2022

Effect of Living Arrangements on Cognitive Function in Chinese Elders: A Longitudinal Observational Study

Yanwei Lin

Qi Zhang
Old Dominion University, qzhang@odu.edu

Tingxian Wang

Zhirong Zeng

Original Publication Citation

Lin, Y., Zhang, Q., Wang, T., & Zeng, Z. (2022). Effect of living arrangements on cognitive function in Chinese elders: A longitudinal observational study. *BMJ Open*, *12*(10), 1-10, Article e050410. https://doi.org/10.1136/bmjopen-2021-050410

BMJ Open

Effect of living arrangements on cognitive function in Chinese elders: a longitudinal observational study

Yanwei Lin,[1,2] Qi Zhang ,[3] Tingxian Wang,[4] Zhirong Zeng[2]

To cite: Lin Y, Zhang Q, Wang T, *et al*. Effect of living arrangements on cognitive function in Chinese elders: a longitudinal observational study. *BMJ Open* 2022;**12**:e050410. doi:10.1136/bmjopen-2021-050410

► Prepublication history for this paper is available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2021-050410).

Received 20 February 2021
Accepted 01 September 2022

[1]Department of Health Sociology, School of Humanities and Management, Guangdong Medical University, Dongguan, Guangdong, China
[2]Institute of Public Health and Wellness, Guangdong Medical University, Dongguan, Guangdong, China
[3]School of Community and Environmental Health, Old Dominion University, Norfolk, Virginia, USA
[4]School of public health, Guangdong Medical University, Dongguan, Guangdong, China

Correspondence to
Dr Zhirong Zeng;
zengzr@gdmu.edu.cn

ABSTRACT

Objective To examine how living arrangement as a social contextual factor can affect Chinese elders' cognitive function.

Setting and participants Our sample consists of 2486 Chinese elders from two waves (2014 and 2018) of the Chinese Longitudinal Healthy Longevity Survey (CLHLS) that was administered in 22 of China's 31 provinces using a multi-stage, disproportionate, purposive random sampling method. The CLHLS aims to better understand the determinants of healthy longevity in China and collects extensive data on a large population of fragile elders aged 80–112 in China.

Outcome measures Cognitive function was measured by the Mini-Mental State Examination (MMSE). Living arrangement was divided into living in an institution, living alone and living with household members. Generalised linear regressions were carried out to examine the associations between baseline characteristics and cognitive function, while controlling age, gender and residential area.

Results A total of 2486 participants were included in the study at baseline in 2014. Of these, 1162 (46.7%) were men and 1324 (53.3%) were women. The mean age at baseline was 75.07 (±8.31) years. The mean years of schooling were 2.86 (±3.68). The number (proportion) of the three living arrangements (lived in institutions, lived alone and lived with household members) were 93 (3.8%), 463 (18.6%) and 1930 (77.6%), respectively. Among all participants, cognitive function declined over time. Those who lived alone presented with the highest MMSE scores at baseline and showed the lowest decline after 4 years. Living arrangements had significant effects on decreasing cognitive function.

Conclusion Chinese elders living in institutions were most vulnerable to cognitive decline. Living alone was not a risk condition in itself for the elderly in terms of cognitive decline. In addition, the benefits of living with household members to support cognitive function were not found in our study.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Use of a 4-year longitudinal study of Chinese elders.
⇒ Valuable evidence on how three main types of living arrangements affect cognitive function.
⇒ Participants with the same living arrangements over the 4-year period were selected.
⇒ Living in institutions was a category of the living arrangements.
⇒ Due to a lack of data, confounding factors cannot be completely ruled out and the sample size was limited, especially for the elders living in institutions.

INTRODUCTION

People aged 65 years or older accounted for 13.5% of China's population and numbered approximately 191 million in 2020, citing data from the seventh national population census. It is projected that their number will be more than doubled by 2050, reaching 366 million or 26.1% of the population.[1] Given this rapid rate of ageing (one of the fastest among Asian nations) and the fact that declining cognitive function often leads to the onset of dementia (one of the most prevalent mental disorders affecting older adults), it is important to understand the severity of declining cognitive function among the elderly in China.[2]

Among Chinese elders aged 60 or above, the prevalence of mild cognitive impairment without dementia was 20.8% in 2009.[3] This mild cognitive impairment had an annual conversion rate to dementia of 15%, but only a 1% conversion to Alzheimer's disease.[2 4] Decline in cognitive function has been recognised as one of the top fears that adults have about the ageing process in many countries,[5] since cognitive function decline leads to loss of independence, higher risk of disability and premature deaths.[6 7] It is well known that general cognitive function declines with the ageing process, depending on genotype and lifestyle.[8] One approach to preventing late-life cognitive impairment is to identify factors associated with the preservation of cognitive function during old age.

