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IADL for identifying cognitive impairment in Chinese older adults: insights from cross-lagged panel network analysis

Xiaotong Zhai[1], Ruizhe Wang[1], Ran Liu[3], Depeng Jiang[1,2*] and Xiaojin Yu[1*]

Abstract

Background As China has entered an aging society, the prevention of cognitive impairment is of great importance. The progression of cognitive impairment is usually a slow and continuous process, with Instrumental Activities of Daily Living (IADL) serving as a sensitive indicator for early prediction of cognitive decline. The objective of this study was to utilize longitudinal network analysis to pinpoint the most sensitive indicators of IADLs to identify cognitive impairment in different populations, and to offer practical recommendations for preventing cognitive impairment among older adults in China.

Methods A total of 2,781 participants were selected from the Chinese Longitudinal Healthy Longevity Survey (CLHLS 2014–2018). Cognitive function and IADLs were assessed by Mini-mental State Examination (MMSE) and Chinese modified Lawton scale, respectively. In this study, the cross-lagged panel network (CLPN) model was employed to construct three separate networks for all Chinese older adults, male Chinese older adults, and female Chinese older adults, respectively. Two centrality indices were used to quantify symptom centrality in directed CLPN: In-Expected-Influence (IEI) and Out-Expected-Influence (OEI).

Results In the IADLs and cognitive function networks, "Use public transit," "Make food" and "Walk 1 km" emerged as the most influential and important indicators. The edge "Use public transit → Attention and Calculation" was the strongest edge connection in all three networks. Among older adult males, "General ability" exhibited the most influence on other cognitive domains, followed by "Language," while "Attention and Calculation" had a weaker influence. Conversely, among older adult females, "Attention and Calculation" was the most influential factor, followed by "General ability" and "Language."

Conclusions This study provides new insights into the associations between specific IADL activities and cognitive function domains among Chinese older adults. Concentrate on monitoring limitations related to "Use public transit," "Make food" and "Walk 1 km," and promoting broader life-space mobility may be beneficial to preventing the decline of cognitive function. The findings underscore the importance of targeting interventions not only by specific cognitive domains, but also potentially by gender.

*Correspondence:
Depeng Jiang
108109130@seu.edu.cn; Depeng.jiang@umanitoba.ca
Xiaojin Yu
xiaojinyu@seu.edu.cn

Full list of author information is available at the end of the article

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Keywords Cognitive impairment, Network analysis, IADL, Preventing dementia

Introduction

China holds one-fifth of the world's older adult population, as the second baby boom generation (born between 1962 and 1975) begins to retire in 2022, the burden of aging in China will further intensify [1]. The ongoing demographic transition means that aging, a critical risk factor for dementia, will drive future prevalence increases in China. In 2021, China reported 16.99 million cases of dementia, constituting approximately 29.8% of the global dementia caseload [2]. In the same year, dementia led to 490,000 deaths in China, representing 25.2% of the global dementia-related mortality rate [2]. Additionally, the dementia-related mortality rate among women is over twice that of men [2]. The total socio-economic cost of Alzheimer's disease (AD) patients in China is expected to reach US $507.49 billion by 2030 and US $1.89 trillion by 2050 [3]. Compared with cognitively normal people, older people with mild cognitive impairment (MCI) had a 39% increased risk of death [4]. Dementia in older adults significantly impacts their personal self-care, social interactions, mental health, and safety, while imposing substantial economic and emotional burdens on families and posing challenges to societal medical care and safety [5–7]. The development of prevention and intervention measures for dementia is of great significance for the long-term health and well-being of the Chinese population.

The progression of cognitive impairment is usually a slow and continuous process, gradually developing from subjective cognitive decline (SCD) to MCI, and then to severe stages such as AD [8]. Early detection can promote timely intervention, effectively delay the deterioration of the disease, and protect brain function [9, 10]. Studies conducted on Chinese older adults have demonstrated that resistance exercise, a varied diet, a healthy lifestyle, and active social participation are effective factors in alleviating cognitive decline [11–14]. A recent study found that IADLs are among the most important factors when forecasting future cognitive impairment risk among Chinese older adults [15].

A study on factors affecting cognitive function among Chinese older adults indicates that a rapid decline of instrumental activities of daily living (IADL) abilities accelerates the decline of cognitive function [16]. In most patients with SCD, IADL holds up well. However, once patients appear difficulties with IADL, their risk of developing dementia is significantly increased [17]. IADL items rely on intricate neurophysiological processes and require sufficient cognitive functions, so they are more susceptible to the early effects of cognitive decline [18, 19]. A number of predictive modeling studies on cognitive function of Chinese older adults have found that IADLs show more significant predictive power than activities of daily living (ADL) [15, 20]. Mild IADL restrictions exist several years before the clinical diagnosis of dementia and can be used as an early predictor of dementia [21, 22]. Therefore, it has been suggested that IADL limitation may serve as a highly effective indicator for assisting in the diagnosis of dementia [23, 24].

