BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-030804
Article Type:	Research
Date Submitted by the Author:	02-Apr-2019
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Keywords:	social capital, health, left-behind older adults, sex disparity, rural China

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Word count: 5400

Abstract

***Objectives*:** To comprehensively examine the association between social capital and health of the left-behind older adults, as well as the sex disparity in this association, in rural China.

***Study design*:** A cross-sectional survey of 691 left-behind older adults aged 60 or above with all children working in cities from Hubei and Shaanxi Provinces of China in 2017.

***Methods*:** Ordinary least square (OLS) model was used to evaluate the association between social capital and specific health outcomes. Social capital included bonding trust, bridging trust, social participation, social network size and social network density. Health outcome consisted of basic activities of daily living (BADL), instrumental activities of daily living (IADL) and depression.

***Results*:** Results show that, in left-behind older adults, bonding trust was positively associated with BADL and negatively associated with depression; bridging trust was negatively associated with depression; participation was positively associated with IADL and negatively associated with depression; social network size was negatively associated with depression only, but social network density had no association with all three health outcomes. For sex disparity, bonding trust was negatively associated with depression in both sexes, but only positively related to BADL and IADL in females; bridging trust, participation and network size were negatively associated with depression in females only, and participation was only positively related to male older adults' IADL.

***Conclusions*:** Social capital plays a significant role in improving left-behind older adults' health. Thus, more attention should be paid to increase the stock of social capital in this special population, and sex disparity should be focused especially.

Keywords: social capital; health; left-behind older adults; sex disparity; rural China

Strengths and Limitations:

1. This study, for the first time, comprehensively evaluated the association between

social capital and health by sex in the left-behind older adults in rural China.

2. Social capital seemed to be related to depression stronger than to BADL and IADL.

3. A significant sex disparity in the association between social capital and health was observed.

4. The causal association between multilevel social capital and health was not examined.

1. Introduction

Since the late 1970s, China has witnessed dramatic economic and social changes; and in 21th century, China has witnessed rapidly growing aging population. By the end of 2016, people aged 60 or above accounted for 16.7% of the total population in China [1]. The rapid development of industrialization and urbanization has attracted tens of millions of rural labors to work in cities, which results in the increase of left-behind older adults living on their own in rural China. In China, the left-behind older adults in rural areas usually refer to older adults who are 60 or above, and all their children are working in other areas (usually cities) and not live with them [2]. Currently there are more than 40 million left-behind older adults in rural China and this trend may continue for foreseeable future [3].

Since the 1990s, the association between social capital and health has been widely discussed [4, 5]. The positive association between them has been observed in numerous studies [6-8]. However, limited studies have examined this association in older adults, especially in the left-behind older adults in rural China [9, 10]. Poor physical and mental health of the left-behind older adults have been reported and gained much attention recently [2, 3, 11]. Compared to other old-age groups, the left-behind older adults in rural areas have its unique features. With their children working in cities much of the time during the year and living far away, they cannot obtain enough support from their children, which results in loss of social connections and, thus, economic and mental instability [3]. Some evidence indicates that both physical and mental health of those left-behind older adults in rural areas are poorer than other older adults [2, 3, 12]. On the other hand, the sex disparity in health is a wide

discussed issue. It is recognized that males usually have a lower level of life expectancy than females, and the sex disparity in the association between social capital and health is also observed in other previous studies [13, 14].

Therefore, two questions aimed to be replied in this study. First, was there an empirical association between social capital and left-behind older adults' health in rural China? Second, was there a sex disparity in the association between social capital and left-behind older adults' health in rural China?

1.1. Definition and measures of social capital

Numerous views on the definition of social capital have been published, and Coleman and Putnam's communitarianism is the most influential one. Coleman and Putnam considers social capital as a kind of social structure and stresses the collective attribute of it as well as its power on individual actors from the perspective of social cohesion [15, 16]. By contrast, Bourdieu and Lin argued that social resource nested in social network was the core of social capital [17, 18]. Thus, social capital is often considered a contested concept, as the definition and measure of it are multiple and not unified [19].

The measure of social capital is another focus. It is recognized that social capital consists of two components: cognitive and structural components. Trust and norm of reciprocity belong to cognitive social capital whereas social network and participation belong to structural social capital [4, 20, 21]. Trust, norm of reciprocity, social network and participation have been treated as basic elements of social capital by most researchers [4, 21]. Trust has been defined as a sense of confidence or expectation generated from the belief that others will behave decently and in a predictable manner [22, 23]. Norm of reciprocity refers to a kind of mutual help where individuals get assistance from others [4]. Social network refers to social contacts between individuals, and it is a relatively stable system formed through social interactions between social members. Social participation, on the other hand, refers to the engagement in various formal or informal associations or activities [24, 25]. Further, the framework proposed by Putnam that social capital can be divided into bonding and bridging forms has been

widely used in the area of public health. Bonding social capital means a kind of in-ward social connection among individuals within homogeneous groups, while bridging social capital refers to a kind of out-ward social connection among members from heterogeneous groups [16, 24, 26].

It should be noted that the measure of social capital should be distinct in different social contexts. In Western countries, bonding social capital happens within a group of people with similar background, such as the same age, sex and class, they can be family members and common friends; whereas bridging social capital happens between people with different backgrounds, such as different age, sex and class, and they also can be family members and common friends [27]. In China, however, the *Chaxu* pattern of social ties used to describe the interpersonal pattern of Chinese residents should be focused. According to the *Chaxu* pattern, the interpersonal pattern of Chinese residents is similar to the ripple that opens wide on water surface, so Chinese residents consider the social connection as a circle, and strong ties locate closer and weak ties locate farther [28]. Accordingly, connections with family members can only be considered bonding social capital, whereas connections with common friends can only be considered bridging social capital.

1.2. Social capital and health in older adults

Limited studies are available on the association between social capital and health in older adults. Pollack and Knesebeck examined the effect of social capital on older adults' health in the US and German in 2004. They reported that a low level of reciprocity, trust and social participation was related to poor self-rated health (SRH) and elevated depression [9], but they were not associated with physical function. Studies conducted in Northern Europe, Eastern and Western Asia also observe an association between social capital and health. For example, evidence from Northern Europe shows that structural social capital, including social contacts with neighbors or friends, significantly reduces older adults' depression, because social contacts with others provide access to resources and support and generate mutual benefits [20]. For cognitive social capital, trust to friends [20] significantly promotes older adults'

psychological health, while general trust [29] and trust to neighbors [20] are not related to their psychological health. Because trust to friends is more self-chosen than trust to neighbors, so it benefits older adults more [20]. Evidence from Japan indicates that elevated social participation is associated with elevated functional capacity of older adults [30], and a well-structured social network reduces older adults' mortality [31, 32]. By contrast, trust and norm of reciprocity are not associated with objective health [31]. Such evidence seems to indicate that structural social capital usually has larger positive effects on objective physical health than cognitive social capital. Certainly, cognitive social capital, including trust and norm of reciprocity, is also proved to be positively related to older adults' SRH [33] and mental health [34], but elevated social network is more likely to be associated with better mental health rather than SRH of older adults [35].

Studies on social capital and health of Chinese older adults are more limited. Based on the Chinese General Social Survey (CGSS) of 2005, Norstrand and Xu argued that bonding trust and bonding network were positively associated with older adults' physical and mental health in urban China, but rural older adults did not yield any health return from bonding trust and network. Norm of reciprocity was not related to any health outcome of older adults across China [10]. Based on China Health and Retirement Longitudinal Study (CHARLS), Xue and Liu found that participation in social activities significantly promoted the SRH of older adults [36]; using instrumental variable approach, Liu et al. also observed that elevated social participation was causally associated with better SRH and Activities of Daily Living (ADL) [37]; however, Shen et al. observed that only perceived help in the future was related to better SRH, and social network was not related to the SRH of older adults in China [38].

What we should notice is the sex disparity in the association between social capital and health. It is observed that trust is not related to female older adults' health. For example, Chemaitelly et al. argued that although social network, trust and norm of reciprocity were significantly associated with older adults' SRH, elevated trust in older females did not produce better SRH [13]. Furthermore, Aida et al. proposed that elevated social trust might increase the all-cause mortality and reduce the physical

health of older females [31]. In China, Xue and Liu proposed that participation in social activities had a stronger promoting effect on the SRH of older female adults [36]; Sun et al. also proposed that although social capital was associated with better physical and mental health of older adults in both sex, the positive association between social capital and mental health was larger in older females in rural China [14]. Accordingly, the sex disparity in the association between social capital and older adult's health has not reached an agreement yet.

In summary, it is evident that studies on the association between social capital and health in rural older adults in China are limited, and only one study has examined this association in left-behind older adults and observed a positive association between social capital and health [39]. However, multiple health outcomes should be examined in older adults when examining the health effect of social capital, and potential sex disparity in this association should also be examined. The left-behind older adults, a by-product of social transition, have unique life experiences that are quite different from other older adults [3]. Studies on the association between social capital and health of the left-behind older adults in rural China have important policy implications in improving the well-being of this vulnerable group. Hence, this study aimed to examine the association between social capital and health of the left-behind older adults in rural China.

2. Data and methods

2.1 Data source

The data used in this study were obtained from a field survey conducted in two counties, Yingcheng and Mian, in the summer of 2017 in China. Yingcheng County locates in the central area of Hubei Province, with the per capita GDP of 39019 CNY and 665.9 thousand populations in 2016. Mian County locates in the southwest corner of Shaanxi Province, with the per capita GDP of 26153 CNY and 426 thousand populations in 2014. These two areas were selected as the representative of central and western China, as Chinese internal migrants usually move from central and western China to eastern China.

In the present study, rural adults aged 60 or above with all children working in urban areas were defined as the left-behind older adults. Simple random sampling and cluster sampling methods were used in the present study [1]. Data were collected from the following rural areas: two towns in Yingcheng County and five towns in Mian County, and 21 villages randomly selected from these seven towns. 716 questionnaires were given out and collected. Finally, questionnaires with more than 20% questions not answered are not included in the analysis. That is, 25 questionnaires were excluded, and the data used in this study were obtained from 691 questionnaires, which accounted for 96.5% of questionnaires collected [2].

2.2 Participants and public involvement

Questionnaire consisted of research questions and health outcome indicators. All the participants were instructed based on the signed consent forms.

2.3 Variables

Three major components of social capital, social trust, social participation and social network were used as independent variables. Trust contained the degree of trust in family members, neighbors and friends; social participation included the participation in chess activities, collective fitness activities, gathering/chatting, organization activities and other activities; the number of friends and the frequency of online and offline contacts with friends were used to measure social network. All these social capital indicators were self-designed. Details can be seen in Table 1.

Table 1 Measures of trust, participation and network

[1] In the process of the field survey, we tried to use stratified sampling method. However, we found that we could not obtain the total composition of the left-behind older adults (such as age, sex) in rural China. Thus, we only use simple random sampling and cluster sampling methods in the survey. In this sense, although our study does not have a strong power to draw conclusions to a larger population, it is still a useful and significant try to examine social capital and health in this unique population.

[2] Questionnaires excluded in the analysis were those with many questions (more than 20%) not answered. Since the missing rate is 3.5% (less than 5%), we think it cannot yield a significant bias for our analysis

Social capital	Indicators	Scale	Reliability M
Trust (cognitive)	Trust towards family members	0-3	0.678
	Trust towards neighbors		
	Trust towards friends		
Participation (structural)	Engagement in chess activities	0-1	0.605
	Engagement in collective fitness activities		
	Engagement in social gatherings		
	Engagement in social organization		
	Engagement in other social activities		
Network (structural)	Number of close friends	count variable	0.592
	Number of weekly meetings with friends in 1 year		
	Contact with friends over the phone in 1 year		

Health outcomes were categorized under two headings: physical and psychological health. Physical health included two categories: Basic Activities of Daily Living (BADL) [40] and Instrumental Activities of Daily Living (IADL) [41]. BADL referred to the ability to eat, walk, visit friends, dress and bath independently. IADL referred to the capacity to cook, shop, clean and take a bus independently. The Life Satisfaction Index Scale was used to measure depression, a psychological health indicator [42, 43]. Details are displayed in Table 2.

Table 2 Measures of physical and psychological health

Health	Indicators	Scale	Reliability M
BADL	Ability to eat independently	0-2	0.813
	Ability to walk independently		
	Ability to visit friends independently		
	Ability to dress independently		
	Ability to bath independently		
IADL	Ability to cook independently	0-2	0.862
	Ability to shop independently		
	Ability to clean independently		
	Ability to take a bus independently		
Depression	Are you satisfied with your life?	0-1	0.834
	Do you continue to pursue hobbies?		
	Do you have a sense of life enrichment?		
	Do you feel upset?		
	Do you feel energetic?		
	Do you have a sense of insecurity?		
	Do you feel happy?		
	Do you have a sense of loneliness?		

Are you motivated to take a new adventure?
Do you feel happy to be alive?
Do you have a sense of unworthiness?
Do you feel hopeless?

Controlling variables of this study included sex, age, marital status, education, family income, living status and regions. For social capital variables, family member trust was treated as bonding trust whereas the sum of neighbor and friend trust was considered bridging trust. Data obtained from engagement in five categories of social participation (0=not participated, 1=participated) was added together to measure the level of social participation. Network size was determined by the number of friends. Frequency of interactions with friends, both online and offline, was used to measure network density. For health outcomes, five indicators listed in Table 2 were added to measure BADL (0=completely depend on others, 1=partly depend on others, 2=do not depend on others completely), four indicators listed in Table 2 were added (0=completely depend on others, 1=partly depend on others, 2=do not depend on others completely) to measure IADL. 13 depression indices (0=no depression, 1=depression) were added to measure the level of depression. More details are provided in Table 3.

Table 3 Description of variables used

Controlling variables	Encoding	N	Percentage (%)	Mean	SE	Scale
Sex	male=1	348	50.4			
	female=0	343	49.6			
Age				70.366	7.005	
Marital status	married=1	466	67.4			
	single/divorce/widow=0	225	32.6			
Education	illiteracy=1	378	56.0			
	primary school =2	193	27.9			
	junior high school =3	89	12.9			
	senior high school or more=4	22	3.2			
Family income	natural logarithmic transformation			8.728	0.876	
Living status	alone=1	184	26.6			
	not alone=0	507	73.4			

Region	Hubei=1	331	47.9			
	Shaanxi=0	360	52.1			
Independent variables						
Bonding trust	family trust			2.867	0.437	1-4
Bridging trust	friends and neighbors trust			4.537	1.207	2-8
Participation	number of activities engaged			1.055	0.681	0-5
Network size	number of friends			2.946	2.386	0-15
Network density	frequency of friends contract			4.227	3.028	0-14
Dependent variables						
BADL				9.855	0.683	0-10
IADL				7.573	1.231	0-8
Depression				4.799	3.452	0-13

Note: N means number, SE means standard deviation.

2.4 Methods

Cronbach's Mcoefficient was used to assess the internal consistency of specific social capital and health outcomes, and Cronbach's MO'1□□was used as the criterion to ensure the reliability [44]. OLS model was used to examine the association, in both sexes and by sex, between various social capital forms and different health outcomes of the left-behind older adults in rural China. SPSS21.0 was used to perform OLS models, and statistical significance was assumed if p<0.1. Model specification was as follows:

$$Health_i = \beta_0 + \sum_1^p (\beta_p * controlling\ variable_i) + \sum_1^k (\beta_k * social\ capital_i) + \varepsilon_i$$

Where $Health_i$ represented the health outcome of individual i; β_0 represented the intercept; β_p represented the estimated coefficient of variables controlled for, β_k represented the estimated coefficient of social capital variables, p represented the number of controlling variables, k represented the number of social capital variables and ε_i represented the residual error of the model.

3. Results

3.1 Correlation analysis between social capital and health

Results of Spearman rank correlation analysis are listed in Table 4. It is observed

that depression was negatively associated with all five forms of social capital, BADL was positively related to network size, and IADL had no association with all forms of social capital.

Table 4 Spearman rank correlation between social capital and health

	Bridging trust	Participation	Network size	Network density	BADL	IADL	Depression
Bonding trust	.274**	0.029	0.039	0.03	0.042	-0.015	-.176**
Bridging trust		.250**	.081*	.159**	0.022	-0.023	-.235**
Participation			.077*	.209**	0.029	0.012	-.200**
Network size				.598**	.092*	0.048	-.128**
Network density					0.052	-0.004	-.120**
BADL						.557**	-.144**
IADL							-.185**

Note: **p<0.01, *p<0.05, ^p<0.1

3.2 Social capital and BADL

Associations between social capital and the BADL of left-behind older adults in rural China are presented in Table 5. With certain demographic variables controlled for, in model 1 with all samples, bonding trust showed a positive association with BADL (Coef.=0.139, p<0.05). However, the positive association between bonding social capital and BADL was observed only in older females (Coef.=0.154, p<0.05). Further, no significant association was observed between other forms of social capital, including bridging trust, participation, network size, and network density, and the BADL of left-behind older adults in both sexes.

Table 5 Regression results of social capital and BADL

	Model 1 (all samples)		Model 2 (males)		Model 3 (females)	
	Coef.	SE	Coef.	SE	Coef.	SE
Intercept	9.855***	0.026	9.815***	0.051	9.889***	0.028
Sex (ref: female)	-0.070	0.059				
Age	-0.011**	0.004	-0.006	0.007	-0.014***	0.004
Married (ref: divorce/widow)	-0.076	0.096	0.019	0.198	-0.109	0.082
Education	-0.003	0.035	0.001	0.057	0.002	0.040
Family income (ln)	0.071*	0.034	0.115^	0.061	0.022	0.033

Living status (ref: not alone)	0.003	0.099	0.176	0.202	-0.094	0.086
Region (ref: Shaanxi)	-0.156**	0.060	-0.242*	0.106	-0.062	0.057
Bonding trust	0.139*	0.062	0.129	0.103	0.154*	0.063
Bridging trust	0.007	0.024	0.008	0.041	0.007	0.023
Participation	0.059	0.041	0.104	0.076	0.019	0.037
Network size	0.000	0.013	-0.004	0.021	0.008	0.014
Network density	0.004	0.010	0.009	0.017	-0.002	0.010
N	691		348		343	
R^2	0.044		0.042		0.083	

Note: ***p<0.001, **p<0.01, *p<0.05, ^p<0.1. Coef.: regression coefficients. SE: standard error.

3.3 Social capital and IADL

Associations between social capital and the IADL of left-behind older adults in rural China are presented in Table 6. With certain demographic variables controlled for, in model 4 with all samples, social participation was positively associated with IADL (Coef.=0.140, p<0.1), and no significant association was observed between other forms of social capital and the IADL of left-behind older adults. Significant sex disparity in the association between social capital and IADL was observed. In older males, only participation was associated with IADL (Coef.=0.234, p<0.05); by contrast, only bonding trust was associated with IADL in older females (Coef.=0.332, p<0.05).

