

Network Analysis of Depressive Symptoms and Activities of Daily Living Disability in Older Adults with Diabetes: A nationwide population-based study

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Abstract

Background

Depressive symptoms and functional disability frequently co-occur among older adults with diabetes, yet their complex interrelationships at the symptom level remain unclear. This study aimed to examine the network analysis linking depressive symptoms and activities of daily living (ADL) disability.

Methods

Data were obtained from the China Health and Retirement Longitudinal Study (CHARLS), including 984 adults aged ≥ 60 years with diabetes. Depressive symptoms were assessed using the CESD-10, and ADL was measured using the Basic Activities of Daily Living (BADL) and Instrumental Activities of Daily Living (IADL). Gaussian Graphical Models (GGM) were used to construct symptom networks. Centrality and bridge strength indices were calculated to identify influential nodes.

Results

Strong associations were observed within depressive symptoms and within ADL domains. Felt depressed (D3) emerged as the central node in both the IADL-depressive (strength = 1.275) and BADL-depressive (strength = 1.273) networks. Bridge strength analysis revealed that B5 (Toileting, bridge strength = 0.177) and D4 (Everything was an effort, bridge strength = 0.159) were the bridge symptoms driving the co-morbidity of depressive symptoms and BADL disability. For depressive symptoms and IADL disability, the bridge symptoms linking this co-occurrence were I1 (Doing housework, bridge strength = 0.195) and D4 (bridge strength = 0.194). Subgroup analyses revealed variations in central and bridge symptoms across sex and gender.

Conclusion

Targeting the central symptom of feeling depressed and specific bridge symptoms offers promising interventions to alleviate comorbid depressive symptoms and disability among older diabetic adults.

1 Introduction

Diabetes has become one of the major chronic diseases affecting the health of older adults, with a steadily increasing prevalence that places a substantial burden on public health systems. Globally, diabetes is one of the most significant non-communicable chronic diseases. In 2022, more than 800 million people were affected worldwide, nearly double the prevalence observed in 1990, with the greatest increases occurring in low- and middle-income countries. Among them, the burden in China is particularly pronounced, with approximately 140.9 million adults aged 20 years and older affected,

accounting for nearly one-quarter of the global diabetes population, and a rapid upward trend over the past two decades [1, 2]. With the acceleration of population aging, diabetes and its related complications increasingly threaten the health of older adults. Patients with diabetes not only face challenges in glycemic control but also commonly experience multiple functional impairments and psychological problems, severely affecting their quality of life.

Among older adults with diabetes, depressive symptoms are highly prevalent and have gradually emerged as a significant public health concern. Existing studies consistently show that individuals with diabetes are more likely to experience depressive symptoms compared to the general population. Data from the China Health and Retirement Longitudinal Study (CHARLS) indicate that the prevalence of depressive symptoms among Chinese middle-aged and older adults with diabetes is approximately 67.5% [3]. In addition, depressive symptoms can impair treatment adherence and are often associated with suboptimal disease management, as reflected in poorer glycemic control, which in turn increases the risk of various diabetes-related complications, including cardiovascular events, cognitive decline, and all-cause mortality [4, 5]. Therefore, depressive symptoms are recognized as a key psychological factor influencing long-term prognosis in patients with diabetes.

Beyond depressive symptoms, limitations in activities of daily living (ADL) are also a common functional impairment among older adults with diabetes. Studies have shown that individuals with diabetes have a significantly higher risk of physical disability [6]. The prevalence of ADL limitations in this population is substantially higher than in non-diabetic individuals and is closely associated with disease duration, glycemic control, and the burden of complications [7]. Functional decline not only reduces patients' independence in daily life but also increases caregiving demands on families and society, lowers quality of life, and represents a key risk factor for disability, hospitalization, and mortality among older adults [8].

Notably, depressive symptoms and ADL limitations often interact bidirectionally among older adults with diabetes, each exacerbating the other [9]. Longitudinal studies have shown that baseline depressive symptoms predict the onset and progression of subsequent functional limitations, while pre-existing ADL impairments also increase the risk of worsening depressive symptoms [10, 11]. However, previous research has largely focused on overall associations and rarely examined the detailed symptom-level interactions between the two conditions. Traditional approaches cannot reveal the complex interrelations among individual symptoms or identify key nodes within the symptom network. In recent years, network analysis has provided a novel perspective for studying comorbidity: by constructing networks of symptom associations, it is possible to identify "core symptoms" that play a dominant role within the system and "bridge symptoms" that connect different symptom clusters, providing a basis for targeted interventions [12, 13].

Despite the advantages of network analysis in studying comorbidity, there remains a lack of research based on nationally representative samples in China that focuses specifically on the comorbidity network of depressive symptoms and ADL limitations among older adults with diabetes. Therefore, the present study uses data from a nationwide survey to construct a symptom-level comorbidity network of

depressive symptoms and ADL limitations in older adults with diabetes in China, identify core and bridge symptoms within the network, and compare network structures across subgroups defined by age, sex, and residential region.

