Research Paper

Network analysis of the relationships between depressive symptoms and social participation activities among Chinese older adults and its implications for nursing

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ABSTRACT

Objective: Network analysis was used to explore the complex inter-relationships between social participation activities and depressive symptoms among the Chinese older population, and the differences in network structures among different genders, age groups, and urban-rural residency would be compared.
Methods: Based on the 2018 wave of the Chinese Longitudinal Healthy Longevity Survey (CLHLS), 12,043 people aged 65 to 105 were included. The 10-item Center for Epidemiologic Studies Depression (CES-D) Scale was used to assess depressive symptoms and 10 types of social participation activities were collected, including housework, tai-chi, square dancing, visiting and interacting with friends, garden work, reading newspapers or books, raising domestic animals, playing cards or mahjong, watching TV or listening to radio, and organized social activities. R 4.2.1 software was used to estimate the network model and calculate strength and bridge strength.
Results: 21.60% (2,601/12,043) of the participants had depressive symptoms. The total social participation score was negatively associated with depressive symptoms after adjusting for sociodemographic factors. The network of social participation and depressive symptoms showed that "D9 (Inability to get going)" and "S9 (Watching TV and/or listening to the radio)" had the highest strength within depressive symptoms and social participation communities, respectively, and "S1 (Housework)", "S9 (Watching TV and/or listening to the radio)", and "D5 (Hopelessness)" were the most prominent bridging nodes between the two communities. Most edges linking the two communities were negative. "S5 (Graden work) - D5 (Hopelessness)" and "S6 (Reading newspapers/books) - D4 (Everything was an effort)" were the top 2 strongest negative edges. Older females had significantly denser network structures than older males. Compared to older people aged 65—80, the age group 81—105 showed higher network global strength.
Conclusions: This study provides novel insights into the complex relationships between social participation and depressive symptoms. Except for doing housework, other social participation activities were found to be protective for depression levels. Different nursing strategies should be taken to prevent and alleviate depressive symptoms for different genders and older people of different ages.

What is known?

- Depressive symptoms are prevalent among older adults.
- Social participation is related to depressive symptoms.
- Gender may influence the relationship between social participation and depressive symptoms.

What is new?

- "S1 (Housework)" was the most prominent node bridging social participation and depressive symptoms.
- Most edges between social participation and depressive symptoms were negative.

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- Significant differences in network global strength existed between genders and age groups among older Chinese adults.

1. Introduction

Depression, a prevalent mental disorder, affects approximately 5% of the adult population worldwide [1], severely impacting the quality of life and imposing a significant health burden. Depressive symptoms are responsible for 7.5% of all years lived with disability [2] and are associated with self-harm behaviors and suicide [3], thereby further aggravating the global disease burden. More critically, depressive symptoms are becoming more and more widespread among older adults and pose a threat to their health. The prevalence of depressive symptoms among old adults was reported to be 13.3% globally [4]. China also confronts this challenge. The prevalences of depressive symptoms were 47.8%, 33.2%, and 39.5% among Chinese older adults living alone, as a couple, and with children, respectively [5]. Therefore, preventing and reducing the risk of depression for older adults is an essential public health concern.

Social participation is a potential factor influencing depressive symptoms. Although there is no universally accepted definition of social participation in academia, Levasseu's definition is frequently cited [6]. After conducting a content and activity analysis of 43 papers, Levasseu proposed that social participation refers to a person's involvement in activities providing interactions with others in society or the community [7]. Additionally, the existing literature suggests that social participation provides opportunities for individuals to accomplish meaningful daily activities and develop more valuable social roles [8].