Table 6 Regression results of social capital and IADL

	Model 4 (all samples)		Model 5 (males)		Model 6 (females)	
	Coef.	SE	Coef.	SE	Coef.	SE
Intercept	7.573***	0.046	7.550***	0.077	7.568***	0.072
Sex (ref: female)	-0.019	0.105				
Age	-0.034***	0.007	-0.028*	0.011	-0.040***	0.010
Married (ref: divorce/widow)	0.090	0.171	-0.003	0.298	0.188	0.207
Education	0.006	0.063	0.051	0.085	-0.037	0.101
Family income (ln)	0.120*	0.061	0.212*	0.092	0.019	0.083
Living status (ref: not alone)	0.218	0.177	0.257	0.304	0.199	0.218
Region (ref: Shaanxi)	-0.243*	0.107	-0.332*	0.160	-0.157	0.145
Bonding trust	0.158	0.110	0.025	0.155	0.332*	0.160
Bridging trust	-0.037	0.042	-0.037	0.062	-0.040	0.058
Participation	0.140^	0.073	0.234*	0.114	0.063	0.095
Network size	0.003	0.023	0.006	0.032	0.010	0.035

Network density	0.003	0.018	-0.003	0.026	0.006	0.026
N	691		348		343	
R^2	0.063		0.064		0.086	

Note: ***p<0.001, **p<0.01, *p<0.05, ^p<0.1. Coef.: regression coefficients. SE: standard error.

3.4 Social capital and depression

Associations between social capital and the depression of left-behind older adults in rural China are presented in Table 7. With certain demographic variables controlled for, in model 7 with all samples, bonding trust, bridging trust, social participation and network size were adversely associated with left-behind older adults' depression in rural China (Coef.=-1.236, p<0.001; Coef.=-0.325, p<0.01; Coef.=-0.641, p<0.01; Coef.=-0.135, p<0.05; respectively). Significant sex disparity in the association between social capital and depression was also observed. In older females, bonding trust, bridging trust, participation, network size were adversely associated with depression (Coef.=-1.680, p<0.001; Coef.=-0.467, p<0.01; Coef.=-0.781, p<0.01; Coef.=-0.242, p<0.05; respectively); by contrast, only bonding trust was adversely associated with depression in older males (Coef.=-0.932, p<0.05).

Table 7 Regression results of social capital and depression

	Model 7 (all samples)		Model 8 (males)		Model 9 (females)	
	Coef.	SE	Coef.	SE	Coef.	SE
Intercept	4.798***	0.122	4.458***	0.183	5.302***	0.211
Sex (ref: female)	-0.859**	0.278				
Age	-0.024	0.019	-0.028	0.026	-0.015	0.029
Married (ref: divorce/widow)	0.437	0.456	0.326	0.707	0.361	0.607
Education	-0.208	0.168	-0.298	0.203	-0.085	0.294
Family income (ln)	-0.608***	0.163	-1.020***	0.218	-0.190	0.242
Living status (ref: not alone)	0.701	0.471	0.678	0.721	0.740	0.637
Region (ref: Shaanxi)	0.416	0.285	0.200	0.379	0.713^	0.424
Bonding trust	-1.236***	0.293	-0.932*	0.367	-1.680***	0.468
Bridging trust	-0.325**	0.113	-0.172	0.148	-0.467**	0.170
Participation	-0.641**	0.193	-0.435	0.271	-0.781**	0.277
Network size	-0.135*	0.062	-0.063	0.076	-0.242*	0.104
Network density	-0.012	0.048	0.029	0.062	-0.059	0.077
N	691		348		343	
R^2	0.158		0.153		0.179	

Note: ***p<0.001, **p<0.01, *p<0.05, ^p<0.1. Coef.: regression coefficients. SE: standard error.

4. Discussion

With the recent rapid urbanization in China, the number of left-behind older adults in rural China is on the rise. Hence the reason, studies on the association between social capital and health in left-behind older adults have substantial and theoretical significance. Based on the survey conducted in two provinces in China, this study, for the first time, comprehensively discussed the association between multiple forms of social capital and physical/psychological health outcomes of the left-behind older adults, in both sexes and by sex, in rural China. Results are summarized in Table 8.

Table 8 Summarized results of social capital and health

		BADL	IADL	Depression
All samples	Bonding trust	+	ns	−
	Bridging trust	ns	ns	−
	Participation	ns	+	−
	Network size	ns	ns	−
	Network density	ns	ns	ns
Males	Bonding trust	ns	ns	−
	Bridging trust	ns	ns	ns
	Participation	ns	+	ns
	Network size	ns	ns	ns
	Network density	ns	ns	ns
Females	Bonding trust	+	+	−
	Bridging trust	ns	ns	−
	Participation	ns	ns	−
	Network size	ns	ns	−
	Network density	ns	ns	ns

Note: + means positive association, − means negative association, ns means nonsignificant.

For physical health, results show that bonding trust was positively related to left-behind older adults' BADL but not associated with their IADL. BADL reflects individuals' basic survival ability, including eating, clothing and walking, and a low level of BADL usually means an extremely poor health status. By contrast, a low

level of IADL reflects a health status that is not such serious, because IADL can be improved by materialistic factors, for example, a more convenient traffic or cooking tools can help individuals go out or cook more easily and independently [45]. Individuals with a low level of BADL can only live a normal life based on the condition that they receive family support, so trust in family members is of vital importance for this unique group. The comparative analysis for sex shows that bonding trust was positively related to female older adults' physical health (both BADL and IADL), but it was not associated with male older adults' physical health. This is mainly determined by the fact that females usually rely more on and benefit more from family support when they have a poor physical health, which is in line with other studies from China [14, 36].

The daily activities of rural left-behind older adults are mainly family-oriented, so bridging trust has little impact on their physical health. In addition, social participation was found to be positively associated with IADL. Social participation increases physical activities and keeps the left-behind older adults healthy, but it may also suggest that older adults with poor physical health are less likely to engage in social activities [46], which reflects a bidirectional causal association. Further, the positive association between participation and IADL was statistically significant in male older adults only, because social participation is usually a major activity of males in China. That is to say, in China, males are in charge of outdoor affairs, and females are usually in charge of indoor affairs [47]. Hence male older adults will obtain more health returns from social participation.

Elevated social capital is strongly associated with better psychological health of the left-behind older adults in rural China. Social trust reflects confidence and positive psychological expectation from others [23]. Hence social trust helps reduce depression and improve left-behind older adults' perceived psychological health. Participation in various social activities provides the left-behind older adults a platform to communicate with others and reduce the possibility of depression. Living alone can bring about a higher risk of depression [48], which further supports the results above. However, in the comparison between males and females, it is observed that social

capital is more beneficial to the psychological health of older females, which is in line with Sun et al.' results [14]. Compared with males, females are more likely to seek support, especially emotional support, from others when they are in trouble [14, 49], so they benefit more from this tendency and get more psychological health returns from interactions with and support from others.

It is important to note that social network was observed not to be related to the health of left-behind older adults in rural China. Having more friends did help reduce depression but was not associated with left-behind older adults' physical health, including BADL and IADL. The frequency of daily contacts with friends had no association with any health outcome. These results are not in line with related evidence from Japan and Northern Europe [20, 31, 32], but are in close agreement with some evidence from China [10]. In rural China, social contact is limited to neighbors or friends from surrounding villages only. Such social interactions have limited impacts on the physical or psychological health of left-behind older adults. That is to say, only social interactions that involve exchange of thoughts and social resources [18] can promote the health of left-behind older adults in rural China.

Structural and cognitive components of social capital are both related to physical and psychological health of the left-behind older adults in China. The positive association between social capital and physical health is much smaller than with psychological health, which may be related to the inadequacy of material resources. Previous evidence has shown that material resources are important for physical health, and the lack of material resources in rural China may dampen the positive association between social capital and physical health [10, 50, 51]. It is proposed that structural social capital is positively associated with the physical health of older adults stronger than cognitive social capital [30-32]. This argument, however, does not apply to the left-behind older adults in rural China. Social participation, a kind of structural social capital, only has a mild protective effect on left-behind older adults' health; by contrast, bonding trust or family trust, a kind of cognitive social capital, has a strong protective effect on left-behind older adults' health.

Based on the above results, several interventions to promote left-behind older

adults' health in rural China are proposed. First, the primary-level organizations should stress the daily collective activities for the left-behind older adults, especially female older adults, encouraging them to engage in social activities, which allows them to increase social interactions and benefits their health. Second, we encourage the children of those left-behind older adults to take good care of their parents, as they need to resolve difficulties through both material rewards and spiritual rewards. Third, village committees should be accountable in developing a healthy neighborhood relationship. This will improve the level of trust among neighbors or friends and, in turn, have a positive impact on left-behind older adults' psychological health. Finally, it is vital to provide sufficient material resources for the left-behind older adults in rural areas so as to promote better well-being and health.

There are several limitations in this study. First, simple random sampling and cluster sampling methods are used in the survey, so this study does not have a strong power to draw conclusions to a larger population. Second, the current results for the association between social capital and health indicate a reverse causal association, so further research using causal inference approaches is needed. Finally, since the population evaluated was from different villages, it is likely that the characteristics of those villages may have some contextual effect on the association between social capital and health [33]. However, this contextual effect is found to be nonsignificant in this study. Thus, macro-level effect of village or community where these older adults lived is not covered in this study. Therefore, more longitudinal and intervention studies is needed in future works.

5. Conclusions

This study, for the first time, comprehensively discussed the association between social capital and physical/psychological health of the left-behind older adults, as well the sex disparity in this association, in rural China. Results show that bonding trust was positively associated with BADL and negatively associated with depression; bridging trust was negatively associated with depression; participation was positively associated with IADL and negatively associated with depression; network size was

negatively associated with depression only, but network density had no association with all three health outcomes. For sex disparity, bonding trust was negatively associated with depression in both sexes, but only positively related to BADL and IADL in female older adults. Bridging trust, participation and network size were negatively associated with depression in female older adults only, and participation was only positively related to male older adults' IADL. Since social capital plays a significant role in improving left-behind older adults' health, more attention should be paid to increase the stock of social capital in this unique group, and sex disparity should be focused especially.

Abbreviations

ADL: Activities of Daily Living

BADL: Basic Activities of Daily Living

CGSS: Chinese General Social Survey

CHARLS: China Health and Retirement Longitudinal Study

Coef.: regression coefficients

IADL: Instrumental Activities of Daily Living

ns: nonsignificant

OLS: ordinary least square

SD: standard deviation

SE: standard error

SRH: self-rated health

Author statements

Contributorship statement

Jiang & Ke designed the study; Jiang & Chen wrote the manuscript; Chen & Ke collected the data; Jiang, Chen & Ke all revised and reviewed the manuscript.

Data sharing statement

No additional data are available.

Ethical approval

We declare that this study is complied with ethical standards. Wuhan University of Science and Technology grants ethical approval for this study.

Funding

This study is supported by the national social science fund: Researches on the quality of life of rural left-behind older adults in the setting of aging (No. 16BRK014).

Acknowledgement

We thank all the participants in the survey. Especially, we appreciate the valuable effort made by Qihong Wang from Bank of America.

Competing interests

The authors declare that they have no competing interests.

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BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-030804.R1
Article Type:	Original research
Date Submitted by the Author:	18-Jul-2019
Complete List of Authors:	Jiang, Junfeng; Wuhan University, School of Health Sciences Yu, Chen; Wuhan University of Science and Technology Ke, Yan; Wuhan University of Science and Technology, School of Literature, Law and Economics
Primary Subject Heading:	Public health
Secondary Subject Heading:	Health services research, Public health
Keywords:	social capital, health, left-behind older adults, sex disparity, rural China

Social capital and health of left-behind older adults in rural China: a cross-sectional study

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Word count: 5600

Abstract

***Objectives*:** To examine the association between social capital and health of male and female left-behind older adults in rural China.

***Study design*:** This is a cross-sectional study, and a cross-sectional survey on left-behind older adults aged 60 and older and with all children working outside from Hubei, Shaanxi and Guangdong Province, China was conducted during 2017-2018. A total of 1106 questionnaires were and collected (participation rate=100.0%) and 1016 samples were used (effective rate=91.9%).

***Methods*:** Ordinary least squares (OLS) model was used to evaluate the association between social capital and health. Social capital included family trust, friend/neighbor trust, stranger trust, social participation, network size and density. Health outcome included basic and instrumental activities of daily living (BADL & IADL) and depression.

***Results*:** Family trust was positively associated with IADL (Coef.=0.602, $p<0.1$) and negatively associated with depression (Coef.=-3.154, $p<0.001$), friend/neighbor trust, stranger trust and network size were negatively associated with depression (Coef.=-0.409, $p<0.001$; Coef.=-0.438, $p<0.001$; Coef.=-0.095, $p<0.05$; respectively), participation was positively associated with BADL (Coef.=0.074, $p<0.1$) and negatively associated with depression (Coef.=-0.441, $p<0.01$), and network density was positively associated with BADL (Coef.=0.019, $p<0.1$). Family trust (Coef._males=-2.792, $p<0.001$; Coef._females=-3.767, $p<0.001$), friend/neighbor trust (Coef._males=-0.249, $p<0.05$; Coef._females=-0.565, $p<0.001$), stranger trust (Coef._males=-0.471, $p<0.01$; Coef._females=-0.406, $p<0.05$) and participation (Coef._males=-0.356, $p<0.1$; Coef._females=-0.535, $p<0.01$) was negatively associated with depression in both sexes. Family trust was positively related to male IADL in (Coef.=0.767, $p<0.1$), participation was positively associated with male BADL (Coef.=0.096, $p<0.1$) and IADL (Coef.=0.193, $p<0.05$), network density was positively associated with female BADL (Coef.=0.033, $p<0.05$) and IADL (Coef.=0.052, $p<0.1$), network size was negatively related to female depression (Coef.=-0.138, $p<0.05$).

***Conclusions*:** Social capital is closely related to left-behind older adults' health in rural China. More attention should be paid to increasing the stock of social capital in this special population, and sex disparity should be focused on especially.

Keywords: social capital; health; left-behind older adults; sex disparity; rural China

Strengths and Limitations:

1. This study, for the first time, evaluated the association between social capital and health by sex in left-behind older adults in rural China.
2. Social capital was more strongly related to depression than to BADL and IADL in left-behind older adults in rural China.
3. A significant sex disparity in the association between social capital and health was observed.
4. The causal association between social capital and health, as well as the relationship between contextual social capital and health, was not examined.

1. Introduction

China has witnessed dramatic economic and social changes, as well as a rapid rise in the number of aging population, over the past several decades. By the end of 2016, people aged 60 and older accounted for 16.7% of the total population in China [1]. The rapid development of urbanization has attracted tens of millions of rural labors to work in cities, which results in the increase of the number of left-behind older adults in rural China. Left-behind older adults usually refer to older adults aged 60 and older, living in rural areas and with all their children working in other areas (usually cities) and not living with them [2]. Currently there are more than 40 million left-behind older adults in rural China and this number may increase in the foreseeable future [3].

Since the 1990s, the association between social capital, which comes from social connections in our daily life [4], and health has been widely discussed [5, 6], and it has been observed to be positive in numerous studies [7-9]. However, limited studies examine this association in older adults, especially in left-behind older adults in rural

China [10, 11]. The poor health status of left-behind older adults has been reported and received much attention [2, 3, 12]. With children working in cities most of the time and living far away, left-behind older adults cannot obtain enough support from their children, which results in the loss of social connections and economic and mental instability [3]. Some evidence indicates that both the physical and mental health of left-behind older adults are poorer than other older adults [2, 3, 13]. On the other hand, the sex disparity in health is widely discussed. It is recognized that males usually have a lower level of life expectancy but better perceived health than females [14], and the sex disparity in the association between social capital and health is also observed in other previous studies [15, 16]. However, no sex disparity in this association has been examined in left-behind older adults.

Therefore, this study aimed to answer two questions. First, was there an empirical association between social capital and left-behind older adults' health in rural China? Second, was there a sex disparity in the association between social capital and left-behind older adults' health in rural China?

1.1. Definition and measures of social capital

Numerous views on the definition of social capital have been proposed, where Putnam's communitarianism is considered the most influential one in the area of public health [5]. Putnam considered social capital as a kind of social structure and emphasized the collective attribute of it as well as its power on individual actors from the perspective of cohesion [17, 18]. Accordingly, trust, social network and participation are the most widely used measures of social capital in the area of public health [5, 19]. Trust is a sense of confidence or expectation generated from the belief that others will behave decently and predictably [20, 21], which is the most widely used measure of social capital in public health. Social network refers to social contacts between individuals, which is a stable system formed through social interactions. Social participation refers to the engagement in formal or informal associations or activities [18, 22]. It is recognized that social capital consists of cognitive and structural components, and trust belongs to the former whereas social network and participation

belong to the latter [5, 17, 23]. Further, the framework, in which social capital can be divided into bonding and bridging forms, has also been widely used in the area of public health [5]. Bonding social capital means a kind of in-ward social connection among individuals within homogeneous groups, while bridging social capital refers to an extroverted social connection between members from heterogeneous groups [17, 18, 24]. Accordingly, trust, social network and participation were used as measures of social capital in this study.

1.2. Social capital and health in older adults

Limited studies are available on the association between social capital and health in older adults. Pollack and Knesebeck examined the association between social capital and older adults' health in the US and German and reported that a low level of reciprocity, trust and social participation was related to poor self-rated health (SRH) and elevated depression [10] but not associated with physical function. Most studies conducted in Europe and Asia also observe an association between social capital and health in older adults. For example, evidence from Northern Europe shows that structural social capital, including social contacts with neighbors/friends, was related to older adults' decreased depression, because contacts with others provide access to resources and support and generate mutual benefits [25]. For cognitive social capital, trust to friends [25] is observed to be positively related to older adults' psychological health, while general trust [26] and trust to neighbors [25] are not related to their psychological health. Evidence from Japan indicates that elevated social participation is associated with elevated functional capacity of older adults [27], and a well-structured social network is negatively related to older adults' mortality [28, 29]. By contrast, trust and norm of reciprocity are not associated with mortality [28]. Further, cognitive social capital, including trust and norm of reciprocity, is also observed to be positively related to older adults' SRH [30] and mental health [31], but elevated social network is more likely to be associated with better mental health rather than SRH of older adults [32].

Studies on social capital and older adults' health in China are also limited. Based

on the Chinese General Social Survey (CGSS), Norstrand and Xu argued that bonding trust and bonding network were positively associated with older adults' physical and mental health in urban China, but rural older adults did not yield health returns from bonding trust and network. Norm of reciprocity was not related to the health of older adults across China [11]. Based on China Health and Retirement Longitudinal Study (CHARLS), Xue and Liu found that participation in social activities significantly promoted the SRH of older adults [33]; using instrumental variable approach, Liu et al. also observed that elevated social participation was causally associated with better SRH and physical health [34]; however, Shen et al. observed that only perceived help in the future was related to better SRH, and social network was not related to the SRH of older adults in China [35].

