results

Descriptive Results

We provide descriptive results of the husbands (on the left) and wives (on the right side) in Table 1. The average wife was 3.9 years younger than her husband. Wives were less likely to be working and were more likely to have never

Table 1. Descriptive Characteristics of Older Husbands and Wives (Age 50+)

	Husbands		Wives	
	Mean	*SD*	Mean	*SD*
Age	66.2	8.6	62.3	8.1
Cognitive scores				
Verbal learning	13.8	3.7	15.0	3.5
Verbal recall	4.1	2.0	4.8	1.9
Visual scanning	29.1	15.2	29.6	15.0
Verbal fluency	15.4	5.1	15.1	5.0
Orientation	2.5	0.8	2.5	0.8
Visuospatial	5.6	0.9	5.5	1.1
Visual memory	4.9	1.6	4.8	1.6
General cognitive ability (*g*)	-0.1	0.9	-0.1	0.9
Locality size				
100,000+ (*n*, %)	2,276	57.1	2,276	57.1
15,000–99,999 (*n*, %)	463	11.6	463	11.6
2,500–14,999 (*n*, %)	435	10.9	435	10.9
<2,500 (*n*, %)	813	20.4	813	20.4
Total (*n*, %)	3,987	100.0	3,987	100.0
Employment history				
Retired (*n*, %)	1,805	44.9	1,685	42.0
Still working (*n*, %)	2,116	52.7	754	18.8
Never worked for pay (*n*, %)	95	2.4	1,575	39.2
Total (*n*, %)	4,016	100.0	4,014	100.0
Education				
No education (*n*, %)	612	15.3	656	16.4
Incomplete elementary (*n*, %)	1,192	29.8	1,233	30.8
Elementary (*n*, %)	898	22.4	952	23.8
Beyond elementary (*n*, %)	1,299	32.5	1,160	29.0
Total (*n*, %)	4,001	100.0	4,001	100.0
Economic variables				
Income decile	5.2	2.8	3.6	2.7
Couple-level wealth decile	5.0	2.7	5.0	2.7
Chronic condition count				
0 (*n*, %)	1,687	42.2	1,261	31.5
1 (*n*, %)	1,385	34.6	1,549	38.7
2+ (*n*, %)	927	23.2	1,195	29.8
Total (*n*, %)	3,999	100.0	4,005	100.0
Functional limitation				
Activity of daily living (ADL) limitation (*n*, %)	541	14.3	678	17.3
Instrumental ADL limitation (*n*, %)	281	7.5	395	10.1
Binge drinking				
Yes, in previous 3 months (*n*, %)	607	15.2	89	2.2
Smoking				
Never smoker (*n*, %)	1,633	40.7	3,318	82.6
Former smoker (*n*, %)	1,668	41.6	449	11.2
Current smoker (*n*, %)	712	17.7	250	6.2
Total (*n*, %)	4,013	100.0	4,017	100.0
Exercise				
Exercise/hard physical work 3+ times weekly	1,767	47.2	1,312	33.7
Depressive symptoms				
Depressive symptoms	2.6	2.3	3.6	2.6
Social support from spouse				
Perceived spousal social support	6.9	1.5	6.0	2.1

Note. Source: Authors' own calculation using husband-wife dyads from the 2012 Mexican Health and Aging Study (n = 4,017). Sample sizes for descriptive statistics may differ due to missing data.

worked for pay than husbands. Husbands (mean: 6.1 years) were more educated than wives (mean: 5.5 years) and were more likely to be in a higher income decile. Approximately 84.4% of dyads had no missing data on independent variables, and approximately 11% had more than one missing independent variable. Husband's perceived social support (7.9%) and depressive symptoms (7.7%) had the most missing data. The majority (25/30) of independent variables had less than 5% missing data. Supplementary Table 3 provides the percentage of missing data for each independent variable and cognitive tasks used to construct *g*.

