Cognitive life expectancy by educational attainment in Mexican adults aged 60 and older

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Abstract

Objective. To estimate cognitively healthy life expectancy (CHLE), cognitive impairment life expectancy (CILE), and dementia life expectancy (DLE) in Mexican adults aged 60 and older stratified by educational attainment. **Materials and methods.** The data were obtained from Waves 1 (2001) to 5 (2018) of the Mexican Health and Aging Study. The life expectancy was estimated using a multistate life table analysis. **Results.** CHLE at age 60 increased with higher educational attainment and ranged from 17.9 to 24.4 years in female participants, and 17.2 to 21.3 in male participants. The CILE and DLE decreased with greater educational attainment. The CILE ranged from 0.7 to 2.8 years in female participants and 0.7 to 2.6 in male participants. **Conclusions.** Older adults in Mexico with higher education live more years with good cognitive health and fewer years with cognitive impairment and dementia. Education has a stronger effect on the length of cognitively healthy life expectancies than on total life expectancies.

Keywords: cognitive aging; dementia; life expectancy; education; Mexico

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Resumen

Objetivo. Estimar la esperanza de vida cognitivamente saludable, con deterioro cognitivo y con demencia en adultos mexicanos mayores de 60 años estratificados por nivel educativo. **Material y métodos.** Los datos provienen de las oleadas 1 (2001) a 5 (2018) del Estudio Nacional de Salud y Envejecimiento en México (Enasem). La esperanza de vida se estimó utilizando un análisis de tablas de vida multiestado. **Resultados.** La esperanza de vida cognitivamente saludable a los 60 años aumentó con un mayor nivel de educación en un rango de 17.9 a 24.4 años en mujeres y de 17.2 a 21.3 en hombres. La esperanza de vida con deterioro cognitivo y la esperanza de vida con demencia disminuyeron con un mayor nivel de educación. La esperanza de vida con deterioro cognitivo varió de 0.7 a 2.8 años en mujeres y de 0.7 a 2.6 en hombres. **Conclusiones.** Los adultos mayores en México con educación superior viven más años cognitivamente saludables y menos años con deterioro cognitivo y demencia. El efecto de la educación es más fuerte en la distinción de la duración de la esperanza de vida cognitivamente saludable que en las esperanzas de vida totales.

Palabras clave: envejecimiento cognitivo; demencia; esperanza de vida; educación; México

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Educational attainment in Mexico has increased dramatically in recent decades. The percentage of people aged 15 and older who are illiterate has decreased from 26% in 1970 to 5% in 2015, while the average years of education have increased from 7.5 years in 2000 to 9.7 in 2020.[1] Population level-related increases in education are also occurring for middle-aged and older adults in Mexico. The percentage of adults aged 50 and older that completed six or more years of education increased from 30.9% in 2000 to 45.2% in 2012.[2] Greater educational attainment is consistently associated with higher late-life cognition and reduced risk for cognitive impairment and dementia,[3,4] also among older adults in Mexico.[5-7] Thus, the gains in educational attainment over the past century have important implications for population aging and health in Mexico.

Rapid population aging in Mexico will contribute to an increase in the prevalence and incidence of cognitive impairment and dementia.[8] A study of 6 204 adults aged 60 and older living in Mexico City reported that the prevalence of dementia in 2017-2018 was 14.2%.[9] As a comparison, previous research using data from the Mexican Health and Aging Study (MHAS) estimated that the prevalence of dementia and cognitive impairment no dementia (CIND) among older adults in Mexico in 2001 was 6.1 and 28.7%, respectively.[10]

Several theories may explain the association between education and late-life cognition. The cognitive reserve theory suggests that adults with high educational attainment can use alternative neural and cognitive pathways to maintain cognitive functioning.[11] The brain reserve theory posits that education influences the structural characteristics of the brain —such as the number of neurons and neuronal connections— that allow the brain to sustain greater neuropathology before cognitive impairment and dementia occur.[12] Lastly, education may protect against declines in cognitive abilities important to crystallized intelligence and, to a lesser extent, in cognitive domains involved in fluid intelligence.[13]