The ageing process is accompanied by a gradual decline in cognitive function and the ageing of the central nervous system.[9] Previous studies have shown that sociodemographic characteristics, such as age, gender, marital status, economic status, health status and intergenerational support, had

significant impacts on the cognitive function of older adults.[7 8 10–12] In addition, a balanced nutritional status and advanced participation in activities of daily living had a positive influence on cognitive function.[9 13–16] However, living arrangements are rarely studied as regards Chinese elders' cognitive function, despite the fact that China is experiencing a dramatic change in social norms given its economic development and other social movements, such as the one-child policy and domestic migration.[17]

Living arrangements as a social contextual factor affect the health of the elderly in many ways. Different living arrangements represent different lifestyles and are closely related to the physical and mental health of the elderly.[18] The transition in living arrangement from living with family to living alone or in institutions is a critical event in many elders' life-cycle.[19] Mainly due to population ageing, widowhood, urbanisation, transitions of culture, individual values, and the availability of social services, the number of older people living alone is rising in most countries.[20] In light of this, empirical studies have measured the impact of living arrangements on cognitive function among the elderly. For example, a study found the association between living arrangements and cognitive decline among people over 65 years in European countries depended on the geographical area and the starting level of cognitive function.[20] A study of 2200 Japanese elders aged 60 or above showed that functional status played a role in living arrangement transitions.[21] A recent survey of 2548 adults aged 60 or older in Singapore found that older adults living in multigenerational households seemed to be disadvantaged in their cognitive function.[22] These studies have shown that the elders' cognitive function was associated with their living arrangements, although the findings on the relationship between these two factors were still mixed.[20]

Some studies have found that living alone is associated with higher levels of cognitive impairments,[18 23] while others have found that living alone had some health advantages.[24 25] The studies that examined the effect of living with others on the elderly's cognitive function were more elusive in their conclusions.[20] Little of this research has examined specifically how living arrangements affect the cognitive function of Chinese elders. Therefore, this study aims to address that issue by taking advantage of a longitudinal study conducted between 2014 and 2018. The results can provide new evidence for stakeholders to create a more supportive environment to prevent cognitive function decline in Chinese elders.

METHODS

Sources of data

We used data from two waves (2014 and 2018) of the Chinese Longitudinal Healthy Longevity Survey (CLHLS), an ongoing longitudinal socioeconomic and health survey of the middle-age and old-age populations that is conducted by the Peking University Center for Healthy Aging and Family Studies and the China Mainland Information Group. The CLHLS aims to better understand the determinants of healthy longevity in China. It collects extensive data on a large population of fragile elders aged 80–112, including health, disability, demographic, family, socioeconomic, and behavioural risk factors for mortality and healthy longevity.[26]

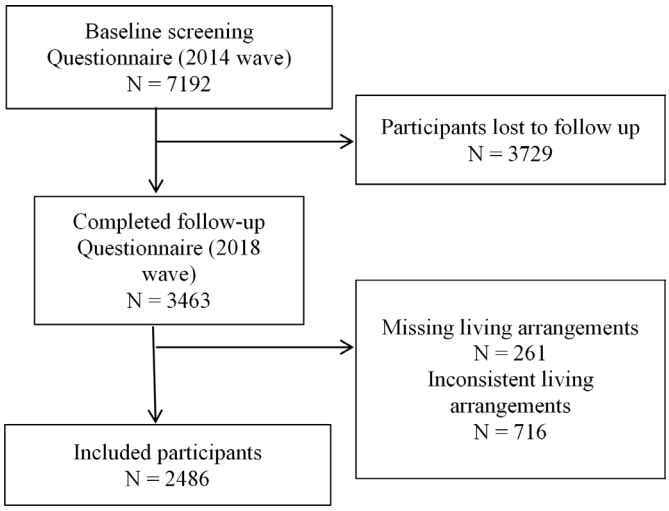

Figure 1 Study sample.

CLHLS was administered in 22 of China's 31 provinces in 1998 using a multi-stage, disproportionate, purposive random sampling method. The first eight waves (1998, 2000, 2002, 2005, 2008, 2011, 2014 and 2018) have been completed. At each wave, survivors from the previous wave were reinterviewed, and the deceased participants were replaced with new ones. In 2014, 7192 elders aged over 65 were interviewed face-to-face. The 2018 wave included 15 874 elders, with 3463 of the participants having been interviewed in 2014. The same living arrangement-related variables were presented in the data of 2018 and 2014. To minimise the potential for selection bias and confounding effects from survivors,[25] we selected participants with the same living arrangements over the 4-year period from the samples interviewed in both 2014 and 2018. We excluded 261 participants (51 participants in the 2014 wave and 214 participants in the 2018 wave, 4 of which were missing in both waves) whose living arrangements were missing and 716 samples whose living arrangements were inconsistent in two waves. The missing living arrangements was completely missing at random that was better for deleting the missing samples directly. See details in figure 1. The final study sample included 2486 Chinese elders.

Significant differences were noted in baseline demographic characteristics between study participants and excluded participants. We found participants excluded had significantly higher ages that might have been too old to follow-up on or had filled in the questionnaire less adequately than the study sample. At the same time, there were more rural participants in the study sample than among the excluded participants (table 1).

Table 1 Baseline characteristics of study samples and samples excluded from study

Characteristic	Study participants (n=2486)	Participants excluded* (n=4706)	χ^2/t value	P value
Mean age, years±SD	75.07±8.308	88.75±10.61	54.597	<0.001
Years of schooling, years±SD	2.86±3.68	2.41+3.48	5.63	<0.001
Gender			4.249	0.041
Males, n (%)	1162 (46.7)	2080 (44.2)		
Females, n (%)	1324 (53.3)	2626 (55.8)		
Residential, area			135.348	<0.001
Urban, n (%)	312 (12.6)	739 (15.7)		
Town, n (%)	502 (20.2)	1459 (31.0)		
Rural, n (%)	1672 (67.3)	2508 (53.3)		
Total	2486 (100)	4706 (100)		

*Subjects who lost to follow-up or had missing, inconsistent living arrangement data.
SD, standard deviation.

