

BMJ Open Built form and depression among the Chinese rural elderly: a cross-sectional study

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ABSTRACT

Objectives Few data on the association between housing structure and depression among rural elders in China are available. We examined the impact of built forms on depression.

Design This is a cross-sectional study.

Setting A representative sample of rural residents aged 60 years or older in China.

Participants A total of 5090 older adults in 2019 in rural Suzhou, China.

Outcome measures Associations of built form with odds of probable and possible depression.

Results There was significant difference among elders living in varied sizes of house. Older age (vs 60–64 years: 75–79 years AdjOR, 1.737; 95% CI, 1.309 to 2.305; ≥80 years AdjOR, 2.072; 95% CI, 1.439 to 2.981), male sex (AdjOR, 0.719; 95% CI, 0.593 to 0.871), single (AdjOR, 1.303; 95% CI, 1.032 to 1.646), self-care disability (AdjOR, 4.761; 95% CI, 3.960 to 5.724), three or more chronic diseases (AdjOR, 2.200; 95% CI, 1.657 to 2.920), living alone (AdjOR, 1.443; 95% CI, 1.059 to 1.966), living in cottage (AdjOR, 1.426; 95% CI, 1.033 to 1.967), living space (vs <50 m²: 201–250 m² AdjOR, 0.566; 95% CI, 0.359 to 0.893; >250 m² AdjOR, 0.337; 95% CI, 0.223 to 0.511) and space per person (vs <30 m²: 30–m² AdjOR, 0.502; 95% CI, 0.362 to 0.697; 40–m² AdjOR, 0.473; 95% CI, 0.347 to 0.646; 50–m² AdjOR, 0.418; 95% CI, 0.339 to 0.515) were associated with risk of depression among Chinese rural elders.

Conclusion The built form was significantly and meaningfully associated with depression among Chinese rural elders. More attention should be paid to preventing mental illness among the rural elderly living in the small housing area and cottages in China.

INTRODUCTION

The White Paper on the Development of China's Aging Career population published in 2018 stated that China had nearly 144 million elderly citizens over 60 years old, 60% of whom were living in rural areas. Currently, the number of rural elders in China has reached 90 million. It is estimated that by 2050, the aged population of China will reach 400 million, accounting for one-third of the general population, at which point China will enter a stage of deep ageing (China Financial Policy Report, 2011).

Strengths and limitations of this study

- To our knowledge, it is the first of its kind in China to shed light on the risk of depression in the built form (building type and living space) among rural aged residents.
- The structured face-to-face interviews were assisted by trained local general practitioners and the standardised rating scale.
- Whether the depression associated with cottages was caused by poor housing quality, low income or low density remained in doubt.

'The suicide rate of the elderly in China is continuing to increase. As China continues to age, this problem will be more serious.' At the Lancet-Chinese Academy of Medical Sciences' Medical Conference held on 27 October and 28 October 2018, Angela Pei-chen Fan explained her latest findings. According to Fan's research, in 2015 the suicide rate of older adults between the ages of 65 and 85 in China was 2.75–7.08 times that of the general population. Among them, the suicide rate in rural areas was significantly higher than that of the urban population. Fan pointed out that in rural areas, 21.99 seniors out of every 100 000 over 65 years of age committed suicide, and the number increases with age. For rural elders over 85 years of age, 65.60 seniors out of every 100 000 committed suicide.

However, in urban areas, the number was 41.09. Mental illnesses and suicide are closely related. According to Lee *et al.*,¹ at least 94% of older adults who committed suicide had moderate depression; 60%–70% had major depression. In the face of changes in the age structure, it is urgent to implement appropriate age-friendly planning and layout. There is a pressing need to identify modifiable factors that influence the mental health of the rural aged population. The built form of the elderly is one of the perspectives. More and more professionals recognise that housing is a major social determinant



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of health. Housing improvement may be an essential mechanism by which public investment results in health improvement.²

The living environment is where people spend most of their time,³ and it is an essential place for communicating with key members of their social network.⁴ For most people, real estate also represents its principal financial and personal investment.⁵ People's physical, psychological and emotional status are deeply affected by their housing and community condition.⁶ Johnson⁷ proposed that having a quality, safe and comfortable living environment is a critical factor for living a high-quality and healthy life. Evans *et al*⁸ proved that the in-house facilities could cause infectious and non-communicable diseases. Saidj *et al*⁹ reported that housing's physical structure significantly impacted public health. Navarro *et al*¹⁰ proposed that built forms could shape people's lifestyle.

