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ORIGINAL ARTICLE

Trends in the prevalence of cognitive impairment in Chinese older adults: based on the Chinese Longitudinal Healthy Longevity Survey cohorts from 1998 to 2014

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In the context of a rapidly ageing Chinese population, this study aims to examine trends in the prevalence of cognitive impairment among people ≥65 y of age in China. Our sample is 72 821 adults aged 65–105 y from the seven waves of the Chinese Longitudinal Healthy Longevity Survey, a national mixed longitudinal cohort. The Chinese version of the Mini-Mental State Examination was used to measure CI. Risk factor-adjusted prevalence trend was examined using multilevel regression models. Age-standardized prevalence of cognitive impairment increased from 11.00% in 1998 to 11.84% in 2008 and decreased to 8.88% in 2014. Older age, female gender, less education, rural residence, not married, lack of physical and cognitive activities, suffering from stroke, vision and hearing impairment, and activities of daily living disability were negatively associated with cognitive impairment. Our study suggests a decreasing trend of cognitive impairment prevalence in China. However, whether decreasing prevalence will contribute to a reduced burden of cognitive impairment given the ageing of the population is unknown.

Keywords: Chinese, cognitive impairment, older adults, prevalence

Introduction

Cognitive impairment is a special cognition status ranging from mild to major that is characterized by declines in memory, attention, language and other cognitive functions. Cognitive impairment is common in the elderly, with an occurrence rate of approximately 21.5–71.3 per 1000 person-years in seniors.[1] Alzheimer's dementia and vascular dementia are the two most common causes of acquired cognitive impairment. Alzheimer's Disease International (ADI) estimates that 50 million people suffered from dementia in 2019 worldwide, and this number will increase to 152 million by 2050.[2] ADI has also estimated that the current annual cost of dementia is US$1 trillion, which will double by 2030.[2] Given the range of people directly and indirectly affected by dementia, along with its huge disease burden, the World Health Organization regards dementia as a public health priority.[3] Due to the lack of effective treatment for dementia, prevention and early identification are essential to delay dementia development. The trend of cognitive impairment, as a screening indicator of dementia, is of great interest because it can help to predict dementia prevalence. The possible explanations from changing related risk factors can also provide important implications for the early prevention of dementia.[3]

Research from Europe and the USA suggests that dementia and cognitive impairment prevalence have been going down over time[4–7] and points to higher education and attention to and management of vascular health as major factors in preventing cognitive decline.[5] China is experiencing rapid transitions in economic, health and population structure. Between 1970 and 2010, male life expectancy increased from 60.4 to 72.9 y and female life expectancy increased from 63.5 to 79.0 y.[8] The proportion of people ≥65 y of age was 5.57% in 1990, 6.96% in 2000, 8.87% in 2010 and 10.5% in 2015, indicating a rapid increase in the ageing population.[8] In tandem with the ageing population, cognitive impairment and dementia prevalence, which are highly related to age, are expected to increase. Researchers have explored dementia prevalence or cognitive impairment prevalence in various regions of China; however, most of these studies are cross-sectional studies within a restricted region that could not observe trends in dementia prevalence over time.[9–11]

Although a previous systematic review reported an increased trend of dementia prevalence in all age groups from 55 to 99 y,[12] the most recent systematic review of the prevalence of dementia in mainland China, Hong Kong and Taiwan found that after taking into account methodological factors and geographic areas, the increasing trend in the prevalence of dementia was not significant.[13] As more and more studies in high-income countries have observed a decreasing incidence and prevalence in dementia or cognitive impairment,[4–7] exploring the trend in cognitive impairment in China using longitudinal data with consistent measures is essential for international comparisons.

Our previous study[14] reported that the incidence of cognitive impairment in the Chinese elderly population has been decreasing over recent decades, but the pattern of prevalence is still uncertain in the context of people's longer survival with cognitive impairment. A trend study of cognitive impairment prevalence can provide different aspects for the whole picture, with information about how many elderly Chinese are at high risk and need further prevention, what the exact trend of prevalence is and which risk factors are responsible for this trend. These implications cannot be fully covered by incidence studies. Therefore this study aims to examine secular trends in cognitive impairment prevalence among Chinese elderly during 1998–2014 based on the Chinese Longitudinal Healthy Longevity Survey (CLHLS), which is a national mixed longitudinal cohort of the Chinese elderly population (≥65 y of age).