Similarly, there is no consensus on the classification of social participation. Given the varied cultural and social customs, this study has selected ten typical types of social activities among Chinese older adults. Playing cards or mahjong, as well as visiting and interacting with friends on holidays, are deeply rooted traditional activities in China that are particularly popular among older Chinese adults [9]. Tai-chi and square dancing, as physical fitness methods, offer further social settings and conversation topics for older adults [10]. In China, increasingly older adults form groups to determine exercise times and venues together, participating in tai-chi or square dancing collectively. Reading, watching TV, and listening to the radio can be viewed as a means for older adults to be passively exposed to social information [11], which allows them to keep pace with the development of society. Housework, garden work, and raising domestic animals are common activities in the routine of most old Chinese people, which involve interaction with family members and reflect the individual values of their family [12]. As for organized social activities for older adults, political activities are comparatively infrequent in China. However, the number of community-organized services for older adults has gradually increased.

Increasing evidence demonstrates that social participation activities can enhance the psychological well-being of older adults. A longitudinal study [13] showed that maintaining social participation in later life was significantly related to lower depressive symptoms. Similar results were identified in the cohort studies conducted among older adults in Japan [14], Korea [15], and the USA [16]. According to social capital theory, social participation could improve the social capital of older adults, which can promote psychological health by enhancing the emotional and material links to other social members [17]. Social integration theory could also be used to explain [18]. Social participation allows older adults to engage in society and cultivates a sense of belonging, endowing their lives meaningfully. This sense of accomplishment and fulfillment is beneficial to their mental health. However, some specific types of social participation may adversely impact psychological health. For example, Yue et al. [19] found that housework predicted increased levels of depressive symptoms. Therefore, we could hypothesize that different kinds of social participation have varying directions and magnitudes of influence on depressive symptoms. It is essential to distinguish the impact of each type of social participation on depressive symptoms. Regrettably, a scarcity of literature has concentrated on this topic.

Besides, the impact of sociodemographic factors should be emphasized in examining the relationship between social participation and mental health. Firstly, gender differences may exist. Takagi et al. [20] reported that females with higher social participation experienced lower levels of depressive symptoms. Older men exhibited stronger associations between depressive symptoms and social and interest group participation compared to older women [21]. Secondly, older people living in urban and rural areas engage in different social participation activities, leading to varying impacts on mental health. The negative association between organized voluntary activities and depression is observed only among urban older adults, and the protective function of joining hobby groups (e.g., playing mahjong and cards) only exists among rural groups [22]. Thirdly, older adults in different age groups may exhibit diverse relationships between depression and social participation. As skills decline and life expectancy shortens, older individuals become increasingly alienated from society, and their levels of social participation diminish [23].

In contrast, longevity seniors may possess unique physical and mental health characteristics. Conducting stratified analyses of sociodemographic factors is essential when examining the relationship between social participation and depressive symptoms. Unfortunately, the separate effects of different types of social participation on depressive symptoms have not been sufficiently explored, and there is a lack of stratified analyses of sociodemographic factors.

Network analysis has been widely applied in psychology in recent years, gradually extending to health behaviors [24]. Based on the network theory, depression can be conceptualized as a causal system of interacting and mutually reinforcing symptoms [25]. Different symptoms of depression and social participation activities can be regarded as distinct nodes within a single network [26]. Network analysis presents some unique advantages. Firstly, it is well suited to elucidate the specific pathways between any two elements [27], taking into account the relationships of other elements. Secondly, network analysis could also reveal the importance of nodes and find the central symptoms, which may have greater power in triggering and maintaining other symptoms [28]. In addition, when researchers want to clarify the strongest connection between two communities of symptoms, termed "bridge symptoms," the network can also function well. By adopting network analysis, the associations between symptoms of depression and some healthy behaviors have been discussed, such as internet addiction [29] and eating disorders [30]. However, few studies have utilized network analysis to explore the inter-relationships between depressive symptoms and social participation activities among the elderly population.

As of today, the specific interactions between different social participation activities and different depressive symptoms in older adults have not been fully discussed. In light of the above concerns, this study aimed to utilize the network approach to establish the social participation–depression network and identify influential nodes of the network, which may be valuable targets for preventing and alleviating depression. Furthermore, considering the diverse sociodemographic characteristics of older adults, we compared the differentiated network structures among older adults of different

genders, ages, and urban-rural areas.