We provide cross-spouse correlations of cognitive ability, cognitive tasks, age, and years of education in Table 2. Significant cross-couple correlations were noted for age ($r = 0.79$, $p < .001$), years of education ($r = 0.71$, $p < .001$), cognitive tasks ($r = 0.12$–0.50, $p < .001$ for all tasks), and *g* ($r = 0.78$, $p < .001$). Husband's education was positively correlated with all cognitive tasks for the wife ($r = 0.22$–0.51, $p < .001$ for all tasks) and wife's education was positively correlated with all cognitive tasks for the husband ($r = 0.19$–0.46, $p < .001$ for all tasks).

We also estimated associations between spousal education and each proposed mechanism for husbands and wives, adjusted for own education (shown in Supplementary Table 4). Above one's own education, spousal education was associated with positive factors including couple-level wealth, spousal income, having fewer depressive symptoms, not having an IADL limitation (husbands only), having fewer chronic conditions (wives only), not having an ADL limitation (wives only), and perceiving more spousal support (wives only). However, higher spousal education was associated with being a former or current (versus never) smoker, and binge drinking (husbands only).

Regression Results for Husbands' Cognitive Ability

Regression results for the husband's cognitive ability are shown on the left-hand side of Table 3. In Model 1, we included spousal education and confounding variables. Compared to husbands married to wives with no education, husbands married to wives with incomplete elementary education (β = 0.19, CI = [0.13, 0.26], $p < .001$), elementary education (β = 0.31, CI = [0.23, 0.38], $p < .001$), and beyond elementary education (β = 0.49, CI = [0.41, 0.57], $p < .001$) exhibited better cognitive ability. Own education was closely associated with cognitive ability. Both spouses' ages were negatively associated with the husband's cognition, whereas own income and locality size were positively associated with the husband's cognition.

We then adjusted for proposed mediating variables in Model 2, including couple-level SES, health behaviors, health, functionality, and perceived spousal social support. Husbands with an IADL limitation performed worse cognitively. Engaging in regular exercise and perceiving one's wife as more socially supportive were associated with better cognitive ability. Proposed mediating variables did not explain associations between spousal education and the husband's cognition. Even after adjusting for mediating variables, husbands with better-educated wives still exhibited better cognitive ability. Spousal education parameter estimates did not differ substantially across Models 1 and 2.

Regression Results for Wives' Cognitive Ability

Regression results for the wife's cognitive ability are shown on the right-hand side of Table 3. In Model 1, compared to wives married to husbands with no education, being married to men with incomplete elementary education (β = 0.10, CI = [0.03, 0.17], $p < .01$), elementary education (β = 0.23, CI = [0.15, 0.31], $p < .001$), and beyond elementary education (β = 0.38, CI = [0.29, 0.46], $p < .001$) were associated with better cognitive ability. Both spouses' ages were negatively associated with the wife's cognitive ability. Similar to husbands, own education was closely associated with cognitive ability. Living in a more rural area was associated

Table 2. Cross-Spouse Correlations between Age, Education, and Cognitive Scores

		Husband's Value									
		Age	Edu	VL	VR	VS	VF	OR	VSP	VSM	*g*
Wife's value	Age	0.79	−0.25	−0.30	−0.27	−0.30	−0.22	−0.18	−0.18	−0.22	−0.41
	Edu	−0.29	0.71	0.38	0.27	0.46	0.35	0.24	0.21	0.19	0.54
	VL	−0.29	0.36	0.34	0.25	0.32	0.27	0.17	0.16	0.15	0.51
	VR	−0.26	0.24	0.27	0.25	0.24	0.20	0.15	0.13	0.14	0.43
	VS	−0.38	0.51	0.38	0.30	0.50	0.37	0.24	0.21	0.21	0.61
	VF	−0.25	0.37	0.29	0.21	0.34	0.37	0.15	0.16	0.14	0.49
	OR	−0.20	0.25	0.18	0.15	0.21	0.16	0.19	0.13	0.12	0.33
	VSP	−0.18	0.23	0.19	0.13	0.23	0.17	0.12	0.27	0.18	0.35
	VSM	−0.20	0.22	0.19	0.16	0.23	0.17	0.14	0.23	0.20	0.37
	g	−0.43	0.54	0.53	0.43	0.57	0.48	0.32	0.32	0.31	0.78