Materials and methods

Study design, participants and procedures

Data in this study were drawn from the participants from seven waves (1998, 2000, 2002, 2005, 2008–2009, 2011–2012, 2014) of the CLHLS. The CLHLS is one of the largest national longitudinal studies for investigating the health of older Chinese adults.[15] A total of 22 Chinese provinces were randomly recruited, covering about half of the cities and counties in each province.[15] The first two waves (1998 and 2000) interviewed all centenarians, and for each centenarian, one octogenarian (80–90 y of age) and one nonagenarian (90–99 y of age) living nearby were also interviewed. Since 2002, adults 65–79 y of age were added to the survey. As a mixed longitudinal study, the CLHLS recruits approximately one-third of the subjects in each wave from those in the previous wave, while recruiting the remainder of the subjects from outside the study entirely. In an effort to preserve sample consistency and decrease selection bias across each wave of the study, new recruits were chosen to match those lost to follow-up in terms of gender, age and education (Table 1).[15] The survival bias analysis is presented in Appendix 1.

After excluding those who reported blindness, deafness or depression, we pooled 74 204 cases from the 1998–2014 waves. We used the Chinese version of the Mini-Mental State Examination (CMMSE) to examine the cognitive function of the respondents. Among 74 204 cases, only 36 965 cases have validated CMMSE results, and 109 cases who were unable to answer the CMMSE due to low cognitive function as coded by the interviewer were coded as cognitive impairment. Among the other 37 130 cases, we excluded 768 cases who had all CMMSE items missing and performed multiple imputation of five for the remaining 36 362 cases who had partial items missing. The imputation returned five datasets, each containing 73 436 cases. We conducted a series of sensitivity analyses to compare the key results of the imputed and completed datasets and obtained similar results. In our study, we chose adults 65–105 y of age as our target population, which resulted in a sample of 72 821 cases.

Face-to-face interviews were conducted in the homes of participants by trained interviewers recruited from among university students and the local centres for disease prevention and control. The data quality of the CLHLS has been reported as satisfactory by previous studies.[16] More details about the CLHLS, including study design, sampling strategies, data collection process, quality control and the questionnaires can be found elsewhere.[15,16]

Statistical analyses

Measurement of cognitive impairment

The CMMSE was employed to test the cognitive function of participants in all waves of the CLHLS. The CMMSE consists of 24 items covering six dimensions: orientation, registration, naming, attention and calculation, recall and language. The total score of the CMMSE ranges from 0 to 30 points. Higher scores indicate better cognitive function.

Compared with the original MMSE scale, the CMMSE omits the dimensions for reading and writing. The CMMSE may be more suitable for measurement of elderly Chinese cognitive function because there is a high illiteracy rate among elderly Chinese. The CMMSE has been validated in previous Chinese studies.[17–19] A CMMSE score of ≤18 points was used as the standard for diagnosing cognitive impairment in our study, and this has been previously validated as an appropriate standard.[18]

Explanatory variables

Factors that may have an impact on the prevalence of cognitive impairment were drawn as explanatory variable from the CLHLS, including wave indicators, age, gender, education, health conditions and physical and cognitive activities. The name, code and definition of each variable are provided in Appendix 2.

We used pooled data from seven waves as the standard population to calculate the age-standardized prevalence of cognitive impairment. And F test of linear regression was used to test the time trends in crude and age-standardized prevalence of cognitive impairment over time. The data have a three-level structure: repeated points (level 1) nested within individuals (level 2) and individuals (level 2) nested within provinces (level 3). We used three-level logistic regression models to estimate the time trends of cognitive impairment prevalence and odds ratios (ORs) with 95% confidence intervals (CIs) after adjustment for covariates.

Ethical approval

The CLHLS study was approved by the Institutional Review Board of Duke University (Pro00062871) and the Biomedical Ethics Committee of Peking University (IRB00001052-13074). Each participant signed a written informed consent.