There is a large amount of research exploring the association between the housing and health of older people. The research covers indirect economic aspects of housing, which include: ownership, affordability and wealth. Many studies have focused on a single aspect of housing, such as barrier-free facilities, lighting, noise and the disrepair of the house.^{11–13} Current research focuses on falls, bathing and dressing disorders, burns, Alzheimer's disease, circadian rhythms, sleep quality and mental health.^{14–16}

Lately, Yang and Fu¹⁷ found a new dynamic perspective on the positive relationship between physical attributes of housing and the elders' health. Moreover, improving built forms could significantly improve health status and reduce medical expenses.

A recent study had examined that kitchen and bathroom facilities in houses were significantly associated with symptoms related to depression among the elderly in rural China.¹⁸ The study is about kitchen and bathroom facilities, as well as what kind of facilities are there, but not about their quality. Nevertheless, to date we are not aware of any reported studies of the associations between housing structure and depression. We examined the association between building types (cottage/apartment) and the living spaces of inhabitants (gross area and space per person), and depression.

METHODS

Study design and participants

This cross-sectional study analysed data from household surveys based on a structured questionnaire with residents ages 60 years or older by trained investigators in village communities across two counties in rural Suzhou between April and November 2019.

Suzhou is a prefecture-level city under the jurisdiction of Jiangsu Province. It is one of the critical central cities in the Yangtze River Delta, and is a national historical and cultural city as well as a scenic tourist city approved by China's State Council. Suzhou is located in the southeast of Jiangsu Province and the east of Shanghai. As of 2018, the city has five districts and four county-level cities under

its jurisdiction, with a permanent population of 10.71217 million and an urban population of 8.153 million. According to statistics released by the Suzhou Municipal Center for Disease Control, the average life expectancy of Suzhou residents in 2018 was 83.54 years, ranking second in mainland China and first in Shanghai (83.63 years). Rural in China refers to agricultural areas consisting of towns and villages, dominated by rural industries (natural economy and primary industries), including various farms (including animal husbandry and aquaculture farms), forest, horticulture and vegetable production. Rural areas have a specific natural landscape and socio-economic conditions.

We used a multistage stratified cluster sampling procedure, which considered economic development status. We looked at gender and age distribution, which was derived from the local government census data, and it addresses selection bias. To be specific, in stage 1, counties were used as the primary sampling unit, the counties were then divided into layers according to the population structure of the province, and two counties were then selected. Each layer's counties were sorted from high to low according to the proportion from the rural population census data. The people for each county within each layer were serially accumulated, and the required number of townships were extracted by the probability-proportional-to-size sampling method. Out of the nine counties in Suzhou, we selected two. The above sampling method was also used to choose in stage 2, and we established 24 townships. According to the scale of the rural population, 12 townships were selected for each county. In step 3, we randomly selected six rural village communities (of about 1000–2000 households) from each township. Finally, the chosen village communities' trained investigators randomly selected residents aged 60 years or more, stratified by sex and age distribution based on local census data.

We collected a dataset of responses from 5090 individuals that included information on participants' demographics, physical and mental health, and built form. Individuals with missing data were excluded. Informed verbal consent was obtained from all respondents before the interview.