Note. Edu = years of education. VL = Verbal Learning. VR = Verbal Recall. VS = Visual Scanning. VF = Verbal Fluency. OR = Orientation. VSP = Visuospatial Ability. VSM = Visual Memory. *g* = General Cognitive Ability. Source: Author's own calculation using data from the 2012 Mexican Health and Aging Study ($n = 4{,}017$ husband-wife dyads). All correlations are statistically significant at $p < .001$.

with poorer cognition for married women, whereas income exhibited a positive association with cognition.

We did not find evidence that proposed mediating variables explained associations between husband's education and wife's cognition in Model 2. Although couple-level wealth, husband's income, and exercising regularly were positively associated with the wife's cognitive ability and having an IADL limitation and depressive symptoms were associated with poorer cognitive ability, including mediating variables in Model 2 did not meaningfully affect spousal education parameters. Although perceived social support was associated with the husband's cognitive ability, the wife's perception of her husband's social support seemed irrelevant for the wife's cognition.

Gender Differences in Spousal Education Associations

Although spousal education parameters were freely estimated for husbands and wives in Table 3, we then constrained spousal education parameter estimates to be equal across gender in Models 1 and 2 to determine whether associations differed by gender. When constrained to equality, compared to having a spouse with no education, having a spouse with incomplete elementary ($\beta = 0.14$, $p < .001$), elementary ($\beta = 0.26$, $p < .001$), or beyond elementary education ($\beta = 0.41$, $p < .001$) were associated with better cognitive ability in the fully adjusted model (Model 2). Using the differences in chi-square (4.69) and degrees of freedom (3), we tested whether the constrained model fit more poorly than the freely estimated model and found no significant difference in model fit ($p = .20$), suggesting that effects of spousal education on cognitive ability did not differ substantially by gender.

Education Interactions

We examined whether associations between spousal education and cognitive ability differ by own education by estimating interactions between own and spousal education categories. Results of interactions are shown in Supplementary Table 5 and sample sizes for husband-wife education categories are shown in Supplementary Table 6. Few dyads (1.1%) had one partner with beyond an elementary education and one with no education. For husbands, several significant interaction terms were observed, which were generally positive, suggesting own and spousal education work together multiplicatively. Most notably, a strong interaction effect was observed for both partners having beyond an elementary education ($\beta = 0.59$, $p = .004$). This was considerably larger than the interaction effect for husband with incomplete elementary education with a wife who went beyond elementary schooling ($\beta = 0.24$, $p > .05$). For wives, only one significant interaction term was observed, and the pattern of interaction effects was generally less positive than those observed for husbands.

Discussion

Spouses were similar in both education and cognitive ability. Own education was closely associated with cognitive ability. However, we also found educational disparities in cognition by spousal education, even after adjusting for own education. This is consistent with prior work suggesting spousal education may improve outcomes (Brown et al., 2014; Huijts et al., 2010; Jaffe et al., 2005; Jaffe et al., 2006; Jang & Kawachi, 2018; Kilpi et al., 2018; Kravdal, 2008; Li et al., 2013; Monden et al., 2003; Skalická & Kunst, 2008) including cognition (Xu, 2019). Researchers should consider spousal education when studying health and cognitive ability in late adulthood. Unlike the majority of prior research, our analyses focused on older adults in a developing country. This is noteworthy as our sample had less education than samples used in previous investigations of spousal education and health, yet we observed associations even at relatively low levels of education.

