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Speed of aging of populations by socioeconomics subgroups in China: A cross-sectional study of cognitive performance

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A R T I C L E I N F O

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A B S T R A C T

Objectives: Although there is an association between socioeconomic factors and cognition, there are shortcomings in terms of examining the age of onset of decline between people with varying social backgrounds. This study aims to present the disparities in cognitive performance among older adults by simultaneously integrating health status, social characteristics, and age into an understandable metric.

Study design: This study is cross-sectional.

Methods: A sample of 3422 adults aged at least 60 was utilised from the 2015 wave of the China Health and Nutrition Survey to analyse the trajectories of cognitive ageing through the Characteristics approach. This approach generates an age-differential schedule whereby, as a hypothetical example, the cognition level Z of an individual aged 60 who has not completed schooling is demonstrated at age 66 by someone who has completed secondary schooling.

Results: There was an increasing advantage with cognitive performance as the level of education completed increased; men aged 61.9 with a primary level of schooling and those aged 67.8 with postsecondary qualifications exhibit the same cognition performance as those aged 60 with no completed schooling. The observation also suggested that cognition advantages diminish through age. In terms of income, the age-differential schedule follows a similar pattern. albeit lower outcomes, to that of education differentials.

Conclusion: When comparing education and income levels and their respective impacts on cognitive functioning, the former has been noted to have a larger effect. Education's effect has continuity in that it can influence opportunities until later ages.

1. Introduction

Differential analyses of subgroups of populations have increased attention in research in recent years, such as in the study of wellbeing (Buathong et al., 2021) and ageing (Scherbov & Sanderson, 2016). This is an important step, particularly for societies with developing economies that are rapidly ageing. Social and health disparities are rife in the said context, especially when human capital development characteristics are concerned. Within health research, there are other issues apart from looking at single-characteristic health markers to estimate the speed of ageing. One of those issues is that many studies focus mainly on physical health. Much attention has been paid to health aspects like handgrip strength and gait speed (Pothisiri et al., 2020; Sanderson et al., 2016). There has been fairly limited focus on other health dimensions, such as the different rates of cognitive ageing across subpopulations by education and income in developing countries (Eshkoor et al., 2015), including China (Jia et al., 2020).

Apart from human capital factors, gender is a characteristic that is linked with cognitive health disparities (Mielke et al., 2014). There are biological underpinnings that results in differences in cognitive health and performance between men and women such that the former have higher risks of cognitive impairment (Petersen et al., 2010) but the latter have been observed to have graver effects of such impairment as women tend to have longer life expectancies (Mielke et al., 2014). Despite these biological reasons, the social implications of gender differentiation manifest themselves across populations. Women in some contexts are likely to have less formal education, which can also interplay with a higher prevalence of economic poverty and the experience of hunger, which can have effects on cognitive development across the lifespan (Vicerra & Estanislao, 2023; Vicerra & Pothisiri, 2020; Zunzunegui et al., 2009).

This study looked at the differences in cognitive aging among

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different subpopulations in China. The country has sustained low fertility levels over the years and has been noted to face the prospects of negative population growth and labour scarcity (Du et al., 2015). The country's economic growth has also been substantial over the years, but in conjunction with this has been the rise of socioeconomic and health inequities among the population (Chen et al., 2017; Wu & Li, 2017). This warrants the study of heterogeneity among the older adults in China because there is a perspective whereby this age group can be seen as a resource rather than as dependents (Lucero-Prisno et al., 2022; Marois et al., 2021). In particular, cognitive status has been linked to productivity (Maitland et al., 2000; Skirbekk et al., 2012). Cognitive capacity is central to engaging in and adapting to work environments, and those with good cognitive performance can be productive individuals regardless of age advancement.

With the availability of data, it is possible to estimate cognitive performance levels based on various cognition tests. Simultaneously combining health status, social characteristics, and age into an accessible and understandable metric is done through the characteristics approach (Sanderson & Scherbov, 2014). As a hypothetical example of the stated approach, the cognition level Z of an individual aged 60 who has not completed schooling is demonstrated at age 66 by someone who has completed secondary schooling. This pertains to the later onset of cognitive ageing for people who have higher levels of education.