Measurement

Outcome: cognitive function

The CLHLS measures the cognitive function of elders with the Mini-Mental State Examination (MMSE). The scale ranges from 0 to 30, with higher scores indicating greater cognitive function. The scale consists of five domains: orientation (10 points), registration (3 points), attention and calculation (5 points), recall (3 points), language and praxis (9 points). Some studies recommended cut-off point of 23/24 or 24/25 in Western countries, so that a score equal to cut-off point or less indicated cognitive impairment.[27 28] However, in China, some researchers found the cut-off points of the MMSE varied according to the respondents' education attainment. Most studies employed the cut-off points recommended by the Shanghai Mental Health Center: 17/18 for those without formal education, 20/21 for those with 1–6 years of education (primary school) and 24/25 for participants with more than 6 years of education (middle school or higher).[29] In our study, 48.6% were illiteracy, 37.5% were 1–6 years of education, 13.9% were more than 6 years of education. Taking into account nearly half of the illiteracy rate, we set the cut-off points for cognitive impairment at 18. Due to the lack of two items in the language and praxis domain of the MMSE in this study, we adjusted the scoring criteria accordingly, subtracting the scores of the two missing items (2 points) from the original scores. So the highest score in this study was 28 points, greater than 16 were considered 'normal', and those less than 16 were considered 'cognitive impairment'. And this study did not classify dementia, and the scores of the scale were used for statistical analysis in terms of the cognitive status of elders only. The percentages of missing MMSE scores were moderate (range: 4%–10%). Different from a situation in which scores are missing completely at random, due to which the corresponding data on living arrangements can be directly deleted, the missing MMSE scores in our study were not random, which called for us to fill in the missing data. Mean Imputation is a simple and fast method of handling missing data that will not affect the estimate of the mean of the variable compared with other ways.[30] This is how we addressed the missing data from the MMSE scores here.

Explanatory variables

In this study, the key explanatory variable was the 'living arrangement' of older adults. In the CLHLS survey, each participant was asked about coresidence. There were three categories to choose from: living with household members (eg, a spouse or other family members like child, spouse of child, grandchild, spouse of grandchild, great grandchild or spouse of great grandchild, sibling, parent or parent-in-law, housemaid and others), living alone and living in an institution. As we know, living alone or in institutions is marked a critical transition event in elders' living arrangements. The aims of this study were to know whether their cognitive decline in these arrangements was greater than that of elders in other living arrangements or not. We adopted a classification of the living arrangements of our survey elders into the following three categories: 'living in an institution', 'living alone', or 'living with household members (eg, a spouse or other family members like child, spouse of child, grandchild, spouse of grandchild, great grandchild or spouse of great grandchild, sibling, parent or parent-in-law, housemaid and others)'.

Based on the literature, we controlled age, gender, years of schooling and residential areas as confounding variables. Referring to earlier studies about the prevalence of dementia in individuals aged 65 years and older,[31 32] we created 5-year age distribution bands. At the same time, considering that China's average life expectancy is less than 80 years,[33] age was categorised into four groups (≥65 and <70; ≥70 and <75; ≥75 and <80; ≥80), gender into two groups (male and female) and residential area into three groups (urban, township and rural).

Table 2 Characteristics of the participants by living arrangement at baseline (n = 2486)

	Living arrangements				
	Institutions	Live alone	Live with household members	χ2/F value	P value
Age, years±SD	76.92±8.52	74.93±7.602	75.02±8.435	2.42	0.089
Years of schooling, years±SD	3.24±4.12	2.49±3.26	2.93±3.74	3.15	0.043
65~, n (%)	1 (1.1)	10 (2.2)	65 (3.4)	2.424	0.089
70~, n (%)	17 (18.3)	88 (19.0)	449 (23.3)		
75~, n (%)	23 (24.7)	138 (29.8)	495 (25.6)		
≥ 80, n (%)	52 (55.9)	227 (49.0)	921 (47.7)		
Gender					
Males, n (%)	44 (47.3)	197 (42.5)	921 (47.7)	4.025	0.134
Females, n (%)	49 (52.7)	266 (57.5)	1009 (52.3)		
Residential area					
Urban, n (%)	26 (28.0)	47 (10.2)	306 (15.9)	25.446	< 0.001
Town, n (%)	30 (32.3)	159 (34.3)	705 (36.5)		
Rural, n (%)	37 (39.8)	257 (55.5)	919 (47.6)		
Total	93 (100)	463 (100)	1930 (100)		

SD, standard deviation.

Statistical analysis

Descriptive statistics (mean, SD, range and percentage) were used to characterise the sample. We compared baseline characteristics between participants with different living arrangements using cross-tabulations and χ^2 tests. T-tests were employed to test the differences in cognitive function from 2014 to 2018. Significance was set at p<0.05. A generalised linear model (GLM) was carried out to examine the associations between baseline characteristics and cognitive function between the two waves, while controlling the confounding factors (age, gender, years of schooling and residence). After stratification by living arrangement, within-subjects effects and between-subjects effects on the outcome of cognitive function and its domains were tested to examine whether the living arrangement at baseline was associated with the decline in functional capacity after 4 years. The Bonferroni method was used for pairwise comparison of living arrangement.