Mechanisms

We hypothesized several mechanisms to explain how spousal education may impact cognition, including enhancing couple-level SES, improving health and health behaviors, and through provision of support, but did not find support for these mechanisms. Although spousal education was associated with higher couple-level SES and several favorable health outcomes, we did not find evidence for benefits of spousal education for health behaviors. In fact, spousal education was generally associated with worse health behaviors. The majority of spousal education-cognitive ability associations were unexplained. There are omitted mediators that may explain our results, including effects of occupational complexity (Andel et al., 2007) and cognitive engagement (Hertzog et al., 2008) on the shared environment. Specifically, we hypothesized that spouses may draw benefits from each other's education by sharing cognitively stimulating environments. This is dependent on higher educated individuals continuing to pursue cognitive stimulation throughout life and shared intellectual engagement. Moreover, having an educated spouse with better cognitive ability may provide opportunities to live a more cognitively engaging lifestyle, which has been suggested to be beneficial for cognitive health (Fratiglioni, Paillard-Borg, & Winblad, 2004). We suggest that future work evaluates cognitive stimulation in the couple's shared environment.

The effects of spousal education on levels of cognitive ability in Mexico were robust and not explained by household economic resources, as was reported in research from a country with higher levels of education, the United States (Xu, 2019). This may reflect differences in both selection into education, as the current cohorts of older adults in Mexico spent their childhoods in periods where access to education was limited, and the opportunity costs of education were high (Wong & DeGraff, 2009), as well as differences in cognitive returns to household resources across the

Table 3. Seemingly Unrelated Regression of Older Husbands' and Wives' Cognitive Ability (n = 4,017 Husband–Wife Dyads)

	Husband's cognition		Wife's cognition	
	Model 1	Model 2	Model 1	Model 2
	β [95% confidence interval]	β [95% confidence interval]	β [95% confidence interval]	β [95% confidence interval]
Spousal education (ref: no education)				
Incomplete elementary	0.19 [0.13, 0.26]***	0.19 [0.12, 0.26]***	0.10 [0.03, 0.17]**	0.10 [0.03, 0.17]**
Complete elementary	0.31 [0.23, 0.38]***	0.30 [0.22, 0.37]***	0.23 [0.15, 0.31]***	0.22 [0.14, 0.29]***
Beyond elementary	0.49 [0.41, 0.57]***	0.47 [0.39, 0.55]***	0.38 [0.29, 0.46]***	0.34 [0.26, 0.42]***
Own education (ref: no education)				
Incomplete elementary	0.21 [0.14, 0.28]***	0.20 [0.13, 0.28]***	0.44 [0.37, 0.51]***	0.43 [0.35, 0.50]***
Complete elementary	0.45 [0.37, 0.53]***	0.44 [0.36, 0.51]***	0.66 [0.58, 0.74]***	0.64 [0.56, 0.72]***
Beyond elementary	0.78 [0.69, 0.86]***	0.75 [0.67, 0.83]***	1.03 [0.95, 1.12]***	0.98 [0.90, 1.07]***
Demographics				
Own age	−0.02 [−0.03, −0.02]***	−0.02 [−0.03, −0.02]***	−0.02 [−0.03, −0.02]***	−0.02 [−0.03, −0.02]***
Spouse age	−0.01 [−0.01, 0.00]***	−0.01 [−0.01, 0.00]***	−0.01 [−0.01, −0.01]***	−0.01 [−0.01, −0.01]***
Locality size (ref: 100,000+)				
15,000–99,999	−0.04 [−0.10, 0.03]	−0.03 [−0.10, 0.03]	−0.01 [−0.08, 0.05]	0.00 [−0.06, 0.06]
2,500–14,999	−0.13 [−0.20, −0.06]***	−0.13 [−0.20, −0.06]***	−0.12 [−0.19, −0.06]***	−0.11 [−0.18, −0.05]**
<2,500	−0.19 [−0.25, −0.13]***	−0.20 [−0.25, −0.14]***	−0.15 [−0.21, −0.09]***	−0.15 [−0.21, −0.09]***
Own employment history (ref: retired)				
Still working	0.05 [0.02, 0.09]**	0.03 [−0.01, 0.07]	0.08 [0.04, 0.12]***	0.07 [0.03, 0.12]**
Never worked for pay	0.04 [−0.06, 0.14]	0.03 [−0.07, 0.13]	−0.07 [−0.11, −0.03]***	−0.07 [−0.10, −0.03]***
Income				
Income decile	0.01 [0.00, 0.02]***	0.01 [0.01, 0.02]**	0.01 [0.00, 0.02]**	0.01 [0.00, 0.02]*
Shared socioeconomic status				
Couple-level wealth decile		0.01 [0.00, 0.01]		0.01 [0.00, 0.02]**
Spouse income decile		0.00 [−0.01, 0.01]		0.01 [0.00, 0.02]*
Own health and health behavior				
Chronic condition count		−0.01 [−0.03, 0.01]		−0.01 [−0.02, 0.01]
Activity of daily living limitation		0.01 [−0.04, 0.06]		0.00 [−0.05, 0.05]
Instrumental activity of daily living limitation		−0.13 [−0.21, −0.05]**		−0.14 [−0.20, −0.08]***
Binge drinking (past 3 months)		−0.01 [−0.05, 0.04]		−0.01 [−0.12, 0.09]
Former smoker (ref: never smoker)		0.05 [0.01, 0.08]**		0.06 [0.01, 0.11]*
Current smoker (ref: never smoker)		0.01 [−0.03, 0.06]		0.01 [−0.05, 0.08]
Exercise/hard physical work 3+ times weekly		0.04 [0.01, 0.08]*		0.05 [0.02, 0.09]**
Depressive symptoms		−0.01 [−0.01, 0.00]		−0.01[−0.01, 0.00]*
Social support from spouse				
Perceived social support		0.02 [0.01, 0.03]**		0.00 [−0.01, 0.01]

