BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-038572
Article Type:	Original research
Date Submitted by the Author:	16-Mar-2020
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Keywords:	EPIDEMIOLOGY, Depression & mood disorders < PSYCHIATRY, Old age psychiatry < PSYCHIATRY, PUBLIC HEALTH

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Housing condition and depression among the Chinese rural elderly

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Word count: 2218

Abstract:

Objectives

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

Design

This cross-sectional study included rural residents aged 60 years or older in two counties in China, using a multi-stage stratified sampling method with parameters derived from local government census. All participants were face-to-face interviewed with the self-design questionnaire and the

Patient Health Questionnaire (PHQ-9) was used to assess depression. By use of regression analyses adjusted for demographics and physical health status, we examined associations of housing condition with odds of probable and possible depression.

Results

From April to November 2019, 5090 participants (2641 men and 2449 women) were included into our study. 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, 1.309-2.305; ≥80 years AdjOR, 2.072; 95% CI, 1.439-2.981), female sex (AdjOR, 0.719; 95% CI, 0.593-0.871), single (AdjOR, 1.303; 95% CI, 1.032-1.646), movement disorder (AdjOR, 4.761; 95% CI, 3.960-5.724), 3 or more chronic diseases (AdjOR, 2.200; 95% CI, 1.657-2.920), living alone (AdjOR, 1.443; 95% CI, 1.059-1.966), living in cottage (AdjOR, 1.426; 95% CI, 1.033-1.967), and living space (vs＜50 m^2 : 201-250 m^2 AdjOR, 0.566; 95% CI, 0.359-0.893; ＞250 m^2 AdjOR, 0.337; 95% CI, 0.223-0.511) were associated with risk of depression among Chinese rural elders.

Conclusion

Housing condition was significantly and meaningfully associated with depression among Chinese rural elders. More attention should be paid to the prevention of mental illness among the rural elderly living in small and remote cottages in China.

Key words: EPIDEMIOLOGY; Depression & mood disorders < PSYCHIATRY; Old age psychiatry < PSYCHIATRY; PUBLIC HEALTH

Strengths and limitations:

- this is a cross-sectional study that does not establish the direction of causality for the association between housing condition and geriatric depression
- the use of structured face-to-face interviews by trained local general practitioners and the standardized rating scale
- to our knowledge, it is the first of its kind in China, to shed light on the risk of depression in housing condition (building type and living space) among rural aged residents

Introduction

The White Paper on the Development of China's Aging Career published in 2018 stated that China had nearly 144 million elderly over 60 years old, of which around 60% were in rural areas. Namely, as of now, the number of rural elders in China has reached 90 million. It is estimated that by 2050, China's aged population will reach 400 million, accounting for 1/3 of the general population, and China will enter the stage of deep aging. (China Financial Policy Report, 2011)

"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 October 27-28, 2018, Angela Pei-chen Fan explained her latest findings. According to Fan's research, in 2015, the suicide rate of elderly people aged 65 to 85 in China was 2.75 to 7.08 times that of the general population. Among them, the suicide rate in rural areas was significantly higher than that in urban. Fan pointed out that in rural areas, 21.99 per 100,000 seniors over 65 years committed suicide and the number increased with age. For rural elders over 85 years, 65.60 per 100,000 of them committed suicide. But in urban areas, the number was 41.09. Mental illness and suicide are closely related. According to [1], at least 94% of elderly people who committed suicide had moderate depression and 60% -70% of them had major depressive disorder. In the face of changes in the age structure, it is urgent to implement appropriate aging-friendly planning and layout. There is a pressing need to identify modifiable factors that influence the mental health of rural aged population. The housing condition of the elderly is one of the perspectives. More and more professionals recognize that housing is a major social determinant of health. Housing improvement may be an important mechanism by which public investment result in health improvement.[2]

The living environment is where people spend most of their time [3], and it is an important place for communicating with key members of their social network. [4] For most people, the real estate also represents their main financial and personal investment. [5] As a space animal, people's physical,

psychological, and emotional are deeply affected by their housing and community condition. [6] Johnson & Robin, 2005 [7] proposed that having a quality, safe and comfortable living environment is a key factor for people to live a high-quality and healthy life. Evans, 2000 [8] proved that the in-house facilities could cause infectious and non-communicable diseases. Saidj et al., 2015 [9] reported that the physical structure of housing had a significant impact on public health. Navarro et al., 2010 [10] proposed that housing conditions could shape people's lifestyle.

There is a large sum of research on housing and health of older persons, covering indirect economic aspects of housing, including the ownership, affordability and wealth of housing, and direct physical detriment to housing as a result of services and resources. Many studies had focused on single aspect of housing, such as barrier-free facilities, lighting, noise and disrepair of the house.[11-13] Current research tends to focus on falls, bathing and dressing disorders, burns, Alzheimer's disease, circadian rhythms, sleep quality and mental health.[14-16]

Lately, Yang & Fu,2019 [17] found a new dynamic perspective on the positive relationship between physical attributes of housing and health of the elders. And improving housing conditions could significantly ameliorate health status and reduce medical expenses.

A recent study had examined that kitchen and bathroom facilities in houses were significantly associated with more depressive symptoms among the elderly in rural China.[18] But to date, we are not aware of any reported studies of the associations between housing structure and depression. We examined the association of building type (cottage/condo), living space and depression.

Methods

Study design and participants

In this cross-sectional study, we analyzed data from household surveys

based on the structured questionnaire with local residents aged 60 years or older by trained general practitioners in village communities across two counties in Suzhou between April and November 2019.

Suzhou is a prefecture-level city under the jurisdiction of Jiangsu Province. It is one of the important central cities in the Yangtze River Delta, a national historical and cultural city and a scenic tourist city approved by the China's State Council. As of 2018, the city has 5 districts and 4 county-level cities under its jurisdiction, with a permanent population of 10.71217 million and an urban population of 8.153 million. Suzhou is located in the southeast of Jiangsu Province and in the east of Shanghai. 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 the second in mainland China, and the first is Shanghai (83.63 years).

We used a multi-stage stratified cluster sampling procedure, which considered economic development status, and the gender and age distribution, derived from the local government census data, to address the selection bias. Briefly, in Stage 1, we randomly selected two counties from all 9 counties in Suzhou. We selected 25 townships, which represented the socioeconomic status and lifestyle of major geographical regions in China in stage 2. In stage 3, we randomly selected 6 rural village communities (of about 1000-2000 households) from every township. Finally, the trained general practitioners of the selected village communities randomly selected residents aged 60 years or more, stratified by sex and age distribution based on local census data.

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

Procedures

We assessed depression by using the Patient Health Questionnaire (PHQ-

9), based on symptoms over the preceding two weeks, which has 9 items, each of which scored from zero to three. The PHQ-9 has good reliability and validity on the Chinese elderly.[19] The items are concise and practical. It is worth promoting in clinic, especially in the community health service center. [20]

Participants self-reported previous diagnosis of non-communicable diseases on the basis of the question "Has a doctor ever told you that you had the following diseases?" We measured housing condition according to participants' self-reported for questions: "Are you living in a cottage or condo?" "What is the gross area of the house you currently living in?" Technicians were trained to avoid information bias.

Statistical analysis

We adjusted analyses for the effect of covariates, including age, gender, educational level, marital status, movement disorder (walkability, bathing and dressing obstacles), numbers of chronic diseases and living alone.

To investigate the association between house types (living in condo/ cottage) and depression, the Pearson χ^2 test was used to assess the differences. We analyzed the effect of housing condition using the binary logistic regression. A threshold of 2-tailed P value of <0·05 was applied for significance. We did all the statistical analyses with IBM SPSS Statistics 23.

Results

Participants were recruited between April and November, 2019. 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) included in our analyses. The demographic and physical characteristics of them are shown in *Table 1*. The overall prevalence of depression was 15.10%. Depression was statistical-significantly more common among the elderly living in

condos than in cottages. (**Fig.1**) Moreover, there was significant difference among elders living in varied sizes of house. The prevalence of depression of those living area was under 50 square meters (29.4%) was the highest, followed by 51-100 square meters (24.8%), 101-150 square meters (21.2%), 151-200 square meters (17.3%), 201-550 square meters (13.6%), and over 250 square meters (7.6%; **Fig. 2**).

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

	Total (n=5090)	**No depression** (n= 4321)	**Depression** (n=769)	**p for difference**
Proportion of participants (%)	100%	84.90%	15.10%	
Age (years)				
60-64	1211 (23.8)	1098 (25.4)	113 (14.7)	0.000
65-69	1545 (30.4)	1352 (31.3)	193 (25.1)	
70-74	1232 (24.2)	1051 (24.3)	181 (23.5)	
75-80	825 (16.2)	641 (14.8)	184 (23.9)	
≥80	277 (5.4)	179 (4.1)	98 (12.7)	
Gender				
Male	2641 (51.9)	2148 (49.7)	493 (64.1)	0.000
Female	2449 (48.1)	2173 (50.3)	276 (35.9)	
Education Level (years)				
0	1478 (29.0)	1128 (26.1)	350 (45.5)	0.000
6	2756 (54.1)	2410 (55.8)	346 (45.0)	
9	697 (13.7)	639 (14.8)	58 (7.5)	
12	139 (2.7)	129 (3.0)	10 (1.3)	
≥13	20 (0.4)	15 (0.3)	5 (0.7)	
Marital status				
Married	4233 (83.2)	3675 (85.0)	558 (72.6)	0.000
Single [a]	857 (16.8)	646 (15.0)	211 (27.4)	
Movement disorder				
No	4282 (84.1)	3850 (89.1)	432 (56.2)	0.000

Yes	804 (15.8)	471 (10.9)	333 (43.3)	
Living alone				
No	4764 (93.6)	4095 (94.8)	669 (87.0)	0.000
Yes	326 (6.4)	226 (5.2)	100 (13.0)	
Number of NCDs [b]				
0	1937 (38.1)	1734 (40.1)	203 (26.4)	0.000
1-2	2724 (53.5)	2297 (53.2)	427 (55.5)	
≥3	429 (8.4)	290 (6.7)	139 (18.1)	
House Type				
Condo	916 (18.0)	752 (17.4)	164 (21.3)	0.011
Cottage	4174 (82.0)	3569 (82.6)	605 (78.7)	
Living area (m^2)				
< 50	177 (3.5)	125 (2.9)	52 (6.8)	0.000
51-100	632 (12.4)	475 (11.0)	157 (20.4)	
101-150	1373 (27.0)	1082 (25.0)	291 (37.8)	
151-200	162 (3.2)	134 (3.1)	28 (3.6)	
201-250	553 (10.9)	478 (11.1)	75 (9.8)	
> 250	2193 (43.1)	2027 (46.9)	166 (21.6)	

[a] Single includes individuals who are divorced, widowed or unmarried. [b] NCD stands for non-communicable disease.

On multivariable analysis without controlling for physical well-being (movement disorder and numbers of chronic diseases), older age (vs 60-64 years: 70-74 years AdjOR,1.436; 95% CI, 1.108-1.861; 75-79 years AdjOR, 2.267; 95% CI, 1.735-2.964; ≥80 years AdjOR, 2.778; 95% CI, 1.972-3.913), female sex (AdjOR, 0.644; 95% CI, 0.536-0.773), years of education (vs 0 year: 6 years AdjOR, 0.721; 95% CI, 0.599-0.868; 9 years AdjOR, 0.569; 95% CI, 0.411-0.788; 12 years AdjOR, 0.422; 95% CI, 0.215-0.830), single (AdjOR, 1.375; 95% CI, 1.101-1.717), living alone (AdjOR, 1.443; 95% CI, 1.059-1.966), living in cottage (AdjOR, 1.424; 95% CI, 1.153-1.759), and living area (vs < 50 m^2 : 201-250 m^2 AdjOR, 0.539;

95% CI, 0.350-0.829; > 250 m^2 AdjOR, 0.327; 95% CI, 0.220-0.485) were associated with risk of depression among Chinese rural elders. These results remained statistically significantly associated with depression after adjusting for movement disorder and numbers of chronic diseases, except for years of education and 70-74 years old (*Table 2*). 65-69 years old, 1 or 2 chronic diseases and living area under 200 m^2 were not associated with risk of depression among Chinese rural elders.