Table 1. Subjects lost to follow-up in each wave

Characteristics	1998	2000	2002	2005	2008	2011	2014	Total
Observations, n	7882	9604	14 076	13 482	13 432	8266	6079	72 821
Respondents first surveyed, n	–	5771	8964	6525	7089	1584	1007	30 940
Respondents deceased[a], n	4049	4492	7119	7139	6750	3194	–	32 965

[a]Lost to follow-up or died before the next wave.

Results

Characteristics of study samples

The characteristics were significantly different between waves (Table 2). This suggested heterogeneity in samples from different waves and the need for adjustment for characteristics in the pooled analysis for time trends.

The total crude prevalence of cognitive impairment was 11.56% in 1998 and 7.06% in 2014, decreasing from 6.36% to 4.23% for males and from 15.4% to 9.7% for females (Table 3). This decline over time was significant ($p<0.05$) for both sexes and the total sample. The crude trend is shown in Figure 1A in the solid curve.

The total age-standardized prevalence of cognitive impairment was 11.00% in 1998 and 8.88% in 2014, decreasing from 6.12% to 5.14% for males and from 14.71% to 12.09% for females (Table 3). This decline over time was insignificant ($p<0.05$) for both sexes and the total standardized sample. The dashed curve in Figure 1A shows the age-standardized trend.

Adjusted time trend in cognitive impairment prevalence

The three-level logistic regression analysis further confirms factors associated with a significantly lower prevalence of cognitive impairment, including male gender, younger age, more education, urban residence, married status, frequent consumption of vegetables, more exercise, more physical or cognitive activities, no previous strokes, better visual or hearing function and no ADL disability (Table 4).

In contrast to the prevalence in 1998, the unadjusted prevalence of cognitive impairment declined, with fluctuations, from 2000 to 2014, as shown in model 1 (Table 3) and Figure 1A (the solid curve). After adjusting for demographics (model 2), education (model 3) and socio-economic and network variables (model 4), there were no declining trends (Table 3). The adjusted prevalence decreased slightly in 2000, then increased greatly in 2002 and remained constant until 2008, after which it gradually decreased through 2014.

Following further adjustment for health practice variables (model 5), the prevalence in other waves was more than that in 1998, but it showed an increasing trend first and a decreasing trend after 2008 (Table 3). Finally, after adjusting for health conditions in addition to the other four blocks of variables, model 6 shows that, compared with 1998 (baseline), the following waves had a higher cognitive impairment prevalence, especially during 2002–2011, where the adjusted cognitive impairment prevalence increased by 61%, 71%, 79% and 26% (Table 3).

Compared with the crude and age-standardized time trends shown in Figure 1A, Figure 1B presents the adjusted cognitive impairment prevalence curves from the final multilevel model. The curve derives from model 6 (Table 3), which shows an increasing trend first, then a declining trend by 2014.

Impact of age, gender and education years on cognitive impairment prevalence

It is not surprising, as shown in Figure 2A, that the prevalence of cognitive impairment increases with age. The prevalence of cognitive impairment in the 75–84 y age group was two to three times higher than that of those in the 65–74 y age group and the prevalence among people ≥85 y was three to four times higher than that of those in the 75–84 y age group. In Figure 2B, curves of cognitive impairment prevalence showed different slopes for females and males, with a steeper slope for female prevalence, especially after age 75 y, indicating a faster cognitive decline in older women. In Figure 2C, people with a higher education level had a slower cognitive decline than their counterparts.

Discussion

To our knowledge, this is the first study to use a national representative mixed longitudinal dataset to examine trends in cognitive impairment prevalence in China over the last 16 y.

There is a lot of evidence showing a stable or reduced prevalence of dementia and cognitive impairment in high-income countries over the last decade.[4–7] However, in low- and middle-income countries, current findings are inconsistent.[9–13,20] Three systematic reviews reported an increased prevalence of dementia in mainland China.[12,21,22] However, Wu et al.[20] observed that this increasing trend of dementia could be a function of changes in study designs and methodological factors. Their opinion is that the trend of prevalence has not significantly increased over the last 30 y. Our study found that the prevalence of cognitive impairment in China is not linear. It showed an increasing trend from 1998 to 2008 and a decreasing trend after 2008. Wu et al. proposed a hypothesis based on the relationship between societal changes, life expectancy and the prevalence of dementia that includes three stages: Stage A: low life expectancy