Procedures

We assessed one's depression using the Patient Health Questionnaire (PHQ-9) which was based on symptoms over the preceding 2 weeks, the questionnaire has nine items, each of which is scored 0–3. A cut-point of 5 was used to identify depression. A PHQ-9 score of 0–4 indicates no depressive disorder. The PHQ-9 has excellent reliability and validity on the Chinese elderly.^{19 20}

Participants self-reported a previous diagnosis of non-communicable diseases based on the question, 'Has a doctor ever told you that you had the following diseases?' Walkability, bathing and dressing obstacles were assessed by answering the question, 'Is it difficult for you to walk around/to bathe or get dressed?' and were defined by

the answer 'Yes'. We measured the built form according to participants' self-reported questions: 'Are you living in a cottage or an apartment?'; 'What is the gross area of the house you are currently living in?' The gross area of the house is defined as the gross construction floor area, excluding outdoor space and agricultural buildings. 'Cottage' is defined as self-built houses; it refers to the homes and buildings built by individuals on their land. It is worth noting that there are no lawns or swimming pools in the cottage in rural China. Cottages in rural China are detached, scattered, multistory, bigger and not necessarily older than apartments. Apartments were built by the government to compensate and resettle people whose cottages were demolished while constructing roads and other public facilities. They are in better condition, in better quality and have better facilities. There is no difference in ownership. Technicians were trained to avoid information bias.

Statistical analysis

We adjusted analyses for the effect of covariates, including age, gender, educational level, marital status, self-care disability (walkability, bathing and dressing obstacles), numbers of chronic diseases and living alone, since these variables have been proven to have had an impact on depression.^{21–32}

To investigate the association between housing types (living in apartment/cottage) and depression, as well as to assess the differences, the Pearson χ^2 test was used. We analysed the effect of a living area (gross and per person) using the binary logistic regression. The cut-offs (<30; 30–40; 50–) were chosen for the living area per person. On 31 July 2019, the National Bureau of Statistics of China announced that, in 2018, the housing area of rural residents per capita in China was 47.3 m². That of urban residents was 39. A threshold of a two-tailed p value of <0.05 was applied for significance. We did all the statistical analyses with IBM SPSS Statistics V.23.

Patient and public involvement

The public were involved in the design, or conduct, or reporting, or dissemination plans of our research. No patient involved.

RESULTS

Participants were recruited between April and November 2019. A total of 6000 older adults aged 60 years or more were invited to the household survey, 447 refused to be interviewed and 463 were excluded from the analysis for not having completed information after the quality control. Therefore, data from 5090 individuals (2641 men and 2449 women) were included in our studies. The overall response rate was 84.8%. The demographic and physical characteristics of them are shown in [table 1](#). The overall prevalence of depression was 15.10%. Depression was more statistically significant among the elderly living in apartments than in cottages ([figure 1](#)). Moreover,

there was a significant difference among elders living in varied sizes of houses. The prevalence of depression in those living area was under 50 m² (29.4%) was the highest, followed by 51–100 m² (24.8%), 101–150 m² (21.2%), 151–200 m² (17.3%), 201–550 m² (13.6%) and over 250 m² (7.6%; [figure 2](#)). The prevalence of depression of those living space per person was under 30 m² (25.5%) was the highest, followed by 30–m² (15.2%), 40–m² (13.0%) and over 50 m² (12.3%).

On multivariable analysis without controlling for physical well-being (self-care disability and numbers of chronic diseases), older age (vs 60–64 years: 70–74 years AdjOR, 1.436; 95% CI, 1.108 to 1.861; 75–79 years AdjOR, 2.267; 95% CI, 1.735 to 2.964; ≥80 years AdjOR, 2.778; 95% CI, 1.972 to 3.913), male sex (AdjOR, 0.644; 95% CI, 0.536 to 0.773), years of education (vs 0 year: 6 years AdjOR, 0.721; 95% CI, 0.599 to 0.868; 9 years AdjOR, 0.569; 95% CI, 0.411 to 0.788; 12 years AdjOR, 0.422; 95% CI, 0.215 to 0.830), single (AdjOR, 1.375; 95% CI, 1.101 to 1.717), living alone (AdjOR, 1.443; 95% CI, 1.059 to 1.966), living in cottage (AdjOR, 1.424; 95% CI, 1.153 to 1.759) and gross living area (vs <50 m²: 201–250 m² AdjOR, 0.539; 95% CI, 0.350 to 0.829; >250 m² AdjOR, 0.327; 95% CI, 0.220 to 0.485) were associated with risk of depression among Chinese rural elders. These results remained statistically significantly associated with depression after adjusting for self-care disability and numbers of chronic diseases, except for years of education and 70–74 years old ([table 2](#)). Ages 65–69 years old, one or two chronic diseases and living area under 200 m² were not associated with risk of depression among Chinese rural elders.