What we should notice is the sex disparity in the association between social capital and health of the elderly. It is observed that trust is not related to female older adults' health. For example, Chemaitelly et al. argued that although social network, trust and norm of reciprocity were positively associated with older adults' SRH, elevated trust in older females was not related to better SRH [15]. Further, Aida et al. proposed that elevated social trust might reduce the physical health of older females [28]. In China, Xue and Liu proposed that participation in social activities had a stronger promoting effect on the SRH of older female adults [33]; Sun et al. also proposed that although social capital was associated with better physical and mental health of older adults in both sexes, the positive association between social capital and mental health was stronger in older females in rural China [16]. Accordingly, the sex disparity in the association between social capital and older adult's health has not reached an agreement yet and needs further discussion.

In summary, it is evident that studies on the association between social capital and health in rural older adults in China are limited, and only one study has examined this association in left-behind older adults [36]. However, multiple health outcomes should be examined in older adults when discussing this issue, and potential sex disparity in this association should also be examined. Left-behind older adults have unique life experiences that are quite different from other older adults [3]. Studies on

the association between social capital and health of left-behind older adults in rural China have important policy implications in improving the well-being of this vulnerable group. Hence, this study aimed to examine the association between social capital and health of left-behind older adults in rural China.

2. Data and methods

2.1 Data source

The data used in this study were obtained from a field cross-sectional survey conducted in five counties or cities, including Yingcheng County and Mian County in July, 2017, as well as Lechang City, Jieyang City, Suixi County in August, 2018, in China. Yingcheng County is located in the central area of Hubei Province, with the per capita GDP of 39,019 Chinese Yuan (CNY) and a population of 666,000 in 2016. Mian County is located in the southwest corner of Shaanxi Province, with the per capita GDP of 26,153 CNY and a population of 426,000 in 2014. Lechang City is located in the north area of Guangdong Province, with the per capita GDP of 19,952 CNY and a population of 521,000 in 2017. Jieyang City is located in the east area of Guangdong Province, with the per capita GDP of 35,327 CNY and a population of 6086,000 in 2017. Suixi County is located in the southwest corner of Guangdong Province, with the per capita GDP of 23,761 CNY and a population of 1039,000 in 2017. Considering the regional difference in socioeconomic development, the above three provinces were randomly selected as the representative of eastern, central and western China, as Chinese internal migrants usually move from central and western China to eastern China across provinces, and move from villages and small cities to provincial capitals within specific province[1].

In the present study, rural adults aged 60 or above with all children working in urban areas were defined as left-behind older adults. Simple random sampling,

[1] According to the data of *China Statistical Yearbook 2018*, the proportion of older adults is 7.8%, 12.2% and 11.1% in Guangdong, Hubei and Shaanxi, respectively in 2017. The aging level in Guangdong is lower than its respective region due to the influx of workers to Pearl River Delta Region, and the aging level in Hubei and Shaanxi is higher than their respective region. There are also numerous rural labors working out in all five counties/cities, suggesting that these areas are nationally representative more or less.

convenience sampling and cluster sampling methods were used in the present study[2]. With the assistance of local officials, a door-to-door investigation was conducted, and trained interviewers knocked on doors or gathered left-behind older adults in village committees for face-to-face interviews. A total of 1106 questionnaires were given out and collected, and no respondent refused to be interviewed. Finally, questionnaires with more than 20% questions unanswered were not included in the analysis (mainly due to physical reasons such as hearing and cognitive impairment). That is, a total of 90 questionnaires were excluded, and the data used in this study were obtained from 1016 questionnaires, which accounted for 91.9% of questionnaires collected[3].

2.2 Participants and public involvement

Questionnaire consisted of research questions and health outcome indicators. All the participants were instructed based on the signed consent forms.

2.3 Variables

2.3.1 Social capital

Three components of social capital, trust (cognitive), social participation (structural) and social network (structural) were used[4]. Trust consisted of trust in

[2] In the process of the field survey, we tried to use stratified sampling method. However, we found that we could not obtain the total composition of left-behind older adults (such as age, sex) in rural China. Thus, we only use random sampling, convenience sampling and cluster sampling methods in the survey. Random number table is used to randomly select three provinces from three different regions. As the level of homogeneity across different towns and villages within a county/city is high, it is considered that using convenience sampling method is acceptable in ensuring the representativeness and makes the survey more feasible. Further, a reliable list is provided by local officials to reduce selection bias when using cluster sampling in villages.

[3] Questionnaires excluded in the analysis were those with many questions (more than 20%) not answered. Since the missing rate is 8.1% (less than 10%), we do not think it yields a significant bias for our analysis. Further, the formula: $N = \frac{Z^2_{1-\alpha/2} * p(1-p)}{d^2}$ was used calculate sample size. α=0.05 was widely used; Z denoted the standard normal distribution; d denoted tolerance for deviation, and we set it as 0.05; p denoted expected rate of bad health. When p=0.5, N_{max} = (1.96*0.5*0.5)/(0.05*0.05)=384. Thus, at least 384 samples were needed. Since the sample size we use was 1016, it was considered to be proper and acceptable.

[4] The reliability (α coefficient) was not reported. First, three aspects of social capital (trust, participation and network) were not used as three but six independent variables in this study, six variables reflected different small

family members, neighbors, friends and strangers, and response options included the following: "0=very distrust, 1=relatively distrust, 2=relatively trust, 3=very trust". Trust in family members was treated as family trust (bonding) with "very distrust and relatively distrust" recoded as "distrust" and "relative trust and trust" recoded as "trust", trust in neighbors and friends was added and used as friend/neighbor trust (bonding), and trust in strangers was used as stranger trust (bridging). It is highlighted that, according to the *Chaxu* pattern, the interpersonal pattern of Chinese residents is similar to the ripple that opens wide on water surface [37]. Thus, although family trust and friend/neighbor trust were bonding social capital according to Putnam's definition [17], they were considered as two different social capital variables in this study, as family members are blood ties, while friends and neighbors are not blood ties. Social participation included participation in chess activities, collective fitness activities, gathering/chatting, organization activities and other activities (0=not participated, 1=participated), and they were added to measure the level of social participation. Social network consisted of network size and density. Network size was determined by the number of close friends (ranged 0~30), and weekly frequency of interactions with friends (ranged 0~7), both online and offline, within one year were added to measure network density.

2.3.2 Health outcomes

Health outcomes consisted of physical and psychological health. Physical health included BADL [38] and IADL [39]. BADL referred to the ability to eat, walk, visit friends, dress and bath, and response options of each item included the following: "0=completely depend on others, 1=partly depend on others, 2=do not depend on others completely". Five items were added to measure BADL. IADL referred to the capacity to cook, shop, clean and take a bus, and response options of each item included the following: "0=completely depend on others, 1=partly depend on others,

aspects of social capital, so the reliability α coefficient was unnecessary to be reported. Second, participation and network were defined in a formative not reflective way, for they were important ways to invest social capital. Thus, there was no need for the reliability α coefficient.

2=do not depend on others completely". Four items were added to measure IADL. The Life Satisfaction Index Scale was used to measure depression, a psychological health indicator [40, 41], and response options of each item included the following: "0=not depressed, 1=depressed". Subsequently, a total of 12 indices were added to measure depression. Details are displayed in Table 1.

Table 1 Measures of health of left-behind older adults in rural China in 2017

Health	Indicators	Range	Reliability α
BADL	Ability to eat independently	0-2	0.879
	Ability to walk independently	0-2	
	Ability to visit friends independently	0-2	
	Ability to dress independently	0-2	
	Ability to bath independently	0-2	
IADL	Ability to cook independently	0-2	0.873
	Ability to shop independently	0-2	
	Ability to clean independently	0-2	
	Ability to take a bus independently	0-2	
Depression	Are you satisfied with your life?	0-1	0.839
	Do you continue to pursue hobbies?	0-1	
	Do you have a sense of life enrichment?	0-1	
	Do you feel upset?	0-1	
	Do you feel good in spirits?	0-1	
	Do you have a sense of insecurity?	0-1	
	Do you feel happy?	0-1	
	Do you have a sense of loneliness?	0-1	
	Do you feel good to be alive?	0-1	
	Do you have a sense of unworthiness?	0-1	
	Do you feel energetic?	0-1	
	Do you feel hopeless?	0-1	

2.3.3 Control variables

Control variables included sex, age, marital status, education, family income (a natural logarithmic transformation was performed), living status (whether living with other people) and province. More details are provided in Table 2.

2.4 Methods

Cronbach's α coefficient was used to assess the internal consistency of specific

social capital and health outcomes, and Cronbach's α>0.60 was used as the criterion to ensure the reliability [42]. Spearman rank correlation was used to examine the simple correlation between social capital and health. Although all three health outcomes were ordinary variables, the parallel-lines assumption was not supported in ordinal regression. Therefore, OLS model was used to examine the association, in both sexes and by sex, between various social capital forms and different health outcomes of left-behind older adults in rural China. This strategy that treats ordinary outcome as continuous outcome is supported and widely used in many other studies, especially when the ordinary outcome has more than three points/options [9, 34]. According to previous studies, there might be sex difference in the association between social capital and health in older adults [16, 28, 33]. Thus, stratification by sex was used, and males and females were analyzed separately to compare the sex disparity in the association between social capital and health in left-behind older adults. Model specification of OLS was as follows:

$$Health_i = \beta_0 + \sum_1^p (\beta_p * control\ variable_i) + \sum_1^k (\beta_k * social\ capital_i) + \varepsilon_i$$

Where $Health_i$ represented the health outcome of individual *i*; β_0 represented the intercept; β_p represented the estimated coefficient of variables controlled for (*p*=1~8 in full samples and 1~7 in male or female samples), β_k represented the estimated coefficient of social capital variables (*k*=1~6), and ε_i represented the residual error of the model.

SPSS21.0 was used to perform OLS models, and statistical significance was assumed if *p*<0.1. In many studies in the area of public health, actually, *p*=0.1 is commonly used as the significance level, because when *p*-value is between 0.05 and 0.1, it is considered marginal significant statistically and usually provides some non-negligible information [43, 44]. Also, some results with a *p*-value ranged 0.05~0.1 are also epidemiologically significant. Thus, *p*=0.1 was used as the significance level.

3. Results

3.1 Descriptive and correlation analysis

Table 2 describes the sample for all 1016 cases, consisted of 484 males and 532 females. Compared to men, women seemed to have a higher level of depression and lower levels of BADL and IADL, but also had higher levels of trust and network density. Further, females in the sample seemed to be older, less educated, have lower family income, less likely to be married, and less likely to live with others, compared to males.

Table 2 Descriptive statistics of variables used (N=1016)

Control variables	Coding	Males (N=484)				Females (N=532)				Range
		N	%	Mean	SD	N	%	Mean	SD	
Age				71.36	7.29			71.57	7.91	60-95
Marital status	married	383	79.1			304	57.1			
	divorce/widow	101	20.9			228	42.9			
Education	illiteracy	165	34.1			369	69.4			
	primary school	199	41.1			130	24.4			
	junior high school	94	19.4			19	3.6			
	≥senior high school	26	5.4			14	2.6			
Family income				8.99	0.92			8.96	1.06	
Living status	alone	87	18.0			161	30.3			
	not alone	397	82.0			371	69.7			
Region	Shaanxi	206	42.6			154	29.0			
	Hubei	142	29.3			189	35.5			
	Guangdong	136	28.1			189	35.5			
Independent variables										
Family trust	trust	474	97.9			524	98.5			0-1
	not trust	10	2.1			8	1.5			
Friend/neighbor trust				4.31	1.11			4.44	1.09	0-6
Stranger trust				0.90	0.78			0.91	0.76	0-3
Participation				0.93	0.68			0.94	0.73	0-5
Network size				2.89	2.84			2.87	2.56	0-30
Network density				3.76	3.04			4.16	3.06	0-14
Dependent variables										
BADL				9.85	0.75			9.80	0.96	0-10
IADL				7.48	1.41			7.24	1.67	0-8
Depression				3.27	2.99			3.90	3.38	0-12

Note: N means number, SD means standard deviation.

Results of Spearman rank correlation analysis are listed in Table 3. Without any variable controlled for, it is observed that depression was negatively associated with all five forms of social capital (all *p*s<0.01), BADL was positively related to network size and network density (both *p*s<0.01), and IADL had no association with all forms of social capital.

Table 3 Spearman rank correlation between social capital and health of left-behind older adults in rural China in 2017

	Friend/neighbor trust	Stranger trust	Participation	Network size	Network density	BADL	IADL	Depression
Family trust	0.111**	0.044	0.040	0.061*	0.026	0.053	0.007	-0.151**
Friend/neighbor trust		0.196**	0.216**	0.084**	0.172**	0.030	0.059	-0.143**
Stranger trust			0.089**	0.030	0.058	-0.011	0.030	-0.142**
Participation				0.126*	0.211**	0.061	0.017	-0.092**
Network size					0.642**	0.092**	0.065	-0.090**
Network density						0.083**	0.043	-0.084**
BADL							0.500**	-0.146**
IADL								-0.144**

Note: **p<0.01, *p<0.05

3.2 Social capital and BADL

Associations between social capital and the BADL of left-behind older adults in rural China are presented in Table 4. With other variables controlled for, social participation and network density were positively associated with BADL (Coef.=0.074, p<0.1; Coef.=0.019, p<0.1; respectively). However, the positive association between social participation and BADL was observed in males only (Coef.=0.096, p<0.1), and the positive association between network density and BADL was observed in females only (Coef.=0.033, p<0.05). Further, no significant association was observed between other forms of social capital, including family trust, friend/neighbor trust, stranger trust and network size, and the BADL of left-behind older adults in all three models.

Table 4 Social capital and BADL of left-behind older adults in rural China in 2017

	Model 1 (all samples)			Model 2 (males)			Model 3 (females)		
	Coef.	SE	Beta	Coef.	SE	Beta	Coef.	SE	Beta
Intercept	9.847***	0.446		9.160***	0.582		10.344***	0.677	
Sex (ref: female)	0.053	0.060	0.030						
Age	-0.014***	0.004	-0.120	-0.005	0.005	-0.047	-0.021**	0.006	-0.170
Married (ref: divorce/widow)	-0.033	0.093	-0.018	-0.001	0.141	-0.001	-0.079	0.126	-0.040
Education	-0.016	0.036	-0.016	0.007	0.041	0.008	-0.009	0.063	-0.006
Family income (ln)	0.061^	0.032	0.070	0.067	0.044	0.083	0.062	0.046	0.067
Living status (ref: not alone)	-0.016	0.097	-0.008	0.072	0.147	0.037	-0.056	0.133	-0.027
Province (ref: Shaanxi)									
Hubei	-0.155*	0.073	-0.084	-0.206*	0.092	-0.126	-0.147	0.114	-0.073
Guangdong	-0.130^	0.079	-0.070	0.019	0.099	0.011	-0.272*	0.122	-0.135
Family trust (ref: not trust)	0.300	0.207	0.046	0.315	0.244	0.060	0.305	0.342	0.039
Friend/neighbor trust	0.018	0.027	0.023	0.013	0.033	0.019	0.033	0.042	0.037
Stranger trust	0.008	0.036	0.007	-0.007	0.046	-0.007	0.005	0.056	0.004
Participation	0.074^	0.042	0.060	0.096^	0.053	0.087	0.031	0.063	0.023
Network size	-0.002	0.014	-0.004	-0.001	0.017	-0.003	-0.003	0.022	-0.007
Network density	0.019^	0.011	0.067	0.003	0.014	0.014	0.033*	0.017	0.106
N	1016			484			532		
R^2	0.040			0.033			0.070		

Note: ***p<0.001, **p<0.01, *p<0.05, ^p<0.1. Coef.: coefficient. SE: standard error. Beta: standardized coefficient.

3.3 Social capital and IADL

Associations between social capital and the IADL of left-behind older adults in rural China are presented in Table 5. With other variables controlled for, family trust was positively associated with IADL (Coef.=0.602, p<0.1), and no significant association was observed between other forms of social capital and IADL. A significant sex disparity in the association between social capital and IADL was observed. For older males, only family trust and social participation were positively associated with IADL (Coef.=0.767, p<0.1; Coef.=0.193, p<0.05; respectively). By contrast, network density was positively associated with IADL in older females only (Coef.=0.052, p<0.1).

Table 5 Social capital and IADL of left-behind older adults in rural China in 2017

	Model 1 (all samples)			Model 2 (males)			Model 3 (females)		
	Coef.	SE	Beta	Coef.	SE	Beta	Coef.	SE	Beta

Intercept	9.965***	0.761		9.970***	1.061		10.079***	1.107	
Sex (ref: female)	0.171^	0.102	0.055						
Age	-0.056***	0.007	-0.273	-0.049***	0.009	-0.252	-0.061***	0.010	-0.288
Married (ref: divorce/widow)	0.015	0.158	0.005	-0.187	0.257	-0.054	0.091	0.206	0.027
Education	0.054	0.061	0.029	0.136^	0.074	0.083	0.009	0.103	0.004
Family income (ln)	0.070	0.055	0.045	0.017	0.081	0.011	0.115	0.074	0.073
Living status (ref: not alone)	0.140	0.166	0.038	0.008	0.267	0.002	0.192	0.217	0.053
Province (ref: Shaanxi)									
Hubei	-0.191	0.125	-0.057	-0.192	0.167	-0.062	-0.237	0.186	-0.068
Guangdong	-0.591***	0.134	-0.177	-0.256	0.180	-0.082	-0.916***	0.200	-0.262
Family trust	0.602^	0.354	0.051	0.767^	0.445	0.077	0.477	0.560	0.035
Friend/neighbor trust	-0.009	0.046	-0.006	-0.047	0.061	-0.037	0.036	0.068	0.024
Stranger trust	0.056	0.062	0.028	0.114	0.084	0.063	-0.029	0.092	-0.013
Participation	0.071	0.071	0.032	0.193*	0.097	0.093	-0.066	0.103	-0.029
Network size	-0.001	0.023	-0.002	-0.006	0.030	-0.011	0.004	0.036	0.005
Network density	0.030	0.019	0.058	0.008	0.025	0.017	0.052^	0.028	0.095
N	1016			484			532		
R^2	0.134			0.106			0.172		

Note: ***p<0.001, **p<0.01, *p<0.05, ^p<0.1. Coef.: coefficient. SE: standard error. Beta: standardized coefficient.

3.4 Social capital and depression

Associations between social capital and the depression of left-behind older adults in rural China are presented in Table 6. With other variables controlled for, family trust, friend/neighbor trust, stranger trust, social participation and network size were adversely associated with depression (Coef.=-3.154, p<0.001; Coef.=-0.409, p<0.001; Coef.=-0.438, p<0.001; Coef.=-0.441, p<0.01; Coef.=-0.095, p<0.05; respectively). A significant sex disparity in the association between social capital and depression was also observed. For older males, family trust, friend/neighbor trust, stranger trust and social participation were adversely associated with depression (Coef.=-2.792, p<0.001; Coef.=-0.249, p<0.05; Coef.=-0.471, p<0.01; Coef.=-0.356, p<0.1; respectively). By contrast, for older females, family trust, friend/neighbor trust, stranger trust, social participation and network size were adversely associated with depression (Coef.=-3.767, p<0.001; Coef.=-0.565, p<0.001; Coef.=-0.406, p<0.05; Coef.=-0.535, p<0.01; Coef.=-0.138, p<0.05; respectively).