Table 2. Demographic characteristics of the prevalence sample[c] by survey wave

Variables	1998 (n=7882)	2000 (n=9604)	2002 (n=14 076)	2005 (n=13 482)	2008 (n=13 432)	2011 (n=8266)	2014 (n=6079)	p-Value[a]
Gender, n (%)								<0.001
Male	3349 (42.49)	4203 (43.76)	6276 (44.59)	6070 (45.02)	6108 (45.47)	3924 (47.47)	2934 (48.26)	
Age (years), n (%)								<0.001
65–69	–[b]	–[b]	1603 (11.39)	1660 (12.31)	1356 (10.1)	645 (7.8)	222 (3.65)	
70–79	–[b]	–[b]	3197 (22.71)	3216 (23.85)	2763 (20.57)	2446 (29.59)	2053 (33.77)	
80–89	3418 (43.36)	4698 (48.92)	3963 (28.15)	3600 (26.7)	3859 (28.73)	2426 (29.35)	2029 (33.38)	
90–99	2715 (34.45)	3287 (34.23)	3134 (22.26)	3254 (24.14)	3590 (26.73)	1952 (23.61)	1336 (21.98)	
100–105	1749 (22.19)	1619 (16.86)	2179 (15.48)	1752 (13.0)	1864 (13.88)	797 (9.64)	439 (7.22)	
Mean (SD)	91.39 (7.32)	90.31 (7.1)	84.89 (11.32)	84.52 (11.25)	85.42 (10.91)	84.1 (10.46)	83.9 (9.45)	<0.001
Education (years), n (%)								<0.001
≥7	753 (9.6)	897 (9.39)	1483 (10.59)	1503 (11.18)	1440 (10.75)	1010 (12.27)	205 (9.86)	
1–6	1991 (25.38)	2732 (28.6)	4174 (29.81)	4055 (30.17)	4009 (29.93)	2685 (32.62)	635 (30.53)	
0	5102 (65.03)	5924 (62.01)	8344 (59.6)	7881 (58.64)	7947 (59.32)	4537 (55.11)	1240 (59.62)	
Mean (SD)	1.91 (3.69)	1.96 (3.5)	2.16 (3.58)	2.27 (3.64)	2.21 (3.51)	2.48 (3.59)	2.17 (3.3)	<0.001
Residence, n (%)								<0.001
Urban	3028 (38.42)	5935 (61.8)	6509 (46.24)	6022 (44.67)	5460 (40.65)	3942 (47.69)	2765 (45.48)	
Marital status, n (%)								<0.001
Married	1489 (18.9)	2093 (21.79)	4813 (34.19)	4821 (35.76)	4765 (35.47)	3456 (41.96)	2596 (43.17)	
Vegetable consumption, n (%)								<0.001
Eat often	6161 (78.21)	7628 (79.43)	12 190 (86.64)	11 669 (86.55)	11 944 (88.93)	7343 (89.02)	5412 (89.22)	

Continued

Table 2. Continuation

Variables	1998 (n=7882)	2000 (n=9604)	2002 (n=14 076)	2005 (n=13 482)	2008 (n=13 432)	2011 (n=8266)	2014 (n=6079)	p-Value[a]
Exercise, n (%)								<0.001
Yes	2320 (29.45)	3456 (35.99)	4784 (34.04)	4516 (33.5)	4051 (30.16)	2963 (36.22)	1739 (29.32)	
Stroke, n (%)								<0.001
No	7117 (96.99)	8740 (96.15)	12 793 (94.78)	11 980 (94.47)	12 457 (94.33)	7261 (91.6)	5159 (90.97)	
Visual function, n (%)								<0.001
Can see and distinguish a break in the circle	5825 (74.45)	7087 (73.95)	10 201 (72.54)	8951 (66.46)	8975 (66.95)	5508 (67.23)	3910 (65.49)	
Can see only	897 (11.46)	–[b]	2076 (14.76)	2417 (17.95)	2503 (18.67)	1133 (13.83)	1023 (17.14)	
Cannot see	1102 (14.08)	2497 (26.05)	1786 (12.7)	2100 (15.59)	1928 (14.38)	1552 (18.94)	1037 (17.37)	
Hearing function, n (%)								<0.001
Can hear without hearing aid	5070 (64.59)	6866 (71.51)	10 749 (76.37)	10 505 (77.93)	10 149 (75.56)	6590 (79.94)	4931 (81.53)	
Can hear with hearing aid	1768 (22.53)	914 (9.52)	1353 (9.61)	1182 (8.77)	1284 (9.56)	508 (6.16)	389 (6.43)	
Can partly hear with hearing aid	1011 (12.88)	1821 (18.97)	1972 (14.01)	1793 (13.3)	1999 (14.88)	1146 (13.9)	728 (12.04)	