2 Methods

2.1 Data Source and Study Population

The data used in this study were obtained from the China Health and Retirement Longitudinal Study (CHARLS) 2015. This nationally representative longitudinal survey collects high-quality microdata on Chinese households and individuals aged 45 years and older. The 2015 wave was specifically selected because it provides comprehensive objective biomarker data, including blood glucose and glycated hemoglobin (HbA1c) tests, which are essential for the accurate identification and clinical assessment of diabetic patients. Compared to later waves, the 2015 dataset remains a authoritative and representative source for metabolic disease research in China, as it combines both self-reported information and clinical laboratory results. CHARLS was approved by the Biomedical Ethics Committee of Peking University Biomedical Ethics Committee (IRB00001052-11015).

The initial dataset included a total of 13,346 participants. First, non-diabetic individuals were excluded, leaving 3,439 participants with diabetes. Subsequently, participants aged ≤ 60 years were excluded, resulting in a sub-sample of 2,058 older adults with diabetes. Finally, after excluding those with missing data on depressive symptoms and ADL, a total of 984 participants were ultimately included in the present study (Fig. 1).

2.2 Assessment of diabetes

This study defined diabetes in older adults according to the 2021 diagnostic criteria of the American Diabetes Association (ADA): (1) fasting plasma glucose (FPG) ≥ 7.0 mmol/L; or (2) glycated hemoglobin (HbA1c) $\geq 6.5\%$; or (3) random plasma glucose (RPG) > 11.1 mmol/L (for participants with random glucose measurements); (4) self-reported physician diagnosis of diabetes; or (5) use of antidiabetic medications. For participants with both self-reported information and laboratory test results, a diagnosis of diabetes was made if any one of the above criteria was met.

2.3 Assessment of Activities of Daily Living

ADL was evaluated by two components: Basic Activities of Daily Living (BADL) and Instrumental Activities of Daily Living (IADL) [14]. The BADL consisted of six tasks: dressing, bathing, eating, getting up, toileting, and controlling urination and defecation. The IADL evaluates six more complex tasks: doing housework, cooking, shopping, making a phone call, taking medication, and managing money.

2.4 Assessment of depressive symptom

This study employed the revised Center for Epidemiologic Studies Depression Scale (CESD-10) by Andresen et al. to assess depression [15]. The items evaluated include “Bothered by things,” “Had trouble keeping mind,” “Felt Depressed,” “Felt everything I did was an effort,” “Felt fearful,” “Sleep was restless,” “Felt lonely,” “Could not get on,” “Felt hopeful about the future,” and “Happy” [16]. Responses are scored from 0 to 3, reflecting severity from “not at all” to “most of the time,” with reverse scoring for “Felt hopeful about the future” and “Happy.” Total scores vary from 0 to 30, with higher scores reflecting greater levels of depression.

2.5 Demographic characteristics

Demographic characteristics included age, sex, education level, marital status, residence, smoking status, alcohol consumption and self-perceived health status.

2.6 Statistical analysis

Statistical analyses were performed using R version 4.2.3 (R Foundation for Statistical Computing). Descriptive data were reported as the mean $\pm$ standard deviation (*SD*) for normally distributed continuous variables, and as medians and interquartile ranges (*IQRs*) for skewed continuous variables, and frequencies and percentages for categorical variables.

Gaussian Graphical Model (GGM) was constructed using R package ‘qgraph’. In the network analysis model, variables were regarded as “nodes” (the nodes of each network in this study correspond to ADL and depressive symptom dimensions), and the “edges” between nodes could be understood as partially correlated, and the depth and thickness of the edges indicate the weight size. Green and gray edges indicated positive and negative relationships respectively between 2 continuous nodes. The location of all nodes was determined by the Fruchterman and Reingold algorithm, which places nodes with stronger associations with other nodes close to the center. The ‘bootnet’ package was used to gain insight into the structural importance of nodes in the network, and three centrality indicators, strength (Strength), closeness (Closeness), and betweenness (Betweenness), were calculated. The accuracy and stability of the network model were tested by evaluating the stability and centrality indexes of edge weights. The stability of the edges was estimated using a non-parametric bootstrap with Bootstrap value set at 1000, and the certainty of edge weight values was measured using bootstrap confidence intervals (CIs), and the differences between edges were tested to determine the 95% CIs for each edge. Corstability (CS) coefficient was used to evaluate the intensity centrality index. CS meant that the maximum proportion of data center index that can be eliminated remains highly correlated with the original centrality index (> 0.70). CS coefficient should be at least 0.25 [17].

3 Results

3.1 Participants characteristics

A total of 984 older adults with diabetes were included in this study, as shown in Table 1. The sample comprised 451 (45.8%) males and 533 (54.2%) females. The majority of participants had primary school

education or below (70.6%), resided in rural areas (69.8%), and were married (85.6%). Most of the study population was aged between 60 and 74 years (81.4%). Regarding lifestyle and health, most participants were non-smokers (59.0%), never drank alcohol (67.1%), and reported a fair self-perceived health status (56.4%).

Detailed item-level descriptive statistics are provided in Supplementary Table S1. For individual depressive items, hopeless about future (1.620 ± 1.306) and restless sleep (1.181 ± 1.267) exhibited the highest mean scores. For the BADL domain, participants reported the most limitation in toileting (0.366 ± 0.716). For IADL, making a phone call (0.585 ± 1.216) was the most challenging tasks.

Table 1
Demographics of the older adults with diabetes
(*N* = 984).