Table 2: Multiple-adjusted ORs for depression associated with risk factors in Chinese rural elderly

	Model 2		Model 3		Model 4	
	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Female sex	0.795 (0.659-0.959)	0.017	0.644 (0.536-0.773)	0.000	0.719 (0.593-0.871)	0.001
Age (years)						
60-64	1.00 (ref)					
65-69	1.214 (0.937-1.575)	0.143	1.282 (0.994-1.653)	0.055	1.229 (0.942-1.600)	0.129
70-74	1.204 (0.921-1.575)	0.174	1.436 (1.108-1.861)	0.006	1.171 (0.892-1.541)	0.253
75-80	1.655 (1.253-2.185)	0.000	2.267 (1.735-2.964)	0.000	1.731 (1.309-2.305)	0.000
≥80	2.656 (1.864-3.783)	0.000	2.778 (1.972-3.913)	0.000	2.074 (1.439-2.981)	0.000
Education Level (years)						

0	1.00 (ref)					
6	0.669 (0.552-0.810)	0.000	0.721 (0.599-0.868)	0.001	2.332 (0.290-18.836)	0.425
9	0.504 (0.362-0.703)	0.000	0.569 (0.411-0.788)	0.001	1.782 (0.222-14.308)	0.587
12	0.436 (0.219-0.867)	0.018	0.422 (0.215-0.830)	0.012	1.465 (0.180-11.925)	0.722
≥13	0.755 (0.219-2.601)	0.656	2.089 (0.693-6.295)	0.190	1.139 (0.128-10.089)	0.909
Marital status						
Married	1.00 (ref)					
Single[a]	1.165 (0.929-1.462)	0.187	1.375 (1.101-1.717)	0.005	1.304 (1.032-1.646)	0.026
Living alone						
No	1.00 (ref)					

Yes	1.800 (1.323-2.448)	0.000	1.443 (1.059-1.966)	0.020	1.420 (1.033-1.967)	0.031
Movement disorder						
No	1.00 (ref)				1.00 (ref)	
Yes	4.834 (4.035-5.791)	0.000			4.764 (3.960-5.724)	0.000
Number of NCDs[b]						
0	1.00 (ref)				1.00 (ref)	
1-2	1.224 (1.012-1.482)	0.038			1.200 (0.990-1.459)	0.064
≥3	2.136 (1.616-2.823)	0.000			2.200 (1.657-2.920)	0.000
Building Type						
Condo			1.00 (ref)		1.00 (ref)	

Cottage	1.424 (1.153-1.759)	0.001	1.420 (1.033-1.967)	0.001
Living area (m²)				
< 50	1.00 (ref)		1.00 (ref)	
51-100	1.188 (0.802-1.760)	0.389	1.268 (0.837-1.923)	0.263
101-150	1.076 (0.738-1.569)	0.702	1.089 (0.730-1.624)	0.675
151-200	0.874 (0.505-1.514)	0.631	0.860 (0.481-1.537)	0.611
201-250	0.539 (0.350-0.829)	0.005	0.569 (0.359-0.893)	0.015
> 250	0.327 (0.220-0.485)	0.000	0.331 (0.223-0.511)	0.000

[a] Single includes individuals who are divorced, widowed or unmarried. [b] NCD stands for non-communicable disease.
(see Model 1 in appendix)

Discussion

This cross-sectional sample of 5090 rural elderly people shows a meaningful association between housing condition and depression, even after adjusting for socio-demographic and physical characteristics which are known to contribute to geriatric depression.

Our results accord with the previous findings of risk factors for depression among Chinese rural elders.[21-31] Higher severity grades in age, number of chronic diseases and living area each independently increases the odds of probable and possible depression among rural older adults in China. Larger housing area to some extent represents higher income and social status and less burden on pension, which proved to have an important impact on mental health. Researches by many groups has established a relation of socioeconomic status and depression. [32-34] Addressing socio-economic factors may have the greatest potential impact on public health, since changing the environment to make healthy decisions is easier to implement with simpler choices, therefore providing more effective public health actions. [35] The rise in housing prices has been associated with the positive impact on the physical health of direct owners. The improvement in the physical health of the owner is due in part to health-related investments and behaviors such increased physical exercise, and increased time

allocated to family production. We found that scattered living in cottages was associated with higher odds of depression. It could be explained by the low population density, remote location and secluded environment that may had indirect effects on health.[36] It has previously been argued that certain features of built environment were in relation of worse mental health.[5] [37] In rural China, condos were built by the government to compensate and resettle people whose cottages are demolished while constructing roads and other public facilities, therefore has better housing condition than cottages built by farmers themselves Persistent poor housing conditions can indicate a deterioration in mental health and living in poor-quality housing for a long time can negatively affect mental health. [38] However, Pettigrew et al.,2002 [39] argued that older adults living in separate houses in Australia were more likely to meet the physical activity guideline of over 150 minutes per week than those living in retirement villages and physical activities had been long proved to be beneficial to mental health.

This study, to our knowledge, 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.,2017 [40] suggested that substantial housing investment through managed upgrade programs resulted in better health outcome and the scale of improvement is proportional to the amount of

investment. An important next step for this line of research is the improvement of livable and age-friendly housing structure and its impact on geriatric mental health. In addition, is urbanization beneficial or harmful to the mental health of rural elderly? Moreover, the development and application of shared conceptual and methodological frameworks of housing condition should be the goal of this research area.

Our study has few limitations. First, this is a cross-sectional study that does not establish the direction of causality for the association between housing condition and geriatric depression. Second, our data were self-reported and likely under-reported because of the low education level of the rural elderly in China. However, our use of structured face-to-face interviews by local general practitioners and the standardized rating scale can partially mitigate this concern. Third, the diagnosis of depression was not clinically confirmed after assessing by PHQ-9. Fourth, our study can only infer the mechanisms linking housing condition to geriatric depression and we cannot exclude the unmeasured factors might have a role in the relation of housing condition to depression, though covariates adjustments can control observable effects of socio-demographic and physical characteristics. Fifth, due to the complex interrelationships between housing, socio-economic 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.[41] Finally, this study was conducted in Suzhou therefore might not well represent the general rural aged population in China.

Conclusion

Housing condition was significantly and meaningfully associated with depression among Chinese rural elders. Our findings call for efforts to ameliorate the prevention and detection of geriatric depression in rural China, especially those living in small and remote cottages.

Acknowledgments:

We are sincerely grateful to the local general physicians and participants enrolled in the household survey. We thank the Suzhou Municipal Center for Disease Control staff, in particular Ying-quan Wang for on-site coordination, Sheng Qian for data management.

Author Contributions:

Conceptualization, Q.Q. and Y.X.; Methodology, Q.Q.; Software, Q.Q.; Validation, Q.Q., Y.X. and J.L.; Formal Analysis, Q.Q.; Investigation, Q.Q.; Resources, Q.Q.; Data Curation, J.L.; Writing – Original Draft Preparation, Q.Q.; Writing – Review & Editing, Y.X.; Visualization, J.L.; Supervision, Y.X.; Project Administration, Y.X.; Funding Acquisition,

Y.X.

Competing Interests:

The authors declare no conflict of interest.

Funding: This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Data statement: Data may be obtained from a third party and are not publicly available.

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Fig.1. Difference among house types in prevalence of depression
Fig.2. Difference among living space in prevalence of depression

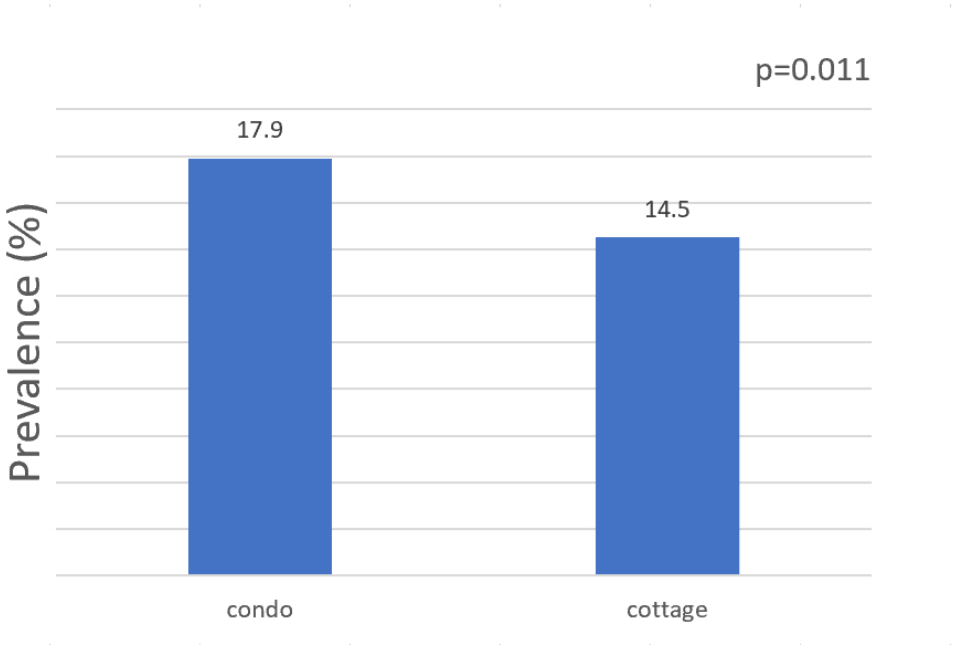

Fig.1. Difference among house types in prevalence of depression

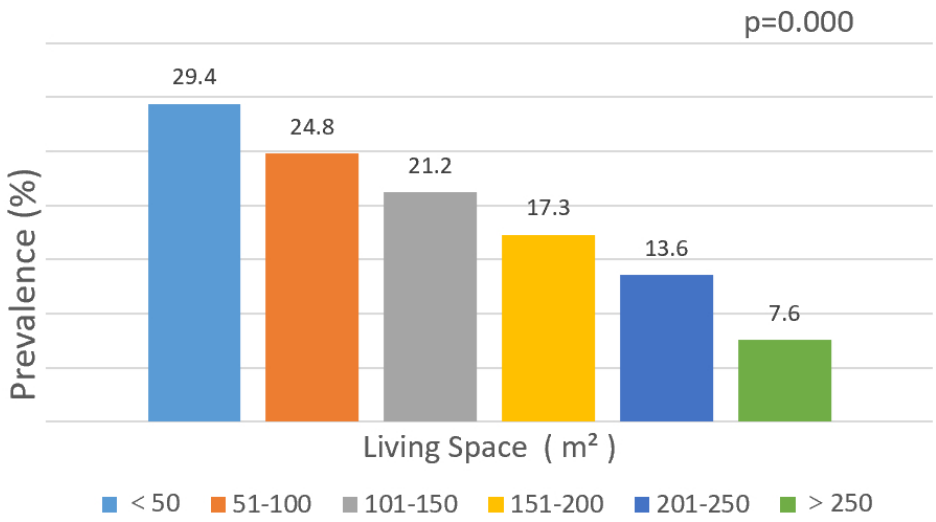

Fig.2. Difference among living space in prevalence of depression

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*
Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2-3
Objectives	3	State specific objectives, including any pre-specified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4-5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4-5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	-
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4-5*
Bias	9	Describe any efforts to address potential sources of bias	4-5
Study size	10	Explain how the study size was arrived at	4-5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	4-5
		(*b*) Describe any methods used to examine subgroups and interactions	4-5
		(*c*) Explain how missing data were addressed	4-5
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	4-5