SD, standard deviation.

[a] $\chi 2$ or F test for a significant difference in proportion or mean between years.

[b] First two surveys (wave 1998 and 2000) focused on the oldest-old Chinese, so people 60–79 y of age were not included; in wave 2000, visual function did not contain a 'can see only' category.

Table 3. Crude and age-standardized cognitive impairment prevalence by wave

Characteristics	1998	2000	2002	2005	2008	2011	2014	p-Value[a]
Crude prevalence, % (n)								
Male	6.36 (213)	6 (252)	6.98 (438)	6.41 (389)	6.4 (391)	4.43 (174)	4.23 (124)	<0.001
Female	15.4 (698)	12.92 (698)	14.35 (1119)	14.18 (1051)	15.51 (1136)	10.87 (472)	9.7 (305)	<0.001
Total	11.56 (911)	9.89 (950)	11.06 (1557)	10.68 (1440)	11.37 (1527)	7.82 (646)	7.06 (429)	<0.001
Age-standardized prevalence, %								
Male	6.12	6.37	7.62	7.10	6.70	5.23	5.14	0.236
Female	14.71	13.55	15.24	15.40	16.03	12.44	12.09	0.290
Total	11.00	10.47	11.83	11.67	11.84	9.14	8.88	0.196

[a]F test of linear regression for a significant difference in cognitive impairment prevalence over time within the same row group.

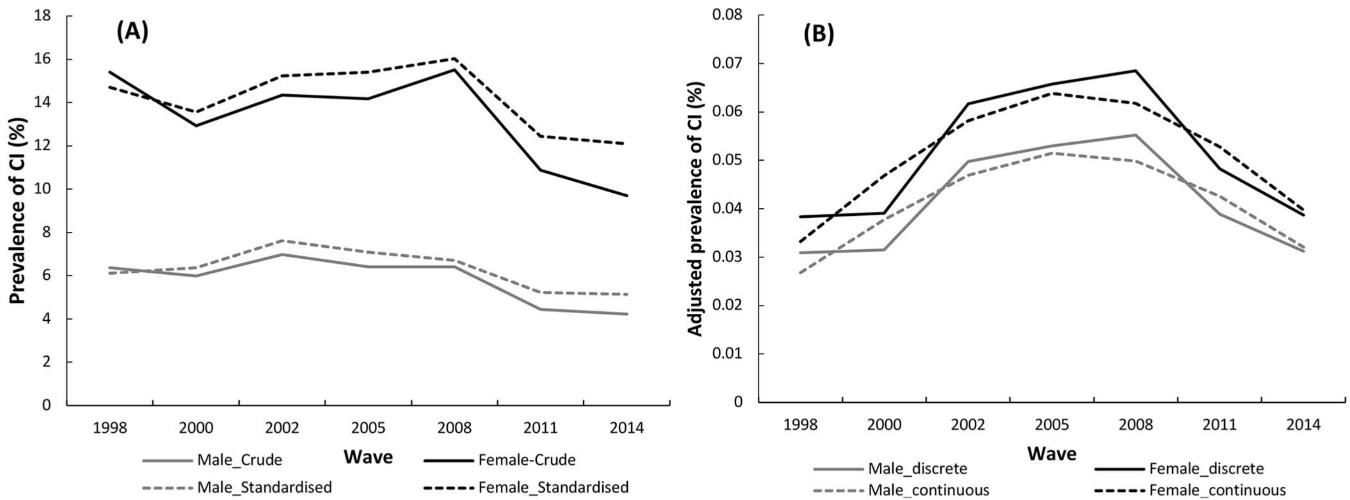

Figure 1. (**A**) The time trends of crude and age-standardized cognitive impairment prevalence by gender. (**B**) The time trends of adjusted cognitive impairment prevalence by gender, from the final multilevel regression model.