Characteristics	n(%)
Age (years)	
60–74	801(81.4)
≥ 75	183(18.6)
Sex	
Male	451(45.8)
Female	533(54.2)
Education Level	
Primary school or below	695(70.6)
Junior high school/High School	215(21.8)
College or above	74(7.5)
Marital status	
Married	842(85.6)
Unmarried/divorced/widowed	142(14.4)
Residence	
Urban	297(30.2)
Rural	687(69.8)
Smoking status	
No	581(59.0)
Yes	403(41.0)
Alcohol consumption	
Never drinker	660(67.1)
Less than once a month	135(13.7)
More than once a month	189(19.2)
Self-perceived health status	
Good	150 (15.2)
Fair	555 (56.4)

Characteristics	n(%)
Age (years)	
Poor	279 (28.4)

3.2 Depressive symptom and ADL network structure

The strongest positive edges were observed within their respective subgroups (Fig. 2). Specifically, within the depressive symptoms subgroup, the strongest connections were identified between Bothered by things and Felt depressed (D1-D3, weight = 0.306), and between Hopeless about future and Felt unhappy (D5-D8, weight = 0.290). Regarding functional status, the strongest edges were observed between Doing housework and Cooking in the IADL subgroup (I1-I2, weight = 0.569) and between Dressing and Bathing in the BADL subgroup (B1-B2, weight = 0.321). In contrast, cross-domain edges between depression and ADL items were generally weaker (Supplementary Tables S2 and S3).

Note

D1, Bothered by things; D2, Trouble concentrating; D3, Felt depressed; D4, Everything was an effort; D5, Hopeless about future; D6, Felt fearful; D7, Restless sleep; D8, Felt unhappy; D9, Felt lonely; D10, Could not get going; B1, Dressing; B2, Bathing; B3, Eating; B4, Getting up; B5, Toileting; B6, Controlling urination and defecation; I1, Doing housework; I2, Cooking; I3, Shopping; I4, Managing money; I5, Taking medication; I6, Making a phone call.

3.3 Depressive symptom and ADL network centrality

As shown in Fig. 3A and Supplementary Table S4, Felt depressed (D3) emerged as the most central node in the network with the highest strength centrality (1.273), followed by Bathing (B2, strength = 1.037) and Getting up (B4, strength = 1.019). Conversely, Hopeless about future (D5) was the least central node (strength = 0.396). Within the depressive symptom subgroup, Felt depressed (D3) also had the highest predictability (0.520), highlighting its strong predictive power over other symptoms in the system. In addition, the bridge strength index (Supplementary Table S4) indicated that B5 (Toileting, bridge strength = 0.177) and D4 (Everything was an effort, bridge strength = 0.159) were the bridge symptoms driving the co-morbidity of depressive symptom and BADL disability (Fig. 3B).

As shown in Fig. 4A and the Supplementary Table S5, Felt depressed (D3) emerged as the most central node in the IADL-depressive symptoms network with the highest strength centrality (1.275), followed closely by Doing housework (I1, strength = 1.094) and Everything was an effort (D4, strength = 1.050). Regarding predictability, Doing housework (I1) and Felt depressed (D3) demonstrated the highest values (0.578 and 0.519, respectively) within their respective domains, highlighting their strong predictive power over other nodes. In addition, the bridge strength index indicated that I1 (Doing housework, bridge strength = 0.195) and D4 (Everything was an effort, bridge strength = 0.194) were the primary bridge symptoms driving the co-morbidity of depressive symptoms and IADL disability (Fig. 4B).

3.4 Depressive symptom and ADL network stability and accuracy

Both networks exhibited adequate stability, with CS-C values for node and bridge strength surpassing the 0.25 threshold in the depressive symptom-BADL (0.750 and 0.439; Figure S1) and depressive symptom-IADL (0.672 and 0.516; Figure S3) networks. Additionally, non-parametric bootstrapping revealed narrow 95% confidence intervals across both networks (Figures S2 and S4), indicating high accuracy.

3.5 Network comparison

To further explore the heterogeneity of the depressive symptom-BADL and depressive symptom-IADL networks among older adults with diabetes, we constructed network structures and conducted comparative analyses across subgroups defined by age, sex, and residence area.

3.5.1 Network comparison of age

In the 60–74 age group, felt depressed (D3) showed the highest node strength in both the BADL (strength = 1.251) and IADL (strength = 1.237) networks. In the BADL network, bathing (B2; strength = 1.098) and everything was an effort (D4; strength = 1.023) were also relatively central, while the main bridge nodes were toileting (B5; bridge strength = 0.178) and everything was an effort (D4; bridge strength = 0.152) (Figures S5 and S6). In the IADL network, everything was an effort (D4; strength = 1.059) and doing housework (I1; strength = 1.009) followed D3 in centrality, with D4 (bridge strength = 0.195) and I1 (bridge strength = 0.176) showing the highest bridge strength (Figures S5 and S7).

In the ≥ 75 age group, felt depressed (D3) remained the most central node in both the BADL (strength = 1.341) and IADL (strength = 1.333) networks. In the BADL network, getting up (B4; strength = 0.937) and everything was an effort (D4; strength = 0.907) were also prominent, whereas bridge nodes were mainly functional items, including controlling urination and defecation (B6; bridge strength = 0.331) and bathing (B2; bridge strength = 0.318) (Figures S8 and S9). In the IADL network, doing housework (I1; strength = 1.169) and managing money (I4; strength = 1.035) showed relatively high node strength, with I1 (bridge strength = 0.190) and shopping (I3; bridge strength = 0.179) as the main bridge nodes (Figures S8 and S10).