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	4-5
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	6
		(c) Consider use of a flow diagram	6
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6
		(b) Indicate number of participants with missing data for each variable of interest	6
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	6
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	-
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	-
		Cross-sectional study—Report numbers of outcome events or summary measures	6
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7-8
		(*b*) Report category boundaries when continuous variables were categorized	7-8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	7-8
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	7-8
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Housing condition and depression among the Chinese rural elderly: a cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-038572.R1
Article Type:	Original research
Date Submitted by the Author:	01-Jul-2020
Complete List of Authors:	Qiu, Qin-wei; Soochow University Medical College, School of Public Health Li, Jing; Soochow University Medical College, School of Public Health Li, Jia-yu; Soochow University Medical College, School of Public Health Xu, Yong; Soochow University Medical College, School of Public Health
Primary Subject Heading:	Public health
Secondary Subject Heading:	Mental health, Public health, Geriatric medicine
Keywords:	EPIDEMIOLOGY, Depression & mood disorders < PSYCHIATRY, Old age psychiatry < PSYCHIATRY, PUBLIC HEALTH

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Housing condition and depression among the Chinese rural elderly: a cross-sectional study

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Word count: 2654

Abstract

Objectives:

Few data on the association between housing structure and depression among rural elders in China are available. We examined the impact of housing conditions 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 housing condition 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, 1.309-2.305; ≥80 years AdjOR, 2.072; 95% CI, 1.439-2.981), female sex (AdjOR, 0.719; 95% CI, 0.593-0.871), single (AdjOR, 1.303; 95% CI, 1.032-1.646), self-care disability (AdjOR, 4.761; 95% CI, 3.960-5.724), 3 or more chronic diseases (AdjOR, 2.200; 95% CI, 1.657-2.920), living alone (AdjOR, 1.443; 95% CI, 1.059-1.966), living in cottage (AdjOR, 1.426; 95% CI, 1.033-1.967), living space (vs < 50 m^2 : 201-250 m^2 AdjOR, 0.566; 95% CI, 0.359-0.893; > 250 m^2 AdjOR, 0.337; 95% CI, 0.223-0.511), and space per person (vs < 30 m^2 : 30- m^2 AdjOR, 0.502; 95% CI, 0.362-0.697; 40- m^2 AdjOR, 0.473; 95% CI, 0.347-0.646; 50- m^2 AdjOR, 0.418; 95% CI, 0.339-0.515) were associated with risk of depression among Chinese rural elders.

Conclusion:

Housing condition was significantly and meaningfully associated with depression among Chinese rural elders. More attention should be paid to the prevention of mental illness among the rural elderly living in the small

housing area and cottages in China.

Keywords: EPIDEMIOLOGY; Depression & mood disorders < PSYCHIATRY; Old age psychiatry < PSYCHIATRY; PUBLIC HEALTH

Strengths and limitations:

- this is a cross-sectional study that does not establish the direction of causality for the association between housing condition and geriatric depression
- the use of structured face-to-face interviews assisted by trained local general practitioners and the standardized rating scale
- to our knowledge, it is the first of its kind in China, to shed light on the risk of depression in housing condition (building type and living space) among rural aged residents

Introduction

The White Paper on the Development of China's Aging Career published in 2018 stated that China had nearly 144 million elderly over 60 years old, of which around 60% were in rural areas. Namely, as of now, the number of rural elders in China has reached 90 million. It is estimated that by 2050, China's aged population will reach 400 million, accounting for 1/3 of the general population, and China will enter the stage of deep aging. (China Financial Policy Report, 2011)

"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 October 27-28, 2018, Angela Pei-chen Fan explained her latest findings. According to Fan's research, in 2015, the suicide rate of elderly people aged 65 to 85 in China was 2.75 to 7.08 times that of the general population. Among them, the suicide rate in rural areas was significantly higher than that in urban. Fan pointed out that in rural areas, 21.99 per 100,000 seniors over 65 years committed suicide and the number increased with age. For rural elders over 85 years, 65.60 per 100,000 of them committed suicide. But in urban areas, the number was 41.09. Mental illness and suicide are closely related. According to Lee and his colleges, 2018 [1], at least 94% of elderly people who committed suicide had moderate depression and 60% -70% of them had a major depressive disorder. In the face of changes in the age structure, it is urgent to implement appropriate aging-friendly planning and layout. There is a pressing need to identify modifiable factors that influence the mental health of the rural aged population. The housing condition of the elderly is one of the perspectives. More and more professionals recognize that housing is a major social determinant of health. Housing improvement may be an important 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 important place for communicating with key members of their social network. [4] For most people, real estate also represents its main financial

and personal investment. [5] As a space animal, people's physical, psychological, and emotional are deeply affected by their housing and community condition. [6] Johnson & Robin, 2005 [7] proposed that having a quality, safe, and comfortable living environment is a key factor for people to live a high-quality and healthy life. Evans, 2000 [8] proved that the in-house facilities could cause infectious and non-communicable diseases. Saidj et al., 2015 [9] reported that the physical structure of housing had a significant impact on public health. Navarro et al., 2010 [10] proposed that housing conditions could shape people's lifestyle.

There is a large sum of research on housing and health of older persons, covering indirect economic aspects of housing, including the ownership, affordability and wealth of housing, and direct physical detriment to housing as a result of services and resources. Many studies had focused on a single aspect of housing, such as barrier-free facilities, lighting, noise and disrepair of the house.[11-13] Current research tends to focus on falls, bathing and dressing disorders, burns, Alzheimer's disease, circadian rhythms, sleep quality and mental health.[14-16]

Lately, Yang & Fu,2019 [17] found a new dynamic perspective on the positive relationship between physical attributes of housing and health of the elders. And improving housing conditions could significantly ameliorate health status and reduce medical expenses.

A recent study had examined that kitchen and bathroom facilities in houses were significantly associated with more depressive symptoms among the elderly in rural China.[18] But to date, we are not aware of any reported studies of the associations between housing structure and depression. We examined the association of building type (cottage/condo), living space (gross area and space per person), and depression.

Methods

Study design and participants

In this cross-sectional study, we analyzed data from household surveys based on the structured questionnaire with residents aged 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 important central cities in the Yangtze River Delta, a national historical and cultural city and a scenic tourist city approved by China's State Council. As of 2018, the city has 5 districts and 4 county-level cities under its jurisdiction, with a permanent population of 10.71217 million and an urban population of 8.153 million. Suzhou is located in the southeast of Jiangsu Province and the east of Shanghai. 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 the second in mainland China, and the first in Shanghai (83.63 years). Suzhou is a district including urban and rural areas. Rural in China refers to an agricultural area, consisting of towns and villages, dominated by agricultural 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 social and economic conditions.

We used a multi-stage stratified cluster sampling procedure, which considered economic development status, and the gender and age distribution, derived from the local government census data, to address the selection bias. To be specific, in Stage 1, counties were used as the primary sampling unit, and counties were divided into layers according to the population structure of the province and 2 counties were to be selected. Namely, the counties of each layer were sorted from high to low according to the proportion of the rural population of the census data, the population of each county in each layer was serially accumulated, and the required number of townships was extracted by the Probability-Proportional-to-Size sampling method. We selected two counties from all 9 counties in Suzhou. The above sampling method was also used to select in stage 2 and we selected 24 townships. Namely, according to the scale of the rural population, 12 townships were selected for each county. In stage 3, we

randomly selected 6 rural village communities (of about 1000-2000 households) from each township. Finally, the trained investigators of the selected village communities randomly selected residents aged 60 years or more, stratified by sex and age distribution based on local census data.

We got a dataset of responses from 5090 individuals that included information on participants' demographics, physical and mental health, and housing condition. Individuals with missing data were excluded. Informed verbal consent was obtained from all respondents before the interview. The study was approved by the Institutional Review Board for the Center for Health Development of Medical College of Soochow University.

Procedures

We assessed depression by using the Patient Health Questionnaire (PHQ-9), based on symptoms over the preceding two weeks, which has 9 items, each of which scored from zero to three. A cut-point of 5 was used to identify depression. PHQ-9 score 0-4 indicates no depressive disorder. The PHQ-9 has good reliability and validity on the Chinese elderly.[19] The items are concise and practical. It is worth promoting in the clinic, especially in the community health service center. [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 / bathing or dressing?" and were defined by the answer “Yes”. We measured the housing condition according to participants’ self-reported for questions: “Are you living in a cottage or condo?” “What is the gross area of the house you currently living in?” “How many people do you live with now?” “Cottage” means self-built houses, refers to the houses and buildings built by individuals themselves on their land. It is worth noting that in rural China, there is no lawn or swimming pool in the cottage. Cottages in rural China are detached, scattered located, multi-story, bigger, and not necessarily older than condos. Condos were built by the government to compensate and resettle people whose cottages are demolished while

constructing roads and other public 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 had been proved to have an impact on depression.[21-32]

To investigate the association between house types (living in condo/ cottage) and depression, the Pearson χ^2 test was used to assess the differences. We analyzed the effect of a living area (gross and per person) using the binary logistic regression. A threshold of a 2-tailed P value of <0·05 was applied for significance. We did all the statistical analyses with IBM SPSS Statistics 23.

Patient and Public Involvement

No patient involved.

Results

Participants were recruited between April and November 2019. 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) included in our analyses. 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 statistical-significantly more common among the elderly living in condos than in cottages. (**Fig.1**) Moreover, there was a significant difference among elders living in varied sizes of houses. The prevalence of depression of those gross

living area was under 50 square meters (29.4%) was the highest, followed by 51-100 square meters (24.8%), 101-150 square meters (21.2%), 151-200 square meters (17.3%), 201-550 square meters (13.6%), and over 250 square meters (7.6%; **Fig. 2**). The prevalence of depression of those living space per person was under 30 square meters (25.5%) was the highest, followed by 30- square meters (15.2%), 40- square meters (13.0%), and over 50 square meters (12.3%).

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					
Male	2641 (51.9)	2148 (49.7)	493 (64.1)	18.7	＜0.001
Female	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 [a]	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 [b]					
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					
Condo	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 (m²)					
<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 (m² 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	

[a] Single includes individuals who are divorced, widowed, or unmarried. [b] NCD stands for non-communicable disease.

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, 1.108-1.861; 75-79 years AdjOR, 2.267; 95% CI, 1.735-2.964; ≥80 years AdjOR, 2.778; 95% CI, 1.972-3.913), female sex (AdjOR, 0.644; 95% CI, 0.536-0.773), years of education (vs 0 year: 6 years AdjOR, 0.721; 95% CI, 0.599-0.868; 9 years AdjOR, 0.569; 95% CI, 0.411-0.788; 12 years AdjOR, 0.422; 95% CI,

0.215-0.830), single (AdjOR, 1.375; 95% CI, 1.101-1.717), living alone (AdjOR, 1.443; 95% CI, 1.059-1.966), living in cottage (AdjOR, 1.424; 95% CI, 1.153-1.759), and gross living area (vs < 50 m^2 : 201-250 m^2 AdjOR, 0.539; 95% CI, 0.350-0.829; > 250 m^2 AdjOR, 0.327; 95% CI, 0.220-0.485) 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*). 65-69 years old, 1 or 2 chronic diseases and living area under 200 m^2 were not associated with risk of depression among Chinese rural elders.

Living in cottage (AdjOR, 1.261; 95% CI, 1.010-1.576) and living space (vs < 30 m^2 : 30- m^2 AdjOR, 0.502; 95% CI, 0.362-0.697; 40- m^2 AdjOR, 0.473; 95% CI, 0.347-0.646; 50- m^2 AdjOR, 0.418; 95% CI, 0.339-0.515) remained statistically significantly associated with depression when considering space per capita (*Table 3*).