Note. Table presents unstandardized parameter estimates with 95% confidence intervals in brackets. Authors' own calculation using data from the 2012 Mexican Health and Aging Study.
*p < .05, **p < .01, ***p < .001. Correlations of spouse-specific error terms were 0.62 (p < .001) and .62 (p < .001) for Models 1 and 2, respectively.

samples. Whereas household income and wealth exhibited significant relationships with levels of cognitive ability in the United States (Xu, 2019), spousal income and couple-level wealth were not associated with the husband's cognitive ability and had relatively small associations with the wife's cognitive ability in our analysis.

Correlations between spousal education and cognitive ability may also be affected by educational assortative mating. Spouses tend to have similar education and cognitive abilities. This may be due, in part, to individuals with high education or intelligence actively selecting partners with similar levels of education and intelligence (Plomin & Deary, 2015), leading to associations between spousal education and cognitive ability. This may also reflect a passive process where spouses from similar cultural/socioeconomic backgrounds are more likely to meet and wed (Luo, 2017). This may affect our conclusions if partners marry due to originating from like environments with similar exposure to factors (such as access to education and educational quality) that affect both partners' education and cognition, thus exaggerating effects of spousal education on cognition. We attempted to adjust for active selection by including one's own education in our models and adjusted for parental education in sensitivity analyses to proxy for background factors that may influence likelihood of partnering, which did not affect our main results. Nevertheless, future work should carefully evaluate partner selection and a broader array of cultural and socioeconomic background factors.

Gender

Consistent with Xu (2019), having a better-educated spouse was positively associated with cognitive ability regardless of gender. However, findings of gender differences in spousal education effects have been mixed. For example, husband's education had larger impacts on wife's self-rated health (Brown et al., 2014) and depression (Jang & Kawachi, 2018), yet wife's education was more protective against husbands' mortality in other studies (Jaffe et al., 2005; Jaffe et al., 2006; Skalická & Kunst, 2008). As mentioned above, the mechanisms through which spousal education may influence health differ in gendered ways, with husband's education likely operating more through economic mechanisms and the wife's education operating more through home life and family health behavioral mechanisms (Jaffe et al., 2006). We hypothesize that the lack of gender differences in spousal education effects may be explained by spousal education influencing cognitive ability in complex ways incorporating both economic and home life mechanisms, as well as through cognitively stimulating environments, which may operate regardless of gender.