2. Methods

2.1. Study design and data source

China Longitudinal Healthy Longevity Survey (CLHLS) was a Chinese national survey established in 1998 and followed up in 2000, 2002, 2005, 2008, 2011, 2014, and 2018, conducted by Peking University and Duke University. In the subsequent waves, some new participants were enrolled, and all responders were tracked, except for cases of death or loss to follow-up [31]. A multi-stage disproportionate and a targeted random-sample design were adopted to ensure representativeness. Now, the data of CLHLS are available for free use by the academic community and society through the Peking University Open Research Data Platform (https://opendata.pku.edu.cn/dataverse/CHADS). Data on CLHLS were collected through face-to-face interviews using standardized questionnaires [32]. Before the interview, the staff of CLHLS had participated in unified training, which included the purpose and importance of the research, the content of the questionnaire, and the matters that needed attention during the interview process. Voluntary agreements and informed consents were obtained from participants, which included the study's purpose, anonymity, confidentiality, and other related rights. Detailed information on the CLHLS has been previously described elsewhere [33].

2.2. Study sample

In this study, we utilized the data from the 2018 wave of the CLHLS, including sociodemographic variables, social participation activities, and depressive symptoms using the Center for Epidemiologic Studies Depression (CES-D) scale. After excluding 271 individuals aged below 65 or above 105 years old and 3,560 individuals with missing data on social participation or depression, a total of 12,043 participants were included in this study.

2.3. Measurement

2.3.1. Depressive symptoms

The CES-D scale was originally published by Radloff in 1977 [34], which is an extensively used and validated self-reported inventory. We used the Chinese version 10-item CES-D in this study [35]. This scale has 10 items rating symptom frequency with four responses: $0 =$ Rarely, $1 =$ Some days, $2 =$ Occasionally, $3 =$ Most of the time. Questions fifth and eighth should be scored reversed. Scores range from 0 to 30, with higher scores indicating more severe depressive symptoms. A total score equal to or greater than 10 indicates depression [35]. CES-D scale has shown high reliability and validity among Chinese people [36]. The Cronbach's α coefficient was 0.738 in this study.

2.3.2. Social participation

This study defined social participation as a person's involvement in activities that interact with others, communities, and society [7]. A total of 10 types of social participation activities were collected, including housework, tai-chi, square dancing, visiting and interacting with friends, garden work, reading newspapers/books, raising domestic animals, playing cards and mahjong, watching TV and listening to radio and organized social activities. This questionnaire containing 10 types of social participation was widely used among older Chinese adults [6,37]. The options were "almost every day" "not every day, but at least once a week" "not every week, but at least once a month" "not every month, but sometimes" and "never" which were coded as 5, 4, 3, 2 and 1 point, respectively.

The total score was 10–50, and the higher total score suggests older adults' more active social participation [38].

2.3.3. Confounding variables

Potential confounding variables included age, gender, ethnicity, recent residency, years of education, marital status, whether or not living alone, and retirement. According to previous studies, these socio-demographic factors may have associations with depression or social participation in older adults [39,40].

2.4. Statistical analysis

Descriptive analysis was used to describe the demographic characteristics of the participants. The Chi-square test was used to test the difference between older adults with and without depressive symptoms. After adjusted for the sociodemographic factors, a multiple linear regression model was used to examine the dose-response relationship between social participation and depressive symptoms. The above statistical analyses were implemented using SPSS version 26.0.