Educational attainment is strongly associated with the proportion of life expectancy spent living with cognitive impairment and dementia. Research from the United States indicates that older adults with higher educational attainment live more years cognitively healthy and fewer years with CIND and dementia.[14] Cognitively healthy life expectancy has increased in high-income populations regardless of educational attainment.[15] However, the effects of education on cognitive healthy life expectancy appear to be greatest for adults with the highest levels of education.[15]

Most evidence of the relationship between education and cognitively healthy life expectancy is found in older adults in high-income countries. Studies from the US and other high-income countries have categorized educational attainment as having completed high school or college. Mexico presents a unique context for studying cognitive aging as it has a lower average educational attainment than high-income countries. Thus, it is unknown whether older adults with low levels of formal education live fewer years with CIND or dementia than those with no formal education or whether the benefits of education in terms of cognitive healthy life expectancies only occur for older adults with high levels of education.

Our objective was to research the relationship between educational attainment and cognitive life expectancies among older adults in Mexico. We hypothesize that higher educational attainment is associated with a longer period of cognitive health and a shorter duration of cognitive impairment and dementia. Our study will provide valuable insights into the influence of educational attainment on cognitive health within the context of an aging Mexican population.

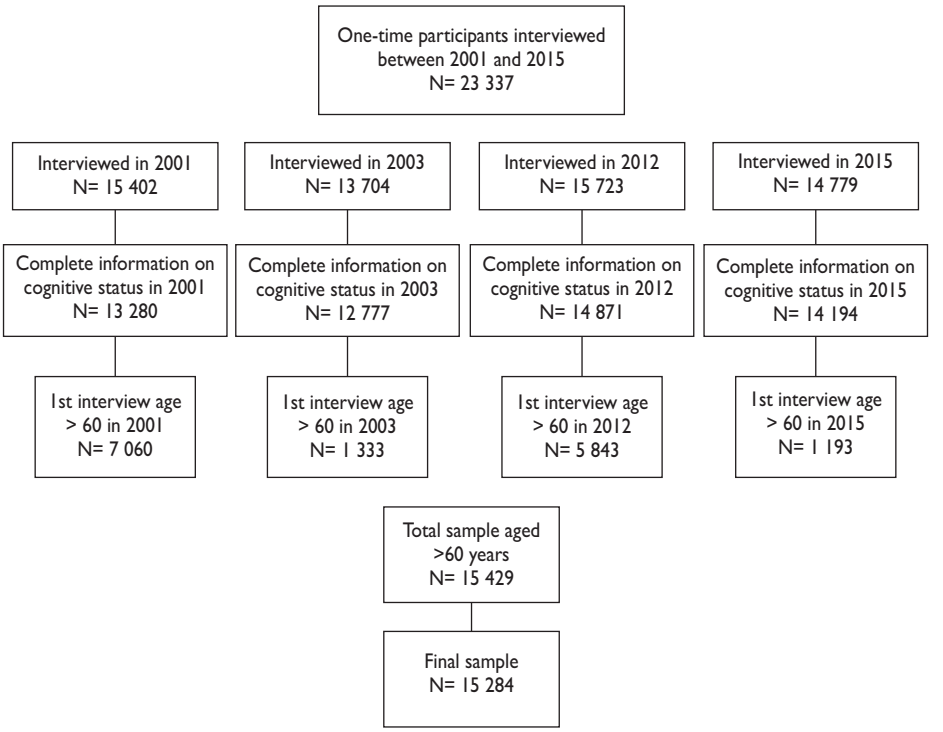
Materials and methods

Data

We used data from the MHAS. The MHAS is a nationally representative, longitudinal study of the Mexican population aged 50 years and older and their spouses of any age. The Study began in 2001 with a sample of 15 186 participants born before 1951. Follow-up interviews were completed in 2003, 2012, 2015, and 2018. The 2012 wave added a new sample with participants born between 1952 and 1962, and the 2018 wave added new participants born between 1963 and 1968.[16] Most participants complete a direct interview, but a spouse or other family member can complete a proxy interview if the participant is absent or cannot complete a direct interview. We also used the MHAS data files with imputed cognitive values for participants aged 50 and older with incomplete data for cognition.