and healthy survivor; Stage B: extended life expectancy but unhealthy ageing; and Stage C: extended life expectancy and healthy ageing.[20] They predicted that the prevalence of dementia and cognitive impairment in East Asia will increase in the coming decades, in line with a Stage B trend, as a result of an increase in non-communicable diseases. However, our previous study found that age-standardized cognitive impairment incidence decreased from 58.77% to 10.09% from 1998 to 2014,[14] similar to the findings in some European countries and the USA,[4–7,23] reflecting a Stage C trend. In the case of cognitive impairment, incidence contributes to the continuous growth of prevalence given increased life expectancies. This could explain why we did not find a linear decreasing trend for incidence. However, prevalence will not continue to grow until mortality equals or exceeds the incidence rate. That may explain why we observed a downward trend in the prevalence of cognitive impairment since 2008.

Many factors influence the prevalence of cognitive impairment. On the one hand, China is experiencing rapid ageing, which may lead to increased prevalence. On the other hand, the government has paid significant attention to the prevention of chronic diseases, which may lead to decreased prevalence. Two recent studies using data from the Global Burden of Disease showed a decreasing trend of age-standardized prevalence of diabetes.[24,25] In addition, people are becoming more educated, both in and after school, which may also lead to a decreased prevalence. However, more time points after 2014 are needed to determine whether the prevalence of cognitive impairment in China is truly decreasing, as only three time points (2008, 2011 and 2014) are currently available.

Consistent with previous studies, older age, female gender, low education attainment and fewer cognitive activities were identified as risk factors for cognitive impairment. The percentage of people in the USA with Alzheimer's dementia increases with age, from 3% among people 65–74 y of age to 17% among people 75–84 y of age and 32% among people ≥85 y of age.[26] In our study, we observed a similar pattern, where the prevalence of cognitive impairment doubled for every additional 10 y of age. We also found that women had a higher prevalence of cognitive impairment than their male counterparts. Researchers

Table 4. Adjusted ORs and 95% CIs of prevalence using a three-level logistic model

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Wave (ref=1998)						
2000	0.84 (0.76–0.93)*	0.92 (0.84–1.02)	0.92 (0.83–1.02)	0.97 (0.87–1.07)	1.2 (1.08–1.34)*	1.02 (0.91–1.15)
2002	0.99 (0.91–1.09)	1.47 (1.34–1.61)*	1.46 (1.33–1.6)*	1.49 (1.35–1.63)*	1.97 (1.79–2.17)*	1.61 (1.45–1.79)*
2005	0.96 (0.88–1.05)	1.48 (1.35–1.63)*	1.47 (1.34–1.62)*	1.5 (1.37–1.65)*	2.03 (1.84–2.24)*	1.71 (1.54–1.91)*
2008	1.01 (0.92–1.11)	1.44 (1.31–1.58)*	1.43 (1.3–1.57)*	1.46 (1.33–1.6)*	2.05 (1.86–2.26)*	1.79 (1.61–1.99)*
2011	0.7 (0.63–0.78)*	1.12 (1–1.26)*	1.13 (1.01–1.27)*	1.18 (1.05–1.32)*	1.64 (1.45–1.85)*	1.26 (1.1–1.44)*
2014	0.56 (0.48–0.66)*	1.06 (0.91–1.24)	0.92 (0.7–1.22)	0.97 (0.73–1.29)	1.37 (1.02–1.86)*	1.01 (0.72–1.41)
Demographic characteristics						
Gender (ref=male)						
Female		1.89 (1.79–2.01)*	1.45 (1.35–1.55)*	1.37 (1.28–1.47)*	1.25 (1.17–1.34)*	1.24 (1.15–1.34)*
Age (years) (ref=65–69)						
70–79		2.97 (2.13–4.16)*	2.78 (1.98–3.9)*	2.64 (1.88–3.7)*	2.23 (1.58–3.14)*	2 (1.4–2.87)*
80–89		10.41 (7.58–14.3)*	9.1 (6.6–12.55)*	7.98 (5.78–11.03)*	4.45 (3.2–6.17)*	3.58 (2.54–5.03)*
90–99		25.18 (18.36–34.52)*	21.01 (15.26–28.92)*	17.5 (12.66–24.18)*	7.16 (5.16–9.94)*	4.46 (3.16–6.3)*
100–105		48.13 (35.11–65.99)*	39.13 (28.38–53.97)*	31.94 (23.07–44.23)*	10.98 (7.9–15.26)*	5.64 (3.99–7.98)*
Education (ref=≥7 y)						
1–6 y			1.64 (1.41–1.92)*	1.57 (1.34–1.84)*	1.13 (0.96–1.33)	1.16 (0.98–1.37)
0 y			2.85 (2.45–3.31)*	2.64 (2.27–3.07)*	1.56 (1.34–1.83)*	1.62 (1.37–1.91)*
Socio-economic						
Residence (ref=urban)						
Rural				1.21 (1.14–1.28)*	1.1 (1.04–1.17)*	1.1 (1.03–1.18)*
Marital status (ref=married)						
Other				1.43 (1.31–1.56)*	1.25 (1.14–1.37)*	1.24 (1.12–1.37)*
Health practice						
Vegetable consumption (ref=often)						
Seldom					1.57 (1.47–1.68)*	1.44 (1.34–1.55)*
Exercise (ref=yes)						
No					1.45 (1.34–1.57)*	1.31 (1.21–1.42)*