Recently, network analysis has been widely used in the field of psychiatry. Previous studies primarily utilized network analysis to examine the relationship between depression and anxiety in various populations, identifying both bridge and core symptoms. Notably, the bridge and core symptoms of depression and anxiety vary among different populations [25–27]. Researchers have utilized network analysis to examine the associations between chronic obstructive pulmonary disease symptoms [28]. Odenthal et al. constructed three cross-lagged panel network models to investigate changes in psychological distress over time [29]. As the investigation of psychopathological symptoms deepens, a growing number of studies are utilizing network analysis to perform more detailed analyses at the symptom level. Recently, network analysis methods have been utilized to explore the cognitive functions of the older adults [30–32]. However, these methods are restricted to cross-sectional data and are deficient in subgroup analysis, which is crucial for identifying the impacts of confounding factors on network structure [30–32].

Prior studies on cognitive function among older Chinese adults have primarily focused on its correlation with overall IADL performance [16, 18, 20, 33]. While a cumulative total score is useful for assessing integral functioning, specific measures from these scales can provide more insightful information [24, 28, 32]. In this study, network analysis can not only enhance the information obtained from the scales but also uncover more precise associations between cognitive functions and IADLs. In terms of symptom network activation, it is important to identify which IADL symptoms cause cognitive symptom activation, as these may be central to intervention and prevention to counteract symptom deterioration at an early stage. Thus, according to network theory, these symptoms may be viable targets to block symptom activation in the network [34, 35]. Longitudinal network analysis is able to identify IADL symptoms that tend to aggravate symptoms of cognitive impairment, which could inform prevention and intervention programs at the early stages of cognitive impairment.

Older adults with cognitive impairment are more likely to encounter more health challenges and limitations due to advancing age. Regrettably, only a handful of scholars have used longitudinal network analysis as a data analysis method to explore the relationship between IADLs and cognitive function in Chinese older adults at the symptom level [15, 20]. Our aim was to pinpoint sensitive IADL indicators to identify cognitive impairment using the network analysis method, and to provide valuable guidance for preventing cognitive decline among older adults in China.

Methods

Participants

The study used data from the sixth to seventh wave (2014 and 2017–2019) of the Chinese Longitudinal Healthy Longevity Survey (CLHLS). CLHLS used a multi-stage cluster random sampling method to survey the older adults aged 60 years and above and their adult children in 23 provinces in China [36]. The baseline survey was conducted in 1998, followed by follow-up surveys in 2000, 2002, 2005, 2008–2009, 2011–2012, 2014, and 2017–2019 [37]. The survey covers the basic situation of older persons and their families, socio-economic background and family structure, economic sources and economic status, self-assessment of health and quality of life, cognitive function, personality and psychological characteristics, ability to perform daily activities, lifestyle, lifestyle care, treatment of diseases and medical expenses [37].

A total of 7,192 older adults from all over China participated in the 2014 CLHLS. Exclusion criteria: (1) participants were not surveyed in the seventh wave; (2) lack of MMSE data; (3) lack of IADL data; (4) younger than 65 years. Finally, 2,781 subjects were included (Fig. 1).

Measurements

Cognitive impairment was measured by the validated Chinese version of the Mini Mental State Examination (MMSE), which included 24 questions involving general ability, memory, attention and calculation, recall and language of the older adults. Correct answers were assigned a score of 1, while incorrect or omitted answers received a score of 0. The sixth item, "Say the number of food items in one minute," carried a maximum score of seven [38]. The scores for each item were eventually standardized, with a maximum score of 6 points for each item. Scores range from 0 to 30, with a higher score indicating better cognitive function. Specific scoring standards are shown in table s1 of supplementary materials.