Subsequentaly, we conducted network analysis with the R program 4.2.1. 1) Network structure. In our network structure, nodes represented the 10 types of social participation activities and 10 symptoms of depression. The links between every two nodes were defined as edges, indicating the association between the two nodes after controlling for other nodes. We used green edges to show positive associations, while the edges in red present negative relationships. An edge with a thicker shape indicates a stronger association. 2) Network construction and visualization. The network model was constructed using the "estimateNetwork" function in the R "bootnet" package with "EBICglasso" as the default method [41]. This method is based on a sparse graphical Gaussian model (GGM) combined with the graphical least absolute shrinkage and selection operator (LASSO). We adopted the package "qgraph" to realize network visualization. 3) Centrality indices. Then, we calculate the centrality index of strength to quantify the importance of each node in the network [42]. To explore bridge symptoms that played important roles in connecting two communities (social participation and depressive symptoms), the bridge centrality index—bridge strength was calculated using the "networktools" package. 4) Stability and difference test. A case-dropped bootstrap method was used to assess the accuracy and stability of the network model. The network structure would be considered stable if most of the samples are excluded and the centrality index of the nodes hasn't changed significantly. The correlation stability coefficient (CS-C) was calculated, which indicates that the largest proportion of the sample can be reduced. The CS-C should generally not be smaller than 0.25 and preferably larger than 0.5 [43]. Besides, a non-parametric bootstrap method was applied to calculate 95% confidence intervals (CIs) for edge weights. Bootstrapped difference tests were also used to estimate the stability of nodes' strength and edge weights. 5) Network comparison. Finally, with the "NetworkComparisonTest" package in R [44], we compared the differences in network models by sex, age groups, urban-rural residency, and whether or not they lived alone. This procedure compares the global network strength by calculating the absolute sum of all the network edge weights. The differences in strength for each edge were compared between the two networks after controlling for multiple tests (Holm–Bonferroni correction of P values) [45].

2.5. Ethical consideration

This study is a secondary analysis of the data from the CLHLS. The CLHLS has obtained ethical approval and informed consent and

was approved by the research ethics committees of Peking University (IRB00001052−13074).

3. Results

3.1. Sociodemographic characteristics

The prevalence of depressive symptoms among participants was 21.60% (2,601/12,043). 53.1% of them were females, and 56.1% of participants were aged 81 to 105. Urban residents accounted for 23.4%, and rural residents were 76.6%. The above half of them had five years or below years of education. Between participants with

and without depressive symptoms, there are differences in gender, age, recent residency, years of education, marital status, whether or not living alone, and retirement (*P* < 0.05). (Table 1).

3.2. The relationship between social participation and depressive symptoms

Table 2 shows the results of the multiple linear regression analysis. After adjusting for sociodemographic variables, the total social participation score was negatively associated with depressive symptoms (B = −0.136, 95% *CI*: −0.150, −0.123). The associations between gender, marital status, and living alone with depressive

Table 1
The comparison of sociodemographic characteristics between participants with and without depression.

Characteristics	Total (*n* = 12,043)	Depression		χ^2	*P*
		No (*n* = 9,442)	Yes (*n* = 2,601)		
Gender				106.69	<0.001
Male	5,643 (46.9)	4,657 (82.5)	986 (17.5)		
Female	6,400 (53.1)	4,785 (74.8)	1,615 (25.2)		
Age (years)				57.27	<0.001
65−80	5,281 (43.9)	4,310 (81.6)	971 (18.4)		
81−105	6,762 (56.1)	5,132 (75.9)	1,630 (24.1)		
Ethnicity				0.20	0.652
Han	9,835 (81.7)	7,703 (78.3)	2,132 (21.7)		
Else	2,208 (18.3)	1,739 (78.8)	469 (21.2)		
Recent residency				43.31	<0.001
Urban	2,824 (23.4)	2,340 (82.9)	484 (17.1)		
Rural	9,219 (76.6)	7,102 (77.0)	2,117 (23.0)		
Years of education				163.95	<0.001
0	4,546 (37.7)	3,313 (72.9)	1,233 (27.1)		
1−5	2,489 (20.7)	1,999 (80.3)	490 (19.7)		
6−12	2,885 (24.0)	2,455 (85.1)	430 (14.9)		
≥ 13	2,123 (17.6)	1,675 (78.9)	448 (21.1)		
Marital status				123.55	<0.001
Married	5,618 (46.6)	4,647 (82.7)	971 (17.3)		
Widowed	6,162 (51.2)	4,617 (74.9)	1,545 (25.1)		
Otherwise	263 (2.2)	178 (67.7)	85 (32.3)		
Living alone				61.51	<0.001
Yes	2,001 (16.6)	1,437 (71.8)	564 (28.2)		
No	10,042 (83.4)	8,005 (79.7)	2,037 (20.3)		
Retirement				66.33	<0.001
Yes	3,421 (28.4)	2,848 (83.3)	573 (16.7)		
No	8,622 (71.6)	6,594 (76.5)	2,028 (23.5)		

Note: Data are *n* (%).