Patient and public involvement

Our analysis is based on secondary data, and all data are publicly available. No patient was directly involved.

RESULTS

Characteristics of the participants

A total of 2486 participants were included in the study at baseline in 2014, with 1162 (46.7%) men and 1324 (53.3%) women (table 2). The mean age (±SD) was 75.07 (±8.308) years and the mean years of schooling were 2.86 (±3.68) in total. The characteristics of participants that were classified in terms of their living arrangements at baseline were summarised. The number (proportion) of the three living arrangements (lived in institutions, lived alone and lived with household members) were 93 (3.8%), 463 (18.6%) and 1930 (77.6%), respectively. The participants who lived in institutions were older than the other two groups. Moreover, the residential area of the three living arrangements was significantly different.

Cognitive function by living arrangement

The participants' scores on the MMSE and its domains in 2014 and 2018 are shown in table 3. In general, cognitive function declined over time, all of which were statistically significant. Participants who lived alone presented the highest MMSE scores (24.99±4.05) and the lowest percentage of cognitive impairment (4.1%) at baseline, and their decline in cognitive function after 4 years was the lowest. On the other side, those who lived in institutions showed the lowest baseline scores (23.56±5.82) and the highest percentage of cognitive impairment (8.6%), and their decline in cognitive function after 4 years was the highest, with the larger declines in the domains of orientation, language and praxis.

Effect of living arrangement on the cognitive function of the elderly

Table 4 presents the effects of older persons' baseline living arrangements on their cognitive function transition by using the GLM. After controlling for age, gender, years of schooling and residential area, living arrangement had significant effects on the decline in cognitive function. In terms of tests of within-subject effects, statistically significant differences were detected at different time points in total cognitive function and its domains (p<0.001). Furthermore, except for the domains of orientation (p=0.680), attention and calculation (p=0.120) and recall (p=0.223), interactions between time and living

Table 3 Cognitive function of participants by living arrangement (n=2486)

	Institutions				Live alone				Live with household members			
	2014	2018	Difference	P value	2014	2018	Difference	P value	2014	2018	Difference	P value
Orientation (SD)	9.04 (1.83)	8.31 (2.57)	−0.73	0.010	9.61 (1.08)	9.07 (1.96)	−0.54	<0.001	9.47 (1.46)	8.89 (2.17)	−0.57	<0.001
Registration (SD)	2.62 (0.87)	2.25 (1.19)	−0.36	0.006	2.73 (0.71)	2.61 (0.91)	−0.12	0.009	2.77 (0.70)	2.46 (1.06)	−0.31	<0.001
Attention and calculation (SD)	3.91 (1.68)	3.25 (2.15)	−0.66	0.004	4.17 (1.56)	3.67 (1.91)	−0.50	<0.001	4.23 (1.50)	3.57 (1.97)	−0.66	<0.001
Recall (SD)	2.20 (1.10)	1.83 (1.32)	−0.37	0.010	2.43 (0.99)	2.20 (1.18)	−0.24	<0.001	2.38 (1.03)	2.04 (1.24)	−0.34	<0.001
Language and praxis (SD)	5.78 (1.69)	4.96 (2.50)	−0.82	0.003	6.05 (1.25)	5.68 (1.74)	−0.37	<0.001	6.07 (1.30)	5.45 (2.03)	−0.62	<0.001
Total (SD)	23.56 (5.82)	20.62 (8.54)	−2.95	0.001	24.99 (4.05)	23.22 (6.40)	−1.77	<0.001	24.92 (4.66)	22.42 (7.27)	−2.50	<0.001
<16 ('cognitive impairment', %)	8 (8.6)	22 (23.7)			19 (4.1)	57 (12.3)			104 (5.4)	321 (16.6)		

SD, standard deviation.

arrangement were significantly different, which meant different living arrangements had an impact on the trends in cognitive function. As regards between-subjects effects, significant differences were detected between the groups according to their living arrangements.

Among the controlling variables, age had significant effects on the decrease of cognitive function no matter which aspect was considered. Except in the domain of recall, years of schooling had significant effects on the decrease of cognitive function, but interactions between time and years of schooling were not significantly different in the domain of registration, recall, language and praxis, which meant years of schooling had no effect on the trends in these respects. Interactions between time and gender showed significant differences in the domains of attention and calculation (p=0.036) and recall (p=0.039), and the cognitive functions of different genders were significantly different. A similar situation prevailed in the variable of residential area.

In view of the significant interaction between time and living arrangement on the cognitive function of older adults, we made further pairwise comparisons of estimated marginal means of cognitive function classified by living arrangement. Table 5 presents the results of pairwise comparisons after controlling for age, gender, years of schooling and residence. Cognitive functions of the participants who were living alone were significantly higher than for those living with household members and those living in institutions. Only in the two domains of attention and calculation and of language and praxis were there no differences between the two groups. It is also worth noting that the participants living in institutions had the lowest means of cognitive function when controlling for age, gender, years of schooling and residence during the follow-up period.