Continued

Table 4. Continuation

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Physical activities (ref=more)						
Less					1.13 (1.12–1.14)*	1.07 (1.06–1.08)*
Cognitive activities (ref=more)						
Less					1.22 (1.2–1.24)*	1.17 (1.15–1.18)*
Health conditions						
Stroke (ref=no)						
Yes						1.33 (1.17–1.51)*
Visual function (ref=can see and distinguish a break in the circle)						
Can see only						1.91 (1.77–2.07)*
Cannot see						1.9 (1.77–2.05)*
Hearing function (ref=can hear without hearing aid)						
Can hear with hearing aid						1.79 (1.65–1.95)*
Can partly hear with hearing aid						2.82 (2.63–3.03)*
ADL disability (ref=no)						
Yes						1.86 (1.74–1.99)*
Multilevel $\sigma 2$ (SE)						
3rd level, provinces	0.06 (0.02)*	0.08 (0.03)*	0.08 (0.03)*	0.09 (0.03)*	0.16 (0.05)*	0.12 (0.04)*
2nd level, individuals	0.54 (0.04)*	0.28 (0.04)*	0.24 (0.04)*	0.23 (0.04)*	0.19 (0.04)*	0.22 (0.05)*

*p>0.05.

SE, standard error;

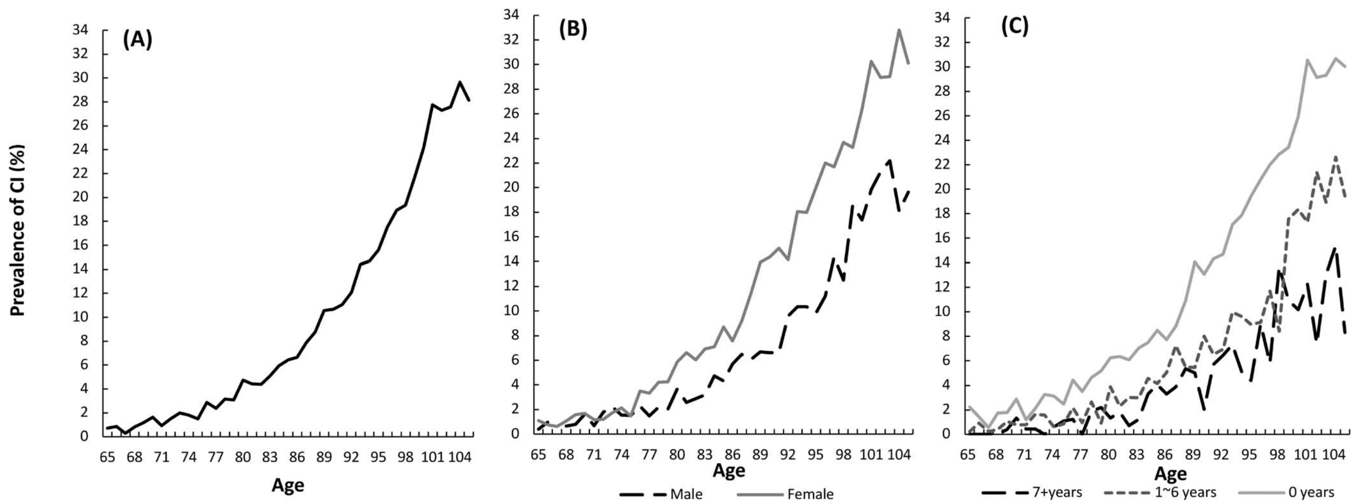

Figure 2. (**A**) Trend of cognitive impairment prevalence with age. (**B**) Impact of gender on cognitive impairment prevalence with age. (**C**) Impact of education years on cognitive impairment prevalence with age.

have attributed this to the longer average life expectancy of females;[27,28] survival bias—males have a higher mortality rate from cardiovascular disease than women in middle age, such that the men who survive to older ages tend to be healthier men;[27] and interactions between the *APOE* e4 genotype and the sex hormone oestrogen, which could cause a higher prevalence of Alzheimer's dementia in women than in men.[29,30] The relationship between education and cognitive function might be explained by the cognitive reserve hypothesis, which proposes that high levels of cognitive activity can help mitigate the negative effects of brain changes in older age.[31,32] Besides age, sex and education, we also found that older people with fewer cognitive activities were more likely to develop cognitive impairment. There is evidence showing that cognitive activity in old age, before the onset of dementia, may have a positive impact on the disease prognosis and, perhaps by increasing cognitive reserve, ultimately help to slow cognitive decline.[33]

In our study we identified rural residence as a risk factor for having impaired cognitive function. In China, everyone has a *hukou*, a registered residence. For decades the *hukou* system had functioned like an 'internal passport system', where one's *hukou* determined where an individual could live and work.