Such an approach to signifying a marker of older age has been done in the literature, e.g., Vaupel (Vaupel, 2010) compared the health performance across places and time periods by referencing life table mortality rates. The characteristics approach's advantage is that the data required and the results that are generated, which are in the form of years of age, are more easily interpretable. The primary objective of this study was to present the cognitive level variations among men and women through the characteristics approach. Furthermore, the focus here was to highlight population heterogeneity, specifically through educational attainment and income level characteristics. The said human capital development factors have been noted to be impactful on social disparities in China between sexes (Chen et al., 2017; Jia et al., 2020; Wu & Li, 2017). Therefore, the stated characteristics are the foci of this study, and the corresponding variations are expected to be significant.

2. Methods

2.1. Data and sample

The 2015 wave of the China Health and Nutrition Survey (CHNS) was used for the present analyses. The CHNS is a longitudinal survey that started in 1989. (The University of North Carolina Population Center) A multistage random cluster approach to sampling was employed. The first step was selecting two cities and four counties from each provincial region. Then, two neighbourhoods each from urban and suburban areas were randomly chosen from cities, while one town and three villages were chosen randomly per county. Each urban and suburban neighbourhood, town, and village represented a community. The third step in the sampling was randomly selecting twenty households from each community. There have been changes in coverage over the course of the survey's implementation, such that by 2011, three metropolitan areas were included, namely Beijing, Chongqing, and Shanghai. Ultimately, by 2015, the survey covered nine provinces and three centrally administered municipalities.

Adults aged at least 60 were the sample for this study. Some exclusion criteria were established. These criteria included: 1) proxies who responded to any relevant item in the present analysis; and b) cases with incomplete responses, i.e., those who did not respond or those who indicated not knowing the answer. The resulting analytic sample consisted of 3422 individuals.

2.2. Measurement

2.2.1. Cognition performance

Memory and numeracy are cognitive tasks observed to be associated with mild cognitive impairment (MCI) (Montero-Odasso et al., 2017; Skirbekk et al., 2012; Vicerra & Estanislao, 2023; Vicerra & Pothisiri, 2020). The CHNS measures memory tasks using immediate and delayed word recall tests. The first part of the test was when respondents were asked to immediately repeat ten words spoken by the survey enumerator. There was an interval involving being asked other survey items, after which the second part of this test was done. The survey enumerator asked respondents to remember the abovementioned list of ten words and recite them again. With this design, the total score an individual can get is 20 if the respondents were able to recite all items in the immediate and delayed portions of the test.

Numeracy here involved two tasks. The first involved a counting-backward test where the person had to count from 20 to one. Each respondent has two chances. In the present analysis, so long as the respondent answered correctly in the first or second attempt, a score of '1' was assigned. This is different from other studies where a higher weight was given to those who replied correctly on the first attempt (Li et al., 2020). The other test for numeracy was the serial sevens, where the person had to subtract seven from 100, and this would continue five times if the respondent maintained being correct. The maximum score for this task was '5'. Altogether, the total score to measure numeracy was six (6).

As both memory and numeracy are required to indicate cognitive performance, the respective totals of both tasks were combined, resulting in an index of 26. To test the appropriateness of the index, the scale reliability coefficient was estimated. The resulting coefficient level was 0.79, which was within the accepted threshold. Although the present study was not based on a standardised test indicative of dementia, the measure of cognitive performance used here has been shown to be reliable and valid in various societal contexts (Ichimura et al., 2009; Vicerra & Estanislao, 2023; Vicerra & Pothisiri, 2020).

2.2.2. Human development factors

Educational attainment was based on levels completed. Primary school consisted of six years, lower and upper middle schools were three years each, and postsecondary had different lengths as long as they completed technical, undergraduate, and postgraduate levels. Income used self-reported household earnings from different sources over the preceding year of the survey. The measure used here was household income per capita, as older individuals earn from a variety of sources in China, including from family members and government welfare, among others (Li & Sicular, 2014). The stated variable was divided into three quintiles, representing low, middle, and high levels. The reference categories for education and income were those with no formal education and those with low income. The use and operationalisation of these stated human development factors have been done in other studies, particularly those involving the characteristics approach (Pothisiri et al., 2020; Sanderson & Scherbov, 2014; Vicerra & Estanislao, 2023; Vicerra & Pothisiri, 2020).