Living in cottage (AdjOR, 1.261; 95% CI, 1.010 to 1.576) and living space (vs <30 m²: 30–m² AdjOR, 0.502; 95% CI, 0.362 to 0.697; 40–m² AdjOR, 0.473; 95% CI, 0.347 to 0.646; 50–m² AdjOR, 0.418; 95% CI, 0.339 to 0.515) remained statistically significantly associated with depression when considering space per capita ([table 3](#)) (see model 1 in the online supplemental file 1). In our univariate analysis, the results indicated that living in the cottage was a protective factor. However, in our regression analyses with multiple factors adjusted, the results indicated that living in the cottage was a risk factor. This is a common pitfall in statistical analysis, known statistically as the Simpson's paradox.

DISCUSSION

This cross-sectional sample of 5090 rural older adults shows a meaningful association between built forms and depression, even after adjusting for sociodemographic and physical characteristics, contributing to geriatric depression. There is no empirical research proving that involuntary settlement (to apartments) could have been a mental health factor. In the on-site interview, the interviewees did not express dissatisfaction with the housing. In reality, the resettlement is not entirely involuntary since the government deals with all the owners and users with millions of monetary compensations (renminbi).

Table 1 Demographics of the rural elderly and risk factors for depression

	Total (n=5090)	No depression (n=4321)	Depression (n=769)	Prevalence (%)	P for difference
Proportion of participants (%)	100	84.90	15.10		
Age (years)					
60–64	1211 (23.8)	1098 (25.4)	113 (14.7)	9.3	<0.001
65–69	1545 (30.4)	1352 (31.3)	193 (25.1)	12.5	
70–74	1232 (24.2)	1051 (24.3)	181 (23.5)	14.7	
75–80	825 (16.2)	641 (14.8)	184 (23.9)	22.3	
≥80	277 (5.4)	179 (4.1)	98 (12.7)	35.4	
Gender					
Female	2641 (51.9)	2148 (49.7)	493 (64.1)	18.7	<0.001
Male	2449 (48.1)	2173 (50.3)	276 (35.9)	11.3	
Education level (years)					
0	1478 (29.0)	1128 (26.1)	350 (45.5)	23.7	<0.001
6	2756 (54.1)	2410 (55.8)	346 (45.0)	12.6	
9	697 (13.7)	639 (14.8)	58 (7.5)	8.3	
12	139 (2.7)	129 (3.0)	10 (1.3)	7.2	
≥13	20 (0.4)	15 (0.3)	5 (0.7)	25.0	
Marital status					
Married	4233 (83.2)	3675 (85.0)	558 (72.6)	13.2	<0.001
Single*	857 (16.8)	646 (15.0)	211 (27.4)	24.6	
Self-care disability					
No	4282 (84.1)	3850 (89.1)	432 (56.2)	10.1	<0.001
Yes	804 (15.8)	471 (10.9)	333 (43.3)	41.4	
Living alone					
No	4764 (93.6)	4095 (94.8)	669 (87.0)	14.0	<0.001
Yes	326 (6.4)	226 (5.2)	100 (13.0)	30.7	
Number of NCDs					
0	1937 (38.1)	1734 (40.1)	203 (26.4)	10.5	<0.001
1–2	2724 (53.5)	2297 (53.2)	427 (55.5)	15.7	
≥3	429 (8.4)	290 (6.7)	139 (18.1)	32.4	
House type					
Apartment	916 (18.0)	752 (17.4)	164 (21.3)	17.9	0.011
Cottage	4174 (82.0)	3569 (82.6)	605 (78.7)	14.5	
Living area (m ²)					
<50	177 (3.5)	125 (2.9)	52 (6.8)	29.4	<0.001
51–100	632 (12.4)	475 (11.0)	157 (20.4)	24.8	
101–150	1373 (27.0)	1082 (25.0)	291 (37.8)	21.2	
151–200	162 (3.2)	134 (3.1)	28 (3.6)	17.3	
201–250	553 (10.9)	478 (11.1)	75 (9.8)	13.6	
>250	2193 (43.1)	2027 (46.9)	166 (21.6)	7.6	
Living area (m ² per person)					
<30	960 (18.9)	715 (16.5)	245 (31.9)	25.5	<0.001
30–	434 (8.5)	368 (8.5)	66 (8.6)	15.2	
40–	563 (11.1)	490 (11.3)	73 (9.5)	13.0	
50–	3133 (61.6)	2748 (63.6)	385 (50.1)	12.3	