[34] This policy has been relaxed since Chinese economic reform policies took hold 30 y ago. Generally speaking, people living in rural areas have less opportunity to get higher-paying jobs, better education and better healthcare than those living in urban areas. In terms of education, although about 90% of the participants received <7 y of education, educational opportunities after graduation were quite different. People living in urban areas could take their parents' positions in factories after their parents retired, and they then received continued educational opportunities provided by these factories. However, people living in rural areas rarely have such opportunities. This could partly explain the difference in cognitive function between rural and urban residents even after controlling for gender, age, education level and other potential risk factors. Moreover, since rural residents have less access to quality healthcare, chronic disease prevention and management are poorer than in their urban counterparts,[35] which might be another potential contributor to the greater prevalence of cognitive impairment in rural residents.

We recognize several important limitations. First, data from the CLHLS are missing from eight provinces in remote western China (Guizhou, Yunnan, Xizang, Gansu, Qinghai, Ningxia, Xinjiang and Inner Mongolia), which tend to be less economically developed regions with fewer educational resources. Hence we must be cautious about generalizing our results to western China. Second, the CLHLS has been carried out in communities, excluding those living in institutions, which may lead to an underestimate of the prevalence of cognitive impairment. Third, information on chronic disease diagnoses was collected by self-reports, which may have been biased. Fourth, we need to bear in mind that although the CMMSE is highly related to cognitive impairment, it is not a clinical diagnosis.

Conclusions

In conclusion, we observed a decreasing trend of cognitive impairment prevalence in China since 2008 after adjusting for factors that might be associated with cognitive impairment. However, whether decreasing prevalence will contribute to a reduced burden of cognitive impairment given the ageing of the population is not known. When planning future healthcare services, it is crucial to take this into account. Moreover, we found in our study that rural residence was associated with a higher prevalence of cognitive impairment, which is a big challenge for China. In rural China, people usually have difficulty accessing health services compared with their urban counterparts. In addition, large-scale rural-to-urban migration over the past four decades has undermined the traditional function of family providing long-term care for the elderly. Therefore future research is needed to study how to address inequality in healthcare and how to provide long-term care for rural residents with cognitive impairment.

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