This research was a secondary analysis of de-identified data previously collected by the MHAS. The Review Board of the University of Texas Medical Branch and the *Instituto Nacional de Estadística y Geografía* (INEGI) and the *Instituto Nacional de Salud Pública* (INSP) have approved the study procedures and survey instruments of the MHAS. All participants provided their informed consent.

Figure 1 shows the selection of the sample population. First, we used the MHAS Master Follow Up File to identify all participants interviewed in the 2001, 2003, 2012, and 2015 waves. We then selected participants



N: Total population.
Note: Cognitive status includes cognitive measures and instrumental activities of daily living to classify dementia.

Figure 1. Sample selection. Mexican Health and Aging Study. Mexico, 2001-2015

from each observation wave with information to determine their cognitive status (see Cognitive status). This step excluded participants younger than 50 years of age at the time of an interview, participants who completed their interview in a language other than Spanish, and participants who completed a direct interview but were missing information for one or more instrumental activities of daily living (IADL). We excluded participants with missing responses for one or more IADLs because we used IADL limitations to differentiate between participants with CIND and dementia (see Cognitive status).

Next, we identified the first observation wave where a participant was 60 or older. We used this approach to include the observations of participants younger than 60 at an earlier wave in the final sample. For example, we included the observations from 2003 and onward for participants aged 59 in 2001. The number of one-time participants at each MHAS observation wave was 7 060 (2001 wave), 1 333 (2003 wave), 5 843 (2012 wave), and 1 193 (2015 wave). Finally, we excluded participants with missing information for educational attainment or who had inconsistent information for age. The final sample included 15 284 one-time participants aged 60 and older. Participants could be observed up to five times, and the total number of observations was 58 617.

Measures

Cognitive status

We used the Mejia-Arango and colleagues approach to classify participants who completed a direct interview as cognitively healthy, CIND, and dementia according to the Cross-Cultural Cognitive Examination (CCCE) and independence in IADLs.[5] This approach is consistent with the National Institute on Aging-Alzheimer's Association classifications of mild cognitive impairment and dementia.[17,18] Mejia-Arango and colleagues have described the cognitive items from the modified CCCE included in every MHAS observation wave.[5] Briefly, the modified CCCE includes the following five cognitive items: 1) immediate recall of an 8-word list (0-8 points); 2) delayed recall of an 8-word list (0-8 points); 3) visual-

constructional abilities (copy a figure; 0-2 points); 4) visual memory (draw the figure from memory; 0-2 points); and 5) attention through a visual scanning task (0-60 points).[19] We used MHAS datasets that include imputed values for participants aged 50 and older with missing data for one or more cognitive items.[20] We converted the raw scores for each cognitive item into z-scores using the sample means and standard deviations for all participants who completed a direct interview.

For IADLs, the survey asks participants if they have difficulty because of health problems: 1) preparing a hot meal; 2) shopping; 3) taking medications; and 4) managing money.[10] We categorized participants who responded yes or can't do as having a limitation for that IADL task. We dichotomized participants according to a limitation in one or more IADLs.