DISCUSSION

This study found that living arrangements were significantly related to the decline in cognitive function in Chinese elderly. Compared with previous studies in China, which only included those living in communities,[34 35] this study expanded the category of living arrangements to take into account elders living in institutions.[1] Few studies have compared cognitive changes between the elderly living in institutions and those living in other settings in China.[25 36 37] Different from many developed countries with joint institutional and family-based long-term care options, China still relies on home-based informal care to meet elders' daily living needs.[38 39] The results from this study reflect this pattern: only 3.8% of the older samples lived in institutions. This is in line with the elderly-care policy adopted by the Chinese government, which suggests that 'home-based care is the foundation, community-based care provides the necessary support, and residential care is supplementary'.[36]

It is notable that cognitive function scores were best for the elderly living alone in the community, while the

Table 4 Results of general linear model of repeated measures between cognitive function and living arrangement among participants (n=2486)

	Type III sum of squares	df	Mean square	F value	P value
Total cognitive functions					
Tests of within-subjects effects					
Times	464.33	1	464.33	23.85	<0.001
Times×Living arrangement	139.65	2	69.83	3.59	0.028
Times×Age	2035.59	3	678.53	38.85	<0.001
Times×Gender	4.91	1	4.91	0.252	0.616
Times×Residential area	19.86	2	9.93	0.51	0.6
Times×Years of schooling	93.161	1	96.161	4.94	0.026
Tests of between-subjects effects					
Living arrangement	751.74	2	375.87	9.05	<0.001
Age	1467.34	3	4890.78	117.71	<0.001
Gender	2328.25	1	2328.25	56.03	<0.001
Residential area	105.02	2	52.51	1.26	0.283
Years of schooling	1251.97	1	1251.97	30.13	<0.001
Orientation					
Tests of within-subjects effects					
Times	30.94	1	30.94	14.87	<0.001
Times×Living arrangement	1.26	2	0.631	0.3	0.739
Times×Age	178.48	3	59.49	28.59	<0.001
Times×Gender	0.52	1	0.52	0.25	0.616
Times×Residential area	4.39	2	2.2	1.06	0.348
Times×Years of schooling	9.28	1	9.28	4.46	0.035
Tests of between-subjects effects					
Living arrangement	71.64	2	35.82	9.08	<0.001
Age	879.43	3	293.14	74.26	<0.001
Gender	98.14	1	98.14	24.86	<0.001
Residential area	2.95	2	1.47	0.37	0.689
Years of schooling	30.39	1	30.39	7.7	0.006
Registration					
Tests of within-subjects effects					
Times	3.21	1	3.21	5.92	0.015
Times×Living arrangement	7.57	2	3.78	6.98	0.001
Times×Age	33.02	3	11.01	20.31	<0.001
Times×Gender	0.01	1	0.01	0.03	0.862
Times×Residential area	1.03	2	0.52	0.95	0.386
Times×Years of schooling	0.33	1	0.33	0.6	0.437
Tests of between-subjects effects					
Living arrangement	9.93	2	4.97	5.54	0.004
Age	208.95	3	69.65	77.66	<0.001
Gender	17.3	1	17.3	19.29	<0.001
Residential area	5.23	2	2.61	2.92	0.054
Years of schooling	3.46	1	3.46	3.86	0.05
Attention and calculation					
Tests of within-subjects effects					
Times	36.71	1	36.71	20.24	<0.001
Times×Living arrangement	7.33	2	3.67	2.02	0.133

Continued

Table 4 Continued

	Type III sum of squares	df	Mean square	F value	P value
Times×Age	89.33	3	29.78	16.42	<0.001
Times×Gender	1.11	1	1.11	0.61	0.435
Times×Residential area	0.21	2	0.11	0.06	0.943
Times×Years of schooling	13.68	1	13.68	7.54	0.006
Tests of between-subjects effects					
Living arrangement	24.75	2	12.37	3.58	0.028
Age	814.68	3	271.56	78.63	<0.001
Gender	341.04	1	341.04	98.75	<0.001
Residential area	20.26	2	10.13	2.93	0.053
Years of schooling	170.27	1	170.27	49.3	<0.001
Recall					
Tests of within-subjects effects					
Times	7.61	1	7.61	7.79	0.005
Times×Living arrangement	2.63	2	1.32	1.35	0.26
Times×Age	28.52	3	9.51	9.73	<0.001
Times×Gender	2.5	1	2.5	2.55	0.11
Times×Residential area	2.12	2	1.06	1.08	339
Times×Years of schooling	0.46	1	0.46	0.47	0.492
Tests of between-subjects effects					
Living arrangement	17.36	2	8.68	6.16	0.002
Age	320.55	3	106.85	75.77	<0.001
Gender	18.39	1	18.39	13.04	<0.001
Residential area	1.58	2	0.79	0.56	0.571
Years of schooling	4.74	1	4.74	3.56	0.067
Language and praxis					
Tests of within-subjects effects					
Times	28.92	1	28.92	16.84	<0.001
Times×Living arrangement	14.43	2	7.22	4.2	0.015
Times×Age	130.2	3	43.4	25.27	<0.001
Times×Gender	1.02	1	1.02	0.6	0.44
Times×Residential area	0.45	2	0.22	0.13	0.879
Times×Years of schooling	3.28	1	3.28	1.91	0.167
Tests of between-subjects effects					
Living arrangement	47.1	1	23.55	7.44	0.001
Age	961.38	3	320.46	101.24	<0.001
Gender	130.66	1	130.66	41.28	<0.001
Residential area	13.34	2	6.67	2.11	0.122
Years of schooling	163.44	1	163.44	51.64	<0.001