*Single includes individuals who are divorced, widowed or unmarried.

NCDs, non-communicable diseases.

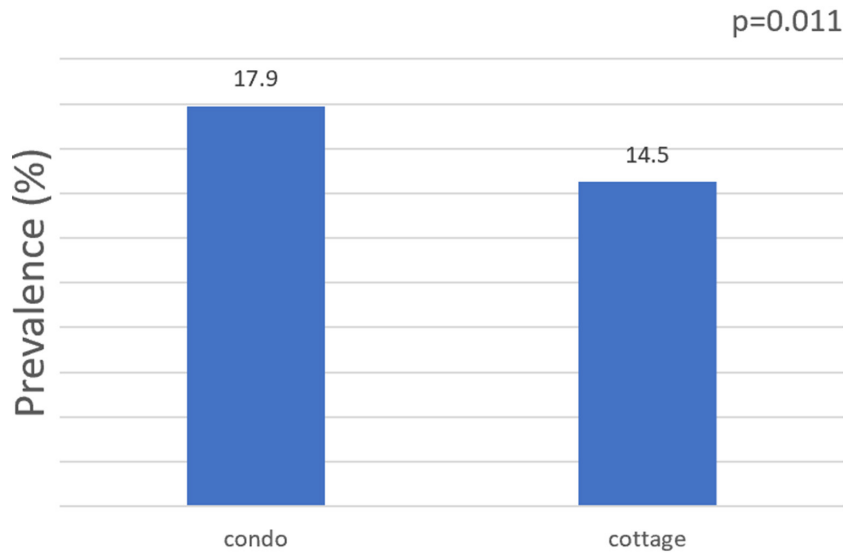


Figure 1 The difference among house types in the prevalence of depression.

Our results accord with the previous findings of risk factors for depression among older Chinese adults.^{33–43} Higher severity grades in age, number of chronic diseases, and living area (gross and per capita) each independently increase probable and possible depression among rural older adults in China. Studies conducted in urban China indicated the same patterns in rural areas.^{33 36 39–41} However, it is reported that the prevalence of depression in urban and rural areas in China is 16.4% and 30.0%, respectively,⁴⁴ and the rural residents have higher levels of depression than urban residents.⁴⁵ Moreover, rural residents are two times as likely to be untreated as urban residents, according to the WHO, 2015 China country assessment report on ageing and health.

Researches have well confirmed that the incidence of depression in women is about two times that of men.⁴⁶

The average gender difference points to more general genetic, neurohormonal or psychological differences associated with gender-related depression.⁴⁷ Cross-sectional studies have documented depression symptoms across life exhibit a U-shape: they are relatively widespread in early adulthood, decline during middle age and rise again during old age.^{48–50} It has been reported that the increase in prevalence with age may be due to age-related factors, such as a higher proportion of women, more significant physical disability, higher cognitive impairment and lower socioeconomic status.⁵¹ It is noteworthy that in our study, older adults with more education had lower rates of depression, except those with a college degree. Previous studies found empirical evidence that education influences depression through other underlying mechanisms, such as economic