We classified participants with a z-score of less than or equal to 1.5 on two or more cognitive items but no IADL limitations as CIND. We classified participants with a z-score of less than or equal to 1.5 on two or more cognitive items and one or more IADL limitations as dementia. We classified all other participants as cognitively healthy.[5]

The cognitive functioning of MHAS participants who require a proxy interview is assessed using the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE).[21] The IQCODE is a 16-item questionnaire that asks an informant to report on changes in the participant's memory, judgement, ability to learn new information, and ability to complete daily tasks over the last two years. The average score for the IQCODE ranges between 1 and 5 points, with a higher score indicating worse cognitive functioning. We used a score of 3.4 points or higher as a cutoff for dementia.[5]

Mortality status

The MHAS Master Follow-up File provides information on the mortality status of all participants. The next-of-kin questionnaire asks a participant's spouse or other family member about the month and year of death.

Educational attainment

We grouped participants into five categories according to the structure of Mexico's educational system: 1) no formal education; 2) incomplete elementary school (reporting less than six years of schooling); 3) complete elementary school; 4) complete middle school; and 5) complete higher-medium (i.e., high school, technical and teaching school), and higher (i.e., professional or graduate).[22]

Analytic approach

We used a multistate life table model to analyze transitions between cognitive status and death. We used a continuous-time Markov process to estimate cognitively healthy life expectancy, CIND life expectancy, dementia life expectancy, and total life expectancy at 60 years by educational attainment and sex. First, we observed the entry to and exit from each cognitive state at every age group for the cohort. We differentiate between exits resulting from the transition of interest (e.g., cognitively healthy to CIND), competing events (i.e., mortality), or the end of the observation period (censoring). Next, we estimated transition rates at each age by dividing the number of transitions by the number of surviving participants at risk of experiencing a transition. Then, we used transition rates organized into a matrix to calculate the probabilities of transitioning from one state to another within a one-year age interval. The product of the transition probability matrix and the state probabilities are the state occupation probabilities. These indicators were predicted at the population level. In addition, we calculated expected occupation times dependent on transition rates for each cognitive state, representing the expected number of years spent in each cognitive state. The total life expectancy is the sum of the years spent in each cognitive state. The method corresponds to the analysis of life stories implemented in the Biography library available in R.[23]

Results

Among 15 284 participants in our sample, 23.8% had no formal education, 33.2% had incomplete elementary education, 20.1% completed elementary school, 7.2% completed middle school, and 15.6% had higher-medium or higher education (table I). The average age of the participants decreased with greater educational attainment. The 'no formal education' category had the highest percentage of female participants (58.2%), while the middle school category had the lowest (46.2%). Finally, 14.4% of the participants with no formal education had CIND, and 9.6% had dementia, whereas less than 2% of participants with middle-school, higher-medium, or higher education were classified as CIND and dementia.

As shown in figure 2, total life expectancy at age 60 increased with higher educational attainment. Total life expectancy ranged from 23.4 years for females with no formal education to 26.5 years for females with higher-medium or higher education. The total life expectancy for males ranged between 21.7 and 22.9 years. This difference in total life expectancy by educational

Table I

Cognitive status, age, and sex by educational attainment at baseline interview. Mexican Health and Aging Study participants aged 60 and older interviewed from 2001 to 2018. Mexico

	No formal education	*Incomplete elementary*	*Complete elementary*	*Middle school*	*Higher-Medium and Higher*
Total, n (row %)	3 642 (23.8)	5 073 (33.2)	3 078 (20.1)	1 102 (7.2)	2 389 (15.6)
Cognitive status (col %)					
Cognitively healthy	2 768 (76)	4 592 (90.5)	2 884 (93.7)	1 072 (97.3)	2 323(97.2)
CIND	524 (14.4)	289 (5.7)	112 (3.6)	15 (1.4)	34 (1.4)
Dementia	350 (9.6)	192 (3.8)	82 (2.7)	15 (1.4)	32 (1.3)
Female	2 120 (58.2)	2 797 (55.1)	1 629 (52.9)	509 (46.2)	1 231 (51.5)
Age, mean (SD)	68.6 (8.2)	66.4 (6.8)	65 (5.9)	64.4 (5.4)	64.5 (5.6)

CIND: Cognitive impairment no dementia.
SD: Standard deviation.
Higher-Medium: high school, technical school, teaching school; Higher: professional or graduate. Percentages are based on column total.
Baseline: First interview when the participant was 60 or older.
The groups are significantly different in all variables ($p<.01$).

attainment was driven by the increase in cognitively healthy life expectancy, which ranged from 17.9 to 24.4 years in female participants and from 17.2 to 21.3 in male participants.