elderly living in institutions had the lowest cognitive function. Moreover, cognitive function decline was the smallest in the elderly living alone, especially in terms of their registration function, which was inconsistent with some studies arguing that living alone was associated with higher cognitive impairments.[24 40–43] Most studies have concluded that this impairment was due to the social isolation caused by living alone, which causes health issues and cognitive impairment.[44] However, there have been some studies that concluded living alone was not a risk condition,[25] in and of itself, for the elderly, which might indicate that those who live alone are likely to seek contact with others.[45] In the current study, those who lived in institutions had the highest levels of cognitive decline compared with elders in other living arrangements. One hypothesis to explain this finding is 'selection bias', that is, elders living alone may have better cognitive function or healthier lifestyles that maintain cognitive function so their family members are willing to let them live alone,[35] whereas for more fragile elders with worse cognitive

Table 5 Pairwise comparisons of estimated marginal means of cognitive function of the participants by living arrangement (n=2486)

	Mean difference (I-J)	SE	P value	95% CI	
				Lower	Upper
Total cognitive functions					
Institutions vs live alone	−2.02	0.53	<0.001	−3.04	−0.1
Institutions vs live with household members	−1.58	0.49	0.01	−2.53	−0.62
Live alone vs live with household members	0.44	0.24	0.064	−0.02	0.91
Orientation					
Institutions vs live alone	−0.66	0.16	< 0.001	−0.97	−0.35
Institutions vs live with household members	−0.5	0.15	0.001	−0.79	−0.21
Live alone vs live with household members	0.16	0.07	0.03	0.02	0.3
Registration					
Institutions vs live alone	−0.23	0.08	0.002	−0.39	−0.08
Institutions vs live with household members	−0.17	0.07	0.014	−0.31	−0.03
Live alone vs live with household members	0.06	0.03	0.088	−0.01	0.13
Attention and calculation					
Institutions vs live alone	−0.34	0.15	0.022	−0.63	−0.05
Institutions vs live with others	−0.32	0.14	0.02	−0.6	−0.05
Live alone vs live with household members	0.02	0.07	0.806	−0.11	0.15
Recall					
Institutions vs live alone	−0.3	0.1	0.002	−0.48	−0.11
Institutions vs live with household members	−0.2	0.09	0.028	−0.37	−0.02
Live alone vs live with household members	0.1	0.04	0.018	0.02	0.19
Language and praxis					
Institutions vs live alone	−0.49	0.14	0.001	−0.77	−0.21
Institutions vs live with household members	−0.39	0.13	0.003	−0.65	−0.13
Live alone vs live with household members	0.1	0.06	0.117	−0.03	0.23

function, their family members may be more likely to send them to institutions given the complexity of the care they require.[46 47]

In addition, compared with living alone, the benefit of living with household members as a way of maintaining cognitive function was not found in our study. Some studies have suggested that living in a partnership has a positive effect on cognitive function, but the effect of living with adult children was instead more uncertain, with a negative effect being shown.[48] Based on our results as well as previous literature, we consider that it may be necessary to distinguish different cognitive impacts depending on the identities of those with whom the elderly are living.

To interpret our finding correctly, a few limitations need to be acknowledged. First, we were unable to break down the question of with whom the elders living in partnership were living. Second, only four confounding variables (age, gender, years of schooling and residence) were controlled due to incomplete data. In other words, if other possible confounding variables were not controlled, an unbalanced distribution of baseline characteristics between groups might exist, which would cause bias in the results and an overestimation of the effect of living arrangements. For example, summarising the relevant literature findings, we thought that marital status, and economic status should also be controlled to eliminate their influence on the results.[25 49] We suggest future studies use some statistical techniques to address the bias of unbalanced baselines when limited variables are available in the dataset, such as propensity score matching, etc.

Third, the sample size was limited, and there was a huge difference between living arrangements, especially for elders living in institutions, which would definitely affect the generalisability of the findings. But GLM can handle a non-equilibrium model in which the percentages of categories are different. This was why we chose GLM for our statistical analysis. Finally, the lack of results from two items in the language and praxis domain of the MMSE and the presence of missing values in the cognitive measurement might lead to measurement error and a loss of precision in the resulting estimates.

Our findings revealed that living in an institution significantly decreased cognitive function compared with other living arrangements among the elderly. To improve cognitive function, both material and psychological support programmes are needed in institutions, such as collaboration with local social workers and primary care to provide appropriate healthcare, including mental health support.[12 13 35] At the same time, the level of resources required for independent living in the community should be encouraged. On the one hand, technological aids may be provided to elders living alone. One example is 'Mobile-care' in Korea, which tracks the phone calls made by the elderly who are living alone and sends a warning signal to a welfare centre if they make no calls for a certain period of time.[50] In addition, various age-friendly physical activity programmes should be encouraged by local governments, such as providing accessible public spaces and transportation enabling older adults to live independently and participate fully in community life.

Acknowledgements The authors thank the Center for Healthy Aging and Development Studies of Peking University for providing the data.

Contributors Conceived and designed the study: YL, QZ, ZZ. Performed the study: YL, ZZ. Analysed the data: YL, TW. Wrote the paper: YL, QZ, ZZ. All authors have read and approved the manuscript. ZZ and YL had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis as guarantors.