We interpret interactions between own and spousal education through the lens of resource substitution and multiplication theories (Ross & Mirowsky, 2006) as we argue that both own and spousal education represent resources that may improve cognitive ability. Resource substitution theory argues that when multiple resources affect health, the presence of one resource may compensate for the lack of another. Conversely, resource multiplication theory argues that in the presence of multiple resources, resources may work together in complementary ways. In our analysis, resource multiplication theory would suggest that spousal education would correlate most strongly with cognitive ability when one has more education. Although exploratory, our results for husbands seemed consistent with resource multiplication theory as cognitive ability increased more steeply with spousal education when husbands were higher educated. This is consistent with prior work finding higher educated husbands enjoy the largest benefits from their wives' education (Egeland et al., 2002; Kilpi et al., 2018). Highly educated husbands may benefit more from the wife's education, given that males tend to hold somewhat more influence over a couple's shared decisions among older Mexican couples (Saenz & Rote, 2019), suggesting that highly educated men may be favorably positioned to mobilize household resources to improve well-being. Although focusing on income, Rojas (2011) research on Mexican families similarly found that disparities in health satisfaction by gender (fathers reporting better health satisfaction than mothers) increase with household income. These patterns further suggest that high SES households may be particularly beneficial for men.

Limitations and Strengths

We note several limitations. First, our analyses did not include measures of couple's shared cognitive stimulation. Future studies should collect detailed information on a couple's shared environment and interactions, including cognitively stimulating shared leisure activities and richness and frequency of intellectually stimulating conversations. Second, associations between spousal education and cognition may be exaggerated because individuals with favorable intellectual abilities may be in better positions to marry someone with higher education. However, adjustment for one's own and parental education, which are likely related to intellectual abilities prior to marriage, did not affect our findings. Third, our analyses were cross-sectional, given that changes in cognitive assessments across waves and an extended time gap between the 2003 and 2012 MHAS waves make it difficult to accurately assess nonlinear cognitive decline. Future work should evaluate trajectories of cognitive decline within couples using mediating variables and cognitive ability in midlife, which precede late-life cognitive evaluations and were not available in our sample. Fourth, small cell sizes in certain husband-wife education categories made our analyses of returns to spousal education by own education exploratory. Future work should evaluate this question using larger samples. Last, social support was assessed as perceived social support, which may differ from received support and may not fully capture the quality of support

received, which may be involved in the relationship between spousal education and cognitive ability. However, the large household-based MHAS sample afforded us the opportunity to analyze thousands of married dyads, consider own and spousal characteristics as independent variables, account for important confounding variables, and test mechanisms that may connect spousal education to cognitive ability.

Implications

Our results have implications for research and public health. Levels of education have increased across subsequent birth cohorts of aged adults in Mexico (Wong et al., 2017). This is significant as our results suggest that education serves as an inter-individual level resource from which both spouses may reap cognitive benefits. The effects of educational improvements on the cognitive function of subsequent aged cohorts of Mexican adults should be understood within the context of marriage and interpersonal relationships. Further, our results may assist in identifying older adults at risk for poor cognitive outcomes. Specifically, targeted cognitive interventions for couples in which both spouses have limited education may be beneficial. Our results also suggest that future research should consider spousal education in educational health gradients.

Supplementary Material

Supplementary data is available at *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences* online.

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Author Contributions

All authors contributed to the conceptualization, theoretical development, writing, and editing of the manuscript. Data management and analysis were conducted by Joseph Saenz with input from both Christopher Beam and Elizabeth Zelinski.

Conflict of Interest

None reported.

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