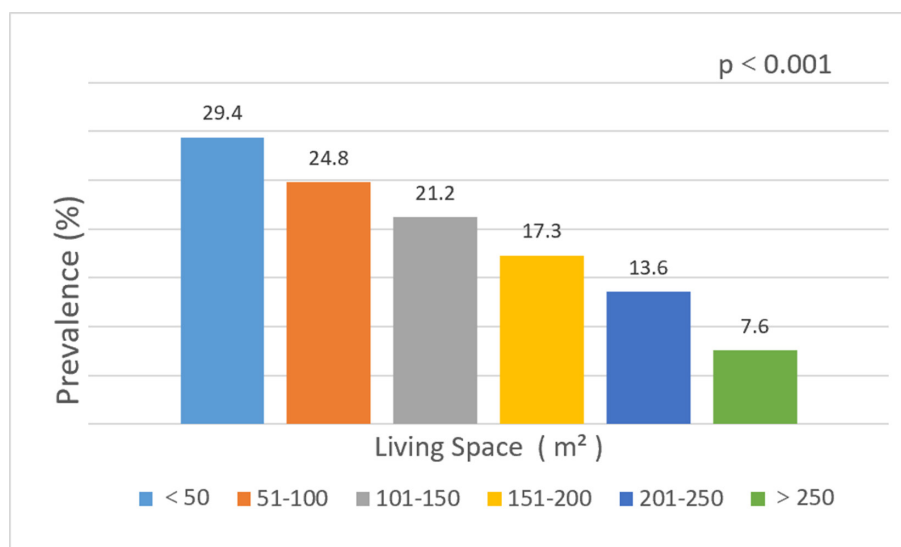


Figure 2 The difference among living space in the prevalence of depression.

Table 2 Multiple-adjusted ORs for depression associated with risk factors in Chinese rural elderly (gross living area m²)

	Model 2		Model 3		Model 4	
	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value
Male sex	0.795 (0.659 to 0.959)	0.017	0.644 (0.536 to 0.773)	<0.001	0.719 (0.593 to 0.871)	0.001
Age (years)						
60–64	1.00 (ref)					
65–69	1.214 (0.937 to 1.575)	0.143	1.282 (0.994 to 1.653)	0.055	1.228 (0.942 to 1.600)	0.129
70–74	1.204 (0.921 to 1.575)	0.174	1.436 (1.108 to 1.861)	0.006	1.172 (0.892 to 1.541)	0.253
75–80	1.655 (1.253 to 2.185)	<0.001	2.267 (1.735 to 2.964)	<0.001	1.737 (1.309 to 2.305)	<0.001
≥80	2.656 (1.864 to 3.783)	<0.001	2.778 (1.972 to 3.913)	<0.001	2.072 (1.439 to 2.981)	<0.001
Education level (years)						
0	1.00 (ref)					
6	0.669 (0.552 to 0.810)	<0.001	0.721 (0.599 to 0.868)	0.001	2.337 (0.290 to 18.836)	0.425
9	0.504 (0.362 to 0.703)	<0.001	0.569 (0.411 to 0.788)	0.001	1.781 (0.222 to 14.308)	0.587
12	0.436 (0.219 to 0.867)	0.018	0.422 (0.215 to 0.830)	0.012	1.463 (0.180 to 11.925)	0.722
≥13	0.755 (0.219 to 2.601)	0.656	2.089 (0.693 to 6.295)	0.190	1.136 (0.128 to 10.089)	0.909
Marital status						
Married	1.00 (ref)					
Single*	1.165 (0.929 to 1.462)	0.187	1.375 (1.101 to 1.717)	0.005	1.303 (1.032 to 1.646)	0.026
Living alone						
No	1.00 (ref)					
Yes	1.800 (1.323 to 2.448)	<0.001	1.443 (1.059 to 1.966)	0.020	1.426 (1.033 to 1.967)	0.031
Self-care disability						
No	1.00 (ref)				1.00 (ref)	
Yes	4.834 (4.035 to 5.791)	<0.001			4.761 (3.960 to 5.724)	<0.001
Number of NCDs						
0	1.00 (ref)				1.00 (ref)	
1–2	1.224 (1.012 to 1.482)	0.038			1.202 (0.990 to 1.459)	0.064
≥3	2.136 (1.616 to 2.823)	<0.001			2.200 (1.657 to 2.920)	<0.001
Building type						
Apartment			1.00 (ref)		1.00 (ref)	
Cottage			1.424 (1.153 to 1.759)	0.001	1.426 (1.033 to 1.967) 0.001	
Living area (m ²)						
<50			1.00 (ref)		1.00 (ref)	
51–100			1.188 (0.802 to 1.760)	0.389	1.268 (0.837 to 1.923) 0.263	
101–150			1.076 (0.738 to 1.569)	0.702	1.089 (0.730 to 1.624) 0.675	
151–200			0.874 (0.505 to 1.514)	0.631	0.860 (0.481 to 1.537) 0.611	
201–250			0.539 (0.350 to 0.829)	0.005	0.566 (0.359 to 0.893) 0.015	
>250			0.327 (0.220 to 0.485)	<0.001	0.337 (0.223 to 0.511) <0.001	