Table 6 Social capital and depression of left-behind older adults in rural China in 2017

	Model 1 (all samples)			Model 2 (males)			Model 3 (females)		
	Coef.	SE	Beta	Coef.	SE	Beta	Coef.	SE	Beta
Intercept	14.867***	1.519		14.440***	2.158		14.963***	2.197	
Sex (ref: female)	-0.625**	0.204	-0.097						
Age	0.005	0.013	0.011	0.002	0.018	0.006	0.010	0.020	0.022
Married (ref: divorce/widow)	-0.356	0.316	-0.052	-0.363	0.522	-0.050	-0.364	0.408	-0.053
Education	-0.148	0.122	-0.038	-0.201	0.151	-0.058	-0.039	0.204	-0.008
Family income (ln)	-0.498***	0.109	-0.154	-0.634***	0.165	-0.195	-0.398**	0.148	-0.124
Living status (ref: not alone)	-0.197	0.331	-0.026	-0.175	0.544	-0.023	-0.206	0.431	-0.028
Province (ref: Shaanxi)									
Hubei	0.602*	0.250	0.088	0.288	0.339	0.044	0.983**	0.370	0.139
Guangdong	-1.312***	0.268	-0.190	-0.995**	0.367	-0.150	-1.530***	0.397	-0.217
Family trust	-3.154***	0.707	-0.129	-2.792**	0.905	-0.133	-3.767**	1.111	-0.136
Friend/neighbor trust	-0.409***	0.091	-0.140	-0.249*	0.124	-0.093	-0.565***	0.136	-0.182
Stranger trust	-0.438***	0.124	-0.105	-0.471**	0.170	-0.124	-0.406*	0.182	-0.091
Participation	-0.441**	0.142	-0.097	-0.356^	0.198	-0.081	-0.535**	0.205	-0.115
Network size	-0.095*	0.047	-0.071	-0.048	0.062	-0.041	-0.138*	0.071	-0.095
Network density	-0.028	0.037	-0.026	-0.009	0.051	-0.010	-0.044	0.055	-0.040
N	1016			484			532		
R^2	0.188			0.171			0.203		

Note: ***p<0.001, **p<0.01, *p<0.05, ^p<0.1. Coef.: coefficient. SE: standard error. Beta: standardized coefficient.

4. Discussion

With the recent rapid urbanization in China, the number of left-behind older adults in rural China is on the rise. For this reason, studies on the association between social capital and health in left-behind older adults have substantial and theoretical significance. Based on the cross-sectional survey conducted in Hubei, Shaanxi and Guangdong Province in China during 2017-2018, this study, for the first time, discussed the association between social capital and health of left-behind older adults by sex in rural China.

For physical health, results show that family trust is positively related to left-behind older adults' IADL, while friend/neighbor and stranger trust are not associated with both BADL and IADL. Older adults with poor physical health can only live a normal life on the condition that they receive family support, so trust in

family members, rather than trust in friends, neighbors or strangers, is important for this unique group. The comparative analysis for sex shows that family trust is positively related to IADL in males only, which is not in line with some previous studies [33]. A potential reason is that, in a patriarchal culture, resources within family are more likely to be used to support males, so old males benefit more from family trust and support when they have a poor physical health.

Social participation is observed to be positively associated with physical health. Social participation usually increases physical activities and keeps left-behind older adults healthy, and older adults with poor physical health are also less likely to engage in social activities [45]. Further, the positive association between participation and physical health is statistically significant in males only, because social participation is usually a major activity of males in China. That is to say, in China, males are usually in charge of outdoor affairs, and females are usually in charge of indoor affairs [33]. Further, compared with females, males' participation usually includes more instrumental values and brings more material benefits [46]. Thus, male older adults obtain more physical health returns from social participation.

The density of social network is observed to be related to the physical health of rural left-behind older adults, but no association is observed between network size and their physical health. That is to say, owning a social network or having many friends is not associated with physical health itself, and only using social network (contacting with friends) matters when it comes to physical health. These results are in line with related evidence from Japan and Northern Europe [25, 28, 29]. Further, females benefit more from contacting with others, mainly as females have a higher level of network density than males (4.16>3.76, in Table 2).

Most elevated social capital indicators are associated with better psychological health of left-behind older adults in rural China. Social trust reflects confidence and positive psychological expectation from others [21], so it helps reduce depression and improve perceived psychological health. Participation in various social activities provides left-behind older adults a platform to communicate with others and reduce the possibility of depression. Owning many friends increases affective interaction and

the sense of belonging, thus reducing mental problems. However, in the comparison between males and females, it is observed that most social capital indicators, including family trust, friend/neighbor trust, participation and network size, are more strongly related to female psychological health, which is similar to Sun et al.' results [16]. Compared with males, females are more likely to seek support, mobilize support resources, especially emotional support, from others and easier to have emotional changes [16, 47]. Further, females have a higher value in most social capital indicators (see Table 2), which also brings them more health benefits. Thus, older females get more psychological health returns from support resources from others.

Based on the above results, several interventions to promote left-behind older adults' health in rural China are proposed. First, the primary-level organizations should stress the daily collective activities for left-behind older adults, especially female older adults, and encourage them to engage in social activities, which allows them to increase social interactions and benefits their health. Second, the children of those left-behind older adults are encouraged to take good care of their parents, as they need to resolve difficulties through both material rewards and spiritual rewards. Third, village committees should take responsibility for developing a healthy neighborhood relationship. This will improve the level of trust among neighbors or friends and, in turn, have a positive impact on left-behind older adults' psychological health. Finally, it is vital to provide sufficient material resources for left-behind older adults in rural areas so as to promote better well-being and health.

There are several limitations in this study. First, this is a cross-sectional study and current results for the association between social capital and health are not causal, so further researches using longitudinal data and causal inference approaches are needed. Second, since the population evaluated are from different villages, it is likely that the characteristics of those villages may have some contextual effect on the association between social capital and health [30]. However, this contextual effect is found to be statistically nonsignificant in this study (for intra-class correlation coefficient, $p>0.1$). Thus, macro-level effect of village where these older adults live is not covered in this study.

5. Conclusions

This study, for the first time, discussed the association between social capital and physical/psychological health of left-behind older adults, as well the sex disparity in this association, in rural China. Results show that, in left-behind older adults, family trust was positively associated with IADL and negatively associated with depression, friend/neighbor trust, stranger trust and network size were negatively related to depression, participation was positively associated with BADL and negatively associated with depression, and network density was positively associated with BADL. For sex disparity, family trust, friend/neighbor trust, stranger trust and participation were negatively associated with depression in both sexes. Family trust was positively related to IADL in males only, participation was positively associated with BADL and IADL in males only, network density was positively associated with BADL and IADL in females only, but network size was negatively related to depression in females only.

Abbreviations

ADL: Activities of Daily Living

BADL: Basic Activities of Daily Living

Beta: standardized coefficient

CGSS: Chinese General Social Survey

CHARLS: China Health and Retirement Longitudinal Study

Coef.: coefficient

IADL: Instrumental Activities of Daily Living

OLS: ordinary least square

SD: standard deviation

SE: standard error

SRH: self-rated health

Author statements

Contributorship statement

Jiang & Ke designed the study; Chen & Ke collected the data; Jiang, Chen & Ke all wrote, revised and reviewed the manuscript.

Data sharing statement

No additional data are available.

Ethical approval

We declare that this study is complied with ethical standards. Wuhan University of Science and Technology grants ethical approval for this study.

Funding

This study is supported by the national social science fund: Researches on the quality of life of rural left-behind older adults in the setting of aging (No. 16BRK014).

Acknowledgement

We thank all the participants in the survey. Especially, we appreciate the valuable effort made by Qihong Wang from Bank of America.

Competing interests

The authors declare that they have no competing interests.

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Title: page 1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract: page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 3-7
Objectives	3	State specific objectives, including any pre-specified hypotheses	Page 4 and 7
Methods			
Study design	4	Present key elements of study design early in the paper	Page 2 and 7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 7-8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page 7-8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 9-11
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	Page 7-8
Bias	9	Describe any efforts to address potential sources of bias	Page 8 (footnote)
Study size	10	Explain how the study size was arrived at	Page 8 (footnote)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 9-11
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 11-12
		(*b*) Describe any methods used to examine subgroups and interactions	Page 11-12
		(*c*) Explain how missing data were addressed	Page 8
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Page 8
		(*e*) Describe any sensitivity analyses	None
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	Page 8-9, page 12-13
		(b) Give reasons for non-participation at each stage	Page 8-9
		(c) Consider use of a flow diagram	None
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 12-13
		(b) Indicate number of participants with missing data for each variable of interest	Page 12-13, no missing data
Outcome data	15*	Report numbers of outcome events or summary measures	Page 12-13
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted	Page 13-16

		estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	None
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	None
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 13-16
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 19
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	Page 18-19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 16-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 8 (footnote 1)
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	Page 20

*Give information separately for exposed and unexposed groups.

BMJ Open

Social capital and the health of left-behind older adults in rural China: a cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-030804.R2
Article Type:	Original research
Date Submitted by the Author:	23-Sep-2019
Complete List of Authors:	Jiang, Junfeng; Wuhan University, School of Health Sciences Yu, Chen; Wuhan University of Science and Technology Ke, Yan; Wuhan University of Science and Technology, School of Literature, Law and Economics
Primary Subject Heading:	Public health
Secondary Subject Heading:	Health services research, Public health
Keywords:	social capital, health, left-behind older adults, sex disparity, rural China

Social capital and the health of left-behind older adults in rural China: a cross-sectional study

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Word count: 5600

Abstract

***Objectives*:** To examine the association between social capital and the health of male and female left-behind older adults in rural China.

***Study design*:** This cross-sectional study among the left-behind older adults aged 60 and older and with all their children working outside from Hubei, Shaanxi and Guangdong Provinces, China was conducted in 2017-2018. A total of 1106 questionnaires were collected (participation rate=100.0%) and questionnaires from 1016 participants were used (effective rate=91.9%).

***Methods*:** An ordinary least squares model was used to evaluate the association between social capital and health. Social capital included family trust, friend/neighbor trust, stranger trust, social participation, network size and density. Health outcomes included basic and instrumental activities of daily living (BADL and IADL) and depression.

***Results*:** Elevated family trust, friend/neighbor trust, stranger trust, high-level participation and middle-level network density were associated with reduced depression (b=-3.231, p<0.001; b=-0.411, p<0.001; b=-0.759, p<0.01; b=-1.040, p<0.05; b=-0.741, p<0.05; respectively). High-level participation and network density were also associated with elevated BADL (b=0.157, p<0.05; b=0.240, p<0.05; respectively). Elevated family trust (b=-2.861, p<0.05 in males; b=-3.855, p<0.001 in females), stranger trust (b=-0.680, p<0.05 for males; b=-0.799, p<0.05 for females) and high-level participation (b=-0.920, p<0.05 for males; b=-1.221, p<0.01 for females) were associated with reduced depression in both sexes. By contrast, elevated friend/neighbor trust was associated with reduced depression (b=-0.558, p<0.001) in females, high-level participation was associated with elevated BADL (b=0.192, p<0.05) and IADL (b=0.431, p<0.05) in males, and high-level network density was associated with elevated BADL (b=0.441, p<0.05) and IADL (b=0.567, p<0.05), and reduced depression (b=-1.050, p<0.05) in females.

***Conclusions*:** Social capital is closely related to left-behind older adults' health in rural China. More attention should be paid to increasing the stock of social capital in this special population, with a particular focus on the sex disparity.

Keywords: social capital; health; left-behind older adults; sex disparity; rural China

Strengths and Limitations:

1. This is the first study to evaluate the association between social capital and health by sex in left-behind older adults in rural China.
2. Social capital was more strongly related to depression than to BADL and IADL in left-behind older adults in rural China.
3. A significant sex disparity in the association between social capital and health was observed.
4. The causal association between social capital and health, as well as the relationship between contextual social capital and health, was not examined.

1. Introduction

China has witnessed dramatic economic and social changes, as well as a rapid rise in the number of aging individuals, over the past several decades. By the end of 2016, people aged 60 and older accounted for 16.7% of the total population in China [1]. The rapid development of urbanization has attracted tens of millions of rural laborers to work in cities, which results in an increase in the number of left-behind older adults in rural China. Left-behind older adults usually refer to older adults aged 60 and older living in rural areas whose children work in other areas (usually cities) and do not live with them [2]. Currently, there are more than 40 million left-behind older adults in rural China, and this number may increase in the foreseeable future [3].

Since the 1990s, the association between social capital, which comes from social connections in our daily lives [4], and health has been widely discussed [5, 6], and it has been observed to be positive in numerous studies [7-9]. However, limited studies examine this association in older adults, especially in left-behind older adults in rural China [10, 11]. The poor health status of left-behind older adults has been reported and has received much attention [2, 3, 12]. With their children working in cities most of the time and living far away, left-behind older adults cannot obtain enough support from them, which results in the loss of social connections and economic and mental

instability [3]. Some evidence indicates that both the physical and the mental health of left-behind older adults are poorer than those of other older adults [2, 3, 13]. Furthermore, the sex disparity in health is widely discussed. It is recognized that males usually have a lower level of life expectancy but better perceived health than females do [14], and the sex disparity in the association between social capital and health is also observed in other studies [15, 16]. However, no sex disparity in this association has been examined in left-behind older adults.

Therefore, this study aimed to answer two questions. First, was there an empirical association between social capital and left-behind older adults' health in rural China? Second, was there a sex disparity in the empirical association above?

1.1. Definition and measures of social capital

Numerous views on the definition of social capital have been proposed, among which Putnam's communitarianism is considered the most influential in the area of public health [5]. Putnam considered social capital to be a kind of social structure and emphasized the collective attributes of it as well as its power on individual actors from the perspective of cohesion [17, 18]. Accordingly, trust, social networks and participation are the most widely used measures of social capital in the area of public health [5, 19]. Trust is a sense of confidence or expectation generated from the belief that others will behave decently and predictably [20, 21], which is the most widely used measure of social capital in public health. Social networks refer to social contacts among individuals, which is a stable system formed through social interactions. Social participation refers to engagement in formal or informal associations or activities [18, 22]. It is recognized that social capital consists of cognitive and structural components, such that trust pertains to the former, whereas social networks and participation pertain to the latter [5, 17, 23]. Furthermore, the framework in which social capital can be divided into bonding and bridging forms has also been widely used in the area of public health [5]. Bonding social capital means a kind of in-ward social connection among individuals within homogeneous groups, while bridging social capital refers to an extroverted social connection among members from heterogeneous groups [17, 18, 24].

Accordingly, trust, social networks and participation were used as measures of social capital in this study.

1.2. Social capital and health in older adults

Limited studies are available on the association between social capital and health in older adults. Pollack and Knesebeck examined the association between social capital and older adults' health in the US and Germany and reported that low-level reciprocity, trust and social participation were related to poor self-rated health (SRH) and elevated depression [10] but were not associated with physical function. Most studies conducted in Europe and Asia also observe an association between social capital and health in older adults. For example, evidence from Northern Europe shows that structural social capital, including social contacts with neighbors/friends, was related to older adults' decreased depression, because contacts with others provide access to resources and support and generate mutual benefits [25]. For cognitive social capital, trust among friends [25] is observed to be positively related to older adults' psychological health, while general trust [26] and trust among neighbors [25] are not related to their psychological health. Evidence from Japan indicates that elevated social participation is associated with elevated functional capacity in older adults [27], and a well-structured social network is negatively related to older adults' mortality [28, 29]. By contrast, trust and norms of reciprocity are not associated with mortality [28]. Furthermore, cognitive social capital, including trust and norms of reciprocity, is also observed to be positively related to older adults' SRH [30] and mental health [31], but an elevated social network is more likely to be associated with better mental health than with better SRH among older adults [32].

Studies on social capital and older adults' health in China are also limited. Based on the Chinese General Social Survey (CGSS), Norstrand and Xu argued that bonding trust and bonding networks were positively associated with older adults' physical and mental health in urban China, but rural older adults did not obtain health returns from bonding trust and networks. The norm of reciprocity was not related to the health of older adults across China [11]. Based on the China Health and Retirement Longitudinal

Study (CHARLS), Xue and Liu found that participation in social activities significantly promoted the SRH of older adults [33]. Using an instrumental variable approach, Liu et al. also observed that elevated social participation was causally associated with better SRH and physical health [34]; however, Shen et al. observed that only perceived help was related to better SRH, and the social network was not related to the SRH of older adults in China [35].

What we should notice is the sex disparity in the association between social capital and health among the older adults. It is observed that trust is not related to female older adults' health. For example, Chemaitelly et al. argued that although social networks, trust and norms of reciprocity were positively associated with older adults' SRH, elevated trust in older females was not related to better SRH [15]. Furthermore, Aida et al. proposed that elevated social trust might reduce the physical health of older females [28]. In China, Xue and Liu proposed that participation in social activities had a stronger promoting effect on the SRH of older female adults [33]; Sun et al. also proposed that although social capital was associated with better physical and mental health of older adults of both sexes, the positive association between social capital and mental health was stronger in older females in rural China [16]. Accordingly, the sex disparity in the association between social capital and older adults' health has not yet been fully established and requires further discussion.

In summary, it is evident that studies on the association between social capital and the health of rural older adults in China are limited, and only one study has examined this association in left-behind older adults [36]. However, multiple health outcomes should be examined in older adults when discussing this issue, and the potential sex disparity in this association should also be examined. Left-behind older adults have unique life experiences that are quite different from those of other older adults [3]. Studies on the association between social capital and the health of left-behind older adults in rural China have important policy implications in improving the well-being of this vulnerable group. Hence, this study aimed to examine the association between social capital and the health of left-behind older adults in rural China.

2. Data and methods

2.1 Data source

The data used in this study were obtained from a field cross-sectional survey conducted in five counties/cities in China, including Yingcheng County and Mian County in July, 2017, as well as Lechang City, Jieyang City, Suixi County in August, 2018. Yingcheng County is located in the central area of Hubei Province, with a per capita GDP of 39,019 Chinese Yuan (CNY) and a population of 666,000 in 2016. Mian County is located in the southwest corner of Shaanxi Province, with a per capita GDP of 26,153 CNY and a population of 426,000 in 2014. Lechang City is located in the northern area of Guangdong Province, with a per capita GDP of 19,952 CNY and a population of 521,000 in 2017. Jieyang City is located in the eastern area of Guangdong Province, with a per capita GDP of 35,327 CNY and a population of 6086,000 in 2017. Suixi County is located in the southwest corner of Guangdong Province, with a per capita GDP of 23,761 CNY and a population of 1039,000 in 2017. Considering the regional differences in socioeconomic development, the above three provinces were randomly selected as representative of Eastern, Central and Western China, as Chinese internal migrants usually move from central and western China to eastern China across provinces, and move from villages and small cities to provincial capitals within specific provinces[1].