2.2.3. Other covariates

Selected covariates were included in the model as they have been observed in other studies to have associations with cognitive functioning (Xu et al., 2017, 2018). Age and urban-rural residence were included. For hypertension, respondents were asked if they had been diagnosed with the condition by a medical doctor. For the other variable, a high body mass index (BMI) was calculated from the self-reported height and weight information. A respondent was classified as overweight if they had a BMI of 24 kg/m^2, which is the threshold for Chinese adults (Zhou, 2002).

The statistical modelling analyses towards generating the final results for the characteristics approach are refined by the addition of a selected number of health factors related to the outcome. In the present case, hypertension and BMI were selected as they have been consistently observed to be associated with cognitive impairment in the context of adults in China over the years (Li et al., 2012; Wang et al., 2021; Xu et al., 2018). Although other factors have been observed to also be associated with cognitive outcomes (Hartanto & Yong, 2018), the aim of using the characteristics approach is to present results utilising concise analytical modelling. Therefore, based on a review of the literature, hypertension and BMI were selected. Although this was the case, sensitivity analysis was performed through the use of multivariate regression analyses. This was done by including other probable determinants of cognitive performance, such as smoking tobacco, drinking alcohol, and being diagnosed with diabetes. The regression analyses were done with the total analytical sample, by male and female subsamples, and by residential subsamples. It was observed that the effect sizes of hypertension and BMI remained high even with the inclusion of smoking, drinking, and the prevalence of diabetes.

2.2.4. Statistical analysis

Descriptive analyses were employed to observe the cognition score patterns by gender and age group. A test for multicollinearity was performed before proceeding to the multivariate analyses, where the Variance Inflation Factor (VIF) test was employed. It was confirmed that the covariates showed no multicollinearity effect as the VIF values were within the acceptable range, which is below 4 (Salmerón et al., 2018). Referring to the total sample, the mean VIF was 1.49. When stratified by male and female subsamples, the mean values of VIF were 2.22 and 1.34, respectively. Multivariate regression model analyses were then done for the health characteristics related to educational attainment and income levels. The model specification for education is:

$$H(k)_i = \beta_0 + \beta_1 \text{age}^2 + \beta_2 \text{Residence} + \beta_3 \text{Primary} + \beta_4 \text{Lowermiddle} + \beta_5 \text{Uppermiddle} + \beta_6 \text{Postsecondary} + \beta_7 \text{Hypertension} + \beta_8 \text{Overweight} + \varepsilon_i$$

And the model specification for income and wealth analyses were mutually exclusive but similar in form:

$$H(k)_i = \beta_0 + \beta_1 \text{age}^2 + \beta_2 \text{Residence} + \beta_3 \text{Middle} + \beta_4 \text{High} + \beta_5 \text{Hypertension} + \beta_6 \text{Overweight} + \varepsilon_i$$

Where *H(k)* pertains to the health characteristic *k* that stands for the cognition level if person *i.* ε_i refers to the random error with zero mean and variance σ^2.

The characteristic-based approach was used to calculate α-ages for each educational attainment level and income tertile in order to estimate age differences in cognition performance across education and income levels (Sanderson & Scherbov, 2014). This required calculating the predicted mean value of the health characteristic, *k*, as a function of chronological age and a set of covariates. The following were the equations for the α-ages of the education subgroups:

$$\alpha_{k,\text{Primary}} = \sqrt{age^2_{Noeduc} - (\widehat{\beta}_3 / \widehat{\beta}_1)}$$

$$\alpha_{k,\text{Lowermiddle}} = \sqrt{age^2_{Noeduc} - (\widehat{\beta}_4 / \widehat{\beta}_1)}$$

$$\alpha_{k,\text{Uppermiddle}} = \sqrt{age^2_{Noeduc} - (\widehat{\beta}_5 / \widehat{\beta}_1)}$$

$$\alpha_{k,\text{Postsecondary}} = \sqrt{age^2_{Noeduc} - (\widehat{\beta}_6 / \widehat{\beta}_1)}$$

α-ages of the income-level and wealth-status subgroups used these equations:

$$\alpha_{k,\text{Middle}} = \sqrt{age^2_{Low} - (\widehat{\beta}_3 / \widehat{\beta}_1)}$$

$$\alpha_{k,\text{High}} = \sqrt{age^2_{Low} - (\widehat{\beta}_4 / \widehat{\beta}_1)}$$

The α-ages of individuals with higher levels of educational attainment and income were compared with their respective less-educated and lower-income counterparts who had the same level of cognitive performance.