3.5.2 Network comparison of sex

In males, felt depressed (D3) showed the highest node strength in both the BADL (strength = 1.288) and IADL (strength = 1.303) networks. In the BADL network, bothered by things (D1; strength = 0.912) and bathing (B2; strength = 0.912) were also relatively central, while the main bridge nodes were bathing (B2; bridge strength = 0.152) and everything was an effort (D4; bridge strength = 0.135) (Figures S11 and S12). In the IADL network, doing housework (I1; strength = 1.153) and cooking (I2; strength = 0.949) followed D3 in centrality, with I1 (bridge strength = 0.187) and everything was an effort (D4; bridge strength = 0.149) showing the highest bridge strength. In females, felt depressed (D3) also showed the

highest node strength in both the BADL (strength = 1.222) and IADL (strength = 1.213) networks (Figures S11 and S13). In the female BADL network, bathing (B2; strength = 1.153) and everything was an effort (D4; strength = 1.047) were also prominent, while the main bridge nodes were bathing (B2; bridge strength = 0.215) and getting up (B4; bridge strength = 0.154) (Figures S14 and S15). In the IADL network, everything was an effort (D4; strength = 1.097) and shopping (I3; strength = 1.004) showed relatively high node strength, with hopeless about future (D5; bridge strength = 0.192) and doing housework (I1; bridge strength = 0.189) as the main bridge nodes (Figures S14 and S16).

4 Discussion

This study was the first to systematically investigate the symptom-level associations between depressive symptoms and ADL (including BADL and IADL) among older adults with diabetes using a network analysis approach. The findings revealed both the internal network structures of depressive symptoms and functional abilities, as well as their cross-domain interaction patterns. In the depressive symptoms-BADL network, Felt depressed (D3), Everything was an effort (D4), and Bathing (B2) were identified as the most central nodes. In the depressive symptoms-IADL network, in addition to Felt depressed (D3) and Everything was an effort (D4), Doing housework (I1) also showed high centrality. Furthermore, Toileting (B5) and Everything was an effort (D4) were key bridge symptoms linking depressive symptoms and BADL, while Doing housework (I1) and Everything was an effort (D4) served as critical bridges between depressive symptoms and IADL. Subgroup analyses further revealed variations in network structures across age, gender, and residential groups.

Across the entire network, the depressive symptom Felt depressed (D3) exhibited the highest strength centrality in both networks, indicating its core role in maintaining the comorbidity between depressive symptoms and functional impairment. Previous research had similarly identified Felt depressed as a central symptom in depressive symptoms-ADL networks [18]. Older adults with diabetes were more likely to experience persistent depressive feelings due to long-term disease management, complications, and uncertainty in glycemic control [19]. Such depressive feelings might have exacerbated psychological burden or indirectly affected individuals' motivation to maintain daily functioning by reducing self-efficacy and treatment adherence, thereby creating a vicious cycle between psychological distress and functional decline. Therefore, interventions targeting Felt depressed might have helped disrupt the spread of symptoms across the network and improve related conditions [20]. Among functional nodes, Bathing (B2) showed high centrality in the depressive symptoms-BADL network, while "Doing housework" (I1) demonstrated the highest strength centrality in the depressive symptoms-IADL network. As one of the most private and physically demanding BADL activities, limitations in bathing often implied dependence on others for basic self-care, which might have significantly undermined an individual's self-esteem and sense of autonomy, thereby triggering or exacerbating depressive symptoms [21, 22]. Similarly, Doing housework was not only a complex instrumental activity but was also closely tied to individuals' roles within the family and their sense of self-worth. In the Chinese cultural context, older adults' sense of value was largely derived from their family roles and contributions [23]. When physical

decline prevented them from performing housework, feelings of uselessness and worthlessness might have arisen, increasing the risk of depression.

Bridge symptom analysis indicated that Everything was an effort (D4) appeared as a key bridge in both networks, serving as a central pathway linking psychological symptoms and functional impairment. This symptom reflected both reduced energy and lack of motivation, and was closely associated with fatigue in individuals with diabetes [24]. Persistent feelings of effortfulness might have led patients to reduce engagement in daily activities, including both basic self-care and more complex instrumental tasks, thereby accelerating functional decline. At the same time, functional limitations might have further intensified feelings of fatigue and helplessness, forming a vicious cycle. Therefore, targeting Everything was an effort through comprehensive interventions might have effectively disrupted the mutual reinforcement between depressive symptoms and ADL disability. Additionally, Toileting (B5) was identified as an important bridge symptom linking depressive symptoms and BADL. As one of the most fundamental functional abilities, impairment in toileting not only caused practical inconvenience but might also have led to feelings of embarrassment and social withdrawal due to its private nature, thereby worsening depressive symptoms. Previous studies had shown that incontinence or toileting difficulties were independent risk factors for depressive symptoms among older adults [25]. Therefore, clinical care should have emphasized the assessment and rehabilitation of toileting function, along with timely provision of assistive devices or environmental modifications to mitigate its negative psychological impact. In the depressive symptoms - IADL network, "Doing housework" also served as a bridge symptom connecting the two domains. As discussed, housework carried social and cultural significance beyond its functional role among older adults in China. When individuals were unable to perform housework due to physical decline, they might have experienced loss of role and diminished self-worth, thereby increasing depressive risk. Conversely, depressive symptoms might have reduced motivation to engage in housework, further accelerating functional deterioration. These findings suggested that intervention strategies should have considered the unique role of housework in maintaining psychological well-being, and supported older adults in continuing participation through family support or occupational therapy.