Table 2: Multiple-adjusted ORs for depression associated with risk factors in Chinese rural elderly (Gross living area m^2)

	Model 2		Model 3		Model 4	
	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Female sex	0.795 (0.659-0.959)	0.017	0.644 (0.536-0.773)	< 0.001	0.719 (0.593-0.871)	0.001
Age (years)						
60-64	1.00 (ref)					
65-69	1.214 (0.937-1.575)	0.143	1.282 (0.994-1.653)	0.055	1.229 (0.942-1.600)	0.129
70-74	1.204 (0.921-1.575)	0.174	1.436 (1.108-1.861)	0.006	1.173 (0.892-1.541)	0.253
75-80	1.655 (1.253-2.185)	< 0.001	2.267 (1.735-2.964)	< 0.001	1.737 (1.309-2.305)	< 0.001
≥80	2.656 (1.864-3.783)	< 0.001	2.778 (1.972-3.913)	< 0.001	2.074 (1.439-2.981)	< 0.001
Education Level (years)						

0	1.00 (ref)					
6	0.669 (0.552-0.810)	< 0.001	0.721 (0.599-0.868)	0.001	2.332 (0.290-18.836)	0.425
9	0.504 (0.362-0.703)	< 0.001	0.569 (0.411-0.788)	0.001	1.782 (0.222-14.308)	0.587
12	0.436 (0.219-0.867)	0.018	0.422 (0.215-0.830)	0.012	1.465 (0.180-11.925)	0.722
≥13	0.755 (0.219-2.601)	0.656	2.089 (0.693-6.295)	0.190	1.136 (0.128-10.089)	0.909
Marital status						
Married	1.00 (ref)					
Single[a]	1.165 (0.929-1.462)	0.187	1.375 (1.101-1.717)	0.005	1.304 (1.032-1.646)	0.026
Living alone						
No	1.00 (ref)					

Yes	1.800 (1.323-2.448)	< 0.001	1.443 (1.059-1.966)	0.020	1.420 (1.033-1.967)	0.031
Self-care disability						
No	1.00 (ref)				1.00 (ref)	
Yes	4.834 (4.035-5.791)	< 0.001			4.764 (3.960-5.724)	< 0.001
Number of NCDs[b]						
0	1.00 (ref)				1.00 (ref)	
1-2	1.224 (1.012-1.482)	0.038			1.200 (0.990-1.459)	0.064
≥3	2.136 (1.616-2.823)	< 0.001			2.200 (1.657-2.920)	< 0.001
Building Type						
Condo			1.00 (ref)		1.00 (ref)	

Cottage	1.424 (1.153-1.759)	0.001	1.420 (1.033-1.967)	0.001
Living area (m²)				
< 50	1.00 (ref)		1.000 (ref)	
51-100	1.188 (0.802-1.760)	0.389	1.268 (0.837-1.923)	0.263
101-150	1.076 (0.738-1.569)	0.702	1.089 (0.730-1.624)	0.675
151-200	0.874 (0.505-1.514)	0.631	0.860 (0.481-1.537)	0.611
201-250	0.539 (0.350-0.829)	0.005	0.566 (0.359-0.893)	0.015
> 250	0.327 (0.220-0.485)	< 0.001	0.331 (0.223-0.511)	< 0.001

[a] Single includes individuals who are divorced, widowed or unmarried. [b] NCD stands for non-communicable disease.
(see Model 1 in the Supplementary file)

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	OR (95% CI)	p	OR (95% CI)	p
Female sex	0.795 (0.659-0.959)	0.017	0.701 (0.585-0.840)	< 0.001	0.769 (0.636-0.930)	0.007
Age (years)						
60-64	1.00 (ref)					
65-69	1.214 (0.937-1.575)	0.143	1.331 (1.035-1.713)	0.026	1.268 (0.976-1.647)	0.076
70-74	1.204 (0.921-1.575)	0.174	1.506 (1.165-1.947)	0.002	1.209 (0.922-1.584)	0.169

75-80	1.655 (1.253-2.185)	< 0.001	2.330 (1.787-3.036)	< 0.001	1.712 (1.292-2.267)	< 0.001
≥80	2.656 (1.864-3.783)	< 0.001	3.541 (2.522-4.971)	< 0.001	2.508 (1.747-3.602)	< 0.001
Education Level (years)						
0	1.00 (ref)					
6	0.669 (0.552-0.810)	< 0.001	0.652 (0.543-0.783)	< 0.001	0.703 (0.579-0.853)	< 0.001
9	0.504 (0.362-0.703)	< 0.001	0.510 (0.369-0.703)	< 0.001	0.564 (0.403-0.790)	0.001

12	0.436 (0.219-0.867)	0.018	0.419 (0.214-0.820)	0.011	0.491 (0.246-0.979)	0.043
≥13	0.755 (0.219-2.601)	0.656	1.722 (0.600-4.942)	0.312	0.977 (0.288-3.309)	0.970
Married	1.00 (ref)					
Single[a]	1.165 (0.929-1.462)	0.187	1.530 (1.258-1.861)	< 0.001	1.198 (0.952-1.506)	0.123
Living alone						
No	1.00 (ref)					
Yes	1.800 (1.323-2.448)	< 0.001			1.940 (1.419-2.653)	< 0.001

Self-care disability						
No	1.00 (ref)				1.00 (ref)	
Yes	4.834 (4.035-5.791)	< 0.001			4.838 (4.030-5.809)	< 0.001
Number of NCDs[b]						
0	1.00 (ref)				1.00 (ref)	
1-2	1.224 (1.012-1.482)	0.038			1.200 (0.990-1.455)	0.063
≥3	2.136 (1.616-2.823)	< 0.001			2.115 (1.595-2.804)	< 0.001
Condo			1.00 (ref)		1.00 (ref)	
Cottage			1.203 (0.974-1.487)	0.087	1.261 (1.010-1.576)	0.041

Living area (m² per person)				
< 30	1.00 (ref)		1.00 (ref)	
30-	0.491 (0.360-0.669)	< 0.001	0.502 (0.362-0.697)	< 0.001
40-	0.442 (0.329-0.594)		0.473 (0.347-0.646)	
50-	0.432 (0.355-0.526)		0.418 (0.339-0.515)	

[a] Single includes individuals who are divorced, widowed, or unmarried. [b] NCD stands for non-communicable disease.
(see Model 1 in the Supplementary file)

Discussion

This cross-sectional sample of 5090 rural elderly people shows a meaningful association between housing conditions and depression, even after adjusting for socio-demographic and physical characteristics which are known to contribute to geriatric depression.

Our results accord with the previous findings of risk factors for depression among Chinese rural elders.[33-43] Higher severity grades in age, number of chronic diseases, and living area (both gross and per capita) each independently increase the odds of probable and possible depression among rural older adults in China. Larger housing area to some extent represents higher income and social status and less burden on pension, which proved to have an important impact on mental health. Researches by many groups have established a relation of socioeconomic status and depression. [44-46] Addressing socio-economic factors may have the greatest potential impact on public health, since changing the environment to make healthy decisions is easier to implement with simpler choices, therefore providing more effective public health actions. [47] The rise in housing prices has been associated with a positive impact on the physical health of direct owners. The improvement in the physical health of the owner is due in part to health-related investments and behaviors 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. It could be explained by the low population density, remote location and secluded environment that may have indirect effects on health.[48] It has previously been argued that certain features of the built environment were in a relation of worse mental health.[5 49] In rural China, condos were built by the government to compensate and resettle people whose cottages are demolished while constructing roads and other public facilities, therefore have unified and standard housing condition, which may have better quality than cottages built by farmers themselves. Persistent poor housing conditions can indicate a deterioration in mental health and live in poor-quality housing for a long time can negatively affect mental health. [50]

This study, to our knowledge, 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.,2017 [51] suggested that substantial housing investment through managed upgrade programs resulted in better health outcomes, and the scale of improvement is proportional to the amount of investment. An important next step for this line of research is the improvement of livable and age-friendly housing structure and its impact on geriatric mental health. Besides, is urbanization beneficial or harmful to the mental health of rural elderly? Moreover, the development and

application of shared conceptual and methodological frameworks of housing conditions should be the goal of this research area.

Our study has a few limitations. First, this is a cross-sectional study that does not establish the direction of causality for the association between housing conditions and geriatric depression. Second, our data were self-reported and likely under-reported because of the low education level of the rural elderly in China. However, our use of structured face-to-face interviews assisted by local general practitioners and the standardized rating scale can partially mitigate this concern. Third, the diagnosis of depression was not clinically confirmed after assessing by PHQ-9. Fourth, our study can only infer the mechanisms linking housing condition to geriatric depression and we cannot exclude the unmeasured factors might have a role in the relation of housing condition to depression, though covariates adjustments can control observable effects of socio-demographic and physical characteristics. Fifth, due to the complex interrelationships 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.[52] Sixth, we did not collect information on income and explore the role of housing space on mental health independent of income. In China, the size of the house itself represents a certain level of economic and social

status because of the large population density. Seventh, we were not able to explore more role of housing characteristics and combinations of characteristics in geriatric depression. Lastly, this study was conducted in Suzhou, therefore, might not well represent the general rural aged population in China.

Conclusion

Housing condition was significantly and meaningfully associated with depression among Chinese rural elders. Our findings call for attention on housing condition and efforts to ameliorate the prevention and detection of geriatric depression in rural China, especially those living in small housing area and cottages.

Acknowledgments:

We are sincerely grateful to the local general physicians and participants enrolled in the household survey. We thank the Suzhou Municipal Health Department and Suzhou Municipal Center for Disease Control and Prevention staff, in particular Ying-quan Wang for on-site coordination, Sheng Qian for data management.

Author Contributions:

Conceptualization, Q.Q. and Y.X.; Methodology, Q.Q.; Software, Q.Q.; Validation, Q.Q., Y.X. and J.L.; Formal Analysis, Q.Q.; Investigation, Q.Q.; Resources, Q.Q.; Data Curation, JY.L.; Writing – Original Draft Preparation, Q.Q.; Writing – Review & Editing, Y.X.; Visualization, J.L.; Supervision, Y.X.; Project Administration, Y.X.; Funding Acquisition, Y.X.

Competing Interests:

The authors declare no conflict of interest.

Funding: This research received no specific grant from any funding agency in the public, commercial,or not-for-profit sectors.

Data statement: Data may be obtained from a third party and are not publicly available.

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Fig.1. The difference among house types in the prevalence of depression
Fig.2. The difference among living space in the prevalence of depression

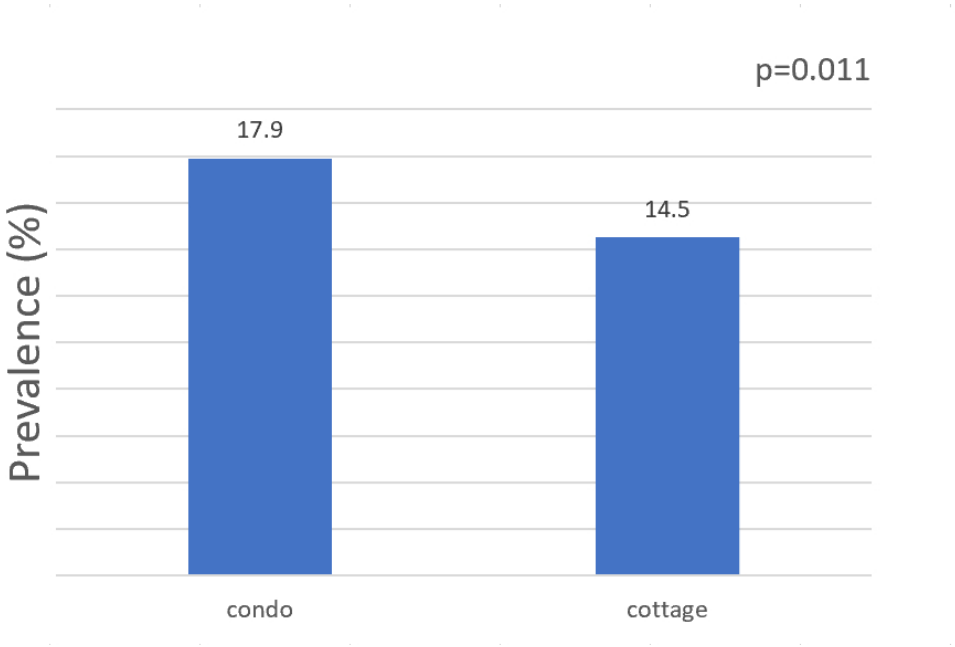
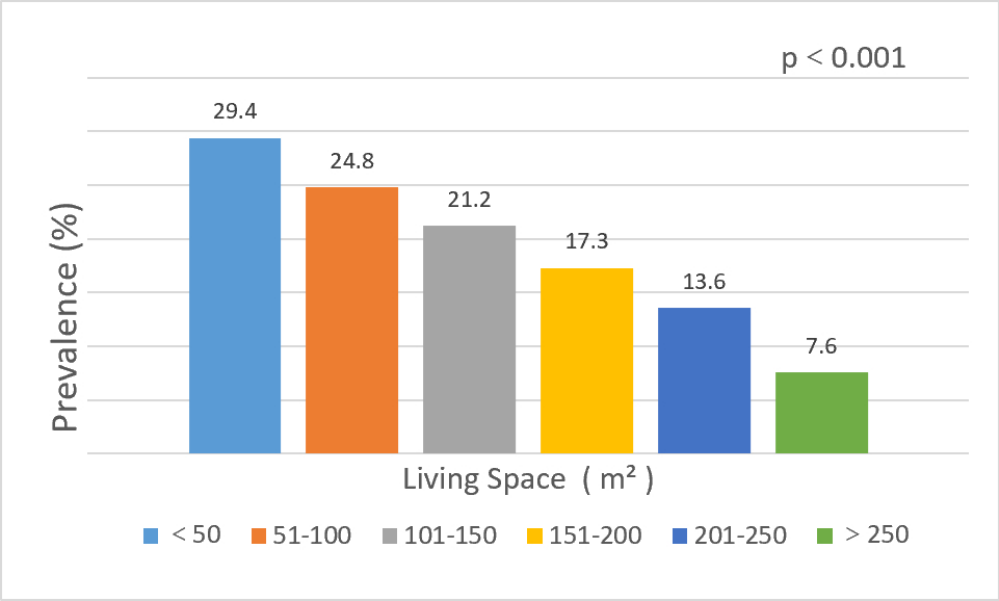