Table 2
Multiple linear regression analysis for the relationship between social participation and depressive symptoms among older Chinese adults (*n* = 12,043).

Variables	*β*	B (95%*CI*)	*P*
Social participation total score	−0.200	−0.136 (−0.150, −0.123)	<0.001
Gender (Reference: Male)			
Female	0.067	0.601 (0.428, 0.774)	<0.001
Age group (years) (Reference: 65−80)			
81−105	−0.019	−0.169 (−0.359, 0.022)	0.082
Ethnicity (Reference: Else)			
Han	0.000	0.004 (−0.250, 0.259)	0.973
Recent residency (Reference: Urban)			
Rural	0.019	0.195 (−0.040, 0.430)	0.104
Years of education (Reference: 0)			
1−5	−0.021	−0.229 (−0.453, −0.005)	0.045
6−12	−0.048	−0.503 (−0.747, −0.260)	<0.001
≥ 13	0.002	0.021 (−0.268, 0.309)	0.889
Marital status (Reference: Married)			
Widowed	−0.114	−1.018 (−1.557, −0.479)	<0.001
Otherwise	−0.116	−1.035 (−1.572, −0.498)	<0.001
Living alone (Reference: No)			
Yes	0.076	0.908 (0.685, 1.131)	<0.001
Retirement (Reference: No)			
Yes	−0.019	−0.184 (−0.412, 0.044)	0.114
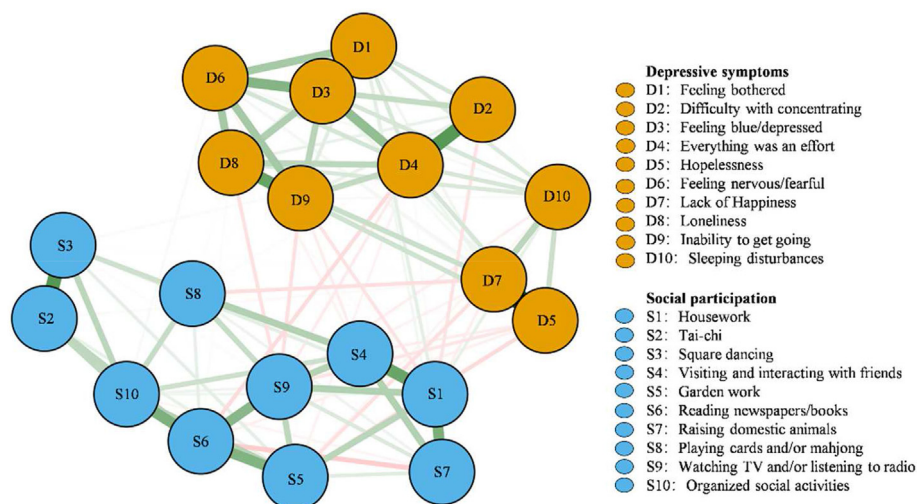
Fig. 1. The network structure of social participation and depressive symptoms among Chinese old adults (n = 12,043). Nodes with strong associations are relatively close to each other. The orange nodes indicate depressive symptoms; the blue nodes indicate social participation activities. The green line represents positive correlations and the red line represents negative correlations. The edge thickness represents the strength of the association between nodes.

symptoms were significant. Older adults with 6—12 years of education had lower levels of depression than those without education ($B = -0.503$, 95% CI: -0.747, -0.260).