The age-stratified analysis revealed clear differences in the network structure linking depressive symptoms and ADL between individuals aged 60–74 years and those aged ≥ 75 years, suggesting that both comorbidity patterns and intervention priorities shift with advancing age. In both groups, Felt depressed (D3) consistently showed the highest strength centrality in the BADL and IADL networks, indicating a stable core role across age strata. However, the surrounding key and bridging symptoms exhibited distinct age-specific patterns. Among individuals aged 60–74 years, Everything was an effort (D4) demonstrated high node strength in both networks and functioned as a major bridge connecting depressive symptoms with functional limitations [26]. In addition, Bathing (B2) and Doing housework (I1) not only showed high centrality within their respective domains but also contributed to cross-domain connections. This pattern suggests that younger older adults may still maintain stronger role engagement and a sense of self-worth. When feelings of effortfulness interfere with activities such as bathing or housework-tasks closely tied to personal identity-interactions between psychological distress

and functional decline may be amplified, potentially leading to a reinforcing negative cycle [18, 27–30]. Therefore, interventions for this group should prioritize the identification and management of effort-related symptoms, alongside rehabilitation and family support to sustain daily functioning and social participation. In contrast, among individuals aged ≥ 75 years, the network core shifted toward more basic functional abilities. In the BADL network, “Getting up” (B4) emerged as a central node, while bridging symptoms were primarily related to fundamental activities such as “Controlling urination and defecation” (B6) and “Bathing” (B2). In the IADL network, cognitively demanding activities such as “Managing money” (I4) and “Shopping” (I3) played key bridging roles. This shift may reflect age-related declines in physiological reserve, the accumulation of comorbid conditions, and deterioration in cognitive function [31, 32]. Impairments in basic functions (e.g., mobility and toileting) can directly threaten independence and dignity, while difficulties in cognitively demanding daily tasks may further contribute to social isolation and psychological distress [11, 32–35]. Overall, the findings indicate a transition in key symptoms from role-related activities to fundamental survival functions with increasing age. Accordingly, clinical interventions should be tailored to age-specific needs: for those aged 60–74 years, emphasis should be placed on alleviating effort-related symptoms and maintaining role functioning, whereas for individuals aged ≥ 75 years, priority should be given to preserving basic functional abilities and cognitive-related instrumental activities through targeted, stratified intervention strategies.

The gender-stratified analysis revealed notable differences in the network structure linking depressive symptoms and ADL between male and female. In the male group, key nodes in the BADL network included Bothered by things (D1) and Bathing (B2), while Bathing (B2) and Everything was an effort (D4) served as major bridging symptoms. In the IADL network, Doing housework (I1) and Cooking (I2) showed high centrality, with I1 and D4 acting as important connectors between psychological and functional domains. These findings suggest that male patients may be more influenced by role-related responsibilities and outward behavioral expressions. When effort-related symptoms limit their ability to perform household tasks or cooking, their psychological burden may be amplified. Previous studies have also indicated that men tend to maintain self-worth through functional independence; thus, impairment in these role-related activities may increase the risk of depression [36–38]. In contrast, a different pattern was observed in female. In the BADL network, Bathing (B2) and Everything was an effort (D4) had high centrality, while Getting up (B4) emerged as an important bridging node. In the IADL network, Everything was an effort (D4) and Shopping (I3) were prominent, with Hopeless about future (D5) and “Doing housework” (I1) forming key bridging pathways. This pattern suggests a closer linkage between basic functional abilities and psychological states in women. Limitations in private activities such as bathing may evoke feelings of dependency and shame, while difficulty getting out of bed may signal overall functional decline and trigger psychological distress. Notably, Hopeless about future (D5) functioned as a key bridge, indicating that women may be more likely to experience depression through emotional processing and negative future expectations. When instrumental activities are restricted, such negative expectations may further intensify psychological burden [33, 39–41]. Overall, male networks place greater emphasis on role-related activities and external emotional responses, whereas female networks are more closely associated with basic functional abilities and negative affective experiences. These

findings highlight the importance of gender-sensitive interventions: for men, efforts should focus on maintaining role-related functioning and reducing stress from daily frustrations; for women, priority should be given to preserving basic functional abilities and addressing negative expectations through psychological support.

This study has several notable strengths. By applying a network analysis framework, it examined the interplay between depressive symptoms and ADL at the symptom level, allowing for a more fine-grained understanding of their interconnections in older adults with diabetes. Central and bridge symptoms were identified, which may help inform more targeted intervention strategies. In addition, the use of a large, nationally representative dataset enhances the generalizability of the findings to some extent. Several limitations should also be acknowledged. First, due to the cross-sectional design, causal relationships between symptoms cannot be established. Longitudinal studies are therefore needed to evaluate the stability of the network structure and to capture potential temporal dynamics among symptoms. Second, both depressive symptoms and ADL were assessed using self-reported measures, which may introduce reporting bias. Third, some relevant factors that could influence the relationship between depression and ADL, such as social support, cognitive function, and the severity of diabetes-related complications, were not included in the analysis and should be considered in future research. Finally, although the data were drawn from a nationwide sample, caution is warranted when extending these findings to populations in different cultural contexts.