In the present study, rural adults aged 60 or older with all children working in urban areas were defined as left-behind older adults. Simple random sampling, convenience sampling and cluster sampling methods were used in the present study. More specifically, since we could not obtain the total composition of left-behind older adults (such as age and sex) in rural China, we used random sampling, convenience sampling and cluster sampling methods at different stages of the survey. First, the

[1] According to the data of *China Statistical Yearbook 2018*, the proportion of older adults is 7.8%, 12.2% and 11.1% in Guangdong, Hubei and Shaanxi Provinces, respectively, in 2017. The aging level in Guangdong Province is lower than that of the other regions due to the influx of workers to Pearl River Delta Region, and the aging level in Hubei and Shaanxi Provinces is higher. There are also numerous rural laborers working out in all five counties/cities, suggesting that these areas are nationally representative more or less.

random number table was used to randomly select one province in each of the three different regions (Eastern China, Central China, and Western China). Second, as the level of homogeneity across different counties/cities within a province or different towns/villages within a county/city was high, the convenience sampling method was considered to be acceptable in ensuring the representativeness and made the survey more feasible; thus, based on the principle of easy access to the survey sites, we contacted the counties/cities that could assist in carrying out the survey, mainly relying on personal social networks. Finally, with the assistance of local officials, a reliable list provided by local officials was used to reduce the selection bias when a cluster sampling method was used to investigate individuals in villages; furthermore, a door-to-door investigation was conducted, and trained interviewers knocked on doors or gathered left-behind older adults in village committees for face-to-face interviews. A total of 1106 questionnaires were distributed and collected, and no respondent refused to be interviewed. Finally, questionnaires with more than 20% unanswered questions were not included in the analysis (mainly due to physical reasons, such as hearing and cognitive impairment). Thus, a total of 90 questionnaires were excluded, and the data used in this study were obtained from 1016 questionnaires, which accounted for 91.9% of the questionnaires collected[2].

2.2 Participants and public involvement

The questionnaire consisted of research questions and health outcome indicators. All participants were instructed based on signed consent forms.

2.3 Variables

2.3.1 Social capital

Three components of social capital, namely, trust (cognitive), social participation

[2] Questionnaires excluded in the analysis were those with many questions (more than 20%) unanswered. Since the missing rate is 8.1% (less than 10%), we do not think it yields a significant bias for our analysis. The final sample size was 1016, indicating a large sample survey, so it was not likely for the statistical power to be low.

(structural) and social networks (structural) were used[3]. Trust encompassed trust in family members, neighbors, friends and strangers, and response options included the following: "0=very distrustful, 1=relatively distrustful, 2=relatively trustful, 3=very trustful". Trust in family members and strangers were treated as family trust (bonding) and stranger trust (bridging), respectively, with "very distrustful" and "relatively distrustful" recoded as "distrustful" and "relatively trustful" and "trustful" recoded as "trustful"; trust scores for neighbors and friends were added and conceptualized as friend/neighbor trust (bonding). It is highlighted that, according to the *Chaxu* pattern, the interpersonal pattern of Chinese residents is similar to the ripple that opens wide on the water surface [37]. Thus, although family trust and friend/neighbor trust were forms of bonding social capital according to Putnam's definition [17], they were considered to be two different social capital variables in this study, as family members are blood ties, while friends and neighbors are not blood ties.

Social participation included participation in chess activities, collective fitness activities, gathering/chatting, organization activities and other activities (0=not participated, 1=participated), and they were added to measure the level of social participation; subsequently, participating in no activity was recoded as low-level participation, participating in only one activity was recoded as middle-level participation, and participating in more than one activity was recoded as high-level participation.

Social network consisted of network size and network density. Network size was determined by the number of close friends (ranging from 0~10); the weekly frequency of interactions with friends (ranging from 0~7) in the past year, both online and offline, were added to measure network density. For the network density, no interaction per week was recoded as low-level network density, less than seven interactions per week were recoded as middle-level network density, and seven or

[3] The reliability (α coefficient) was not reported, as participation and networks were defined in a formative not a reflective way; trust was encompassed by three independent variables, and they pertained to different forms of social capital (bonding and bridging). Thus, there was no need for the reliability α coefficient.

more interactions per week were recoded as high-level network density.

2.3.2 Health outcomes

Health outcomes consisted of physical and psychological health. Physical health included BADL [38] and IADL [39]. BADL referred to the ability to eat, walk, visit friends, dress and bathe, and the response options for each item included the following: 0=completely depend on others, 1=partly depend on others, 2=do not depend on others completely. Five items were added to measure BADL. IADL referred to the capacity to cook, shop, clean and take a bus, and the response options for each item included the following: 0=completely depend on others, 1=partly depend on others, 2=do not depend on others completely. Four items were added to measure IADL. The Life Satisfaction Index Scale was used to measure depression, a psychological health indicator [40, 41], and the response options for each item included the following: 0=not depressed, 1=depressed. Subsequently, a total of 12 indices were added to measure depression. Details are displayed in Table 1.

Table 1 Measures of health of left-behind older adults in rural China in 2017-2018 (N=1016)

Health	Indicators	Range	Reliability α
BADL	Ability to eat independently	0-2	0.879
	Ability to walk independently	0-2	
	Ability to visit friends independently	0-2	
	Ability to dress independently	0-2	
	Ability to bath independently	0-2	
IADL	Ability to cook independently	0-2	0.873
	Ability to shop independently	0-2	
	Ability to clean independently	0-2	
	Ability to take a bus independently	0-2	
Depression	Are you satisfied with your life?	0-1	0.839
	Do you continue to pursue hobbies?	0-1	
	Do you have a sense of life enrichment?	0-1	
	Do you feel upset?	0-1	
	Do you feel good in spirits?	0-1	
	Do you have a sense of insecurity?	0-1	
	Do you feel happy?	0-1	
	Do you have a sense of loneliness?	0-1	

Do you feel good to be alive?	0-1
Do you have a sense of unworthiness?	0-1
Do you feel energetic?	0-1
Do you feel hopeless?	0-1

2.3.3 Control variables

Control variables included sex, age, marital status, education, family income (a natural logarithmic transformation was performed), living status (whether living with other people or not) and province. More details are provided in Table 2.

2.4 Methods

Cronbach's α coefficient was used to assess the internal consistency of specific health outcomes, and Cronbach's α>0.60 was used as the criterion to ensure reliability [42]. χ^2 tests and t-tests were used to examine whether the sex differences in different variables were statistically significant. Although all three health outcomes were ordinary variables, the parallel-lines assumption was not supported in ordinal regression. Therefore, the OLS model was used to examine the association, in both sexes and by sex, between various forms of social capital and different health outcomes of left-behind older adults in rural China. This strategy, which treats ordinal outcome as continuous outcomes, is supported and widely used in many other studies [9, 34]. According to previous studies, there might be sex disparities in the association between social capital and health in older adults [16, 28, 33]. Thus, stratification by sex was used, and males and females were analyzed separately to compare the sex disparity in the association between social capital and health in left-behind older adults. The model specification of OLS was as follows:

$$Health_i = \beta_0 + \sum_1^p (\beta_p * control\ variable_i) + \sum_1^k (\beta_k * social\ capital_i) + \varepsilon_i$$

where $Health_i$ represented the health outcome of individual i; β_0 represented the intercept; β_p represented the estimated coefficients of variables controlled for (p=1~8 in full samples and 1~7 in male or female samples), β_k represented the estimated coefficients of social capital variables (k=1~6), and ε_i represented the

residual error of the model.

SPSS version 21.0 was used to perform OLS models; robust standard error was used to adjust for potential heteroscedasticity, given that a cluster sampling method was used to interview respondents within villages. Statistical significance was assumed if $p<0.05$.

3. Results

3.1 Descriptive analysis

Table 2 describes the sample of 1016 participants, consisting of 484 males and 532 females. Compared to males, females seemed to have a higher level of depression ($p=0.002$) and a lower level of IADL ($p=0.013$) but also had slightly higher levels of friend/neighbor trust ($p=0.060$) and network density ($p=0.057$). Furthermore, compared to males, females in the sample seemed to be less educated ($p<0.001$), less likely to be married ($p<0.001$) and less likely to live with others ($p<0.001$).

Table 2 Descriptive information of left-behind older adults in rural China in 2017-2018 (N=1016)

Control variables	Coding	Males (N=484)				Females (N=532)				Range	*p*-value of χ^2/T test
		N	%	Mean	SD	N	%	Mean	SD		
Age				71.36	7.29			71.57	7.91	60-95	0.656
Marital status	married	383	79.1			304	57.1				<0.001
	divorce/widow	101	20.9			228	42.9				
Education	illiteracy	165	34.1			369	69.4				<0.001
	primary school	199	41.1			130	24.4				
	junior high school	94	19.4			19	3.6				
	≥senior high school	26	5.4			14	2.6				
Family income				8.99	0.92			8.96	1.06		0.602
Living status	alone	87	18.0			161	30.3				<0.001
	not alone	397	82.0			371	69.7				
Region	Shaanxi	206	42.6			154	29.0				<0.001
	Hubei	142	29.3			189	35.5				
	Guangdong	136	28.1			189	35.5				
Independent variables											
Family trust	trust	474	97.9			524	98.5			0-1	0.497
	not trust	10	2.1			8	1.5				

Friend/neighbor trust				4.31	1.11			4.44	1.09	0-6	0.060
Stranger trust	trust	96	19.8			109	20.5			0-1	0.795
	not trust	388	80.2			423	79.5				
Participation	low	124	25.6			142	26.7			0-2	0.916
	middle	275	56.8			296	55.6				
	high	85	17.6			94	17.7				
Network size				2.89	2.84			2.87	2.56	0-30	0.933
Network density	low	113	23.3			107	20.1			0-2	0.057
	middle	224	46.3			226	42.5				
	high	147	30.4			199	37.4				
Dependent variables											
BADL				9.85	0.75			9.80	0.96	0-10	0.358
IADL				7.48	1.41			7.24	1.67	0-8	0.013
Depression				3.27	2.99			3.90	3.38	0-12	0.002

Note: N means number, SD means standard deviation.

3.2 Social capital and BADL

Associations between social capital and the BADL of left-behind older adults in rural China are presented in Table 3. With other variables controlled for, compared with low-level social participation and network density, high-level social participation and network density were associated with elevated BADL (b=0.157, $p<0.05$; b=0.240, $p<0.05$; respectively). However, the association between high-level social participation and elevated BADL was observed in males only (b=0.192, $p<0.05$), and the association between middle- or high-level network density and elevated BADL was observed in females only (b=0.520, $p<0.05$; b=0.441, $p<0.05$; respectively). Furthermore, no significant association was observed between other forms of social capital, including family trust, friend/neighbor trust, stranger trust and network size, and the BADL of left-behind older adults in all three models.

Table 3 Social capital and BADL of left-behind older adults in rural China in 2017-2018 (N=1016)

	Model 1 (all samples)			Model 2 (males)			Model 3 (females)		
	b	R_SE	Beta	b	R_SE	Beta	b	R_SE	Beta
Intercept	9.752***	0.482		9.287***	0.751		10.036***	0.612	
Sex (ref: female)	0.046	0.057	0.026						

Age	-0.014**	0.005	-0.119	-0.005	0.006	-0.047	-0.021**	0.006	-0.174
Married (ref: divorce/widow)	-0.024	0.098	-0.013	-0.023	0.086	-0.013	-0.039	0.130	-0.020
Education (ref: illiteracy)									
primary school	0.072	0.063	0.039	0.147*	0.073	0.097	0.030	0.119	0.013
junior high school	-0.063	0.103	-0.023	-0.011	0.121	-0.006	0.102	0.080	0.020
senior high school or above	-0.106	0.145	-0.024	0.054	0.091	0.016	-0.370	0.338	-0.061
Family income (ln)	0.060	0.026	0.069	0.061	0.045	0.075	0.058^	0.031	0.063
Living status (ref: not alone)	-0.015	0.104	-0.007	0.038	0.081	0.020	-0.034	0.148	-0.016
Province (ref: Shaanxi)									
Hubei	-0.131	0.082	-0.071	-0.250	0.132	-0.153	-0.025	0.083	-0.012
Guangdong	-0.130	0.073	-0.070	0.024	0.080	0.015	-0.230	0.122	-0.114
Family trust (ref: not trust)	0.284	0.296	0.043	0.309	0.406	0.059	0.300	0.460	0.038
Friend/neighbor trust	0.022	0.029	0.028	0.012	0.044	0.018	0.049	0.038	0.056
Stranger trust (ref: not trust)	-0.045	0.078	-0.021	-0.058	0.117	-0.031	-0.023	0.094	-0.010
Participation (ref: low)									
middle	0.064	0.081	0.037	0.086	0.103	0.057	0.038	0.128	0.020
high	0.157*	0.075	0.069	0.192*	0.095	0.098	0.103	0.113	0.041
Network size	-0.008	0.016	-0.022	0.008	0.017	0.026	-0.019	0.024	-0.047
Network density (ref: low)									
middle	0.176	0.122	0.101	-0.162	0.095	-0.109	0.520*	0.211	0.266
high	0.240*	0.109	0.131	-0.004	0.085	-0.003	0.441*	0.172	0.222
N	1016			484			532		
R^2	0.047			0.053			0.098		

Note: ***p<0.001, **p<0.01, *p<0.05. b: coefficient. R_SE: robust standard error. Beta: standardized coefficient.

3.3 Social capital and IADL

Associations between social capital and the IADL of left-behind older adults in rural China are presented in Table 4. With other variables controlled for, no significant association was observed between social capital and IADL. However, a significant sex disparity in the association between social capital and IADL was observed. For older males, only high-level social participation was associated with elevated IADL (b=0.431, p<0.05). By contrast, compared with low-level network density, middle- and high-level network density was associated with elevated IADL in older females only (b=0.607, p<0.05; b=0.567, p<0.05; respectively).

Table 4 Social capital and IADL of left-behind older adults in rural China in 2017-2018 (N=1016)

	Model 1 (all samples)			Model 2 (males)			Model 3 (females)		
	b	R_SE	Beta	b	R_SE	Beta	b	R_SE	Beta
Intercept	10.001***	0.954	0.044	10.289***	1.423		9.802***	1.265	
Sex (ref: female)	0.136	0.104	-0.268						
Age	-0.055***	0.008	0.011	-0.048***	0.010	-0.245	-0.061***	0.012	-0.288
Married (ref: divorce/widow)	0.037	0.168	0.044	-0.229	0.177	-0.066	0.159	0.223	0.047
Education (ref: illiteracy)									
primary school	0.248*	0.113	0.074	0.447**	0.157	0.156	0.127	0.177	0.033
junior high school	0.107	0.151	0.022	0.273	0.187	0.076	0.209	0.192	0.023
senior high school or above	-0.016	0.254	-0.002	0.412	0.246	0.066	-0.597	0.536	-0.057
Family income (ln)	0.066	0.059	0.042	0.010	0.093	0.006	0.105	0.076	0.067
Living status (ref: not alone)	0.143	0.183	0.040	-0.058	0.163	-0.016	0.241	0.262	0.066
Province (ref: Shaanxi)									
Hubei	-0.216	0.122	-0.065	-0.312	0.183	-0.101	-0.149	0.162	-0.043
Guangdong	-0.624***	0.131	-0.187	-0.277	0.167	-0.088	-0.892***	0.200	-0.255
Family trust (ref: not trust)	0.599	0.568	0.051	0.770	0.918	0.078	0.481	0.739	0.035
Friend/neighbor trust	-0.018	0.042	-0.013	-0.055	0.059	-0.044	0.044	0.058	0.028
Stranger trust (ref: not trust)	0.163	0.126	0.042	0.227	0.172	0.064	0.099	0.175	0.024
Participation (ref: low)									
middle	-0.023	0.132	-0.007	0.090	0.175	0.032	-0.154	0.191	-0.046
high	0.192	0.143	0.047	0.431*	0.200	0.116	-0.058	0.213	-0.013
Network size	-0.001	0.024	-0.001	0.016	0.026	0.028	-0.011	0.038	-0.015
Network density (ref: low)									
middle	0.170	0.171	0.054	-0.271	0.182	-0.096	0.607*	0.267	0.180
high	0.280	0.171	0.085	-0.045	0.185	-0.015	0.567*	0.261	0.164
N	1016			484			532		
R^2	0.140			0.123			0.187		

Note: ***p<0.001, **p<0.01, *p<0.05. b: coefficient. R_SE: robust standard error. Beta: standardized coefficient.

3.4 Social capital and depression

Associations between social capital and the depression of left-behind older adults in rural China are presented in Table 5. With other variables controlled for, elevated family trust, friend/neighbor trust, stranger trust, high-level social participation and middle-level network density were associated with reduced depression (b=-3.231, p<0.001; b=-0.411, p<0.001; b=-0.759, p<0.01; b=-1.040, p<0.001; b=-0.741, p<0.05; respectively). A significant sex disparity in the association between social capital and depression was also observed. For older males, elevated family trust and stranger trust and high-level social participation were associated with reduced depression

(b=-2.861, p<0.05; b=-0.680, p<0.05; b=-0.920, p<0.05; respectively). By contrast, for older females, elevated family trust, friend/neighbor trust and stranger trust, as well as high-level social participation and middle-level network density, were associated with reduced depression (b=-3.855, p<0.001; b=-0.558, p<0.001; b=-0.799, p<0.05; b=-1.221, p<0.01; b=-1.050, p<0.05; respectively).

Table 5 Social capital and depression of left-behind older adults in rural China in 2017-2018 (N=1016)

	Model 1 (all samples)			Model 2 (males)			Model 3 (females)		
	b	R_SE	Beta	b	R_SE	Beta	b	R_SE	Beta
Intercept	14.930***	1.533		14.303***	2.168		15.187***	2.211	
Sex (ref: female)	-0.619**	0.200	-0.096						
Age	0.005	0.014	0.012	0.002	0.018	0.004	0.010	0.021	0.024
Married (ref: divorce/widow)	-0.347	0.337	-0.051	-0.323	0.552	-0.044	-0.434	0.428	-0.064
Education (ref: illiteracy)									
primary school	-0.206	0.212	-0.030	-0.035	0.303	-0.006	-0.327	0.310	-0.042
junior high school	-0.268	0.323	-0.026	-0.373	0.395	-0.049	0.164	0.666	0.009
senior high school or above	-0.362	0.399	-0.022	-0.720	0.440	-0.054	0.429	0.751	0.020
Family income (ln)	-0.505***	0.104	-0.156	-0.644***	0.166	-0.198	-0.386**	0.141	-0.120
Living status (ref: not alone)	-0.178	0.360	-0.024	-0.175	0.581	-0.023	-0.200	0.456	-0.027
Province (ref: Shaanxi)									
Hubei	0.474^	0.276	0.069	0.229	0.359	0.035	0.770	0.426	0.109
Guangdong	-1.313***	0.253	-0.191	-0.992**	0.339	-0.150	-1.501***	0.395	-0.212
Family trust (ref: not trust)	-3.231***	0.840	-0.133	-2.861*	1.262	-0.136	-3.855***	0.956	-0.139
Friend/neighbor trust	-0.411***	0.097	-0.141	-0.264	0.136	-0.098	-0.558***	0.138	-0.180
Stranger trust (ref: not trust)	-0.759**	0.239	-0.095	-0.680*	0.342	-0.091	-0.799*	0.339	-0.095
Participation (ref: low)									
middle	-0.330	0.225	-0.051	-0.231	0.320	-0.038	-0.444	0.317	-0.065
high	-1.040***	0.294	-0.123	-0.920*	0.402	-0.117	-1.221**	0.441	-0.138
Network size	-0.074	0.042	-0.055	-0.032	0.057	-0.027	-0.106	0.061	-0.073
Network density (ref: low)									
middle	-0.741*	0.290	-0.115	-0.457	0.400	-0.076	-1.050*	0.429	-0.153
high	-0.465	0.332	-0.069	-0.175	0.466	-0.027	-0.739	0.481	-0.106
N	1016			484			532		
R^2	0.191			0.170			0.212		

Note: ***p<0.001, **p<0.01, *p<0.05. b: coefficient. R_SE: robust standard error. Beta: standardized coefficient.