Fig.1. Difference among house types in prevalence of depression



The difference among living space in the prevalence of depression

	Model 1	
	OR (95% CI)	p
Female sex	0.718 (0.600-0.858)	0.000
Age (years)		
60-64	1.00 (ref)	
65-69	1.280 (0.996-1.643)	0.053
70-74	1.501 (1.163-1.937)	0.002
75-80	2.218 (1.705-2.885)	0.000
≥80	3.611 (2.586-5.044)	0.000
Education Level (years)		
0	1.00 (ref)	
6	0.619 (0.516-0.742)	0.000
9	0.452 (0.329-0.622)	0.000
12	0.365 (0.186-0.714)	0.003
≥13	1.211 (0.412-3.561)	0.728
Marital status		
Married	1.00 (ref)	
Single	1.226 (0.988-1.522)	0.064
Living alone		
No	1.00 (ref)	
Yes	1.840 (1.372-2.469)	0.000
Movement disorder		
No		
Yes		
Number of NCDs		
0		
1-2		
≥3		
Building Type		
Condo		
Cottage		
Living area (m²)		
＜50		
51-100		
101-150		

151-200	
201-250	
>250	

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2-3
Objectives	3	State specific objectives, including any pre-specified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4-5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4-5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	-
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4-5*
Bias	9	Describe any efforts to address potential sources of bias	4-5
Study size	10	Explain how the study size was arrived at	4-5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	4-5
		(*b*) Describe any methods used to examine subgroups and interactions	4-5
		(*c*) Explain how missing data were addressed	4-5
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	4-5

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	4-5
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	6
		(c) Consider use of a flow diagram	6
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6
		(b) Indicate number of participants with missing data for each variable of interest	6
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	6
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	-
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	-
		Cross-sectional study—Report numbers of outcome events or summary measures	6
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7-8
		(*b*) Report category boundaries when continuous variables were categorized	7-8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	7-8
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	7-8
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

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

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-038572.R2
Article Type:	Original research
Date Submitted by the Author:	26-Oct-2020
Complete List of Authors:	Qiu, Qin-wei; Soochow University Medical College, School of Public Health Li, Jing; Soochow University Medical College, School of Public Health Li, Jia-yu; Soochow University Medical College, School of Public Health Xu, Yong; Soochow University Medical College, School of Public Health
Primary Subject Heading:	Public health
Secondary Subject Heading:	Mental health, Public health, Geriatric medicine
Keywords:	EPIDEMIOLOGY, Depression & mood disorders < PSYCHIATRY, Old age psychiatry < PSYCHIATRY, PUBLIC HEALTH

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

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Word count: 2920

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, 1.309-2.305; ≥80 years AdjOR, 2.072; 95% CI, 1.439-2.981), male sex (AdjOR, 0.719; 95% CI, 0.593-0.871), single (AdjOR, 1.303; 95% CI, 1.032-1.646), self-care disability (AdjOR, 4.761; 95% CI, 3.960-5.724), 3 or more chronic diseases (AdjOR, 2.200; 95% CI, 1.657-2.920), living alone (AdjOR, 1.443; 95% CI, 1.059-1.966), living in cottage (AdjOR, 1.426; 95% CI, 1.033-1.967), living space (vs < 50 m^2 : 201-250 m^2 AdjOR, 0.566; 95% CI, 0.359-0.893; > 250 m^2 AdjOR, 0.337; 95% CI, 0.223-0.511), and space per person (vs < 30 m^2 : 30- m^2 AdjOR, 0.502; 95% CI, 0.362-0.697; 40- m^2 AdjOR, 0.473; 95% CI, 0.347-0.646; 50- m^2 AdjOR, 0.418; 95% CI, 0.339-0.515) 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.

Keywords: EPIDEMIOLOGY; Depression & mood disorders < PSYCHIATRY; Old age psychiatry < PSYCHIATRY; PUBLIC HEALTH

Strengths and limitations:

- this is a cross-sectional study that does not establish the direction of causality for the association between built form and geriatric depression
- the use of structured face-to-face interviews assisted by trained local general practitioners and the standardized rating scale
- 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

Introduction

The White Paper on the Development of China's Aging Career published in 2018 stated that China had nearly 144 million elderly over 60 years old, of which around 60% were in rural areas. Namely, as of now, the number of rural elders in China has reached 90 million. It is estimated that by 2050, China's aged population will reach 400 million, accounting for 1/3 of the general population, and China will enter the stage of deep aging. (China Financial Policy Report, 2011)

"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 October 27-28, 2018, Angela Pei-chen Fan explained her latest findings. According to Fan's research, in 2015, the suicide rate of older adults aged 65 to 85 in China was 2.75 to 7.08 times that of the general population. Among them, the suicide rate in rural areas was significantly higher than that in urban. Fan pointed out that in rural areas, 21.99 per 100,000 seniors over 65 years committed suicide, and the number increased with age. For rural elders over 85 years, 65.60 per 100,000 of them committed suicide. However, in urban areas, the number was 41.09. Mental illness and suicide are closely related. According to Lee and his colleagues, 2018[1], at least 94% of older adults who committed suicide had moderate depression, and 60% -70% had a major depressive disorder. In the face of changes in the age structure, it is urgent to implement appropriate aging-friendly planning and layout. There is a pressing need to identify modifiable factors that influence the rural-aged population's mental health. The built form of the elderly is one of the perspectives. More and more professionals recognize that housing is a major social determinant 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] Johnson & Robin, 2005[7] proposed that having a quality, safe, and comfortable living environment is a critical factor for living a high-quality and healthy life. Evans, 2000[8] proved that the in-house facilities could cause infectious and non-communicable diseases. Saidj et al., 2015[9] reported that housing's physical structure significantly impacted public health. Navarro et al., 2010[10] proposed that built forms could shape people's lifestyle.

There is a large sum of research on housing and health of older persons, covering indirect economic aspects of housing, including the ownership, affordability and wealth of housing, and direct physical detriment to housing due to services and resources. Many studies had focused on a single aspect of housing, such as barrier-free facilities, lighting, noise, and 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 & Fu,2019,[17] found a new dynamic perspective on the positive relationship between physical attributes of housing and the elders' health. Moreover, improving built forms could significantly ameliorate health status and reduce medical expenses.

A recent study had examined that kitchen and bathroom facilities in houses were significantly associated with more depressive symptoms among the elderly in rural China.[18] Nevertheless, to date, we are not aware of any reported studies of the associations between housing structure and depression. We examined the association of building type (cottage/apartment), living space (gross area and space per person), and depression.

Methods

Study design and participants

This cross-sectional study analyzed data from household surveys based on the structured questionnaire with residents aged 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, a national historical and cultural city and a scenic tourist city approved by China's State Council. 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. Suzhou is located in the southeast of Jiangsu Province and the east of Shanghai. 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 the second in mainland China and the first in Shanghai (83.63 years). Suzhou is a district, including urban and rural areas. Rural in China refers to an agricultural area 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 social and economic conditions.

We used a multi-stage stratified cluster sampling procedure, which considered economic development status. The gender and age distribution, derived from the local government census data, addresses selection bias. To be specific, in Stage 1, counties were used as the primary sampling unit, and counties were divided into layers according to the population structure of the province, and two counties were to be selected. Namely, each layer's counties were sorted from high to low according to the proportion of the rural population of the census data. The people of each county in each layer were serially accumulated, and the required number of townships was extracted by the Probability-Proportional-to-Size sampling method. We selected two counties from all nine counties in Suzhou. The above sampling method was also used to choose in stage 2, and we established 24 townships. Namely, according to the scale of the rural population, 12 townships were chosen 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. The Institutional Review Board approved the study for the Center for Health Development of Medical College of Soochow University.

Procedures

We assessed depression using the Patient Health Questionnaire (PHQ-9), based on symptoms over the preceding two weeks, which has nine items, each of which scored zero to three. A cut-point of 5 was used to identify depression. PHQ-9 score 0-4 indicates no depressive disorder. The PHQ-9 has excellent reliability and validity on the Chinese elderly.[19] The items are concise and practical. It is worth promoting in the clinic, especially in the community health service center.[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 / bathing or dressing?" 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 apartment?" "What is the gross area of the house you currently living in?" "How many people do you live with now?" "Cottage" means self-built houses; It refers to the homes and buildings built by individuals on their land. It is worth noting that there is no lawn or swimming pool in the cottage in rural China. Cottages in rural China are detached, scattered, multi-story, bigger, and not necessarily older than apartments. Apartments were built by the government to compensate and resettle people whose cottages are demolished while constructing roads and

other public facilities. They are in better condition, of 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 had been proved to have an impact on depression.[21-32]

To investigate the association between house types (living in apartment/ cottage) and depression, and to assess the differences, the Pearson χ^2 test was used. We analyzed the effect of a living area (gross and per person) using the binary logistic regression. A threshold of a 2-tailed P value of <0·05 was applied for significance. We did all the statistical analyses with IBM SPSS Statistics 23.

Patient and Public Involvement

No patient involved.

Results

Participants were recruited between April and November 2019. 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 statistical-significantly more common among the elderly living in apartments than in cottages. (**Fig.1**) Moreover, there was a significant difference among elders

living in varied sizes of houses. The prevalence of depression of those gross living area was under 50 square meters (29.4%) was the highest, followed by 51-100 square meters (24.8%), 101-150 square meters (21.2%), 151-200 square meters (17.3%), 201-550 square meters (13.6%), and over 250 square meters (7.6%; **Fig. 2**). The prevalence of depression of those living space per person was under 30 square meters (25.5%) was the highest, followed by 30- square meters (15.2%), 40- square meters (13.0%), and over 50 square meters (12.3%).

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 [a]	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 [b]					
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 (m²)					
<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 (m² 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	

[a] Single includes individuals who are divorced, widowed, or unmarried. [b] NCD stands for non-communicable disease.