The network model of social participation and depressive symptoms and its weighted adjacency matrix are shown in Fig. 1 and Appendix A. Within the depressive symptoms section, most edges were positive, and the strongest positive edge was "D5 (Hopelessness) - D7 (Lack of Happiness)". Similarly, most edges within the social participation section were positive. "S6 (Reading newspapers/books) - S7 (Raising domestic animals)" was negatively strong. Between the two communities, the majority of edges were negative, especially "S5 (Graden work) - D5 (Hopelessness)" and "S6 (Reading newspapers/books) - D4 (Everything was an effort)". There were few positive edges between the two groups, such as "S1 (Housework) - D1 (Feeling bothered)" and "S1 (Housework) - D10 (Sleeping disturbances)".

As to the centrality results, "D9 (Inability to get going)" and "S9 (Watching TV and/or listening to the radio)" had the highest strength within the depressive symptoms and social participation communities, respectively. Regarding the bridge strength, "S1 (Housework)," "S9 (Watching TV and/or listening to the radio)," and "D5 (Hopelessness)" were the most prominent bridging nodes in this network (Appendix B).

The CS-coefficient of strength and bridge strength generated by the case-dropping bootstrap method were both 0.750, indicating that the present network structure was stable (Appendix C). Appendix D shows that the bootstrapped 95% CIs of edge weights were narrow, indicating that the reliability of the network model was acceptable. Appendix E and F showed the results of non-parametric bootstrapped difference tests of edge weights and node strengths, respectively. Most edges and nodes differed significantly from others, revealing that the primary results were trustworthy.

3.3. Network structure comparison

Appendix G shows gender differences in network global strength: female = 7.549, male = 6.738 (P < 0.001). Thirteen edges between social participation and depressive symptoms presented significantly gender difference, such as "D1 (Feeling bothered) — S1 (Housework)" and "D2 (Difficulty with concentrating) — S1

(Housework)". Regarding age groups, older adults aged 65-80 (global strength = 6.362) had significantly sparser networks than 81-105 years older adults (global strength = 7.549), with seven different edges linking the two communities, such as "D1 (Feeling bothered) — S1 (Housework)" and "D1 (Feeling bothered) — S4 (Visiting and interacting with friends)". Although urban and rural networks had ten different edges between the two communities, the global strength of their networks showed no significant difference.

Besides, we found that the global strength of the "social participation-depressive symptoms" network is significantly higher for older adults not living alone (Global strength = 7.545) than for those living alone (Global strength = 6.022). Among the old people who were not living alone, "S1 (Housework)" was positively associated with "D1 (Feeling bothered)" and "D10 (Sleeping disturbances)". In contrast, the two edges above were both zero among living-alone older adults.

4. Discussion

Applying network analysis, the current study investigated the inter-relationships between social participation activities and depressive symptoms among Chinese older adults. We identified that "S1 (Housework)", "S9 (Watching TV and/or listening to the radio)", and "D5 (Hopelessness)" were the most prominent bridging nodes in the network. Most edges between social participation and depressive symptoms were negative, especially "S5 (Graden work) - D5 (Hopelessness)" and "S6 (Reading newspapers/books) - D4 (Everything was an effort)". While "S1 (Housework)" was positively correlated with "D1 (Feeling bothered)" and "D10 (Sleeping disturbances)" between the two communities. Moreover, significant differences in global strength were observed between different genders and age groups.

We found that "S9 (Watching TV and/or listening to the radio)" played a central role in social activities. Approximately 43.7% of elderly individuals regularly engage in watching TV or listening to the radio [46]. Overcoming spatial limitations, older adults can stay informed about global events through television or radio broadcasts. Those who enjoy watching TV tend to exhibit greater curiosity about the outside world and report feeling less lonely, which may motivate them to participate more actively in other social

activities [46]. These results indicated that most social participation activities were positively correlated with each other. Nevertheless, the association between "S6 (Reading newspapers/books)" and "S7 (Raising domestic animals)" was strongly negative. This result may be attributed to education and socioeconomic status. Elderly individuals who frequently read books might possess higher levels of education or seek spiritual fulfillment after their material needs are met [47]. Conversely, those who raise poultry may face comparatively lower economic and educational conditions [48]. Consequently, there is minimal intersection between these two demographic groups.