In this study, we used the Chinese modified Lawton Scale to measure IADL, which reflects the socialization ability and health status of older adults in Chinese communities [39]. IADL was composed of eight items, including visiting friends, shopping, cooking, washing, carrying heavy objects, walking 1 km, squatting 3 times,

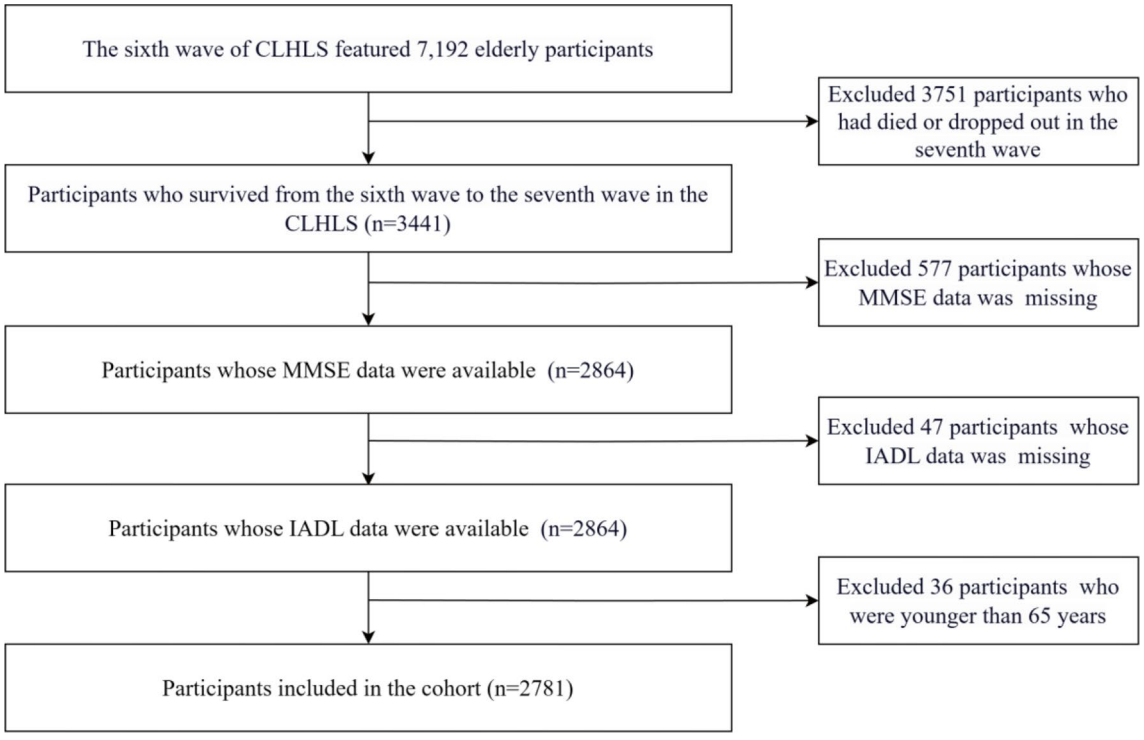

Fig. 1 The flow chart of sample selection in the present study. Note: CLHLS, the Chinese Longitudinal Health Longevity Survey; MMSE, Mini Mental State Examination; IADL, instrumental activities of daily living

and taking bus. Each item had three response options: 3 (very limited), 2 (somewhat limited), and 1 (not limited). All results were reverse-coded to correspond to cognitive function scores. Higher scores on the IADL scale indicate better self-care ability, with scores ranging from 8 to 24.

Statistical analyses

Cross-lagged panel network

All statistical analyses were performed with the use of R (version 4.3.2). The cross-lagged panel network (CLPN) model was used to analyze the ability of IADL to identify cognitive impairment. Three longitudinal networks were analyzed: (1) Chinese older adults, (2) Chinese male older adults, and (3) Chinese female older adults. We calculate both cross-lagged and autoregressive pathways. The cross-lagged pathway measures the impact of one symptom at an earlier time point on another symptom at a later time point, reflecting the predictive ability of one symptom on the other. The autoregressive effect pertains to the variation of the same variable over time, specifically the change in symptoms from one time point to the next [29]. We calculated three CLPNs using the glmnet package (version 4.1-8) [40]. The qgraph package (version 1.9.8) was used for the visualization of the networks [41].

We quantified symptom centrality in directed CLPN using two centrality indices: In-Expected-Influence (IEI) and Out-Expected-Influence (OEI) [42]. The OEI is used to quantify the extent to which one symptom predicts other symptoms. The IEI is used to quantify the degree to which a symptom is predicted by other symptoms.

To focus on the cross-lagged effects, which were particularly relevant to our analysis, we set the autoregressive paths to 0. In addition, threshold was set to 0.1, excluding all relationships < 0.1. This suppression allowed us to emphasize the cross-lagged pathway as well as make the picture concise to highlight key symptoms and edges, as it was of particular interest to our current study.