3. Results

Descriptive statistics of the total sample and according to gender are presented in Table 1. The mean age of the analytic sample was 68 years, regardless of gender. Men have higher average cognition test scores as well as higher education levels. There were also more women who had low and middle levels of household income. Older females who were overweight were also observed to have a higher prevalence than males.

Fig. 1 shows the adjusted average cognition score of men and women in the sample across educational attainment levels. Regardless of gender, in each age group, people who had not completed any level of schooling had the lowest mean score. Another aspect of the observation was the tendency for scores to decrease as age advances. One aspect that needs highlighting is that the scores of women who have postsecondary education were similar to, or even higher than, men's.

The adjusted average cognition scores based on income levels are shown in Fig. 2. The high income level was observed to be consistently at par with higher levels of educational attainment. The scores of men and women with low and middle income levels change depending on which has the advantage. Similar to the trends in educational differentials, general scores at younger ages were higher than those of older ages.

The initial procedure for the characteristics approach was performed for educational attainment (See Table A1 in Appendix 1). It was observed from the sample that higher educational attainment levels had a positive association with improved cognition. The α-ages according to educational levels were observed (Table 2). The category of having completed no schooling was used as the age pattern for the schedule. For both genders, the level of education completed increased the advantage with cognitive performance; for example, men aged 61.9 with primary level of schooling and those aged 67.8 with postsecondary qualifications exhibit the same cognition performance as those aged 60 with no completed schooling. The observation also revealed that men's and women's advantages diminish as they age. Lastly, the advantage of women who have postsecondary education was higher than men's, whereby the cognition level of individuals with no schooling at age 80

Table 1
Descriptive statistics of analytic sample by gender.

	Total	Male	Female	p-value+
Mean age	68.20	68.19	68.22	0.88
Mean cognition	13.69	14.36	13.08	<0.001
Educational attainment				
No completed schooling	18.41	6.21	29.68	<0.001
Primary	27.94	28.42	27.49	
Lower middle	27.62	33.54	22.15	
Upper middle	10.43	12.96	8.09	
Postsecondary	15.6	18.87	12.59	
Income level				
Low	11.92	11.14	12.65	0.030
Middle	13.35	12.11	14.5	
High	74.72	76.75	72.85	
Residence				
Rural	55.67	56.06	55.31	0.662
Urban	44.33	43.94	44.69	
Diagnosed hypertension				
No	68.43	69.08	68.41	0.672
Yes	31.27	30.92	31.59	
Overweight				
No	48.63	51.13	46.32	0.005
Yes	51.37	48.87	53.68	
Total (n)	3422	1643	1779	

Note: Based on *t*-test and χ^2 test where applicable.
Source: 2015 China Health and Nutrition Survey