Funding This study was supported by the National Natural Science Foundation of China (Grant Number: 71804029), Guangdong Medical Research Fund (Grant Number: C2018081), Doctoral Research Start-up Foundation of Guangdong Medical University in 2019 (B2019033), Discipline construction project of Guangdong Medical University (4SG22001G) and the 111 Project (Grant Number B16031) from the Department of Education.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by All procedures involving human subjects/patients of the CLHLS study were approved by Biomedical Ethics Committee of Peking University (IRB00001052-13074). All participants signed a consent form. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement The data, itself, is third party data, and the authors did not produce any of the original data. Interested researchers can apply for access to the data at https://opendata.pku.edu.cn/dataverse/CHADS.

ORCID iD

Qi Zhang http://orcid.org/0000-0002-4546-0620

REFERENCES

1 Feng Z, Glinskaya E, Chen H, *et al*. Long-Term care system for older adults in China: policy landscape, challenges, and future prospects. *Lancet* 2020;396:1362–72.
2 Sosa AL, Albanese E, Stephan BCM, *et al*. Prevalence, distribution, and impact of mild cognitive impairment in Latin America, China, and India: a 10/66 population-based study. *PLoS Med* 2012;9:e1001170.
3 Jia J, Zhou A, Wei C, *et al*. The prevalence of mild cognitive impairment and its etiological subtypes in elderly Chinese. *Alzheimers Dement* 2014;10:439–47.
4 Hall KS, Gao S, Emsley CL, *et al*. Community screening interview for dementia (CSI 'D'); performance in five disparate study sites. *Int J Geriatr Psychiatry* 2000;15:521–31.
5 Jorm AF, Mackinnon AJ, Henderson AS, *et al*. The psychogeriatric assessment scales: a multi-dimensional alternative to categorical diagnoses of dementia and depression in the elderly. *Psychol Med* 1995;25:447–60.
6 Hu B. Projecting future demand for informal care among older people in China: the road towards a sustainable long-term care system. *Health Econ Policy Law* 2019;14:61–81.
7 Hughes TB, Black BS, Albert M, *et al*. Correlates of objective and subjective measures of caregiver burden among dementia caregivers: influence of unmet patient and caregiver dementia-related care needs. *Int Psychogeriatr* 2014;26:1875–83.
8 Mungas D, Reed BR, Farias ST, *et al*. Age and education effects on relationships of cognitive test scores with brain structure in demographically diverse older persons. *Psychol Aging* 2009;24:116–28.
9 Assis APM, de Oliveira BTN, Gomes AL, *et al*. The association between nutritional status, advanced activities of daily living, and cognitive function among Brazilian older adults living in care homes. *Geriatr Nurs* 2020;41:899–904.
10 Ariane B, Susanne S. Spousal care-giving arrangements in Europe. The role of gender, socio-economic status and the welfare state. *Ageing and Society* 2018;40:735–58.
11 Biernacki MP, Lewkowicz R. Evidence for the role of personality in the cognitive performance of older male drivers. *Transportation Research Part F: Traffic Psychology and Behaviour* 2020;69:385–400.
12 Otter CEM, Smit J, Hagedoorn EI, *et al*. Nurses' perceptions of self-management and self-management support of older patients during hospitalization. *Geriatr Nurs* 2021;42:159–66.
13 Sebastião E. Activity behavior and cognitive performance in older adults living in a senior housing facility: the impact of frailty status. *Aging Clin Exp Res* 2020;32:703–9.
14 Miyawaki CE, Bouldin ED, Kumar GS, *et al*. Associations between physical activity and cognitive functioning among middle-aged and older adults. *J Nutr Health Aging* 2017;21:637–47.
15 Kim MJ, Tsutsumimoto K, Doi T, *et al*. Relationships between cognitive leisure activities and cognitive function in older adults with depressive symptoms: a cross-sectional study. *BMJ Open* 2020;10:e032679.
16 Formica MB, Gianoudis J, Nowson CA, *et al*. Effect of lean red meat combined with a multicomponent exercise program on muscle and cognitive function in older adults: a 6-month randomized controlled trial. *Am J Clin Nutr* 2020;112:113–28.
17 Fang EF, Xie C, Schenkel JA, *et al*. A research agenda for ageing in China in the 21st century (2nd edition): focusing on basic and translational research, long-term care, policy and social networks. *Ageing Res Rev* 2020;64:101174.
18 Imamura H, Uchiyama E, Akiyama M, *et al*. Relationship of living arrangement with the decline in functional capacity in elderly people by gender: a longitudinal observational study. *Environ Health Prev Med* 2020;25:15.
19 IK A, Rockwood K. Social vulnerability predicts cognitive decline in a prospective cohort of older Canadians Alzhmers & Dementia 2010;6:319–25.
20 Stefano M, Silvia M, Fausta O. Living arrangement and cognitive decline among older people in Europe. *Agng & Society* 2016;1:1–23.
21 Brown JW, Liang J, Krause N, *et al*. Transitions in living arrangements among elders in Japan: does health make a difference? *J Gerontol B Psychol Sci Soc Sci* 2002;57:S209–20.
22 Roystonn K, Abdin E, Shahwan S, *et al*. Living arrangements and cognitive abilities of community-dwelling older adults in Singapore. *Psychogeriatrics* 2020;20:625–35.
23 Fingerman KL, YT N, Zhang S. Living alone during COVID-19: social contact and emotional well-being among older adults. *The Journals of Gerontology Series B* 2020.
24 Koivunen K, Sillanpää E, von Bonsdorff M, *et al*. Living alone vs. living with someone as a predictor of mortality after a bone fracture in older age. *Aging Clin Exp Res* 2020;32:1697–705.
25 Zhou Z, Mao F, Ma J, *et al*. A longitudinal analysis of the association between living arrangements and health among older adults in China. *Res Aging* 2018;40:72–97.