5 Conclusions

This study employed network analysis to systematically examine the complex relationships between depressive symptoms and activities of daily living disability (BADL and IADL) in older adults with diabetes. Results indicated that Felt depressed (D3) was the central symptom across the overall sample and subgroups, highlighting its key role in the depressive symptom-functional comorbidity network. Everything was an effort (D4) emerged as a bridging symptom, linking psychological and functional domains and representing a potential target to interrupt the comorbidity cycle. Age-stratified analyses showed that for patients aged 60–74, central symptoms centered on effortfulness and role-related activities, whereas those ≥ 75 years exhibited central and bridging effects in basic functions and cognitively demanding instrumental activities. Gender-stratified analyses revealed that male patients' networks emphasized role responsibilities and outward emotional expression, while female patients' networks were more associated with basic functions and negative expectations about the future. These findings suggest that interventions targeting depressive symptom-functional comorbidity in older adults with diabetes should account for age and gender differences, implementing stratified and precise approaches. Future research incorporating longitudinal data is needed to validate dynamic changes in symptom networks and explore personalized interventions based on central and bridging symptoms, aiming to reduce comorbidity burden and promote healthy aging.

Declarations

Ethical approval

CHARLS was approved by the Biomedical Ethics Committee of Peking University Biomedical Ethics Committee .Written informed consent was obtained from each participant.

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CRediT authorship contribution statement

Dongrui Miao: Formal analysis, Interpretation of data, Writing - original draft, Writing - review & editing. **Jiangyan Dong:** Formal analysisWriting - review & editing. **Dong Song:** Writing - review & editing. **Yanxia Guo:** Writing - review & editing. **Yuqing Zhang:**Writing - review & editing. **Jiaojiao Zhu:** Writing - review & editing. **Ran Chen:** Formal analysis, Writing - review & editing. **Yuanling Xu:** Conceptualization, Writing - original draft, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data Availability

The China Health and Retirement Longitudinal Study (CHARLS) data are publicly available via the official website (<https://charls.pku.edu.cn>)