Life expectancy with CIND and dementia was the highest for participants with no formal education. Females with no formal education had a CIND and dementia life expectancy of 2.8 and 2.7 years, respectively. Males with no formal education had a CIND life expectancy of 2.6 years and a dementia life expectancy of 1.8 years. CIND life expectancy and dementia life expectancy were lowest for participants with higher-medium or higher education at 0.7 and 1.3 years for female participants, and 0.7 and 0.9 years for male participants.

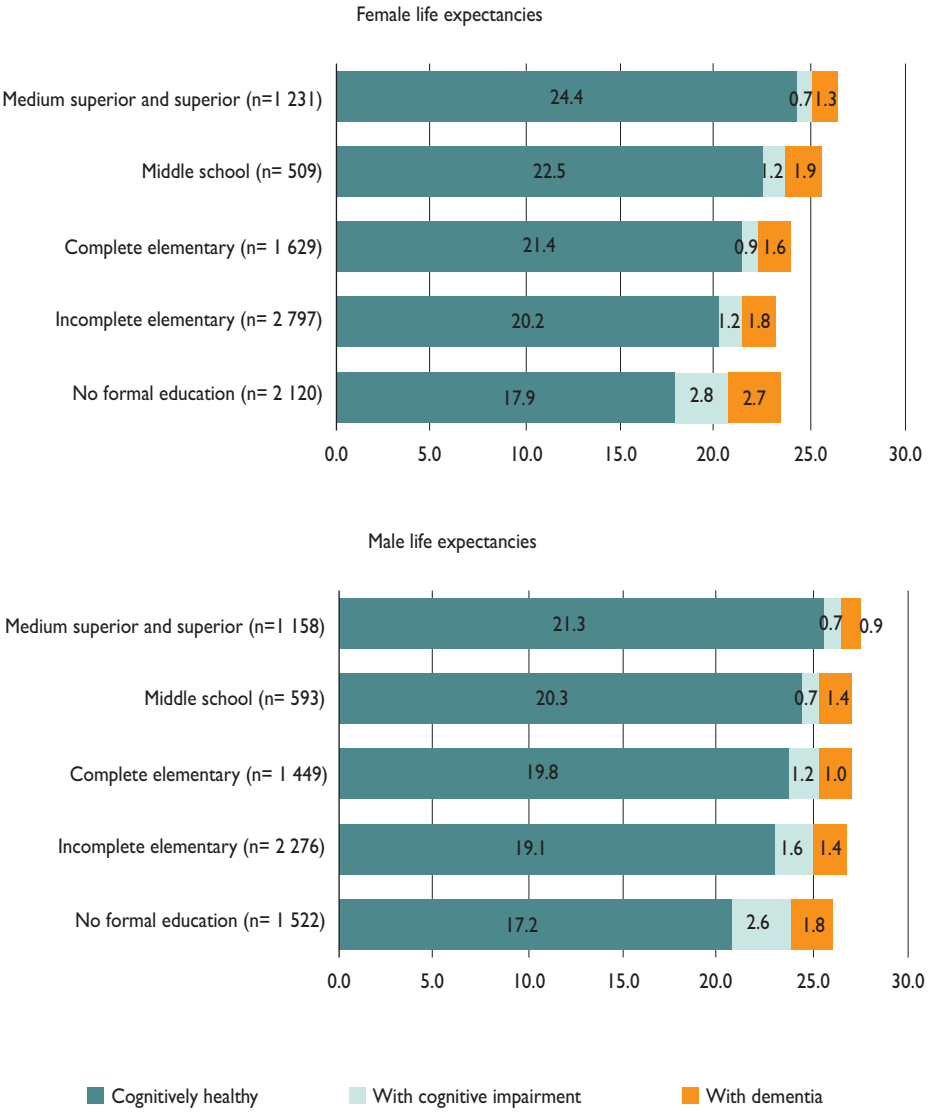
We detected large differences in cognitive life expectancy between participants with no formal education and those with incomplete elementary education. Cognitively healthy life expectancy was 2.3 years higher for females and 1.9 years higher for males with incomplete elementary education compared to participants with no formal education. This was complemented by lower CIND and dementia life expectancy of 1.6 years and 0.9 years for female participants, and 1 year and 1.4 years for male participants, respectively.