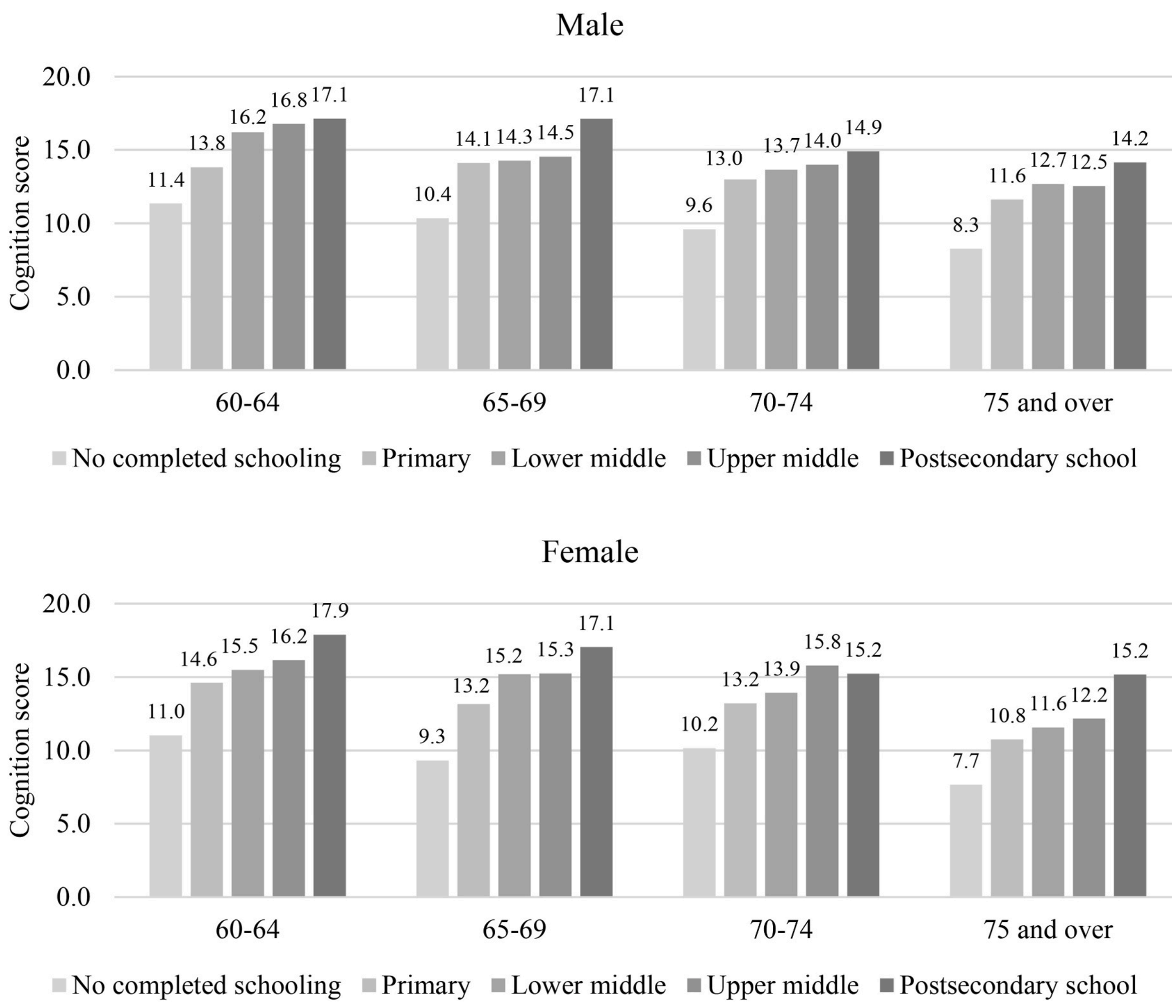

Fig. 1. Mean cognition score across education level by age and gender.

was exhibited by men at almost 86 years, while it was about 89 years among women.

Table A2 as presented in Appendix 1 shows the regression analysis results regarding income analyses for men and women subgroups. A notable finding was the lack of statistical significance between low and middle income levels in terms of cognition. Having a high household income per capita was seen as having a positive association with the outcome. In terms of income levels, the advantage conferred by income level is shown in Table 3. As the middle-income level lacked statistical association based on the previously stated regression analysis on income, the resulting alpha-ages are minimal. The benefits of having a high income level are more pronounced. The schedule's alpha-ages follow a similar pattern to education differentials, whereas gains from higher income categories decrease as age increases. Among men, for example, there was about a 10-year difference between the low and high income levels at age 60, and by age 80, the difference was 8 years.

4. Discussion

The present study observed socioeconomic disparities concerning cognitive performance. There were increasing benefits to higher education levels and income categories. Also, the advantages differ between men and women. In general, these findings on human capital development factors and their impact on health performance outcomes were in line with previous studies on physical health in multiple societies, including developing economies (Pothisiri et al., 2020; Sanderson & Scherbov, 2014). A previous study on cognition status also observed similar trends among men and women across older ages (Vicerra & Pothisiri, 2020).