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Figures

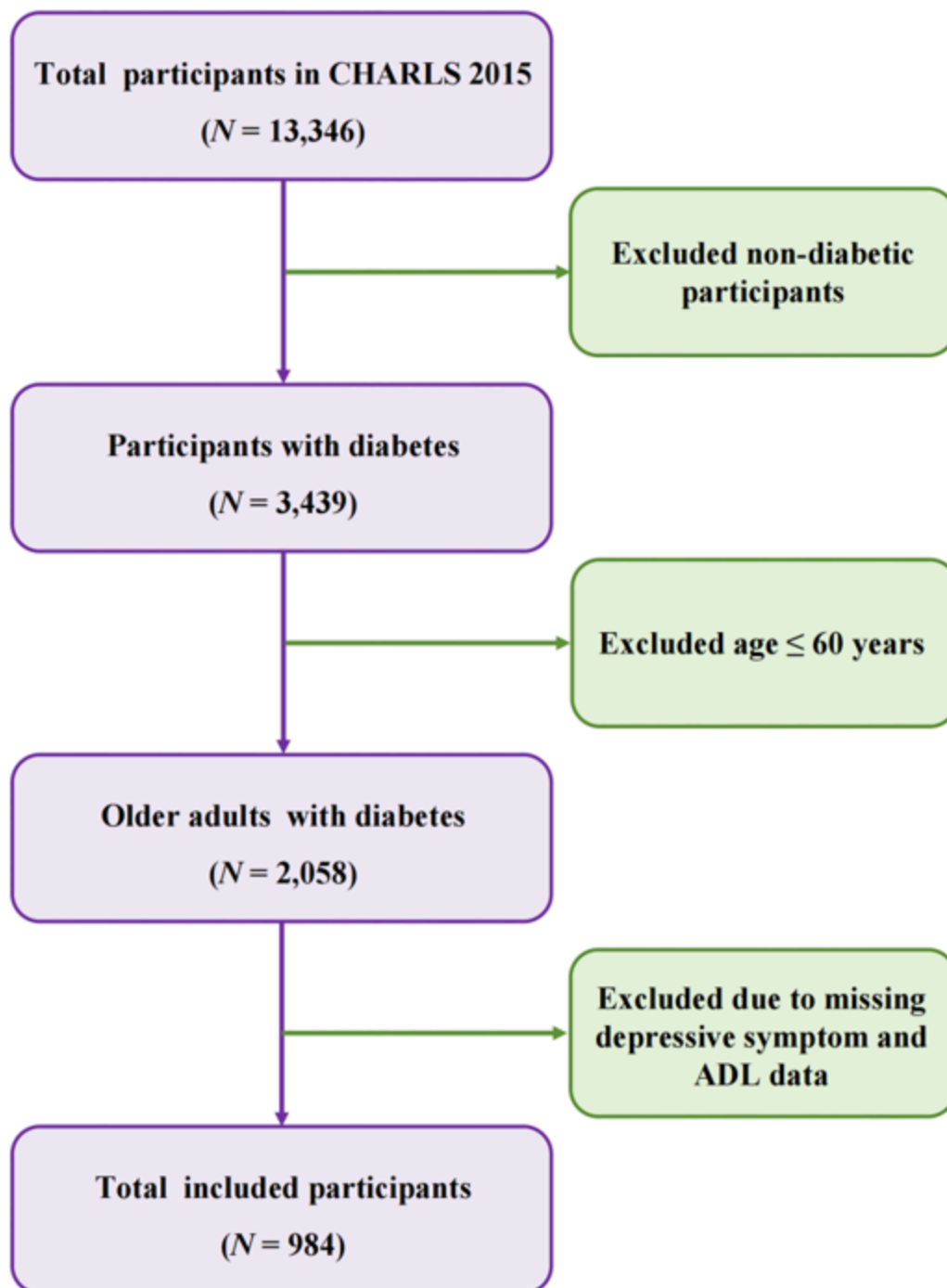


Figure 1

Flowchart of the participants included and excluded in this study.

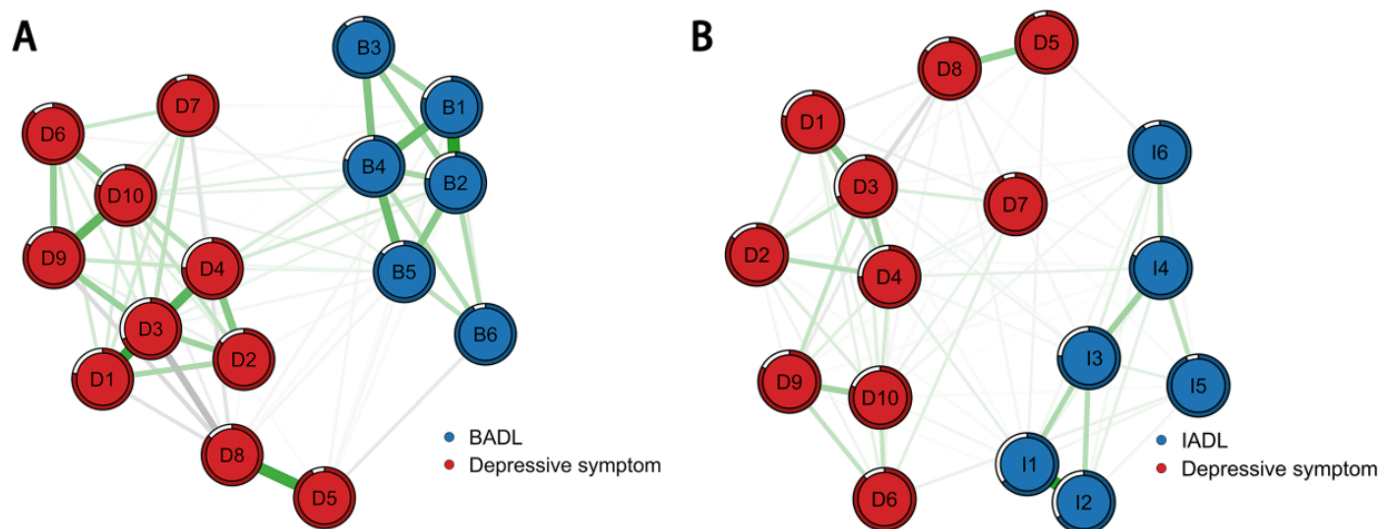


Figure 2

The network structure of depressive symptoms and ADL in older adults with diabetes. A) network of depressive symptoms and BADL; B) network of depressive symptoms and IADL.

Note: D1, Bothered by things; D2, Trouble concentrating; D3, Felt depressed; D4, Everything was an effort; D5, Hopeless about future; D6, Felt fearful; D7, Restless sleep; D8, Felt unhappy; D9, Felt lonely; D10, Could not get going; B1, Dressing; B2, Bathing; B3, Eating; B4, Getting up; B5, Toileting; B6, Controlling urination and defecation; I1, Doing housework; I2, Cooking; I3, Shopping; I4, Managing money; I5, Taking medication; I6, Making a phone call.