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, 1.108-1.861; 75-79 years AdjOR, 2.267; 95% CI, 1.735-2.964; ≥80 years AdjOR, 2.778; 95% CI, 1.972-3.913), male sex (AdjOR, 0.644; 95% CI, 0.536-0.773), years of education (vs 0 year: 6 years AdjOR, 0.721; 95% CI, 0.599-0.868; 9 years AdjOR,

0.569; 95% CI, 0.411-0.788; 12 years AdjOR, 0.422; 95% CI, 0.215-0.830), single (AdjOR, 1.375; 95% CI, 1.101-1.717), living alone (AdjOR, 1.443; 95% CI, 1.059-1.966), living in cottage (AdjOR, 1.424; 95% CI, 1.153-1.759), and gross living area (vs < 50 m^2 : 201-250 m^2 AdjOR, 0.539; 95% CI, 0.350-0.829; > 250 m^2 AdjOR, 0.327; 95% CI, 0.220-0.485) 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*). 65-69 years old, 1 or 2 chronic diseases and living area under 200 m^2 were not associated with risk of depression among Chinese rural elders.

Living in cottage (AdjOR, 1.261; 95% CI, 1.010-1.576) and living space (vs < 30 m^2 : 30- m^2 AdjOR, 0.502; 95% CI, 0.362-0.697; 40- m^2 AdjOR, 0.473; 95% CI, 0.347-0.646; 50- m^2 AdjOR, 0.418; 95% CI, 0.339-0.515) remained statistically significantly associated with depression when considering space per capita (*Table 3*). (see Model 1 in the Supplementary file)

Table 2: Multiple-adjusted ORs for depression associated with risk factors in Chinese rural elderly (Gross living area m^2) (see Model 1 in the Supplementary file)

	Model 2		Model 3		Model 4	
	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Male sex	0.795 (0.659-0.959)	0.017	0.644 (0.536-0.773)	< 0.001	0.719 (0.593-0.871)	0.001
Age (years)						
60-64	1.00 (ref)					
65-69	1.214 (0.937-1.575)	0.143	1.282 (0.994-1.653)	0.055	1.229 (0.942-1.600)	0.129
70-74	1.204 (0.921-1.575)	0.174	1.436 (1.108-1.861)	0.006	1.179 (0.892-1.541)	0.253
75-80	1.655 (1.253-2.185)	< 0.001	2.267 (1.735-2.964)	< 0.001	1.737 (1.309-2.305)	< 0.001
≥80	2.656 (1.864-3.783)	< 0.001	2.778 (1.972-3.913)	< 0.001	2.074 (1.439-2.981)	< 0.001
Education Level (years)						

0	1.00 (ref)					
6	0.669 (0.552-0.810)	< 0.001	0.721 (0.599-0.868)	0.001	2.332 (0.290-18.836)	0.425
9	0.504 (0.362-0.703)	< 0.001	0.569 (0.411-0.788)	0.001	1.782 (0.222-14.308)	0.587
12	0.436 (0.219-0.867)	0.018	0.422 (0.215-0.830)	0.012	1.465 (0.180-11.925)	0.722
≥13	0.755 (0.219-2.601)	0.656	2.089 (0.693-6.295)	0.190	1.139 (0.128-10.089)	0.909
Marital status						
Married	1.00 (ref)					
Single[a]	1.165 (0.929-1.462)	0.187	1.375 (1.101-1.717)	0.005	1.304 (1.032-1.646)	0.026
Living alone						
No	1.00 (ref)					

Yes	1.800 (1.323-2.448)	< 0.001	1.443 (1.059-1.966)	0.020	1.420 (1.033-1.967)	0.031
Self-care disability						
No	1.00 (ref)				1.00 (ref)	
Yes	4.834 (4.035-5.791)	< 0.001			4.764 (3.960-5.724)	< 0.001
Number of NCDs[b]						
0	1.00 (ref)				1.00 (ref)	
1-2	1.224 (1.012-1.482)	0.038			1.200 (0.990-1.459)	0.064
≥3	2.136 (1.616-2.823)	< 0.001			2.200 (1.657-2.920)	< 0.001
Building Type						
Apartment			1.00 (ref)		1.00 (ref)	

Cottage	1.424 (1.153-1.759)	0.001	1.420 (1.033-1.967)	0.001
Living area (m²)				
< 50	1.00 (ref)		1.00 (ref)	
51-100	1.188 (0.802-1.760)	0.389	1.268 (0.837-1.923)	0.263
101-150	1.076 (0.738-1.569)	0.702	1.089 (0.730-1.624)	0.675
151-200	0.874 (0.505-1.514)	0.631	0.860 (0.481-1.537)	0.611
201-250	0.539 (0.350-0.829)	0.005	0.566 (0.359-0.893)	0.015
> 250	0.327 (0.220-0.485)	< 0.001	0.331 (0.223-0.511)	< 0.001

[a] Single includes individuals who are divorced, widowed or unmarried. [b] NCD stands for non-communicable disease.
(see Model 1 in the Supplementary file)

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	OR (95% CI)	p	OR (95% CI)	p
Male sex	0.795 (0.659-0.959)	0.017	0.701 (0.585-0.840)	< 0.001	0.769 (0.636-0.930)	0.007
Age (years)						
60-64	1.00 (ref)					
65-69	1.214 (0.937-1.575)	0.143	1.331 (1.035-1.713)	0.026	1.268 (0.976-1.647)	0.076
70-74	1.204 (0.921-1.575)	0.174	1.506 (1.165-1.947)	0.002	1.209 (0.922-1.584)	0.169

75-80	1.655 (1.253-2.185)	< 0.001	2.330 (1.787-3.036)	< 0.001	1.712 (1.292-2.267)	< 0.001
≥80	2.656 (1.864-3.783)	< 0.001	3.541 (2.522-4.971)	< 0.001	2.508 (1.747-3.602)	< 0.001
Education Level (years)						
0	1.00 (ref)					
6	0.669 (0.552-0.810)	< 0.001	0.652 (0.543-0.783)	< 0.001	0.703 (0.579-0.853)	< 0.001
9	0.504 (0.362-0.703)	< 0.001	0.510 (0.369-0.703)	< 0.001	0.564 (0.403-0.790)	0.001

12	0.436 (0.219-0.867)	0.018	0.419 (0.214-0.820)	0.011	0.491 (0.246-0.979)	0.043
≥13	0.755 (0.219-2.601)	0.656	1.722 (0.600-4.942)	0.312	0.977 (0.288-3.309)	0.970
Married	1.00 (ref)					
Single[a]	1.165 (0.929-1.462)	0.187	1.530 (1.258-1.861)	< 0.001	1.198 (0.952-1.506)	0.123
Living alone						
No	1.00 (ref)					
Yes	1.800 (1.323-2.448)	< 0.001			1.940 (1.419-2.653)	< 0.001

Self-care disability						
No	1.00 (ref)				1.00 (ref)	
Yes	4.834 (4.035-5.791)	< 0.001			4.838 (4.030-5.809)	< 0.001
Number of NCDs[b]						
0	1.00 (ref)				1.00 (ref)	
1-2	1.224 (1.012-1.482)	0.038			1.200 (0.990-1.455)	0.063
≥3	2.136 (1.616-2.823)	< 0.001			2.115 (1.595-2.804)	< 0.001
Apartment			1.00 (ref)		1.00 (ref)	
Cottage			1.203 (0.974-1.487)	0.087	1.261 (1.010-1.576)	0.041

Living area (m² per person)				
< 30	1.00 (ref)		1.00 (ref)	
30-	0.491 (0.360-0.669)	< 0.001	0.502 (0.362-0.697)	< 0.001
40-	0.442 (0.329-0.594)		0.473 (0.347-0.646)	
50-	0.432 (0.355-0.526)		0.418 (0.339-0.515)	

[a] Single includes individuals who are divorced, widowed, or unmarried. [b] NCD stands for non-communicable disease.
(see Model 1 in the Supplementary file)

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.

Our results accord with the previous findings of risk factors for depression among Chinese older 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 twice as likely to be untreated as urban residents, according to WHO, 2015 China country assessment report on aging and health.

Researches have well confirmed that the incidence of depression in women is about twice 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 resources and social network—although evidence varies depending on the age cohort. Also, education leads to better health behaviors. The more educated are more likely to quit smoking, exercise regularly, and take preventative health screening exams.[52] Further research is needed to explain why highly educated, older adults in rural China had most odds of depression.

To some extent, the broader housing area represents higher income and social status, which proved to have a significant impact on mental health. 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 on direct owners' physical health. The improvement in the owner's physical health is due to health-related investments and behaviors 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 built environment were in a worse mental health.[58] In rural China, apartments were built by the government to compensate and resettle people whose cottages are demolished while constructing roads and other public facilities. Therefore, they have unified, and standard built forms, which are in better condition, of better quality, and have better facilities. Persistent inferior built forms can indicate a deterioration in mental health, and live 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 more living space 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.,2017[60] suggested that substantial housing investment through managed upgrade programs 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 livable and age-friendly housing structure and its impact on geriatric mental health. Besides, is urbanization 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 the depression 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 assessing 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 the relation of built form to depression. However, covariates adjustments can control the

observable effects of sociodemographic and physical characteristics. Fourth, due to the complex interrelationships 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 and 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 role of housing characteristics and combinations of attributes in geriatric depression. Seventh, no information is given on the two housing types in the sense of repair 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 was significantly and meaningfully associated with depression among Chinese rural elders. Our findings call for attention to built forms and efforts to facilitate the prevention and detection of geriatric depression in rural China, especially those living in small housing areas and cottages.

Acknowledgments:

We are sincerely grateful to the local general physicians and participants enrolled in the household survey. We thank the Suzhou Municipal Health Department and Suzhou Municipal Center for Disease Control and Prevention staff, notably Ying-quan Wang, for on-site coordination, Sheng Qian, for data management.

Author Contributions:

Conceptualization, Q.Q. and Y.X.; Methodology, Q.Q.; Software, Q.Q.; Validation, Q.Q., Y.X. and J.L.; Formal Analysis, Q.Q.; Investigation, Q.Q.; Resources, Q.Q.; Data Curation, JY.L.; Writing – Original Draft Preparation, Q.Q.; Writing – Review & Editing, Y.X.; Visualization, J.L.; Supervision, Y.X.; Project Administration, Y.X.; Funding Acquisition, Y.X.

Competing Interests:

The authors declare no conflict of interest.

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Data statement: Data may be obtained from a third party and are not publicly available.

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Fig.1. The difference among house types in the prevalence of depression
Fig.2. The difference among living space in the prevalence of depression