See model 1 in the online supplemental file 1.

*Single includes individuals who are divorced, widowed or unmarried.

NCDs, non-communicable diseases.

resources and social network—although evidence varies depending on the age cohort. The more educated are more likely to quit smoking, exercise regularly and take preventative health screening examinations. Further research is needed to explain why highly educated,

older adults in rural China have the most odds to be diagnosed with depression.⁵²

To some extent, the broader housing size represents higher income and social status, which proved to have a significant impact on mental health. Housing size is

Table 3 Multiple-adjusted ORs for depression associated with risk factors in Chinese rural elderly (living area m² per person)

	Model 2		Model 3		Model 4	
	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value
Male sex	0.795 (0.659 to 0.959)	0.017	0.701 (0.585 to 0.840)	<0.001	0.769 (0.636 to 0.930)	0.007
Age (years)						
60–64	1.00 (ref)					
65–69	1.214 ((0.937 to 1.575)	0.143	1.331 (1.035 to 1.713)	0.026	1.268 (0.976 to 1.647)	0.076
70–74	1.204 (0.921 to 1.575)	0.174	1.506 (1.165 to 1.947)	0.002	1.209 (0.922 to 1.584)	0.169
75–80	1.655 (1.253 to 2.185)	<0.001	2.330 (1.787 to 3.036)	<0.001	1.712 (1.292 to 2.267)	<0.001
≥80	2.656 (1.864 to 3.783)	<0.001	3.541 (2.522 to 4.971)	<0.001	2.508 (1.747 to 3.602)	<0.001
Education level (years)						
0	1.00 (ref)					
6	0.669 (0.552 to 0.810)	<0.001	0.652 (0.543 to 0.783)	<0.001	0.703 (0.579 to 0.853)	<0.001
9	0.504 (0.362 to 0.703)	<0.001	0.510 (0.369 to 0.703)	<0.001	0.564 (0.403 to 0.790)	0.001
12	0.436 (0.219 to 0.867)	0.018	0.419 (0.214 to 0.820)	0.011	0.491 (0.246 to 0.979)	0.043
≥13	0.755 (0.219 to 2.601)	0.656	1.722 (0.600 to 4.942)	0.312	0.977 (0.288 to 3.309)	0.970
Married	1.00 (ref)					
Single*	1.165 (0.929 to 1.462)	0.187	1.530 (1.258 to 1.861)	<0.001	1.198 (0.952 to 1.506)	0.123
Living alone						
No	1.00 (ref)					
Yes	1.800 (1.323 to 2.448)	<0.001			1.940 (1.419 to 2.653)	<0.001
Self-care disability						
No	1.00 (ref)				1.00 (ref)	
Yes	4.834 (4.035 to 5.791)	<0.001			4.838 (4.030 to 5.809)	<0.001
Number of NCDs						
0	1.00 (ref)				1.00 (ref)	
1–2	1.224 (1.012 to 1.482)	0.038			1.200 (0.990 to 1.455)	0.063
≥3	2.136 (1.616 to 2.823)	<0.001			2.115 (1.595 to 2.804)	<0.001
Apartment			1.00 (ref)		1.00 (ref)	
Cottage			1.203 (0.974 to 1.487)	0.087	1.261 (1.010 to 1.576)	0.041
Living area (m ² per person)						
<30			1.00 (ref)		1.00 (ref)	
30–			0.491 (0.360 to 0.669)	<0.001	0.502 (0.362 to 0.697)	<0.001
40–			0.442 (0.329 to 0.594)		0.473 (0.347 to 0.646)	
50–			0.432 (0.355 to 0.526)		0.418 (0.339 to 0.515)	