Figure 3 shows area charts with the probabilities of occupying each cognitive state and mortality from 60 to 100 years of age for participants with no formal education and higher-medium or higher education. Participants with no formal education represent a smaller area of the cognitively healthy state, and a larger area of the cognitive impairment and dementia states, compared to higher education groups. This translates into a steeper drop in the probability of being cognitively healthy in the group with no formal education. Participants with no formal education reached less than 50% probability of being cognitively healthy at 78 years, while participants with higher-medium or higher education reached the same point at 84 years. This translates into a 6-year delay to reach the same probability distribution for participants with higher-medium education relative to those with no formal education. This finding also suggests that participants with higher education have a lower cognitive age relative to their chronological age than those with low education.

The highest probability of occupying a state of CIND or dementia for participants with no formal education was 18.3%, which occurred at 79 years. Conversely, participants with medium superior or higher education had 3.6% probability of occupying a state of CIND or dementia at 79 years of age. The highest probability of cognitive impairment or dementia in the higher-medium or higher education group was 7.9% at 86 years. The probability of death surpassed 50% at 84 years for participants with no formal education and 86 years for those with medium superior or higher education.

Discussion

This study estimated cognitive life expectancies by educational attainment for Mexican adults aged 60

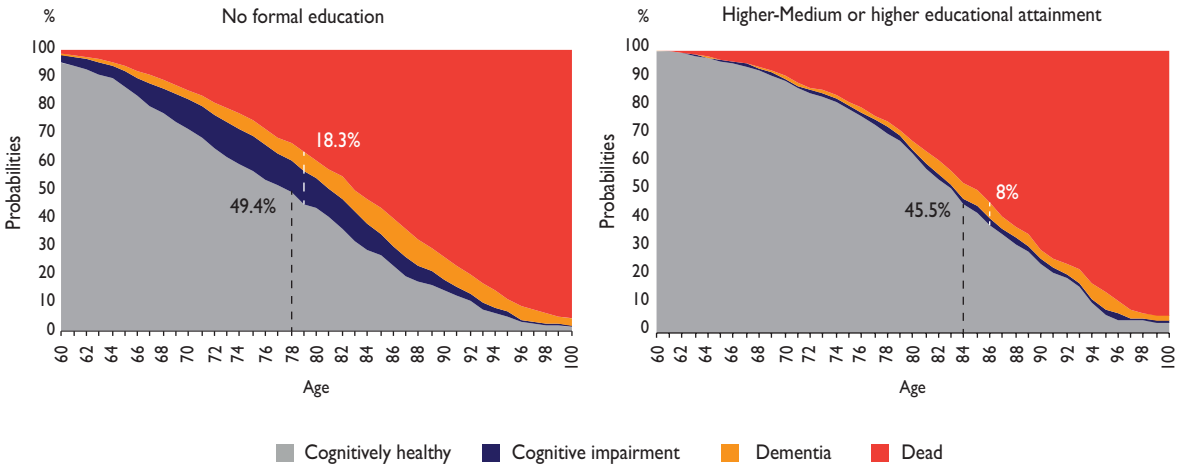


Higher-Medium: high school, technical school, teaching school; Higher: professional or graduate.