Table 1 Demographic characteristics of the older adults in China

Total (%) / Mean (SD)	All	Male	Female
N	*N* = 2781	*N* = 1343	*N* = 1438
Age	81.68(8.86)	80.14(8.19)	83.11(9.21)
Ethnicity			
Han	2320(83.42)	1110(82.65)	1210(84.14)
Other	210(7.55)	96(7.15)	114(7.93)
Missing	251(9.03)	137(10.20)	114(7.93)
Place of residence			
City	335(12.05)	148(11.02)	187(13.00)
Town	882(31.71)	416(30.98)	466(32.41)
Rural	1564(56.24)	779(58.00)	785(54.59)

Note: SD is standard deviation

Accuracy and stability

The accuracy and stability of the network were tested using the R package bootnet (version 1.6) [43]. First, we employed the bootstrap method to calculate 95% confidence intervals (CI) of the edge weights, providing an estimate of the accuracy of the edges in the network. Second, the network stability was examined using the case-dropping subset bootstrap function of the correlated stability coefficient (CS coefficient). The CS coefficient should not be lower than 0.25. Values of CS coefficient above 0.50 indicate strong stability and interpretability [43]. Finally, we used the edge weight difference test and centrality difference test to separately identify significant differences in edges and centrality indices.

Marginal correlation

Marginal correlations between IADLs and MMSE were calculated using the Hmisc package (version 5.1-0), and correlation matrices were plotted using the corrplot package (version 0.92).

Linear regression

We utilized the IADLs data from sixth wave to predict the MMSE scores in seventh wave, and conducted separate univariate and multiple linear regression analyses. A $P < 0.05$ was considered statistically significant.

Results

Descriptive statistics

The participants within the three included populations shared comparable demographic characteristics (Table 1). As shown in Table 2, all cognitive functions and IADL scores in the seventh wave survey decreased compared with the sixth wave survey. "Visit friends" had the highest mean score of 2.89 (SD = 0.43) and 2.67 (SD = 0.71) in the two surveys, respectively. Among all cognitive function scores, "Language" had the highest mean score of 5.60 (SD = 1.17) and 5.15 (SD = 1.76), respectively.

Accuracy and stability

As shown in Figs. S6–S8 (see supplemental material), the bootstrap 95% CI of the edge weights were narrow, indicating that the results of the network model were reliable. The CS coefficient of 0.75 for node IEI and OEI indicated that when 75% of the sample was dropped, the structure of the network did not significantly change. The case-drop bootstrapping results indicate a high stability of the centrality indices (Figs. S9–S11 in the supplemental material). Figures S12-S20 present the results of non-parametric bootstrap difference tests for edge weights and centralities, respectively. Most of the edges and node strengths were significantly different from the others, providing credibility to the preliminary results.

Table 2 Mean and standard deviation of each MMSE and IADL item

Items context	All (2014)	All (2018)	Male (2014)	Male (2018)	Female (2014)	Female (2018)
Visit friends	2.89 (0.43)	2.67 (0.71)	2.95 (0.28)	2.78(0.59)	2.83 (0.52)	2.56(0.79)
Do shopping	2.76 (0.59)	2.50 (0.81)	2.89 (0.41)	2.67(0.69)	2.65 (0.70)	2.34(0.88)
Make food	2.77 (0.59)	2.49 (0.83)	2.84 (0.50)	2.56(0.78)	2.71 (0.65)	2.41(0.86)
Wash clothes	2.78 (0.58)	2.49 (0.81)	2.82 (0.52)	2.55(0.78)	2.74 (0.63)	2.45(0.84)
Walk 1 km	2.60 (0.70)	2.28 (0.85)	2.75 (0.57)	2.46(0.78)	2.45 (0.57)	2.11(0.88)
Lift 5 kg	2.61 (0.69)	2.29 (0.86)	2.80 (0.52)	2.51(0.77)	2.44 (0.79)	2.08(0.90)
Squat 3 times	2.52 (0.73)	2.18 (0.86)	2.69 (0.61)	2.36(0.81)	2.36 (0.80)	2.00(0.86)
Use public transit	2.51 (0.78)	2.15 (0.91)	2.73 (0.62)	2.39(0.84)	2.30 (0.86)	1.93(0.92)
General ability	5.54 (0.82)	5.06 (1.58)	5.65 (0.71)	5.27(1.41)	5.45 (0.91)	4.87(1.71)
Memory	5.49 (1.50)	5.03 (2.04)	5.67 (1.19)	5.24(1.85)	5.32 (1.72)	4.83(2.19)
Attention and Calculation	4.64 (1.78)	4.00 (2.22)	5.17 (1.34)	4.63(1.92)	4.15 (1.98)	3.41(2.33)
Recall	4.77 (2.12)	4.23 (2.46)	4.95 (2.00)	4.54(2.29)	4.60 (2.21)	3.93(2.58)
Language	5.60 (1.17)	5.15 (1.76)	5.75 (0.94)	5.36(1.55)	5.46 (1.34)	4.95(1.91)

Cross-lagged panel networks

Correlation matrices were shown in the Supplementary Tables S2-S4. Based on the estimated 133, 116, and 121 non-zero edges, respectively, among all possible 169 edges, the network density is approximately 78.70% for the Chinese older adults network, 68.64% for the Chinese male older adults network, and 71.60% for the Chinese female older adults network.