See model 1 in the online supplemental file 1.

*Single includes individuals who are divorced, widowed or unmarried.

NCDs, non-communicable diseases.

a proxy, as it is in many countries. Researches by many groups have established a relationship between socioeconomic status and depression.^{53–55} Addressing socioeconomic factors, including housing, may have the most significant potential impact on public health. Changing the environment to make healthy decisions is more comfortable to implement with more straightforward choices than advocate people to achieve a healthy lifestyle. They are, therefore, providing more effective public health actions.⁵⁶ The rise in housing prices has been associated with a positive impact directly on the owners'

physical health. The improvement in the owner's physical health is due to health-related investments and behaviours such as increased physical exercise and increased time allocated to family production. We found that scattered living in cottages was associated with higher odds of depression. The low population density could explain it, remote location and secluded environment that may indirectly affect health.⁵⁷ It has previously been argued that certain features of the buildings' environment put residents in a worse mental health.⁵⁸ In rural China, apartments were built by the government to compensate and



resettle people whose cottages were demolished while constructing roads and other public facilities. Therefore, they have unified and standardised built forms, which are in better condition, better quality and have better facilities. Persistent inferior built forms can indicate a deterioration in mental health, and living in poor-quality housing for a long time can negatively affect mental health.⁵⁹

Depression may be affected by absolute housing space and income or relative space and income related to the relative status, which results in two different policy implications: either let everyone have a more living area and income or reduce inequality.

To our knowledge, this study is the first of its kind in China to shed light on the risk of depression among rural aged residents living in small cottages. Poortinga *et al*⁶⁰ suggested that substantial housing investment through managed upgrade programmes resulted in better health outcomes, and the scale of improvement is proportional to the amount of investment. An essential next step for this research line is improving liveable and age-friendly housing structure and its impact on geriatric mental health. Besides, is urbanisation beneficial or harmful to the mental health of rural elderly? Moreover, the development and application of shared conceptual and methodological frameworks of built forms should be the research area's goal.

Our study has a few limitations. First, whether depression is associated with cottages was caused by poor housing quality, low income, or low density remained in doubt. Second, the diagnosis of depression was not clinically confirmed after assessment by PHQ-9. Third, our study can only infer the mechanisms linking built form to geriatric depression. We cannot exclude the unmeasured factors that might have a role in building form to depression. However, covariates adjustments can control the observable effects of sociodemographic and physical characteristics. Fourth, due to the complex inter-relationships between housing, socioeconomic status, health and the heterogeneity of capabilities of the elderly, there is a theoretical and empirical challenge to find concrete evidence of the impact of housing on health.⁶¹ Fifth, we did not collect income information nor did we explore the role of housing space on mental health independent of income. In China, the house's size represents a specific economic and social status because of the large population density. Sixth, we could not explore more roles of housing characteristics and combinations of attributes in geriatric depression. Seventh, no information is given on the two housing types regarding repairs or housing amenities, which may differ between the house type and mental health. Lastly, this study was conducted in Suzhou; therefore, it might not sufficiently represent the general rural aged population in China.

CONCLUSION

The built form is significantly and meaningfully associated with depression among Chinese rural elders. Our

findings call for attention to building forms and efforts to facilitate the prevention and detection of geriatric depression in rural China, especially those living in small housing areas and cottages.

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