FIGURE 2. COGNITIVELY HEALTHY, COGNITIVE IMPAIRMENT AND DEMENTIA LIFE EXPECTANCIES BY EDUCATIONAL ATTAINMENT AND GENDER. MEXICAN HEALTH AND AGING STUDY. MEXICO, 2001-2018

and older. We found that older adults with higher educational attainment live more years when they are cognitively healthy, and fewer years with CIND and dementia. Our findings are evidence that the benefits of formal education to late-life cognitive functioning are not limited to older adults with high levels of education, and older adults with low levels of formal education have longer cognitively healthy life expectancy than older adults with no formal education. Our findings also indicate that higher educational attainment is accompanied by a higher probability of occupying a cognitively healthy state at any age and a lower probability of CIND and dementia. Our results support the hypothesis that education contributes to cognitive reserve, which may delay the onset of clinical signs of cognitive impairment and dementia.[24]

Our study categorized education based on the structure of the Mexican education system.[22] This offers



Higher-Medium: high school, technical school, teaching school.

FIGURE 3. STATE OCCUPATION PROBABILITIES BY EDUCATIONAL ATTAINMENT. MEXICAN HEALTH AND AGING STUDY. MEXICO, 2001-2018

an alternative to previous studies based on MHAS data that used total years of formal education.[2,5,7] We utilized educational attainment instead of years of education in order to reflect the social status that comes with completing each level of education. Educational attainment is closely related to employment opportunities, and working in cognitively demanding occupations with higher social status can also benefit cognitive functioning in old age.

We found that greater educational attainment was also associated with longer life expectancy. Similarly, a study of twenty-three member countries of the OECD (Organisation for Economic Co-operation and Development) reported that total life expectancy at age 65 for highly educated women and men was 2.5 years and 3.5 years longer than for women and men with low levels of education.[25] Studies of Latin American countries have also found a positive relationship between higher education and longer total life expectancy.[26] The higher total life expectancies in our analysis were mainly driven by the increase in cognitively healthy life expectancy. Prior research has shown that decreased mortality increases life expectancy in all cognitive states, counterbalancing the decreases in years lived with cognitive impairment and dementia.[15]

We estimated predicted probabilities for being cognitively healthy, CIND, and dementia according to educational attainment in order to further demonstrate how higher educational attainment contributes to longer cognitively healthy life expectancies. Our findings reflect a compression of morbidity due to the shorter life expectancy with dementia. Greater educational attainment is associated with higher cognitive functioning, but longitudinal studies suggest that cognitive decline accelerates after the onset of dementia among older adults with high levels of education.[27-29] An accelerated rate of cognitive decline after dementia onset may contribute to the shorter life expectancy with dementia for participants with higher levels of education.

Limitations

We could use only the five cognitive items included in every MHAS wave. The MHAS survey added three more cognitive tasks after the first wave, which include orientation, numeracy, and semantic verbal fluency, in order to provide additional data for cognitive function research. Moreover, repeated cognitive assessments can lead to the "practice effect" bias. This bias can lead to overestimating the cognitive abilities of the participants. Another limitation is that the multistate life table methodology assumes that the participants experience only one transition between two survey waves. This can result in underestimating the frequency of transitions, particularly in the long period between the 2003 and 2012 MHAS waves. Additionally, we cannot determine exactly when the transitions between cognitive states occur.

Our study presents evidence of the magnitude of disparities in cognitive life expectancies by education among older adults in Mexico. Future research should

consider the role of occupation over the life course, leisure activities, and other lifestyle factors associated with educational attainment that contribute to cognitive reserve. Such research will advance knowledge on life course determinants that may reduce the risk of dementia and extend the share of total life expectancy spent in good cognitive health.

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Declaration of conflict of interest. The authors declare that they have no conflict of interest.

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