4. Discussion

With the recent rapid urbanization in China, the number of left-behind older adults in rural China is on the rise. For this reason, studies on the association between social capital and health in left-behind older adults have substantial and theoretical significance. Based on a cross-sectional survey conducted in Hubei, Shaanxi and Guangdong Provinces in China in 2017-2018, this is the first study to discuss the association between social capital and the health of left-behind older adults by sex in rural China.

A higher level of social participation is associated with better physical health, especially better BADL. Social participation usually increases physical activities and keeps left-behind older adults healthy, and older adults with poor physical health are also less likely to engage in social activities [43]. Furthermore, the positive association between participation and physical health is statistically significant in males only, because social participation is usually a major activity among males in China. That is, in China, males are usually in charge of outdoor affairs, and females are usually in charge of indoor affairs [33]. Furthermore, compared with females, males' participation usually includes more instrumental values and brings more material benefits [44]. Thus, older males obtain more physical health benefits from social participation.

A higher level of density of social networks is observed to be related to better physical health of rural left-behind older adults, but no association is observed between social network size and the two physical health outcomes. That is, for left-behind older adults, having high-quality social networks or many friends is not associated with physical health itself; rather, the mere presence of any social network (contact with friends) is what matters with respect to physical health. These results are in line with related evidence from Japan and Northern Europe [25, 28, 29]. Furthermore, older females benefit more from contact with others, potentially because older females have a higher level of network density than older males do (see Table 2).

Most elevated social capital indicators are associated with better psychological health of left-behind older adults in rural China. Social trust reflects confidence and positive psychological expectation from others [21], so it helps reduce depression and improve perceived psychological health. Participating in various social activities

provides left-behind older adults with a platform to communicate with others and reduces the possibility of depression. Contact with friends directly increases affective interactions and the sense of belonging, thus reducing mental health problems. However, in the comparison between males and females, it is observed that most social capital indicators, including family trust, friend/neighbor trust, stranger trust, social participation and network density, are more strongly related to female psychological health, which is similar to the results of Sun et al. [16]. Compared with males, females are more likely to seek support and mobilize support resources (especially emotional support) from others and navigate emotional changes with greater ease [16, 45]. Furthermore, females have higher levels of some social capital indicators (see Table 2), which also brings them more health benefits. Thus, older females receive more psychological health returns from support resources from others.

Based on the above results, several interventions to improve the stock of social capital in left-behind older adults in China are proposed. First, primary-level organizations should stress daily collective activities for left-behind older adults, especially female older adults. Senior centers should be built to provide left-behind older adults with a platform to engage in social activities, which allows them to increase social interactions and benefits their health. Second, the children of left-behind older adults are encouraged to take good care of their parents, as they need to resolve difficulties through both material rewards and spiritual rewards. Finally, village committees should take responsibility for developing a healthy neighborhood relationship, which can improve the level of trust in left-behind older adults and, in turn, improve their psychological health.

There are several limitations in this study. First, this is a cross-sectional study and current results for the association between social capital and health cannot be explained as causal, so further studies using longitudinal data and causal inference approaches are needed. Second, because the populations evaluated are from different villages, it is likely that the characteristics of those villages may have some contextual effect on the association between social capital and health [30]. However, this contextual

effect was found to be statistically nonsignificant in this study (the *p*-value of the intraclass correlation coefficient was larger than 0.05). Thus, the macrolevel effect of the villages where these older adults live is not reported in this study, and further studies on this topic are needed.

5. Conclusions

This is the first study to discuss the association between social capital and the physical/psychological health of left-behind older adults, as well as the sex disparity in this association, in rural China. The results show that in left-behind older adults, multiple forms of social capital were associated with health outcomes, but cognitive social capital was associated with depression only. Furthermore, a significant sex disparity in the association between social capital and health in left-behind older adults was also observed. According to these results, interactions should be encouraged between older adults and their family members or neighbors/friends to build trust, and senior centers should be built to provide left-behind older adults with a platform for social participation and interaction in rural China.

Abbreviations

BADL: Basic Activities of Daily Living

Beta: standardized coefficient

CGSS: Chinese General Social Survey

CHARLS: China Health and Retirement Longitudinal Study

IADL: Instrumental Activities of Daily Living

OLS: ordinary least square

R_SE: robust standard error

SD: standard deviation

SRH: self-rated health

Author statements

Contributorship statement

Jiang & Ke designed the study; Chen & Ke collected the data; Jiang, Chen & Ke all wrote, revised and reviewed the manuscript.

Data sharing statement

No additional data are available.

Ethical approval

We declare that this study is complied with ethical standards. Wuhan University of Science and Technology grants ethical approval for this study.

Funding

This study is supported by the national social science fund: Researches on the quality of life of rural left-behind older adults in the setting of aging (No. 16BRK014).

Acknowledgement

We thank all the participants in the survey. Especially, we appreciate the valuable effort made by Qihong Wang from Bank of America.

Competing interests

The authors declare that they have no competing interests.

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Title: page 1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract: page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 3-6
Objectives	3	State specific objectives, including any pre-specified hypotheses	Page 4 and 6
Methods			
Study design	4	Present key elements of study design early in the paper	Page 2 and 6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 7-8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page 7-8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 8-11
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	Page 7-8
Bias	9	Describe any efforts to address potential sources of bias	Page 7-8 (footnote)
Study size	10	Explain how the study size was arrived at	Page 8 (footnote)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 8-11
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 11-12
		(*b*) Describe any methods used to examine subgroups and interactions	Page 11
		(*c*) Explain how missing data were addressed	Page 8
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Page 7-8
		(*e*) Describe any sensitivity analyses	None
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	Page 7-8, page 12-13
		(b) Give reasons for non-participation at each stage	Page 8
		(c) Consider use of a flow diagram	None
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 12-13
		(b) Indicate number of participants with missing data for each variable of interest	Page 12-13, no missing data
Outcome data	15*	Report numbers of outcome events or summary measures	Page 12-13
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted	Page 13-16

		estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	Page 9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	None
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 13-16
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 19
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	Page 18-19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 16-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 8 (footnote 1)
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	Page 20

*Give information separately for exposed and unexposed groups.

BMJ Open

Social capital and the health of left-behind older adults in rural China: a cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-030804.R3
Article Type:	Original research
Date Submitted by the Author:	21-Oct-2019
Complete List of Authors:	Jiang, Junfeng; Wuhan University, School of Health Sciences Yu, Chen; Wuhan University of Science and Technology Ke, Yan; Wuhan University of Science and Technology, School of Literature, Law and Economics
Primary Subject Heading:	Public health
Secondary Subject Heading:	Health services research, Public health
Keywords:	social capital, health, left-behind older adults, sex disparity, rural China

Social capital and the health of left-behind older adults in rural China: a cross-sectional study

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Word count: 5600

Abstract

***Objectives*:** To examine the association between social capital and the health of male and female left-behind older adults in rural China.

***Study design*:** This cross-sectional study among the left-behind older adults aged 60 and older and with all their children working outside from Hubei, Shaanxi and Guangdong Provinces, China was conducted in 2017-2018. A total of 1106 questionnaires were collected (participation rate=100.0%) and questionnaires from 1016 participants were used (effective rate=91.9%).

***Methods*:** An ordinary least squares model was used to evaluate the association between social capital and health. Social capital included family trust, friend/neighbor trust, stranger trust, social participation, network size and density. Health outcomes included basic and instrumental activities of daily living (BADL and IADL) and depression.

***Results*:** Elevated family trust, friend/neighbor trust, stranger trust, high-level participation and middle-level network density were associated with reduced depression (b=-3.23, p<0.001; b=-0.41, p<0.001; b=-0.76, p<0.01; b=-1.04, p<0.05; b=-0.74, p<0.05; respectively). High-level participation and network density were also associated with elevated BADL (b=0.16, p<0.05; b=0.24, p<0.05; respectively). Elevated family trust (b=-2.86, p<0.05 in males; b=-3.86, p<0.001 in females), stranger trust (b=-0.68, p<0.05 for males; b=-0.80, p<0.05 for females) and high-level participation (b=-0.92, p<0.05 for males; b=-1.22, p<0.01 for females) were associated with reduced depression in both sexes. By contrast, elevated friend/neighbor trust was associated with reduced depression (b=-0.56, p<0.001) in females, high-level participation was associated with elevated BADL (b=0.19, p<0.05) and IADL (b=0.43, p<0.05) in males, and high-level network density was associated with elevated BADL (b=0.44, p<0.05) and IADL (b=0.57, p<0.05), and reduced depression (b=-1.05, p<0.05) in females.

***Conclusions*:** Social capital is closely related to left-behind older adults' health in rural China. More attention should be paid to increasing the stock of social capital in this special population, with a particular focus on the sex disparity.

Keywords: social capital; health; left-behind older adults; sex disparity; rural China

Strengths and Limitations:

1. This is the first study to evaluate the association between social capital and health by sex in left-behind older adults in rural China.
2. Social capital was more strongly related to depression than to BADL and IADL in left-behind older adults in rural China.
3. A significant sex disparity in the association between social capital and health was observed.
4. The causal association between social capital and health, as well as the relationship between contextual social capital and health, was not examined.

1. Introduction

China has witnessed dramatic economic and social changes, as well as a rapid rise in the number of aging individuals, over the past several decades. By the end of 2016, people aged 60 and older accounted for 16.7% of the total population in China [1]. The rapid development of urbanization has attracted tens of millions of rural laborers to work in cities, which results in an increase in the number of left-behind older adults in rural China. Left-behind older adults usually refer to older adults aged 60 and older living in rural areas whose children work in other areas (usually cities) and do not live with them [2]. Currently, there are more than 40 million left-behind older adults in rural China, and this number may increase in the foreseeable future [3].

Since the 1990s, the association between social capital, which comes from social connections in our daily lives [4], and health has been widely discussed [5, 6], and it has been observed to be positive in numerous studies [7-9]. However, limited studies examine this association in older adults, especially in left-behind older adults in rural China [10, 11]. The poor health status of left-behind older adults has been reported and has received much attention [2, 3, 12]. With their children working in cities most of the time and living far away, left-behind older adults cannot obtain enough support from them, which results in the loss of social connections and economic and mental

instability [3]. Some evidence indicates that both the physical and the mental health of left-behind older adults are poorer than those of other older adults [2, 3, 13]. Furthermore, the sex disparity in health is widely discussed. It is recognized that males usually have a lower level of life expectancy but better perceived health than females do [14], and the sex disparity in the association between social capital and health is also observed in other studies [15, 16]. However, no sex disparity in this association has been examined in left-behind older adults.

Therefore, this study aimed to answer two questions. First, was there an empirical association between social capital and left-behind older adults' health in rural China? Second, was there a sex disparity in the empirical association above?

1.1. Definition and measures of social capital

Numerous views on the definition of social capital have been proposed, among which Putnam's communitarianism is considered the most influential in the area of public health [5]. Putnam considered social capital to be a kind of social structure and emphasized the collective attributes of it as well as its power on individual actors from the perspective of cohesion [17, 18]. Accordingly, trust, social networks and participation are the most widely used measures of social capital in the area of public health [5, 19]. Trust is a sense of confidence or expectation generated from the belief that others will behave decently and predictably [20, 21], which is the most widely used measure of social capital in public health. Social networks refer to social contacts among individuals, which is a stable system formed through social interactions. Social participation refers to engagement in formal or informal associations or activities [18, 22]. It is recognized that social capital consists of cognitive and structural components, such that trust pertains to the former, whereas social networks and participation pertain to the latter [5, 17, 23]. Furthermore, the framework in which social capital can be divided into bonding and bridging forms has also been widely used in the area of public health [5]. Bonding social capital means a kind of in-ward social connection among individuals within homogeneous groups, while bridging social capital refers to an extroverted social connection among members from heterogeneous groups [17, 18, 24].

Accordingly, trust, social networks and participation were used as measures of social capital in this study.

1.2. Social capital and health in older adults

Limited studies are available on the association between social capital and health in older adults. Pollack and Knesebeck examined the association between social capital and older adults' health in the US and Germany and reported that low-level reciprocity, trust and social participation were related to poor self-rated health (SRH) and elevated depression [10] but were not associated with physical function. Most studies conducted in Europe and Asia also observe an association between social capital and health in older adults. For example, evidence from Northern Europe shows that structural social capital, including social contacts with neighbors/friends, was related to older adults' decreased depression, because contacts with others provide access to resources and support and generate mutual benefits [25]. For cognitive social capital, trust among friends [25] is observed to be positively related to older adults' psychological health, while general trust [26] and trust among neighbors [25] are not related to their psychological health. Evidence from Japan indicates that elevated social participation is associated with elevated functional capacity in older adults [27], and a well-structured social network is negatively related to older adults' mortality [28, 29]. By contrast, trust and norms of reciprocity are not associated with mortality [28]. Furthermore, cognitive social capital, including trust and norms of reciprocity, is also observed to be positively related to older adults' SRH [30] and mental health [31], but an elevated social network is more likely to be associated with better mental health than with better SRH among older adults [32].

Studies on social capital and older adults' health in China are also limited. Based on the Chinese General Social Survey (CGSS), Norstrand and Xu argued that bonding trust and bonding networks were positively associated with older adults' physical and mental health in urban China, but rural older adults did not obtain health returns from bonding trust and networks. The norm of reciprocity was not related to the health of older adults across China [11]. Based on the China Health and Retirement Longitudinal

Study (CHARLS), Xue and Liu found that participation in social activities significantly promoted the SRH of older adults [33]. Using an instrumental variable approach, Liu et al. also observed that elevated social participation was causally associated with better SRH and physical health [34]; however, Shen et al. observed that only perceived help was related to better SRH, and the social network was not related to the SRH of older adults in China [35].

What we should notice is the sex disparity in the association between social capital and health among the older adults. It is observed that trust is not related to female older adults' health. For example, Chemaitelly et al. argued that although social networks, trust and norms of reciprocity were positively associated with older adults' SRH, elevated trust in older females was not related to better SRH [15]. Furthermore, Aida et al. proposed that elevated social trust might reduce the physical health of older females [28]. In China, Xue and Liu proposed that participation in social activities had a stronger promoting effect on the SRH of older female adults [33]; Sun et al. also proposed that although social capital was associated with better physical and mental health of older adults of both sexes, the positive association between social capital and mental health was stronger in older females in rural China [16]. Accordingly, the sex disparity in the association between social capital and older adults' health has not yet been fully established and requires further discussion.

In summary, it is evident that studies on the association between social capital and the health of rural older adults in China are limited, and only one study has examined this association in left-behind older adults [36]. However, multiple health outcomes should be examined in older adults when discussing this issue, and the potential sex disparity in this association should also be examined. Left-behind older adults have unique life experiences that are quite different from those of other older adults [3]. Studies on the association between social capital and the health of left-behind older adults in rural China have important policy implications in improving the well-being of this vulnerable group. Hence, this study aimed to examine the association between social capital and the health of left-behind older adults in rural China.

2. Data and methods

2.1 Data source

The data used in this study were obtained from a field cross-sectional survey conducted in five counties/cities in China, including Yingcheng County and Mian County in July, 2017, as well as Lechang City, Jieyang City, Suixi County in August, 2018. Yingcheng County is located in the central area of Hubei Province, with a per capita GDP of 39,019 Chinese Yuan (CNY) and a population of 666,000 in 2016. Mian County is located in the southwest corner of Shaanxi Province, with a per capita GDP of 26,153 CNY and a population of 426,000 in 2014. Lechang City is located in the northern area of Guangdong Province, with a per capita GDP of 19,952 CNY and a population of 521,000 in 2017. Jieyang City is located in the eastern area of Guangdong Province, with a per capita GDP of 35,327 CNY and a population of 6086,000 in 2017. Suixi County is located in the southwest corner of Guangdong Province, with a per capita GDP of 23,761 CNY and a population of 1039,000 in 2017. Considering the regional differences in socioeconomic development, the above three provinces were randomly selected as representative of Eastern, Central and Western China, as Chinese internal migrants usually move from central and western China to eastern China across provinces, and move from villages and small cities to provincial capitals within specific provinces[1].

In the present study, rural adults aged 60 or older with all children working in urban areas were defined as left-behind older adults. Simple random sampling, convenience sampling and cluster sampling methods were used in the present study. More specifically, since we could not obtain the total composition of left-behind older adults (such as age and sex) in rural China, we used random sampling, convenience sampling and cluster sampling methods at different stages of the survey. First, the

[1] According to the data of *China Statistical Yearbook 2018*, the proportion of older adults is 7.8%, 12.2% and 11.1% in Guangdong, Hubei and Shaanxi Provinces, respectively, in 2017. The aging level in Guangdong Province is lower than that of the other regions due to the influx of workers to Pearl River Delta Region, and the aging level in Hubei and Shaanxi Provinces is higher. There are also numerous rural laborers working out in all five counties/cities, suggesting that these areas are nationally representative more or less.

random number table was used to randomly select one province in each of the three different regions (Eastern China, Central China, and Western China). Second, as the level of homogeneity across different counties/cities within a province or different towns/villages within a county/city was high, the convenience sampling method was considered to be acceptable in ensuring the representativeness and made the survey more feasible; thus, based on the principle of easy access to the survey sites, we contacted the counties/cities that could assist in carrying out the survey, mainly relying on personal social networks. Finally, with the assistance of local officials, a reliable list provided by local officials was used to reduce the selection bias when a cluster sampling method was used to investigate individuals in villages; furthermore, a door-to-door investigation was conducted, and trained interviewers knocked on doors or gathered left-behind older adults in village committees for face-to-face interviews. A total of 1106 questionnaires were distributed and collected, and no respondent refused to be interviewed (The questionnaire was uploaded as a supplementary file). Finally, questionnaires with more than 20% unanswered questions were not included in the analysis (mainly due to physical reasons, such as hearing and cognitive impairment). Thus, a total of 90 questionnaires were excluded, and the data used in this study were obtained from 1016 questionnaires, which accounted for 91.9% of the questionnaires collected[2].

2.2 Patient and public involvement

This study did not involve patients in the setting of the research question, the design of the study or the recruitment to and conduct of the study. The dissemination of the results will include communication channels that will involve local communities.