More importantly, we discovered that "S1 (Housework)" was the most salient bridge symptom between social participation and depressive symptoms in the network, suggesting that doing housework frequently could exacerbate depression symptoms. According to Golding [49], housework indirectly affects depression by increasing family stress. The absence of social recognition and positive feedback for housework may result in an accumulation of irritability due to excessive housework [50]. As social pressures mount in China, young people are busy with their careers, and an increasing number of older adults have taken on the responsibility of raising their grandchildren [51]. Intergenerational care for grandchildren increases the physical labor of older adults and gives rise to intergenerational conflicts, especially the contradiction between mother and daughter-in-law [52]. As a result, housework has a negative effect on the sleep quality and emotional health of older Chinese adults. The situation is somewhat different for older adults who live alone. Since they do not live with their families, the social participation aspect of their housework is diminished. Still, their self-care can alleviate the burden on their children and contribute to family harmony to a certain extent. At the same time, the outcomes of their housework—a clean and tidy home—become evident when friends visit, which can bolster their confidence and self-efficacy. Nonetheless, as they age and their physical strength wanes, housework becomes a burden for older people living alone [53]. The Fourth Plenary Session of the 19th Central Committee of the Communist Party of China proposed "actively respond to the aging population and accelerate the construction of an elderly care service system that combines home-based community institutions and medical services." Under the government's leadership, the older adults care infrastructure in communities should be continuously fortified, and regular housekeeping services should be rendered to older adults.

Besides doing housework, other social participation activities were found to protect against depressive symptoms. Older adults may experience the loss or change of their social roles due to the death of spouses or retirement [54]. According to the activity theory, social participation can assist older adults in establishing a new social role, adapting to society, obtaining psychological satisfaction, and alleviating the depressive symptoms caused by role changes [55]. In detail, "S5 (Graden work) - D5 (Hopelessness)" and "S6 (Reading newspapers/books) - D4 (Everything was an effort)" exhibited the strongest negative associations. And the link between S3 (Square dancing) and D4 (Everything was an effort) was also negative. Square dancing is a type of social participation with typical Chinese characteristics. It is easy to learn with energetic and similar rhythms and is usually performed in large public places. Pedestrians can join the dance team at any time [56]. On the one hand, as the process of square dancing is involved with personal interaction, it is reported to have the ability to ameliorate loneliness and isolation [57]. On the other hand, the simple dance steps of square dancing lower the barriers to participation, thereby enhancing older adults' self-confidence and feelings of achievement [58]. The stronger interpersonal support and the better self-affirmation could improve older adults' life satisfaction [59] and further strengthen their

expectations for the future. Reading newspapers or books offers effects similar to those of square dancing. Older people with reading habits continue to learn new things and maintain relatively high learning abilities. This youthful mindset will facilitate their ability to overcome life's difficulties [60].

Comparing the differences in network models by demographic factors, we found that old females had denser networks than old males. This is consistent with previous research [20,61], which suggests that for elderly women, the correlation between social participation and depressive symptoms is stronger. Lee [61] thought that employment for men and social participation for women was protective against depressive symptoms. It could be assumed that older males pursue feelings of achievement from social participation and other methods, such as employment. Meanwhile, elderly females emphasize interpersonal relationships, which can only be obtained from social participation. Secondly, our results also showed that younger elderly (65—80 years old) had sparser networks than older elderly (81—105 years old). There is a potential reason that the physical capabilities of older adults decline, leading to diminished interpersonal support and leisure activities [62]. Consequently, social participation is deemed increasingly vital for older adults in mitigating depressive symptoms, especially when compared to younger adults who possess greater mobility. Thirdly, the network structures of urban and rural older people had no significant difference in global strength, which could be attributed to the swift economic growth in rural regions of China in recent years [63]. The living conditions of older people in urban and rural areas are increasingly similar, resulting in little difference in social participation activities. For instance, square dancing, which was initially a city-based activity, is now also enjoyed by the rural elderly population [64].