As shown in Fig. 2, the CLPN model for the Chinese older adult population demonstrates characteristics highly similar to those of the gender-based subgroups. In the networks of both all older adults and female older adults, "Wash clothes" was negatively correlated with "Attention and Calculation." By contrast, as Figures S4 and S5 in the supplementary material illustrate, when other IADLs are excluded, "Wash clothes" exhibits a positive correlation with "Attention and Calculation."

As shown in Fig. 3, in the network of Chinese older adults and Chinese female older adults, "Use public transit" had the highest OEI, followed by "Make food" and "Walk 1 km". In the network of Chinese male older adults, "Use public transit" also had the highest OEI, followed by "Walk 1 km" and "Make food."

The five strongest edges for all three networks are depicted in Table 3. Overall, the strongest edge connections in the three networks are mainly contributed by "Use public transit." The connection "Use public transit → Attention and Calculation" was the strongest edge in all three networks (range: $\beta = 0.40–0.52$). "General ability," "Attention and Calculation," and "Language" had a strong impact on other cognitive functions across the entire older adult population. Among male older adults, "General ability" had the greatest impact on other cognitive functions, followed by "Language," while "Attention and Calculation" had a relatively weaker impact. "Attention and Calculation" had the most significant impact on other cognitive functions in the female older adult population, followed by "General ability" and "Language." To explore the specific connections of all indicators, see Tables S2-S4 in the supplementary material.

Marginal correlation

As shown in Figures S2 and S3 in the supplementary material, there was a positive marginal correlation between IADLs and the MMSE items. In particular, the internal correlation of IADLs was high. The values of correlations between specific indicators are presented in supplemental material, Tables S5-S10.

Linear regression

Univariate linear regression analysis showed that all IADL items were positively associated with each MMSE item. In the multiple linear regression analysis, "Make food" and "Use public transit" were most strongly associated with MMSE scores. For detailed results, see Supplementary Tables S11-S12.

Discussion

This study is the first to use longitudinal network analysis to examine the interaction between IADL and cognitive function in Chinese older adults. Across different populations, our CLPN models showed similar characteristics; however, in older adult group, we observed a negative association between "Wash clothes" and "Attention and Calculation." This is contrary to the general understanding that IADL is positively correlated with cognitive function [44], and may be attributed to excessive marginal correlation among the IADL indicators. Sensitivity analysis revealed that when only "Wash clothes" was retained, it exhibited a positive association with all other MMSE indicators. Additionally, a significant positive correlation emerged between "Wash clothes" and "Attention and Calculation" when analyzed separately. Our linear regression analyses were consistent with these findings:

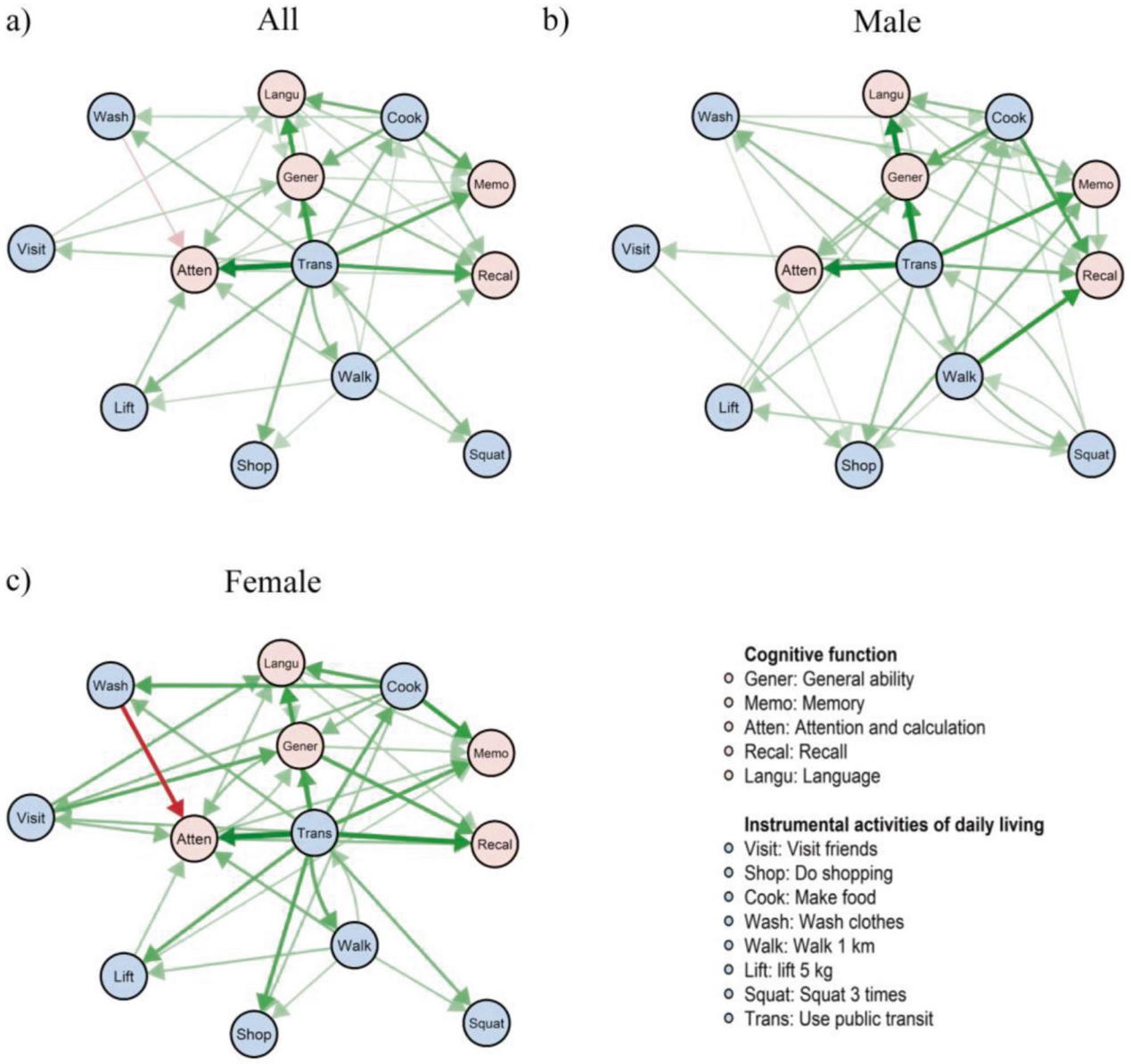

Fig. 2 The cross-lagged panel networks of MMSE and IADLs in Chinese older adults. (**a**)The older adults; (**b**) Male older adults; (**c**) Female older adults. Note: The relationship of the symptoms is indicated by the arrow's color (green = positive, red = negative), the strength of the relationship is indicated by the arrow's thickness (thicker = stronger). In these networks, autoregressive effects are excluded. Threshold was set to 0.1, excluding all relationships < 0.1. MMSE, Mini Mental State Examination; IADL, instrumental activities of daily living

while univariate linear regression demonstrated positive associations between IADLs and MMSE items, in multiple linear regression analysis, a small number of IADL items showed negative associations with MMSE items, likely due to the high correlations among independent variables.

Compared with previous studies, this study used longitudinal data and network analysis to explore the association between IADLs and cognitive function at the symptom level across different gender groups. Among the IADLs and cognitive function items, "Use public transit," "Make food" and "Walk 1 km" were the most influential and important. Previous research found that these activities were highly discriminative in distinguishing AD and MCI patients [44], and central to daily functioning in older adults with health challenges [45, 46].

In the CLPN network of older adults, "Use public transit" exhibited the highest OEI, and "Walk 1 km" ranked third. "Use public transit" and "Walk 1 km" may affect the cognitive function of older adults by affecting their life space mobility [47]. Research has demonstrated that going outdoors daily is correlated with the activation of the prefrontal cortex [48]. To access entertainment resources, many older adults in China frequently take