2.3 Variables

[2] Questionnaires excluded in the analysis were those with many questions (more than 20%) unanswered. Since the missing rate is 8.1% (less than 10%), we do not think it yields a significant bias for our analysis. The final sample size was 1016, indicating a large sample survey, so it was not likely for the statistical power to be low.

2.3.1 Social capital

Three components of social capital, namely, trust (cognitive), social participation (structural) and social networks (structural) were used[3]. Trust encompassed trust in family members, neighbors, friends and strangers, and response options included the following: "0=very distrustful, 1=relatively distrustful, 2=relatively trustful, 3=very trustful". Trust in family members and strangers were treated as family trust (bonding) and stranger trust (bridging), respectively, with "very distrustful" and "relatively distrustful" recoded as "distrustful" and "relatively trustful" and "trustful" recoded as "trustful"; trust scores for neighbors and friends were added and conceptualized as friend/neighbor trust (bonding). It is highlighted that, according to the *Chaxu* pattern, the interpersonal pattern of Chinese residents is similar to the ripple that opens wide on the water surface [37]. Thus, although family trust and friend/neighbor trust were forms of bonding social capital according to Putnam's definition [17], they were considered to be two different social capital variables in this study, as family members are blood ties, while friends and neighbors are not blood ties.

Social participation included participation in chess activities, collective fitness activities, gathering/chatting, organization activities and other activities (0=not participated, 1=participated), and they were added to measure the level of social participation; subsequently, participating in no activity was recoded as low-level participation, participating in only one activity was recoded as middle-level participation, and participating in more than one activity was recoded as high-level participation.

Social network consisted of network size and network density. Network size was determined by the number of close friends (ranging from 0~10); the weekly frequency of interactions with friends (ranging from 0~7) in the past year, both online and offline, were added to measure network density. For the network density, no

[3] The reliability (α coefficient) was not reported, as participation and networks were defined in a formative not a reflective way; trust was encompassed by three independent variables, and they pertained to different forms of social capital (bonding and bridging). Thus, there was no need for the reliability α coefficient.

interaction per week was recoded as low-level network density, less than seven interactions per week were recoded as middle-level network density, and seven or more interactions per week were recoded as high-level network density.

2.3.2 Health outcomes

Health outcomes consisted of physical and psychological health. Physical health included BADL [38] and IADL [39]. BADL referred to the ability to eat, walk, visit friends, dress and bathe, and the response options for each item included the following: 0=completely depend on others, 1=partly depend on others, 2=do not depend on others completely. Five items were added to measure BADL. IADL referred to the capacity to cook, shop, clean and take a bus, and the response options for each item included the following: 0=completely depend on others, 1=partly depend on others, 2=do not depend on others completely. Four items were added to measure IADL. The Life Satisfaction Index Scale was used to measure depression, a psychological health indicator [40, 41], and the response options for each item included the following: 0=not depressed, 1=depressed. Subsequently, a total of 12 indices were added to measure depression. Details are displayed in Table 1.

Table 1 Measures of health of left-behind older adults in rural China in 2017-2018 (N=1016)

Health	Indicators	Range	Reliability α
BADL	Ability to eat independently	0-2	0.879
	Ability to walk independently	0-2	
	Ability to visit friends independently	0-2	
	Ability to dress independently	0-2	
	Ability to bath independently	0-2	
IADL	Ability to cook independently	0-2	0.873
	Ability to shop independently	0-2	
	Ability to clean independently	0-2	
	Ability to take a bus independently	0-2	
Depression	Are you satisfied with your life?	0-1	0.839
	Do you continue to pursue hobbies?	0-1	
	Do you have a sense of life enrichment?	0-1	
	Do you feel upset?	0-1	
	Do you feel good in spirits?	0-1	

Do you have a sense of insecurity?	0-1
Do you feel happy?	0-1
Do you have a sense of loneliness?	0-1
Do you feel good to be alive?	0-1
Do you have a sense of unworthiness?	0-1
Do you feel energetic?	0-1
Do you feel hopeless?	0-1

Note: A total of 15 items were used to measure depression in the questionnaire, and three of them were excluded in the analysis because their single-item reliability α were less than 0.800.

2.3.3 Control variables

Control variables included sex, age, marital status, education, family income (a natural logarithmic transformation was performed), living status (whether living with other people or not) and province. More details are provided in Table 2.

2.4 Methods

Cronbach's α coefficient was used to assess the internal consistency of specific health outcomes, and Cronbach's α>0.60 was used as the criterion to ensure reliability [42]. χ^2 tests and t-tests were used to examine whether the sex differences in different variables were statistically significant. Although all three health outcomes were ordinary variables, the parallel-lines assumption was not supported in ordinal regression. Therefore, the OLS model was used to examine the association, in both sexes and by sex, between various forms of social capital and different health outcomes of left-behind older adults in rural China. This strategy, which treats ordinal outcome as continuous outcomes, is supported and widely used in many other studies [9, 34]. According to previous studies, there might be sex disparities in the association between social capital and health in older adults [16, 28, 33]. Thus, stratification by sex was used, and males and females were analyzed separately to compare the sex disparity in the association between social capital and health in left-behind older adults. The model specification of OLS was as follows:

$$Health_i = \beta_0 + \sum_1^p (\beta_p * control\ variable_i) + \sum_1^k (\beta_k * social\ capital_i) + \varepsilon_i$$

where $Health_i$ represented the health outcome of individual i; β_0 represented

the intercept; β_p represented the estimated coefficients of variables controlled for (p=1~8 in full samples and 1~7 in male or female samples), β_k represented the estimated coefficients of social capital variables (k=1~6), and ε_i represented the residual error of the model.

SPSS version 21.0 was used to perform OLS models; robust standard error was used to adjust for potential heteroscedasticity, given that a cluster sampling method was used to interview respondents within villages. Statistical significance was assumed if p<0.05.

3. Results

3.1 Descriptive analysis

Table 2 describes the sample of 1016 participants, consisting of 484 males and 532 females. Compared to males, females seemed to have a higher level of depression (p=0.002) and a lower level of IADL (p=0.013) but also had slightly higher levels of friend/neighbor trust (p=0.060) and network density (p=0.057). Furthermore, compared to males, females in the sample seemed to be less educated (p<0.001), less likely to be married (p<0.001) and less likely to live with others (p<0.001).

Table 2 Descriptive information of left-behind older adults in rural China in 2017-2018 (N=1016)

Control variables	Coding	Males (N=484)				Females (N=532)				Range	p-value of χ^2/T test
		N	%	Mean	SD	N	%	Mean	SD		
Age				71.36	7.29			71.57	7.91	60-95	0.656
Marital status	married	383	79.1			304	57.1				<0.001
	divorce/widow	101	20.9			228	42.9				
Education	illiteracy	165	34.1			369	69.4				<0.001
	primary school	199	41.1			130	24.4				
	junior high school	94	19.4			19	3.6				
	≥senior high school	26	5.4			14	2.6				
Family income				8.99	0.92			8.96	1.06		0.602
Living status	alone	87	18.0			161	30.3				<0.001
	not alone	397	82.0			371	69.7				
Region	Shaanxi	206	42.6			154	29.0				<0.001

	Hubei	142	29.3			189	35.5			
	Guangdong	136	28.1			189	35.5			
Independent variables										
Family trust	trust	474	97.9			524	98.5		0-1	0.497
	not trust	10	2.1			8	1.5			
Friend/neighbor trust				4.31	1.11			4.44	1.09	0-6	0.060
Stranger trust	trust	96	19.8			109	20.5		0-1	0.795
	not trust	388	80.2			423	79.5			
Participation	low	124	25.6			142	26.7		0-2	0.916
	middle	275	56.8			296	55.6			
	high	85	17.6			94	17.7			
Network size				2.89	2.84			2.87	2.56	0-30	0.933
Network density	low	113	23.3			107	20.1		0-2	0.057
	middle	224	46.3			226	42.5			
	high	147	30.4			199	37.4			
Dependent variables										
BADL				9.85	0.75			9.80	0.96	0-10	0.358
IADL				7.48	1.41			7.24	1.67	0-8	0.013
Depression				3.27	2.99			3.90	3.38	0-12	0.002

Note: N means number, SD means standard deviation.

3.2 Social capital and BADL

Associations between social capital and the BADL of left-behind older adults in rural China are presented in Table 3. With other variables controlled for, compared with low-level social participation and network density, high-level social participation and network density were associated with elevated BADL (b=0.16, $p<0.05$; b=0.24, $p<0.05$; respectively). However, the association between high-level social participation and elevated BADL was observed in males only (b=0.19, $p<0.05$), and the association between middle- or high-level network density and elevated BADL was observed in females only (b=0.52, $p<0.05$; b=0.44, $p<0.05$; respectively). Furthermore, no significant association was observed between other forms of social capital, including family trust, friend/neighbor trust, stranger trust and network size, and the BADL of left-behind older adults in all three models.

Table 3 Social capital and BADL of left-behind older adults in rural China in

2017-2018 (N=1016)

	Model 1 (all samples)		Model 2 (males)		Model 3 (females)	
	b	R_SE	b	R_SE	b	R_SE
Intercept	9.75***	0.48	9.29***	0.75	10.04***	0.61
Sex (ref: female)	0.05	0.06				
Age	-0.01**	0.00	-0.01	0.01	-0.02**	0.01
Married (ref: divorce/widow)	-0.02	0.10	-0.02	0.09	-0.04	0.13
Education (ref: illiteracy)						
primary school	0.07	0.06	0.15*	0.07	0.03	0.12
junior high school	-0.06	0.10	-0.01	0.12	0.10	0.08
senior high school or above	-0.11	0.15	0.05	0.09	-0.37	0.34
Family income (ln)	0.06	0.03	0.06	0.05	0.06	0.03
Living status (ref: not alone)	-0.02	0.10	0.04	0.08	-0.03	0.15
Province (ref: Shaanxi)						
Hubei	-0.13	0.08	-0.25	0.13	-0.03	0.08
Guangdong	-0.13	0.07	0.02	0.08	-0.23	0.12
Family trust (ref: not trust)	0.28	0.30	0.31	0.41	0.30	0.46
Friend/neighbor trust	0.02	0.03	0.01	0.04	0.05	0.04
Stranger trust (ref: not trust)	-0.05	0.08	-0.06	0.12	-0.02	0.09
Participation (ref: low)						
middle	0.06	0.08	0.09	0.10	0.04	0.13
high	0.16*	0.08	0.19*	0.10	0.10	0.11
Network size	-0.01	0.02	0.01	0.02	-0.02	0.02
Network density (ref: low)						
middle	0.18	0.12	-0.16	0.10	0.52*	0.21
high	0.24*	0.11	-0.00	0.09	0.44*	0.17
N	1016		484		532	
R^2	0.047		0.053		0.098	

Note: ***p<0.001, **p<0.01, *p<0.05. b: coefficient. R_SE: robust standard error.

3.3 Social capital and IADL

Associations between social capital and the IADL of left-behind older adults in rural China are presented in Table 4. With other variables controlled for, no significant association was observed between social capital and IADL. However, a significant sex disparity in the association between social capital and IADL was observed. For older males, only high-level social participation was associated with elevated IADL (b=0.43, p<0.05). By contrast, compared with low-level network density, middle- and high-level network density was associated with elevated IADL in older females only (b=0.61, p<0.05; b=0.57, p<0.05; respectively).

Table 4 Social capital and IADL of left-behind older adults in rural China in 2017-2018 (N=1016)

	Model 1 (all samples)		Model 2 (males)		Model 3 (females)	
	b	R_SE	b	R_SE	b	R_SE
Intercept	10.00***	0.95	10.29***	1.42	9.80***	1.27
Sex (ref: female)	0.14	0.10				
Age	-0.06***	0.01	-0.05***	0.01	-0.06***	0.01
Married (ref: divorce/widow)	0.04	0.17	-0.23	0.18	0.16	0.22
Education (ref: illiteracy)						
primary school	0.25*	0.11	0.45**	0.16	0.13	0.18
junior high school	0.11	0.15	0.27	0.19	0.21	0.19
senior high school or above	-0.02	0.25	0.41	0.25	-0.60	0.54
Family income (ln)	0.07	0.06	0.01	0.09	0.11	0.08
Living status (ref: not alone)	0.14	0.18	-0.06	0.16	0.24	0.26
Province (ref: Shaanxi)						
Hubei	-0.22	0.12	-0.31	0.18	-0.15	0.16
Guangdong	-0.62***	0.13	-0.28	0.17	-0.89***	0.20
Family trust (ref: not trust)	0.60	0.57	0.77	0.92	0.48	0.74
Friend/neighbor trust	-0.02	0.04	-0.06	0.06	0.04	0.06
Stranger trust (ref: not trust)	0.16	0.13	0.23	0.17	0.10	0.18
Participation (ref: low)						
middle	-0.02	0.13	0.09	0.18	-0.15	0.19
high	0.19	0.14	0.43*	0.20	-0.06	0.21
Network size	-0.00	0.02	0.02	0.03	-0.01	0.04
Network density (ref: low)						
middle	0.17	0.17	-0.27	0.18	0.61*	0.27
high	0.28	0.17	-0.05	0.19	0.57*	0.26
N	1016		484		532	
R^2	0.140		0.123		0.187	

Note: ***p<0.001, **p<0.01, *p<0.05. b: coefficient. R_SE: robust standard error.

3.4 Social capital and depression

Associations between social capital and the depression of left-behind older adults in rural China are presented in Table 5. With other variables controlled for, elevated family trust, friend/neighbor trust, stranger trust, high-level social participation and middle-level network density were associated with reduced depression (b=-3.23, p<0.001; b=-0.41, p<0.001; b=-0.76, p<0.01; b=-1.04, p<0.001; b=-0.74, p<0.05; respectively). A significant sex disparity in the association between social capital and

depression was also observed. For older males, elevated family trust and stranger trust and high-level social participation were associated with reduced depression (b=-2.86, p<0.05; b=-0.68, p<0.05; b=-0.92, p<0.05; respectively). By contrast, for older females, elevated family trust, friend/neighbor trust and stranger trust, as well as high-level social participation and middle-level network density, were associated with reduced depression (b=-3.86, p<0.001; b=-0.56, p<0.001; b=-0.80, p<0.05; b=-1.22, p<0.01; b=-1.05, p<0.05; respectively).

Table 5 Social capital and depression of left-behind older adults in rural China in 2017-2018 (N=1016)

	Model 1 (all samples)		Model 2 (males)		Model 3 (females)	
	b	R_SE	b	R_SE	b	R_SE
Intercept	14.93***	1.53	14.30***	2.17	15.19***	2.21
Sex (ref: female)	-0.62**	0.20				
Age	0.01	0.01	0.00	0.02	0.01	0.02
Married (ref: divorce/widow)	-0.35	0.34	-0.32	0.55	-0.43	0.43
Education (ref: illiteracy)						
primary school	-0.21	0.21	-0.04	0.30	-0.33	0.31
junior high school	-0.27	0.32	-0.37	0.40	0.16	0.67
senior high school or above	-0.36	0.40	-0.72	0.44	0.43	0.75
Family income (ln)	-0.51***	0.10	-0.64***	0.17	-0.39**	0.14
Living status (ref: not alone)	-0.18	0.36	-0.18	0.58	-0.20	0.46
Province (ref: Shaanxi)						
Hubei	0.47	0.28	0.23	0.36	0.77	0.43
Guangdong	-1.31***	0.25	-0.99**	0.34	-1.50***	0.40
Family trust (ref: not trust)	-3.23***	0.84	-2.86*	1.26	-3.86***	0.96
Friend/neighbor trust	-0.41***	0.10	-0.26	0.14	-0.56***	0.14
Stranger trust (ref: not trust)	-0.76**	0.24	-0.68*	0.34	-0.80*	0.34
Participation (ref: low)						
middle	-0.33	0.23	-0.23	0.32	-0.44	0.32
high	-1.04***	0.29	-0.92*	0.40	-1.22**	0.44
Network size	-0.07	0.04	-0.03	0.06	-0.11	0.06
Network density (ref: low)						
middle	-0.74*	0.29	-0.46	0.40	-1.05*	0.43
high	-0.47	0.33	-0.18	0.47	-0.74	0.48
N	1016		484		532	
R^2	0.191		0.170		0.212	

Note: ***p<0.001, **p<0.01, *p<0.05. b: coefficient. R_SE: robust standard error.

4. Discussion

With the recent rapid urbanization in China, the number of left-behind older adults in rural China is on the rise. For this reason, studies on the association between social capital and health in left-behind older adults have substantial and theoretical significance. Based on a cross-sectional survey conducted in Hubei, Shaanxi and Guangdong Provinces in China in 2017-2018, this is the first study to discuss the association between social capital and the health of left-behind older adults by sex in rural China.

A higher level of social participation is associated with better physical health, especially better BADL. Social participation usually increases physical activities and keeps left-behind older adults healthy, and older adults with poor physical health are also less likely to engage in social activities [43]. Furthermore, the positive association between participation and physical health is statistically significant in males only, because social participation is usually a major activity among males in China. That is, in China, males are usually in charge of outdoor affairs, and females are usually in charge of indoor affairs [33]. Furthermore, compared with females, males' participation usually includes more instrumental values and brings more material benefits [44]. Thus, older males obtain more physical health benefits from social participation.

A higher level of density of social networks is observed to be related to better physical health of rural left-behind older adults, but no association is observed between social network size and the two physical health outcomes. That is, for left-behind older adults, having high-quality social networks or many friends is not associated with physical health itself; rather, the mere presence of any social network (contact with friends) is what matters with respect to physical health. These results are in line with related evidence from Japan and Northern Europe [25, 28, 29]. Furthermore, older females benefit more from contact with others, potentially because older females have a higher level of network density than older males do (see Table 2).

Most elevated social capital indicators are associated with better psychological health of left-behind older adults in rural China. Social trust reflects confidence and positive psychological expectation from others [21], so it helps reduce depression and

improve perceived psychological health. Participating in various social activities provides left-behind older adults with a platform to communicate with others and reduces the possibility of depression. Contact with friends directly increases affective interactions and the sense of belonging, thus reducing mental health problems. However, in the comparison between males and females, it is observed that most social capital indicators, including family trust, friend/neighbor trust, stranger trust, social participation and network density, are more strongly related to female psychological health, which is similar to the results of Sun et al. [16]. Compared with males, females are more likely to seek support and mobilize support resources (especially emotional support) from others and navigate emotional changes with greater ease [16, 45]. Furthermore, females have higher levels of some social capital indicators (see Table 2), which also brings them more health benefits. Thus, older females receive more psychological health returns from support resources from others.

Based on the above results, several interventions to improve the stock of social capital in left-behind older adults in China are proposed. First, primary-level organizations should stress daily collective activities for left-behind older adults, especially female older adults. Senior centers should be built to provide left-behind older adults with a platform to engage in social activities, which allows them to increase social interactions and benefits their health. Second, the children of left-behind older adults are encouraged to take good care of their parents, as they need to resolve difficulties through both material rewards and spiritual rewards. Finally, village committees should take responsibility for developing a healthy neighborhood relationship, which can improve the level of trust in left-behind older adults and, in turn, improve their psychological health.