The differentiation of outcomes among males and females has been linked to both biological and sociological underpinnings. It was observed that there are hormonal and chromosomal factors that underlie the general performance among people of different sexes starting from childhood to old age (Mielke et al., 2014). The said biological factors tend to and affect health and cognitive capacities. Socially, it is suggested that women tend to have fewer resources, so they compensate in terms of the resources that they do possess (Ross & Mirowsky, 2010). This resource substitution theory points specifically to the general benefits of education and has been observed among Chinese older women with regards to self-rated health (Zhu & Ye, 2020). There are various sources of inequity between genders in China (Wang et al., 2009; Yang et al., 2014). For those who have achieved higher educational levels, greater advantages may be exhibited.

When comparing education and income levels, the former has been noted to have a larger effect on cognitive functioning (Richards & Sacker, 2011). Education's effect has continuity in that it can influence opportunities throughout life and the activities selected until later ages (Schöllgen et al., 2010). Income, on the other hand, does not have such continuity and represents only the status of individuals and households at the time of the survey and its scope. Education can train and improve cognitive processes during the younger years, potentially delaying cognitive ageing and impairment (Zahodne et al., 2015).

This study has limitations. Firstly, causality cannot be established due to the cross-section of data used. The CHNS is a longitudinal survey,

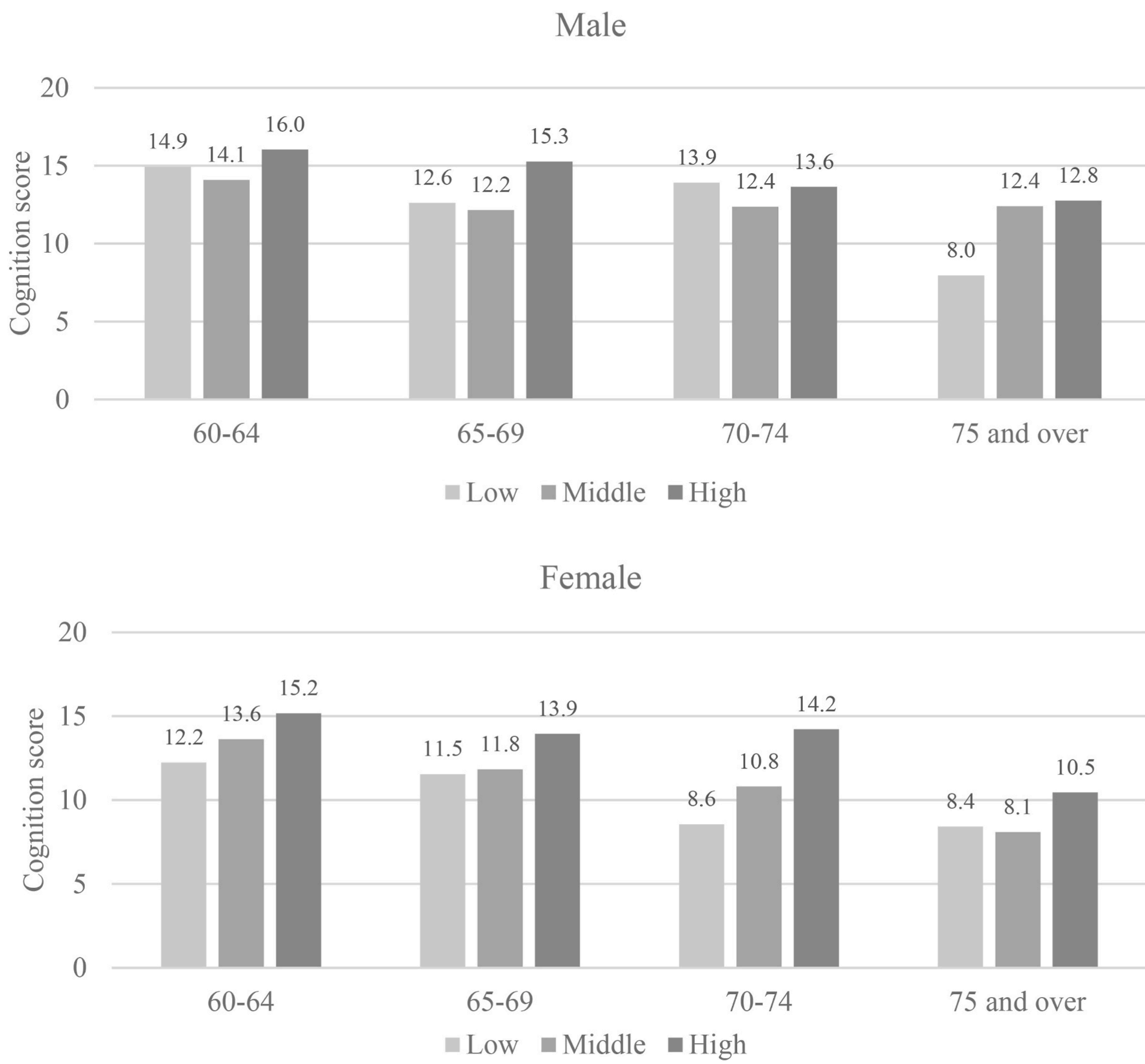

Fig. 2. Mean cognition scores of men and women by income level and age.

Table 2
Alpha-age schedule for men and women by completed education level.

Age with no completed schooling	Educational attainment			
	Primary	Lower middle	Upper middle	Postsecondary
Men				
60	61.86	64.09	65.62	67.76
65	66.72	68.79	70.22	72.22
70	71.60	73.54	74.87	76.75
75	76.50	78.31	79.57	81.34
80	81.41	83.11	84.30	85.97
Women				
60	66.35	69.30	69.98	71.31
65	70.90	73.67	74.31	75.57
70	75.51	78.12	78.72	79.91
75	80.17	82.63	83.20	84.32
80	84.86	87.20	87.73	88.80

Note: Cognition level age-specific schedule of subgroup with no completed schooling as the reference.

Table 3
Alpha-ages by income level and gender.

Age with low income level	Income level	
	Middle	Higher
Men		
60	61.09	69.86
65	66.01	74.20
70	70.94	78.62
75	75.88	83.10
80	80.82	87.64
Women		
60	61.33	68.57
65	66.23	72.99
70	71.14	77.47
75	76.07	82.02
80	81.00	86.61

Note: Cognition level age-specific schedule of subgroup of low income level as the reference.