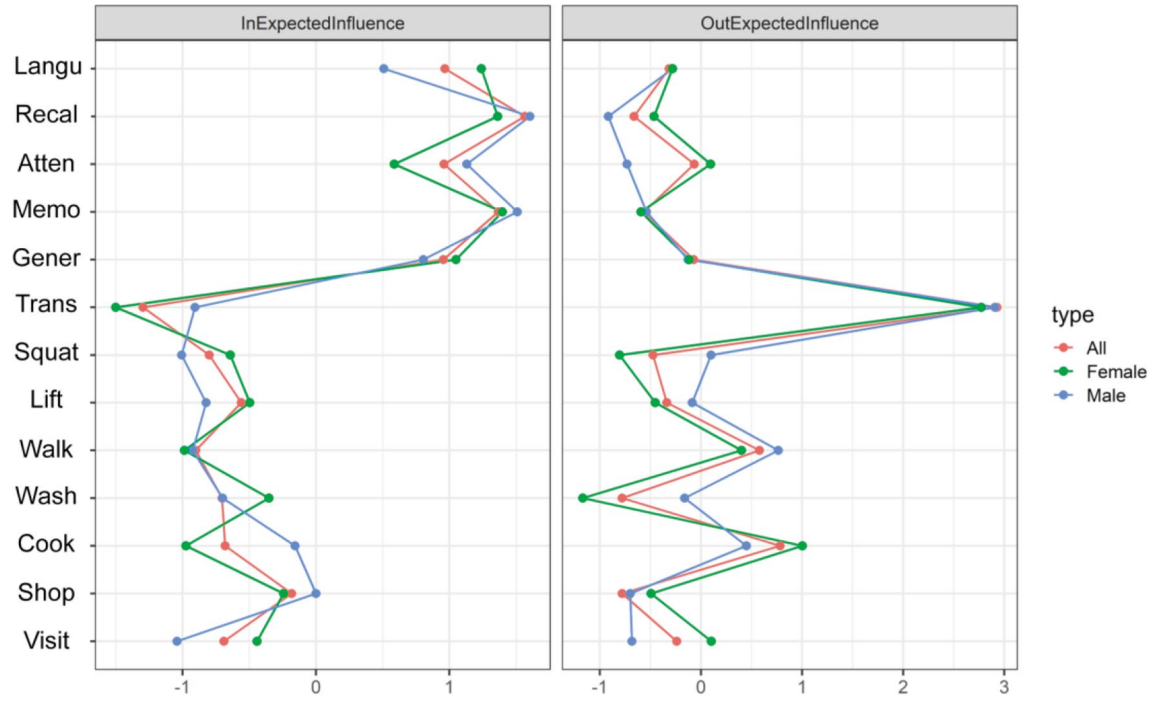

Fig. 3 Symptom centrality estimates for the networks using z-values. Note: Greater values indicate greater centrality. Out-Expected-Influence (OEI) is the degree to which a symptom predicts other symptoms at the subsequent relevant point. In-Expected-Influence (IEI) is the degree to which a symptom is predicted by other symptoms at the subsequent relevant point. Cognitive domains assessed by the Mini-Mental State Examination, including general ability (Gener), memory (Memo), attention and computation (Atten), recall (Recal), and language (Langu). Instrumental activities of daily life included visiting friends (Visit), shopping (Shop), cooking (Cook), washing clothes (Wash), walking 1 km (Walk), lifting 5 kg (Lift), squat 3 times (Squat), and using public transit (Trans)

Table 3 The 5 strongest edges for all three networks

Edges	Network		
	All	**Male**	**Female**
1st strongest	Use public transit → Attention and Calculation	Use public transit → Attention and Calculation	Use public transit → Attention and Calculation
2nd strongest	Use public transit → Language	Use public transit → Language	Use public transit → Recall
3rd strongest	Use public transit → Recall	Walk 1 km → Recall	Make food → Memory
4th strongest	Use public transit → Memory	Use public transit → Memory	Use public transit → Language
5th strongest	Use public transit → General ability	Use public transit → General ability	Make food → Recall

buses to travel farther away to entertainment destinations, while most of them typically walk within a 2 km radius of their homes for shopping and picking up their grandchildren from and to school [49]. Baker et al. suggested that the restriction of life space preceded the limitation of other IADLs [50]. A study by Japanese scholars have found that participants with take public transportation limitation are at an increased risk of developing MCI [51]. Substantial evidence indicates that life space constriction was highly associated with cognitive decline among older adults [52, 53]. "Make food" ranked second in the OEI. A study in China suggests that cooking regularly may improve survival in older adults [54]. Cooking involves the efficient and timely finding of one or several objects in a complex environment. Therefore, cooking may be disrupted by visual search deficits. These deficits

result from impairment of multiple attention and memory mechanisms [55]. In the early stages of AD, attention is the first non-memory domain to be affected [56].