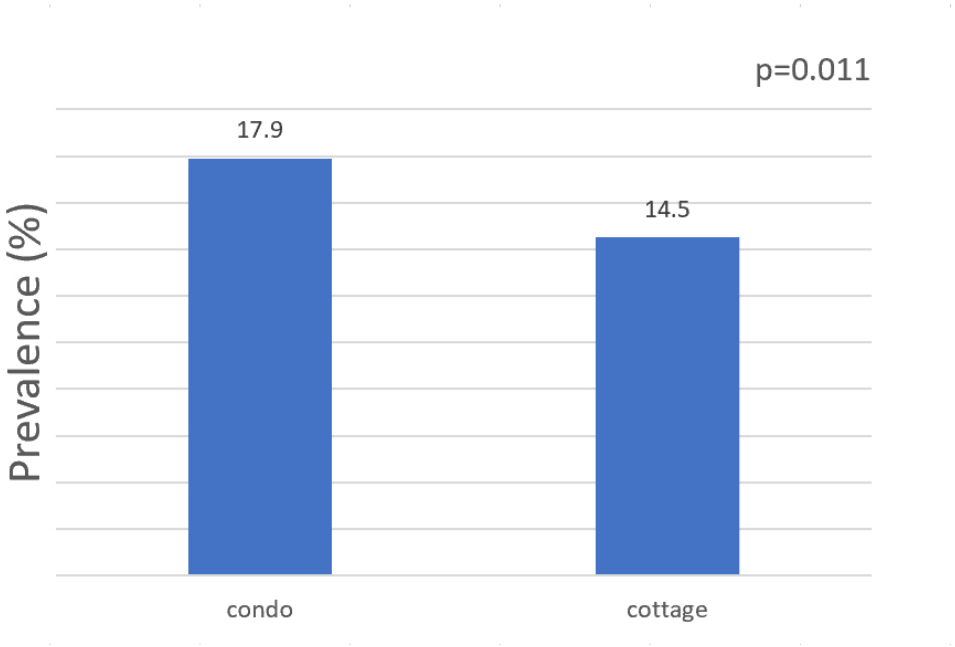

Fig.1. Difference among house types in prevalence of depression

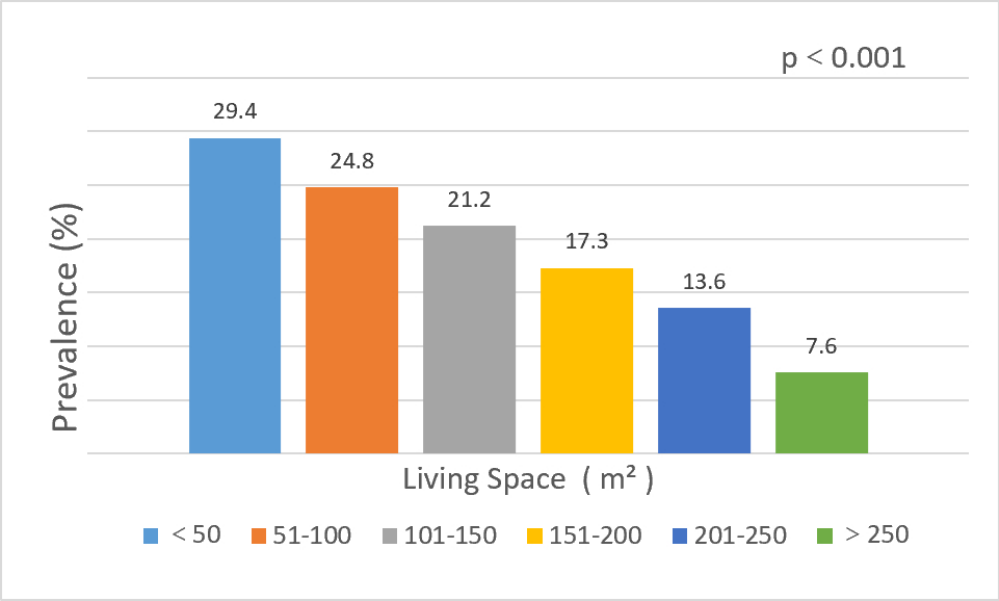

Figure 2
The difference among living space in the prevalence of depression

	Model 1	
	OR (95% CI)	p
Female sex	0.718 (0.600-0.858)	0.000
Age (years)		
60-64	1.00 (ref)	
65-69	1.280 (0.996-1.643)	0.053
70-74	1.501 (1.163-1.937)	0.002
75-80	2.218 (1.705-2.885)	0.000
≥80	3.611 (2.586-5.044)	0.000
Education Level (years)		
0	1.00 (ref)	
6	0.619 (0.516-0.742)	0.000
9	0.452 (0.329-0.622)	0.000
12	0.365 (0.186-0.714)	0.003
≥13	1.211 (0.412-3.561)	0.728
Marital status		
Married	1.00 (ref)	
Single	1.226 (0.988-1.522)	0.064
Living alone		
No	1.00 (ref)	
Yes	1.840 (1.372-2.469)	0.000
Movement disorder		
No		
Yes		
Number of NCDs		
0		
1-2		
≥3		
Building Type		
Condo		
Cottage		
Living area (m²)		
＜50		
51-100		
101-150		

151-200	
201-250	
>250	

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2-3
Objectives	3	State specific objectives, including any pre-specified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4-5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4-5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	-
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4-5*
Bias	9	Describe any efforts to address potential sources of bias	4-5
Study size	10	Explain how the study size was arrived at	4-5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	4-5
		(*b*) Describe any methods used to examine subgroups and interactions	4-5
		(*c*) Explain how missing data were addressed	4-5
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	4-5

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	4-5
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	6
		(c) Consider use of a flow diagram	6
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6
		(b) Indicate number of participants with missing data for each variable of interest	6
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	6
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	-
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	-
		Cross-sectional study—Report numbers of outcome events or summary measures	6
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7-8
		(*b*) Report category boundaries when continuous variables were categorized	7-8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	7-8
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	7-8
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

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

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-038572.R3
Article Type:	Original research
Date Submitted by the Author:	11-Nov-2020
Complete List of Authors:	Qiu, Qin-wei; Soochow University Medical College, School of Public Health Li, Jing; Soochow University Medical College, School of Public Health Li, Jia-yu; Soochow University Medical College, School of Public Health Xu, Yong; Soochow University Medical College, School of Public Health
Primary Subject Heading:	Public health
Secondary Subject Heading:	Mental health, Public health, Geriatric medicine
Keywords:	EPIDEMIOLOGY, Depression & mood disorders < PSYCHIATRY, Old age psychiatry < PSYCHIATRY, PUBLIC HEALTH

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

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Word count: 3186

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, 1.309-2.305; ≥80 years AdjOR, 2.072; 95% CI, 1.439-2.981), male sex (AdjOR, 0.719; 95% CI, 0.593-0.871), single (AdjOR, 1.303; 95% CI, 1.032-1.646), self-care disability (AdjOR, 4.761; 95% CI, 3.960-5.724), 3 or more chronic diseases (AdjOR, 2.200; 95% CI, 1.657-2.920), living alone (AdjOR, 1.443; 95% CI, 1.059-1.966), living in cottage (AdjOR, 1.426; 95% CI, 1.033-1.967), living space (vs < 50 m^2 : 201-250 m^2 AdjOR, 0.566; 95% CI, 0.359-0.893; > 250 m^2 AdjOR, 0.337; 95% CI, 0.223-0.511), and space per person (vs < 30 m^2 : 30- m^2 AdjOR, 0.502; 95% CI, 0.362-0.697; 40- m^2 AdjOR, 0.473; 95% CI, 0.347-0.646; 50- m^2 AdjOR, 0.418; 95% CI, 0.339-0.515) 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.

Keywords: EPIDEMIOLOGY; Depression & mood disorders < PSYCHIATRY; Old age psychiatry < PSYCHIATRY; PUBLIC HEALTH

Strengths and limitations:

- 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 standardized rating scale.
- Whether the depression associated with cottages was caused by poor housing quality, low income, or low density remained in doubt.

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 1/3 of the general population, at which point China will enter a stage of deep aging. (China Financial Policy Report, 2011)

"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 October 27 and October 28, 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 to 85 in China was 2.75 to 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 and his colleagues, 2018[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 forms of the elderly is one of the perspectives. More and more professionals recognize that housing is a major social determinant 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] Johnson & Robin, 2005[7] proposed that having a quality, safe, and comfortable living environment is a critical factor for living a high-quality and healthy life. Evans, 2000[8] proved that the in-house facilities could cause infectious and non-communicable diseases. Saidj et al., 2015[9] reported that housing's physical structure significantly impacted public health. Navarro et al., 2010[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 & Fu,2019,[17] 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 analyzed 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 multi-stage 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. The Institutional Review Board approved the study for the Center for Health Development of Medical College of Soochow University.

Procedures

We assessed one's depression using the Patient Health Questionnaire (PHQ-9) which was based on symptoms over the preceding two weeks, the questionnaire has nine items, each of which is scored zero to three. 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] We assessed one's depression using the Patient Health Questionnaire (PHQ-9), which was based on symptoms over the preceding two weeks. The questionnaire has nine items, each of which is scored zero to three. 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.[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 apartment?"; "What is the gross area of the house you 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, multi-story, 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 $\chi 2$ test was used. We analyzed the effect of a living area (gross and per person) using the binary logistic regression. The cutoffs (<30; 30-; 40-; 50-) were chosen for the living area per person. On July 31, 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 square meters. That of urban residents was 39. A threshold of a 2-tailed P value of <0·05 was applied for significance. We did all the statistical analyses with IBM SPSS Statistics 23.

Patient and Public Involvement

The public was 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. 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 statistical-significantly more common among the elderly living in apartments than in cottages. (**Fig.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 square meters (29.4%) was the highest, followed by 51-100 square meters (24.8%), 101-150 square meters (21.2%), 151-200 square meters (17.3%), 201-550 square meters (13.6%), and over 250 square meters (7.6%; **Fig. 2**). The prevalence of depression of those living space per person was under 30 square meters (25.5%) was the highest, followed by 30- square meters (15.2%), 40- square meters (13.0%), and over 50 square meters (12.3%).

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 [a]	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 [b]					
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 (m²)					
＜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 (m² 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	

[a] Single includes individuals who are divorced, widowed, or unmarried. [b] NCD stands for non-communicable disease.

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, 1.108-1.861; 75-79 years AdjOR, 2.267; 95% CI, 1.735-2.964; ≥80 years AdjOR, 2.778; 95% CI, 1.972-3.913), male sex (AdjOR, 0.644; 95% CI, 0.536-0.773), years of education (vs 0 year: 6 years AdjOR, 0.721; 95% CI, 0.599-0.868; 9 years AdjOR, 0.569; 95% CI, 0.411-0.788; 12 years AdjOR, 0.422; 95% CI, 0.215-0.830), single (AdjOR, 1.375; 95% CI, 1.101-1.717), living alone (AdjOR, 1.443; 95% CI, 1.059-1.966), living in cottage (AdjOR, 1.424; 95% CI, 1.153-1.759), and gross living area (vs < 50 m^2 : 201-250 m^2 AdjOR, 0.539; 95% CI, 0.350-0.829; > 250 m^2 AdjOR, 0.327; 95% CI, 0.220-0.485) 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*). 65-69 years old, 1 or 2 chronic diseases and living area under 200 m^2 were not associated with risk of depression among Chinese rural elders.

Living in cottage (AdjOR, 1.261; 95% CI, 1.010-1.576) and living space (vs < 30 m^2 : 30- m^2 AdjOR, 0.502; 95% CI, 0.362-0.697; 40- m^2 AdjOR, 0.473; 95% CI, 0.347-0.646; 50- m^2 AdjOR, 0.418; 95% CI, 0.339-0.515) remained statistically significantly associated with depression when considering space per capita (*Table 3*). (see Model 1 in the Supplementary file) In our univariate analysis, the results indicated that living in the

cottage was a protective factor. However, in our regression analyzes 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.

Table 2: Multiple-adjusted ORs for depression associated with risk factors in Chinese rural elderly (Gross living area m²) (see Model 1 in the Supplementary file)

	Model 2		Model 3		Model 4	
	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Male sex	0.795 (0.659-0.959)	0.017	0.644 (0.536-0.773)	< 0.001	0.719 (0.593-0.871)	0.001
Age (years)						
60-64	1.00 (ref)					
65-69	1.214 (0.937-1.575)	0.143	1.282 (0.994-1.653)	0.055	1.228 (0.942-1.600)	0.129
70-74	1.204 (0.921-1.575)	0.174	1.436 (1.108-1.861)	0.006	1.173 (0.892-1.541)	0.253
75-80	1.655 (1.253-2.185)	< 0.001	2.267 (1.735-2.964)	< 0.001	1.737 (1.309-2.305)	< 0.001
≥80	2.656 (1.864-3.783)	< 0.001	2.778 (1.972-3.913)	< 0.001	2.074 (1.439-2.981)	< 0.001
Education Level (years)						

0	1.00 (ref)					
6	0.669 (0.552-0.810)	< 0.001	0.721 (0.599-0.868)	0.001	2.332 (0.290-18.836)	0.425
9	0.504 (0.362-0.703)	< 0.001	0.569 (0.411-0.788)	0.001	1.782 (0.222-14.308)	0.587
12	0.436 (0.219-0.867)	0.018	0.422 (0.215-0.830)	0.012	1.465 (0.180-11.925)	0.722
≥13	0.755 (0.219-2.601)	0.656	2.089 (0.693-6.295)	0.190	1.139 (0.128-10.089)	0.909
Marital status						
Married	1.00 (ref)					
Single[a]	1.165 (0.929-1.462)	0.187	1.375 (1.101-1.717)	0.005	1.304 (1.032-1.646)	0.026
Living alone						
No	1.00 (ref)					