Taken together, some essential implications can be drawn. First of all, as the most influential node between social participation and depressive symptoms in the network, "S1 (Housework)" could be the possible treatment target for depressive symptoms among older Chinese adults. Reducing the burden of housework on older adults is of utmost importance. There is a need to expedite the construction of elderly care institutions and enhance the training of pertinent personnel. Implementing a home-based community care system for older adults should be vigorously promoted, and the advantages of such a system should be optimally utilized. Establishing community canteens for older adults will significantly alleviate the workload of older adults in cooking. Communities should concentrate on assisting older adults living alone by recruiting volunteers to help with basic cleaning tasks. For older individuals living with their relatives, the community should provide health education to the co-habitants, encouraging them to assume a greater share of housework and fostering their value of appreciation for domestic contributions.

Additionally, the strongest associations between social participation and depressive symptoms, including "S5 (Graden work) - D5 (Hopelessness)" and "S6 (Reading newspapers/books) - D4 (Everything was an effort)", reveal that different social participation activities are correlated with different symptoms of depression. To promote the psychological health of older people, it is essential to develop innovative treatment approaches rooted in various social activities. Relevant research institutions can cooperate with the government or the community to organize activities such as square dancing competitions and reading-sharing meetings for older adults, potentially leading to a significant reduction in their levels of depression and an enhancement of their mental well-being.

Finally, this study also offers profound insights into the sociodemographic characteristics of the internal mechanism of social participation and depressive symptoms. Utilizing the findings, we have been able to identify pivotal subgroups for targeted "social

participation-depressive symptoms" intervention. More attention should be paid to old females and elderly aged above 80 years old, as social participation has more power to reduce their depression symptoms. When advocating for social participation initiatives, older women and senior elderly should be more included to enhance the overall social participation and mental health of the elderly group.

Several limitations to this study deserve attention. Firstly, as a cross-sectional study, we could not conclude causal relationships. The direction of the effect between social engagement and depressive symptoms remains unclear. Secondly, the use of self-reported scales to assess participants' depressive symptoms may introduce self-bias, potentially affecting the accuracy of the results. Thirdly, we adopted self-administered questionnaires to measure social participation, as there is currently no unified standard for social participation scale. This constrains the comparability of our findings to some extent. Fourthly, this study argues that housework is also a form of social participation for older adults who live alone. However, prior research has seldom explored this issue, and no consensus has been reached. Lastly, although we have taken gender, age, and urban-rural residency into consideration, there is no control for other demographic variables when we established network models.

5. Conclusion

This study is the first to investigate the network structure between social participation activities and depressive symptoms in Chinese older adults. Our results revealed influential bridging nodes, such as "S1 (Housework)", and potential pathways between social participation activities and depressive symptoms, such as "S5 (Graden work) - D5 (Hopelessness)" and "S6 (Reading newspapers/books) - D4 (Everything was an effort)". These bridge symptoms and strong edges might offer an enlightening contribution to the design of interventions and treatments for depression in older adults after taking gender and age into consideration.

Data availability statement

The data can be obtained at: https://opendata.pku.edu.cn/dataverse/CHADS. Researchers are required to apply for permission to use the data.

CRediT authorship contribution statement

Yebo Yu: Methodology, Formal analysis, Investigation, Data curation, Writing — original draft, Writing — review & editing. **Hewei Min:** Writing — review & editing, Supervision. **Wei Pan:** Methodology, Validation. **Ping Chen:** Investigation, Writing — review & editing. **Xuxi Zhang:** Resources, Project administration. **Xinying Sun:** Conceptualization, Funding acquisition, Project administration.

Declaration of competing interest

All authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Appendices. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijnss.2024.08.011.

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