There are several limitations in this study. First, this is a cross-sectional study and current results for the association between social capital and health cannot be explained as causal, so further studies using longitudinal data and causal inference approaches are needed. Second, because the populations evaluated are from different villages, it is likely that the characteristics of those villages may have some contextual

effect on the association between social capital and health [30]. However, this contextual effect was found to be statistically nonsignificant in this study (the *p*-value of the intraclass correlation coefficient was larger than 0.05). Thus, the macrolevel effect of the villages where these older adults live is not reported in this study, and further studies on this topic are needed.

5. Conclusions

This is the first study to discuss the association between social capital and the physical/psychological health of left-behind older adults, as well as the sex disparity in this association, in rural China. The results show that in left-behind older adults, multiple forms of social capital were associated with health outcomes, but cognitive social capital was associated with depression only. Furthermore, a significant sex disparity in the association between social capital and health in left-behind older adults was also observed. According to these results, interactions should be encouraged between older adults and their family members or neighbors/friends to build trust, and senior centers should be built to provide left-behind older adults with a platform for social participation and interaction in rural China.

Abbreviations

BADL: Basic Activities of Daily Living

CGSS: Chinese General Social Survey

CHARLS: China Health and Retirement Longitudinal Study

IADL: Instrumental Activities of Daily Living

OLS: ordinary least square

R_SE: robust standard error

SD: standard deviation

SRH: self-rated health

Author statements

Contributorship statement

Jiang & Ke designed the study; Chen & Ke collected the data; Jiang, Chen & Ke all wrote, revised and reviewed the manuscript.

Data sharing statement

No additional data are available.

Ethical approval

We declare that this study is complied with ethical standards. Wuhan University of Science and Technology grants ethical approval for this study.

Funding

This study is supported by the national social science fund: Researches on the quality of life of rural left-behind older adults in the setting of aging (No. 16BRK014).

Acknowledgement

We thank all the participants in the survey. Especially, we appreciate the valuable effort made by Qihong Wang from Bank of America.

Competing interests

The authors declare that they have no competing interests.

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Questionnaire number： □□□□

Questionnaire on the quality of life of the left-behind older adults in rural China

* *

Address：

province（municipality）________________________ city\district\county____________________

town_________________________village committee/community____________________________

Access object number (four figures)______________Interviewer signature_________________

* * * * * * * * * * * * * * * * * 【Preface】 * * * * * * * * * * * * * * * * *

Dear grandpa/grandma:

I am an interviewer from Wuhan University of Science and Technology. We are conducting a survey on the quality of life of rural left-behind older adults. The purpose of this survey is to know the living conditions and the needs of rural left-behind older adults, as well as to provide a scientific basis for the government to make policy.

There is no right or wrong answer to the question in the questionnaire. You only need to answer it according to the actual situation. For your answer, we will strictly keep confidential according to the provisions of the Statistical Law, and only for statistical analysis, please do not have any concerns. We hope you can help us complete this survey. Thanks for your cooperation.

Research Group of Rural left-behind elderly life quality

Wuhan University of Science and Technology

Note: All the scores in this questionnaire are subject to the following satisfaction scale. Using the 1-10 point, indicate your agreement with each item.

0	1	2	3	4	5	6	7	8	9	10
Extremely dissatisfied	**Dissatisfied**		**Slightly dissatisfied**		**Neutral**	**Slightly satisfied**		**Satisfied**		**Extremely satisfied**

A. Basic situations

A1. Sex

1. Male 2.Female

A2. How old are you? ______

A3. Which of the following is your current marital status? (If he or she chooses 3, skip F1-1)

1. Married 2. Divorced 3. Widowed 4. Unmarried 5. Cohabitation

A4.What is your education level?

1. Illiteracy 2. Elementary school 3. Junior high school 4. Senior high school

5. Professional high school / Technical school 6. College or university

A5. Are you a religious believer? If so, please choose which religion you belong to.

1. No religion. 2. Buddhist 3. Christian 4. Taoism 5. Islam 6. Others

A6. What is your current living style? (If he or she does not choose 2, skip E3/E4)

1. Living with spouse 2. Living with spouse and grandchildren 3. Separating with spouse

4. Living alone 5. Living with relatives 6. Others

A7.How many people are living in your family? ______ how many people are under 15 years old (including 15 years old)? _______

B Life needs and satisfaction

B1 Please judge the importance of the following options to your life (a larger number means a stronger need).

Life needs	0	1	2	3	4	5	6	7	8	9	10
1.Income											
2.Money for food											
3.Medical money											
4.House											
5.Living facility											
6.Physical health											
7.Mental health											
8.Conjugal relations											
9.Filial piety											
10.Family harmony											
11.Interpersonal relationship											
12.Social support											
13.Productive labor											
14.Leisure life											
15.Participate in social activities											
16.Community leisure places and facilities											
17.Leisure activities organized by the community											
18.Community air quality											
19. Community water quality											
20.Community security situation											
21.Community public transportation											
22.Living environment											
23.New rural social pension insurance policy											
24.New rural cooperative medical policy											
25.Public pension service											
26.Public medical service											
27.Respected in society											
28.Be cared in society											
29.Self- fulfillment											

B2 Do you agree the following statements?

	Life satisfaction index	agree	disagree	depends
1	As I grow older, things seem to be better than I thought they would be.			
2	This is the dreariest time of my life.			
3	This is the dreariest time of my life.			
4	I am just as happy as when I was younger.			
5	These are the best years of my life.			
6	Most things I am doing are boring or monotonous.			
7	I expect some interesting and pleasant things to happen to me in the future.			
8	The things I do are as interesting to me as they ever were.			
9	I feel old and somewhat tired.			
10	As I look back on my life I am fairly well satisfied.			
11	I would not change my past life even if I could.			
12	Compared to other people my age, I make a good appearance.			
13	I have made plans for thing I'll be doing a month or a year from now.			
14	Compared to other people, I get down in the dumps too often.			
15	I've gotten pretty much what I expected out of life.			

B3 In general, how satisfied are you with your current life?

Extremely dissatisfied Extremely satisfied

0 1 2 3 4 5 6 7 8 9 10

C Economic situation

C1Did you have the following personal income last year? (if have, how much?)

1. Subsistence allowance assistance（Including medical assistance） 1.Yes _____ Yuan 0.No

2. Collective village assistance 1. Yes _____ Yuan 0. No

3.Social pension insurance 1. Yes _____ Yuan 0. No

4.Money given by children (including physical, purchased services and 1. Yes_____ Yuan 0. No

5.Money given by grandchildren 1. Yes _____Yuan 0. No

6.Money given by relatives 1. Yes _____Yuan 0. No

7.Income from farming 1. Yes _____Yuan 0. No

8.Work income 1. Yes _____Yuan 0. No

9.Others_____ 1. Yes _____Yuan 0. No

C2 How much did your family earn last year? How much was left after the cost of living?

C3 How much is your family's monthly living expenses? How much does it cost to eat?

C4 How much money did you spend on medical treatment last year? _____Yuan.

C5 How many rooms does your house have? （Only living rooms and bedrooms are counted）

C6 What is the square meter of your bedroom?

C7 Do you have an indoor bathroom?

1.Yes 2. No

C8 Do you have the following living facilities? (multiple choices)

1.TV 2. Refrigerator 3. Washing machine 4. Air conditioner 5. Gas stove 6.Mobile phone

C9 Please rate the following options according to your satisfaction.

		0	1	2	3	4	5	6	7	8	9	10
1	Income											
2	Money for food											
3	Medical money											
4	House											
5	Living facility											
6	General economic situation											

D Health and function

D1 Can you complete the following activities independently?

	Yes	Partly dependent on others	No
1.Eating			
2.Walking			
3.Toilet			
4.Dressing			
5.Bath			
6.Cooking			
7.Shopping			
8.Cleaning			
9.Taking a bus			

D2 Please judge the following statements based on the past week.

item	yes	no
1. Are you satisfied with your life?		
2. Do you continue to pursue hobbies?		
3. Do you have a sense of life enrichment?		
4. Do you feel upset?		
5. Do you feel good in spirits?		
6. Do you have a sense of insecurity?		
7. Do you feel happy most of the time?		
8. Do you have a sense of loneliness?		
9. Do you prefer to stay at home rather than go out and try new things?		
10. Do you feel you have more problems with your memory than most?		

11. Do you feel good to be alive?		
12. Do you have a sense of unworthiness?		
13. Do you feel energetic?		
14. Do you feel hopeless?		
15. Do you think most people are richer than you?		

D3 Do you suffer from any of the following diseases? (multiple choices)

1. Respiratory system diseases (chronic bronchitis, pulmonary tuberculosis, etc.)
2. Digestive system Diseases (chronic gastritis, etc.)
3. Circulatory system disease (heart disease, high blood pressure, stroke, etc.)
4. Endocrine and metabolic diseases (diabetes)
5. Diseases of genitourinary system (chronic nephritis, etc.)
6. Malignant tumor
7. Nothing

D4 Have the above diseases affected your life greatly? （If last question selected seven ,skip this question）

1.Great effect 2. Some effect 3. Neutral 4. A little effect 5. No effect

D5 In the past year, did you delay treatment for two weeks? （If he chooses 2, skip the next problem）

1.Yes 2. No

D6 Why you delay treatment for two weeks? （Multiple selection）

1.Economic difficulties 2. Feel not serious 3. No time 4. Inconvenient transportation
5. No effective measures 6. Others

D7 Please rate the following options according to your satisfaction.

	0	1	2	3	4	5	6	7	8	9	10
1.Physical health											
2.Mental health											

E Productive labor and leisure life

E1 How many hours do you work per week during busy seasons? How many hours do you work odd jobs during slack seasons?

E2 Do you think the burden of production labor is heavy?

1. No 2. A little 3. Neutral 4. Heavier 5. Quite

E3 How many hours do you take care of your grandchildren every week? (If A6 selects options other than 2, then E3/E4 is skipped)

E4 Do you think that the burden of caring for grandchildren is heavy?

1. No 2.A little 3.Neutral 4、Heavier 5、Quite

E5 Which of the following activities have you participated in during the past month? (Multiple choices)

1. Chess and mahjong 2. Physical fitness activities (square dance, etc.)
3. Gathering/chatting 4. Social organization activities 5. Travel
6. Watch TV/listen to radio 7.Reading books\newspapers 8. Others_____
9. None of the above

E6 Which of the following activities or facilities in the community? (Multiple choices)

1. Old-age activity room 2. Sports grounds and physical exercise facilities
3. Library room 4. Chess room 5. Cable TV/broadcast station

6.Others_____ _____ _____ 7. None of the above

E7 In the past year, did the community (village committee) organize the following activities? (Multiple choice)

1.Physical fitness activities (square dancing, etc.) 2. Chess and mahjong activities

3. Interest group (drama, calligraphy and painting) 4. Watching movies and plays

5. Visiting activities 6.Others_____ 7. None of the above

E8 Please rate the following options according to your satisfaction.

		0	1	2	3	4	5	6	7	8	9	10
1	Productive labor											
2	Community leisure places and facilities											
3	Leisure activities organized by the community											
4	Participate in social activities											
5	General leisure life											

F Family and social support

F1 In the past year, when you were in trouble, whether the people around you could offer the following help? (Note: Older people with multiple sons/daughters，Which son /daughter helped you most and how was the help? 】

supporter	A Financial support ①Yes ②No	B Daily care ①Never; ②Several times a year; ③At least once a month ④At least once a week; ⑤Almost every day	C Feeling comfort ①Never; ②Several times a year; ③At least once a month ④At least once a week; ⑤Almost every day	Rank
1.Spouse				
2.Son				
3.Daughter				
4.Neighbour				
5.Friend				
6.Relative				
7.Village committee staff				
8.Volunteer/non-profit organization				
9.Social worker				

F2 How many sons and daughters do you have? _____

F3 In the past year, how many times did you meet with your child each month? _____ How many times do you contact them by phone? _____

F4 How many important friends do you have? _____

F5 In the past year, how many times do you see your friends every week? _____ How many times

do you contact them by phone? _____

F6 Have you suffered the following abuses in the past year? (Multiple choices)_____

1. Economic abuse 2. Mental abuse 3. Physical abuse 4. Negligence in care

5. None of the above

F7 Please rate the following options according to your satisfaction.

		0	1	2	3	4	5	6	7	8	9	10
1	Marriage relationship											
2	Child relationship											
3	Family harmony											
4	Interpersonal relation											
5	Social support											

G Surroundings

G1 If you could live where you want, which one would you prefer?

1. Large cities 2. Medium-sized cities 3. Small cities 4. Towns or villages

5. Remote rural areas

G2 Are you afraid of being attacked when you walk alone in your neighborhood at night?

1.Yes 2. No

G3 How many crimes and disputes have occurred in your village in the past year?

G4 Where does the water you drink every day come from?

1. Well water 2. Tap water 3. River, lake, stream, spring water 4. Pond water

5. Pit water 6. Others_____

G5 Is there any public transportation in your village?

1. Yes 2. No

G6 Please rate the following options according to your satisfaction.

		0	1	2	3	4	5	6	7	8	9	10
1	Air quality											
2	Water quality											
3	Community security											
4	Community public transportation											
5	Total living environment											

H Public policy and pension services

H1 Have you joined the new rural social pension insurance?

1. No 2. Yes. How much do you pay each year?_____Yuan. How much do you get each month?_____Yuan.

H2 Have you participated in the new rural cooperative medical treatment?

1. No 2.Yes，What is the reimbursement rate?

H3 Does your village (town) have the following medical institutions? (Multiple choices)

H4 How far is the clinic (or hospital) from your home? How many meters?

H5 How far is the nearest nursing home/ aged home from your home? How many meters?

H6 Let me ask you some questions about the elderly services and institutions in your community (village).

Community service/organization	A Do you need		B Do you have		C Will you pay for the service?	
1.Health lectures and consultation	Yes	No	Yes	No	Yes	No
2.Periodic physical examination						
3. Rehabilitation training						
4. Psychological counseling						
5. Family doctor						
6. Meals-on-wheels						
7. shower\haircut help						
8. cleaning help						
9. First aid						
10. walking help						
11.Home appliance repair						
12.Chatting						
13. Family relationship mediation						
14.Day care center						
15.Nursing home						

H7 Please rate the following options according to your satisfaction.

		0	1	2	3	4	5	6	7	8	9	10
1	The new rural insurance policy											
2	The new rural cooperative medical policy											
3	Public pension service											
4	Public health services											

I Solutions

When you meet troubles or setbacks, how do you deal with them? Please answer them according to the option.

	Never	Occasionally	Sometimes	Often
1.Freed from work study or some other activities				
2.Change your mind and rediscover what is important in life				
3.Try to see the good sides of things				
4.Talk to people and share your worries				
5.Don't take the problem too seriously				
6.Stick to your own position and fight for what you want				
7.Find out several different ways to solve problems				

8.Seek advice from relatives or friends				
9.Change the original practices or problems				
10.Learning from others to deal with similar difficult situations				
11.Looking for a hobby, and actively participate in recreational sports activities				
12.Try to restrain disappointment, remorse, sadness, and anger				
13.Try to take a break and temporarily leave the problem				
14.Dispel troubles by smoking, drinking, taking medicine or eating				
15. Time will change the situation, and the only thing to do is to wait				
16.Try to forget the whole thing				
17.Rely on others to solve problems				
18. Accept it because there is no other choice				
19.It might happen some miracle to change the current situation				
20.Comfort yourself				

J Value

J1 What do you think of your life compared with the old people around you?

1.Worse 2. The same 3. Better

J2 What do you think of your life compared with the elderly in the city?

1.Worse 2. The same 3. Better

J3 How do you think your life has changed compared with the past?

1.Worse 2. The same 3. Better

J4 What do you think will change in your life in the future?

1.Worse 2. The same 3. Better

J5 What is the difference between your actual life and your life goals?

1.Great difference 2. A little difference 3. No difference

J6 Which class do you think you belong to?

1. The upper class 2. The upper middle class 3. The middle class 4. The middle and lower class 5. The lower class

J7 Who do you think should be responsible for the care of elderly with children?

1. The government is responsible 2. The children are responsible 3. The elderly are responsible for themselves 4. The government/children/old people should share the responsibility

J8 What kind of pension model do you want?

1. Home care 2. Institutional care 3. Community care 4. Others_____

J9 Are you willing to accept the following things?

	Yes	No
1.Become a volunteer to take care of other old man		
2.Accept to be taken care of by volunteers		
3.Engaged in paid work to take care of the other old man		

J10 Please rate the following options according to your satisfaction.

In social	0	1	2	3	4	5	6	7	8	9	10
1.Be respected											
2.Be loved											
3.Achieve personal values											

J11 How much trust do you have in the following groups?

	Totally	More	Less	Not at all
1.Your family				
2.Your neighbors				
3.Your friends				
4.Someone you meet for the first time				

K Life satisfaction and happiness (According to the score of K1/K2 and the willingness of the elderly to identify in-depth interviewees.)

K In general, how satisfied are you with your current life?

Extremely dissatisfied Extremely satisfied

0 1 2 3 4 5 6 7 8 9 10

K2 In general, do you feel happy? (Interviewer prompts respondents to answer it according to the satisfaction with life scale)

Very unhappy Very happy

0 1 2 3 4 5 6 7 8 9 10

K3 What is the most dissatisfied thing in your current life? 【Read the question but not to read the option. Circle the options according to the respondent's answers. If the respondent is not clear, you can read the option prompt to answer】（Multiple choices）

1. Insufficient money for food 2. Insufficient money for medical treatment 3. Unhealthy body 4. Bad relationship with spouse 5. Children are not filial 6. Children live far away 7. Bad relationship with neighbors / friends 8. Housing conditions are too poor 9. living with no care 10. lonely life 11. Overburden with taking care of grandchildren 12. Overburden with caring for sick family members 13. Subsidizing children (grandchildren) too much 14.Others_____

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Title: page 1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract: page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 3-6
Objectives	3	State specific objectives, including any pre-specified hypotheses	Page 4 and 6
Methods			
Study design	4	Present key elements of study design early in the paper	Page 2 and 6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 7-8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page 7-8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 8-11
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	Page 7-8
Bias	9	Describe any efforts to address potential sources of bias	Page 7-8 (footnote)
Study size	10	Explain how the study size was arrived at	Page 8 (footnote)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 8-11
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 11-12
		(*b*) Describe any methods used to examine subgroups and interactions	Page 11
		(*c*) Explain how missing data were addressed	Page 8
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Page 7-8
		(*e*) Describe any sensitivity analyses	None
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	Page 7-8, page 12-13
		(b) Give reasons for non-participation at each stage	Page 8
		(c) Consider use of a flow diagram	None
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 12-13
		(b) Indicate number of participants with missing data for each variable of interest	Page 12-13, no missing data
Outcome data	15*	Report numbers of outcome events or summary measures	Page 12-13
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted	Page 13-16

		estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	Page 9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	None
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 13-16
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 19
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	Page 18-19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 16-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 8 (footnote 1)
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	Page 20

*Give information separately for exposed and unexposed groups.