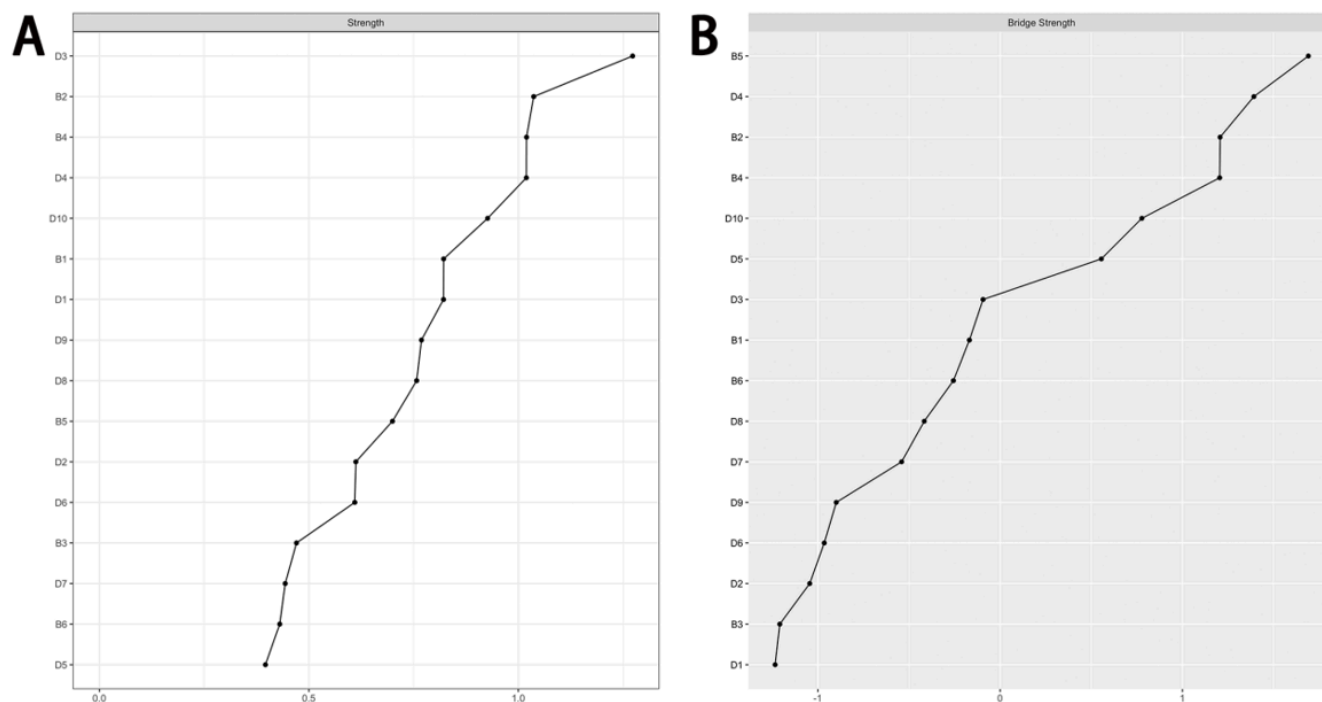


Figure 3

The node strength and bridge strength of depressive symptoms and BADL in older adults with diabetes.

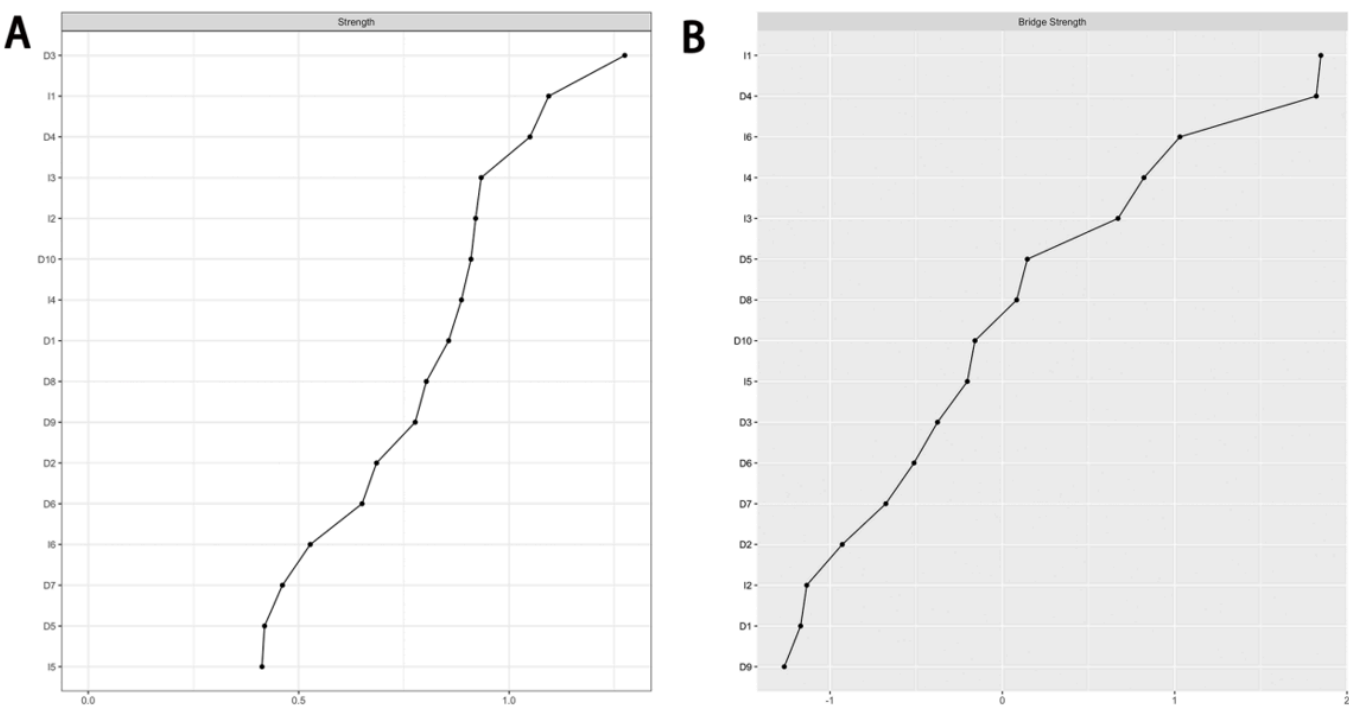


Figure 4

The node strength and bridge strength of depressive symptoms and IADL in older adults with diabetes.

Supplementary Files

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