26 Yi Z, Dudley L, Jr P. Healthy Longevity in China vol 20. In: *Introduction to the Chinese longitudinal healthy longevity survey*. Dordrecht: Springer, 2008: 23–8.
27 Kay DW, Henderson AS, Scott R, *et al*. Dementia and depression among the elderly living in the Hobart community: the effect of the diagnostic criteria on the prevalence rates. *Psychol Med* 1985;15:771–88.
28 Schultz-Larsen K, Lomholt RK, Kreiner S. Mini-Mental status examination: a short form of MMSE was as accurate as the original MMSE in predicting dementia. *J Clin Epidemiol* 2007;60:260–7.
29 Cui G-H, Yao Y-H, Xu R-F, *et al*. Cognitive impairment using education-based cutoff points for CMMSE scores in elderly Chinese people of agricultural and rural Shanghai China. *Acta Neurol Scand* 2011;124:361–7.
30 Cheung YB, Daniel R, Ng GY. Response and non-response to a quality-of-life question on sexual life: a case study of the simple mean imputation method. *Qual Life Res* 2006;15:1493–501.
31 Matthews FE, Arthur A, Barnes LE, *et al*. A two-decade comparison of prevalence of dementia in individuals aged 65 years and older from three geographical areas of England: results of the cognitive function and ageing study I and II. *Lancet* 2013;382:1405–12.
32 Tucker-Drob EM. Cognitive aging and dementia: a life span perspective. *Annu Rev Dev Psychol* 2019;1:177–96.
33 Mi H, Fan X, Lu B, *et al*. Preparing for population ageing: estimating the cost of formal aged care in China. *The Journal of the Economics of Ageing* 2020;17:100–183.
34 Waseem F, Jibeen T, Iqbal WZ. Determinants of life satisfaction: role of living arrangements, social status, and perceived satisfaction in women. *J Int Migr Integr* 2020;21:335–49.
35 Fan Y, Fang S, Yang Z. Living arrangements of the elderly: a new perspective from choice constraints in China. *China Econ Rev* 2018;50:101–16.
36 Feng Z, Zhan HJ, Feng X, *et al*. An industry in the making: the emergence of institutional elder care in urban China. *J Am Geriatr Soc* 2011;59:738–44.
37 Hu Z, Zhu X, Kaminga AC, *et al*. Association between poor sleep quality and depression symptoms among the elderly in nursing homes in Hunan Province, China: a cross-sectional study. *BMJ Open* 2020;10:e036401.
38 Liu J, Cook J. Ageing and intergenerational care in rural China: a qualitative study of policy development. *Contemporary Social Science Journal of the Academy of Social Sciences* 2018;15:378–91.
39 Liu J. Intimacy and intergenerational relations in rural China. *Sociology* 2016;51:1–16.
40 Portacolone E, Rubinstein RL, Covinsky KE, *et al*. The precarity of older adults living alone with cognitive impairment. *Gerontologist* 2019;59:271–80.
41 Grande G, Vetrano DL, Cova I, *et al*. Living alone and dementia incidence: a Clinical-Based study in people with mild cognitive impairment. *J Geriatr Psychiatry Neurol* 2018;31:107–13.
42 Desai R, John A, Stott J, *et al*. Living alone and risk of dementia: a systematic review and meta-analysis. *Ageing Res Rev* 2020;62:101122.
43 Liu N, Andrew NE, Cadilhac DA, *et al*. Health-Related quality of life among elderly individuals living alone in an urban area of Shaanxi Province, China: a cross-sectional study. *J Int Med Res* 2020;48:1–14.
44 Huang X, Liu J, Bo A. Living arrangements and quality of life among older adults in China: does social cohesion matter? *Aging Ment Health* 2020;24:2053–62.
45 Cudjoe TKM, Roth DL, Szanton SL, *et al*. The epidemiology of social isolation: National health and aging trends study. *The Journals of Gerontology: Series B* 2020;75:107–13.
46 Zhou Q, Zhou J, Ku M. The prevalence and determinants of cognitive frailty among institutionalized older adults. *Journal of Nursing Science* 2020;35:88–92.
47 Zhou Z, Zhou Z, Gao J, *et al*. Urban-Rural difference in the associations between living arrangements and the health-related quality of life (HRQOL) of the elderly in China-Evidence from Shaanxi Province. *PLoS One* 2018;13:e0204118.
48 Bordone V, Weber D. Number of children and cognitive abilities in later life. *Vienna Yearb Popul Res* 2012;10:95–126.
49 Martikainen P, Murphy M, Moustgaard H, *et al*. Living arrangements of older persons in 1987–2035 in Finland: trends by age, sex and educational attainment. *Ageing Soc* 2019;39:358–80.
50 Roh M, Weon S. Living arrangement and life satisfaction of the elderly in South Korea. *Social Indicators Research* 2020.