and cognition test items have been asked in much earlier waves of the panel data, but there have been withdrawals from the survey. Additional respondents have also been added over the years, and in 2011, three metropolitan locations were added as stated previously. For these reasons, the 2015 cross-section was used to include a broader range of older Chinese adults. Secondly, the questions on cognitive performance used are not diagnostic in nature and therefore cannot replace official diagnoses of mild cognitive impairments. Still on the selection of variables to create the outcome measure, the present study used an index of cognitive performance based on available survey items, which was found to be sufficient in the literature. Comparison with other studies pertaining to cognition should be cautioned, such as those that have utilised standardised measures indicative of dementia and other cognitive diseases. Another limitation that needs acknowledgement is in the method of analysis, particularly in the selection of variables included in the regression model for generating the final results. A simple, concise, but representative set of factors that have been observed in the literature to be associated with cognitive health is optimal since the focus was on human capital development factors. This may be a point of bias, but this is minimised since a sensitivity analysis has been performed. Lastly, the present analytic sample was not nationally representative of community-dwelling adults, and the survey data also did not collect information from individuals in institutional settings. Despite these limitations, the vast and diverse locations used for the total survey sample allowed for the observation of certain associations with the cognition status of older people across education and income levels.

Current cohorts of older adults have better health status and performance than previous ones (Scherbov & Sanderson, 2016). This trend may continue such that future cohorts will continue to have higher levels of cognitive performance. Such an outcome has to be secured through sound and consistent policies, whereby human capital development should be ensured in its universality. The young people of today in all locations of the country would need to have access to education in order to be more productive individuals in adulthood and have better cognition levels even at more advanced ages.

Ethical approval

No ethical approval was applicable. The present study did not involve human participants or animal subjects. This manuscript also does not contain personal information about any individual or a case history.

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Ethical statement

No ethical approval was applicable because of the use of secondary data from https://www.cpc.unc.edu/projects/china. The present study did not involve human participants or animal subjects. This manuscript also does not contain personal information about any individual or a case history.

Author statement

Paolo M.M. Vicerra: Conceptualization, Project administration, Formal analysis, Methodology, Writing – original draft, Writing – review & editing.

Jinjing Wu: Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing.

Ying Wu: Formal analysis, Writing – original draft, Writing – review & editing.

Declaration of conflicting interests

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary data

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