Yes	1.800 (1.323-2.448)	< 0.001	1.443 (1.059-1.966)	0.020	1.420 (1.033-1.967)	0.031
Self-care disability						
No	1.00 (ref)				1.00 (ref)	
Yes	4.834 (4.035-5.791)	< 0.001			4.764 (3.960-5.724)	< 0.001
Number of NCDs[b]						
0	1.00 (ref)				1.00 (ref)	
1-2	1.224 (1.012-1.482)	0.038			1.200 (0.990-1.459)	0.064
≥3	2.136 (1.616-2.823)	< 0.001			2.200 (1.657-2.920)	< 0.001
Building Type						
Apartment			1.00 (ref)		1.00 (ref)	

Cottage	1.424 (1.153-1.759)	0.001	1.420 (1.033-1.967)	0.001
Living area (m²)				
< 50	1.00 (ref)		1.000 (ref)	
51-100	1.188 (0.802-1.760)	0.389	1.268 (0.837-1.923)	0.263
101-150	1.076 (0.738-1.569)	0.702	1.089 (0.730-1.624)	0.675
151-200	0.874 (0.505-1.514)	0.631	0.860 (0.481-1.537)	0.611
201-250	0.539 (0.350-0.829)	0.005	0.565 (0.359-0.893)	0.015
> 250	0.327 (0.220-0.485)	< 0.001	0.331 (0.223-0.511)	< 0.001

[a] Single includes individuals who are divorced, widowed or unmarried. [b] NCD stands for non-communicable disease.
(see Model 1 in the Supplementary file)

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	OR (95% CI)	p	OR (95% CI)	p
Male sex	0.795 (0.659-0.959)	0.017	0.701 (0.585-0.840)	< 0.001	0.769 (0.636-0.930)	0.007
Age (years)						
60-64	1.00 (ref)					
65-69	1.214 (0.937-1.575)	0.143	1.331 (1.035-1.713)	0.026	1.268 (0.976-1.647)	0.076
70-74	1.204 (0.921-1.575)	0.174	1.506 (1.165-1.947)	0.002	1.209 (0.922-1.584)	0.169

75-80	1.655 (1.253-2.185)	< 0.001	2.330 (1.787-3.036)	< 0.001	1.712 (1.292-2.267)	< 0.001
≥80	2.656 (1.864-3.783)	< 0.001	3.541 (2.522-4.971)	< 0.001	2.508 (1.747-3.602)	< 0.001
Education Level (years)						
0	1.00 (ref)					
6	0.669 (0.552-0.810)	< 0.001	0.652 (0.543-0.783)	< 0.001	0.703 (0.579-0.853)	< 0.001
9	0.504 (0.362-0.703)	< 0.001	0.510 (0.369-0.703)	< 0.001	0.564 (0.403-0.790)	0.001

12	0.436 (0.219-0.867)	0.018	0.419 (0.214-0.820)	0.011	0.491 (0.246-0.979)	0.043
≥13	0.755 (0.219-2.601)	0.656	1.722 (0.600-4.942)	0.312	0.977 (0.288-3.309)	0.970
Married	1.00 (ref)					
Single[a]	1.165 (0.929-1.462)	0.187	1.530 (1.258-1.861)	< 0.001	1.198 (0.952-1.506)	0.123
Living alone						
No	1.00 (ref)					
Yes	1.800 (1.323-2.448)	< 0.001			1.940 (1.419-2.653)	< 0.001

Self-care disability						
No	1.00 (ref)				1.00 (ref)	
Yes	4.834 (4.035-5.791)	< 0.001			4.838 (4.030-5.809)	< 0.001
Number of NCDs[b]						
0	1.00 (ref)				1.00 (ref)	
1-2	1.224 (1.012-1.482)	0.038			1.200 (0.990-1.455)	0.063
≥3	2.136 (1.616-2.823)	< 0.001			2.115 (1.595-2.804)	< 0.001
Apartment			1.00 (ref)		1.00 (ref)	
Cottage			1.203 (0.974-1.487)	0.087	1.261 (1.010-1.576)	0.041

Living area (m² per person)				
< 30	1.00 (ref)		1.00 (ref)	
30-	0.491 (0.360-0.669)	< 0.001	0.502 (0.362-0.697)	< 0.001
40-	0.442 (0.329-0.594)		0.473 (0.347-0.646)	
50-	0.432 (0.355-0.526)		0.418 (0.339-0.515)	

[a] Single includes individuals who are divorced, widowed, or unmarried. [b] NCD stands for non-communicable disease.
(see Model 1 in the Supplementary file).

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 (RMB).

Our results accord with the previous findings of risk factors for depression among Chinese older 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 twice as likely to be untreated as urban residents, according to WHO, 2015 China country

assessment report on aging and health.

Researches have well confirmed that the incidence of depression in women is about twice 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 socio-economic 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 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 exams. 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 a proxy, as it is in many countries. Researches by many groups have established a relationship between socio-economic status and depression.[53-55] Addressing socio-economic 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 behaviors 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 standardized 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.,2017[60] suggested that substantial housing investment through managed upgrade programs 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 livable and age-friendly housing structure and its impact on geriatric mental health. Besides, is urbanization 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 interrelationships between housing, socio-economic 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.

Acknowledgments:

We are sincerely grateful to the local general physicians and participants enrolled in the household survey. We thank the Suzhou Municipal Health Department and Suzhou Municipal Center for Disease Control and Prevention staff, notably Ying-quan Wang, for on-site coordination, Sheng Qian, for data management. We sincerely appreciate Slade Hall from Towson University, MD to polish the English language.

Author Contributions:

Conceptualization, Q.Q. and Y.X.; Methodology, Q.Q.; Software, Q.Q.; Validation, Q.Q., Y.X. and J.L.; Formal Analysis, Q.Q.; Investigation, Q.Q.; Resources, Q.Q.; Data Curation, JY.L.; Writing – Original Draft Preparation, Q.Q.; Writing – Review & Editing, Y.X.; Visualization, J.L.; Supervision, Y.X.; Project Administration, Y.X.; Funding Acquisition, Y.X.

Competing Interests:

The authors declare no conflict of interest.

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Data statement: Data may be obtained from a third party and are not publicly available. Readers can send an email to Center for Health Development of Soochow University if you need the data. Email：childhealth@suda.edu.cn

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Fig.1. The difference among house types in the prevalence of depression
Fig.2. The difference among living space in the prevalence of depression

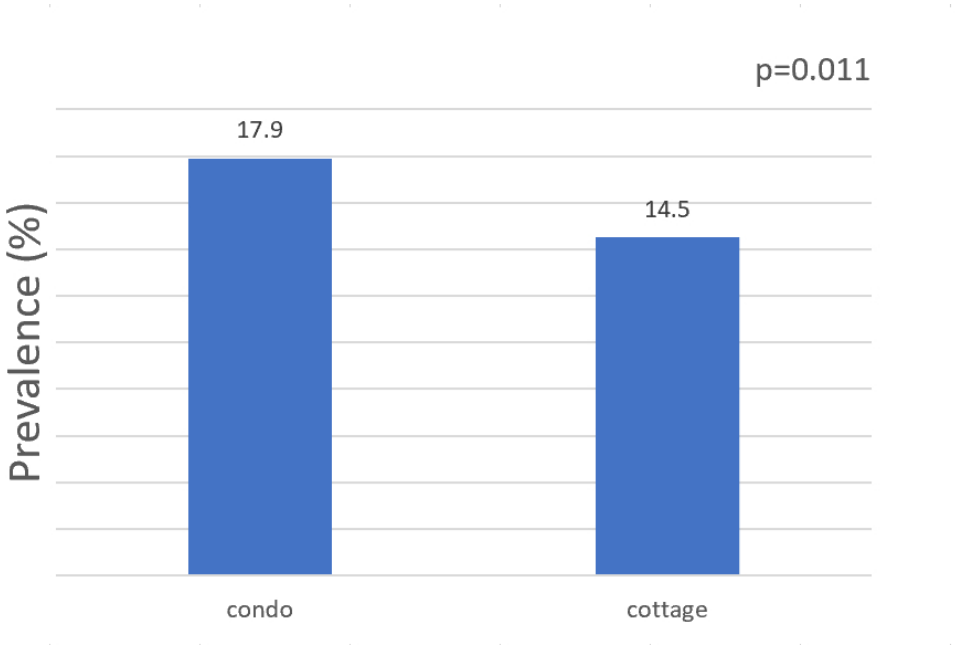

Fig.1. Difference among house types in prevalence of depression

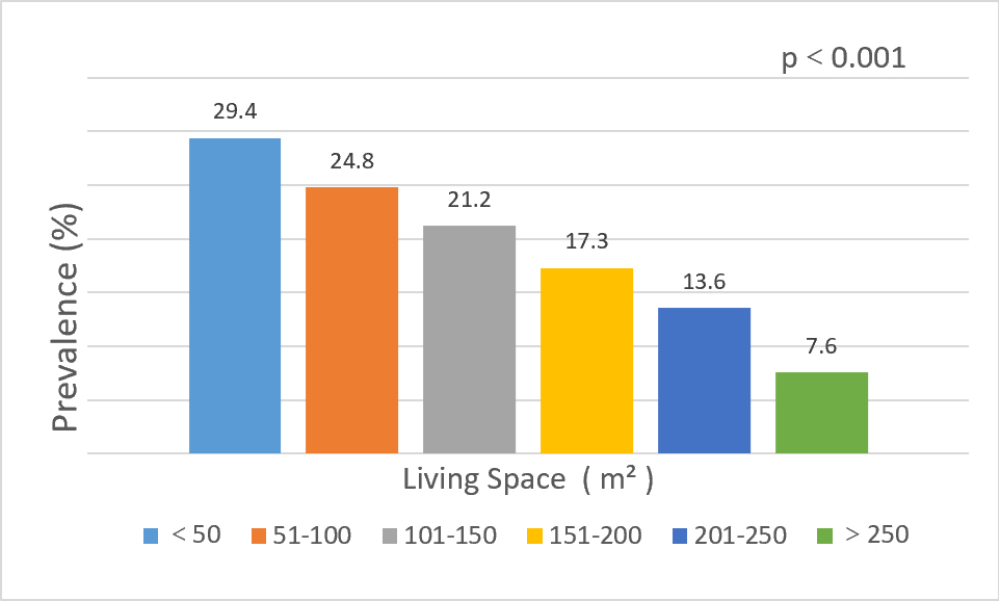

Figure 2
The difference among living space in the prevalence of depression

	Model 1	
	OR (95% CI)	p
Female sex	0.718 (0.600-0.858)	0.000
Age (years)		
60-64	1.00 (ref)	
65-69	1.280 (0.996-1.643)	0.053
70-74	1.501 (1.163-1.937)	0.002
75-80	2.218 (1.705-2.885)	0.000
≥80	3.611 (2.586-5.044)	0.000
Education Level (years)		
0	1.00 (ref)	
6	0.619 (0.516-0.742)	0.000
9	0.452 (0.329-0.622)	0.000
12	0.365 (0.186-0.714)	0.003
≥13	1.211 (0.412-3.561)	0.728
Marital status		
Married	1.00 (ref)	
Single	1.226 (0.988-1.522)	0.064
Living alone		
No	1.00 (ref)	
Yes	1.840 (1.372-2.469)	0.000
Movement disorder		
No		
Yes		
Number of NCDs		
0		
1-2		
≥3		
Building Type		
Apartment		
Cottage		
Living area (m²)		
＜50		
51-100		
101-150		

151-200	
201-250	
>250	

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any pre-specified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-7
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6-7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	-
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	8
Study size	10	Explain how the study size was arrived at	6-7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	8
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	8

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	8
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	9
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	9
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	-
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	-
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	-
		Cross-sectional study—Report numbers of outcome events or summary measures	9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11
		(*b*) Report category boundaries when continuous variables were categorized	11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	11
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11
Discussion			
Key results	18	Summarise key results with reference to study objectives	16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	20
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	20
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	22

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.