In our study, the strongest correlated edges of all three networks were "Use public transit → Attention and calculation." Limitation in older adults' ability to "Use public transit" may indicate impaired "Attention and Calculation" ability. "Attention and Calculation," "General ability" and "Language" were the indicators that had an impact on other cognitive domains. Attention and calculation, unlike other cognitive functions, require substantial effort to maintain [57]. The active attention control ability of Chinese older adults with SCD is worse than that of healthy control participants [58]. The control of attention has been shown to maintain the stability of multiple cognitive functions, including memory, and is particularly susceptible to the impacts of aging [59]. Older adults who experience difficulty regulating basic attention may face challenges in effectively encoding new information [60]. Memory problems can actually stem from impaired attention function, as evidenced by research conducted [61]. The hypothesis posits that dysregulation within attentional control systems may underlie the initial stages of SCD [60]. Chinese older adults with amnestic mild cognitive impairment exhibit poorer performance in spoken language expression, hearing comprehension, and reading comprehension compared to healthy individuals [62]. Neuroimaging data suggest that portions of key neural networks dedicated to language function serve non-linguistic functions, such as executive system function, working memory, or attentional control, which contribute to various aspects of language performance [63]. Semantic-based memory coding strategies were more effective than cognitive stimulation in improving daily task performance, attention, memory, and general cognitive function in Chinese older adults with mild cognitive impairment [64].

In general, effective strategies to prevent cognitive decline include regular monitoring, promotion of healthy lifestyles, and cognitive training [65]. Based on the results of this study, for the prevention of cognitive decline in older adults, we should concentrate on monitoring limitations related to using public transit, making food, and walking, promoting broader life-space mobility [48], cognitive training for women, specifically targeting attention and calculation [66], as well as language abilities. For men, cognitive training focuses on language ability [64].

Strengths and limitations

A strength of our study is the utilization of a large and representative longitudinal data set, which enabled detailed analysis of associations between IADLs and cognitive function at the symptom level using network analysis. In addition, the use of OEI provided a quantitative estimate of the strength of these associations. Subgroup analysis based on gender allowed us to examine the influence of gender in the structure of these associations.

However, there are some limitations. First, the sample consisted mainly of Chinese older adults in the community, so caution should be exercised when generalizing the findings to other populations or to older adults with a clinical diagnosis of cognitive impairment. Second, the sample used the Chinese modified version of the Lawton Scale to evaluate IADL, some items such as financial management, telephone use, and medication use were not included, potentially limiting the comprehensiveness of our findings [67]. Finally, our analyses were observational, and although we used longitudinal data, we cannot infer causality from these associations. Potential confounding factors such as age, depressive symptoms, and dietary habits were not fully controlled for, and future studies should consider these variables.

Conclusions

This study provides new insights into the associations between specific IADL activities and cognitive function domains among Chinese older adults. Concentrate on monitoring limitations related to "Use public transit," "Make food" and "Walk 1 km," and promoting broader life-space mobility may be beneficial to preventing the decline of cognitive function, although further research is required to evaluate their effectiveness. The findings underscore the importance of targeting interventions not only by specific cognitive domains, but also potentially by gender. Future studies should include more diverse populations and control for additional confounders to further examine the nature of these associations.

Abbreviations

ADL	Activities of daily living
IADL	Instrumental activities of daily living
CLHLS	Chinese Longitudinal Healthy Longevity Survey
MMSE	Mini-mental State Examination
CLPN	Cross-lagged panel network
IEI	In-Expected-Influence
OEI	Out-Expected-Influence
MCI	Mild cognitive impairment
AD	Alzheimer's disease
SCD	Subjective cognitive decline
CS Coefficient	correlated stability coefficient
CI	Confidence intervals
SD	Standard deviation

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12877-025-06017-1.

Supplementary Material 1

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Author contributions
XZ, XY and DJ conceived the ideas and designed the research; XZ conducted the research and analyzed the data; and XZ wrote the original draft. DJ, XY, RL and RW reviewed and revised the manuscript critically. XZ had primary responsibility for final content. All authors have read and approved the final manuscript.

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Data availability
The data are held in a public repository. The details of the CLHLS were presented online(https://opendata.pku.edu.cn/dataverse/CHADS;jsessionid=121de1752184d9c4953cc0f28935).

Declarations

Ethics approval and consent to participate
This study was conducted according to the guidelines laid down in the Declaration of Helsinki. The studies involving humans were approved by Biomedical Ethics Committee, Peking University (IRB00001052–13074), and the Institutional Review Board, Duke University (Pro00062871). The participants provided their written informed consent to participate in this study.

Consent for publication
No applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Department of Epidemiology and Biostatistics, School of Public Health, Southeast University, Nanjing, China
[2]Department of Community Health Sciences, University of Manitoba, 7750 Bannatyne Ave, Winnipeg, MB, Canada
[3]Key Laboratory of Environmental Medicine Engineering, School of Public Health, Ministry of Education, Southeast University, Nanjing, Jiangsu 210009, China

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