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Core and bridge symptoms in self-perceived aging, depression, and anxiety among the elderly with multiple chronic conditions in Chinese communities: a network analysis perspective

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Abstract

Background Previous research has overlooked the role of self-perceived aging in the psychological well-being of older adults with multiple chronic conditions, and few studies have analyzed specific symptom interactions from a symptom network perspective. Our study aimed to explore the structure of the network among self-perceived aging, depression, and anxiety in community-dwelling older adults with multiple chronic conditions.

Methods This was a cross-sectional survey conducted using convenience sampling from four prefecture-level cities in Jiangsu Province, China, between November 2022 and May 2023. A total of 478 participants were included in the analysis. The Brief Ageing Perceptions Questionnaire (B-APQ) and the Depression Anxiety and Stress Scales-21 (DASS-21) were used to assess self-perceived aging, depression, and anxiety among older adults. Network analysis was performed using R to explore the interrelationships among symptoms in the network and identify the core symptoms and bridge symptoms.

Results Network analysis revealed that, after controlling for covariates, the node S5 ('Emotional-Representations') had the highest strength, followed by D7 ('Meaningless'), S2 ('Consequences-Positive'), S1 ('Consequences and Control Negative'), and D6 ('Worthless'). Furthermore, based on the bridge strength values, A5 ('Panic'), D7 ('Meaningless'), and S5 ('Emotional-Representations') were identified as bridge symptoms connecting self-perceived aging, depression, and anxiety. The study also identified several strong edge weight, most of which were linked to core symptoms and bridge symptoms.

Conclusion The study suggests that targeting "Emotional-Representations" as a core symptom can be effective in addressing psychological issues in older adults with multiple chronic conditions. Furthermore, preventing and inhibiting bridge symptoms such as "panic," "Meaningless," and "Emotional-Representations" could be potentially effective prevent widespread activation of symptoms (e.g., from self-perceived aging to depression).

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Keywords Elderly, Multiple chronic conditions, Self-Perceived aging, Depression, Anxiety, Network analysis

Introduction

As the global population ages, chronic diseases among older adults have become a growing public health issue [1]. In China, approximately 180 million older adults suffer from chronic diseases, making up 75% of the elderly population [2], with 65.14% experiencing multiple chronic conditions (MCCs) [3]. These comorbidities not only reduce quality of life but also contribute to psychological problems. Factors like fear of disease progression [4], ineffective disease control [5], self-management challenges [6], and financial stress [7] can lead to depression and anxiety, which negatively impact both well-being and treatment outcomes for older adults with MCCs [8]. However, the role of self-perceived aging (SPA) in this process is often overlooked.

SPA refers to how older adults perceive and emotionally respond to the threats of aging, including physiological, psychological, and social changes [9]. SPA consists of five dimensions: negative consequences and control, positive consequences, chronicity of aging, positive control, and emotional representations. These dimensions assess how individuals view aging, its effects, control over the aging process, and their emotional experiences, providing a comprehensive understanding of aging and supporting interventions for older adults' health and well-being [9]. According to stereotype embodiment theory (SET) [10], individuals develop stereotypes about aging before reaching old age, which, over time, become internalized. Once labeled as "older," these stereotypes can shape self-perceptions of aging, affecting mental well-being [11]. Research shows that positive SPA helps older adults accept themselves and enhances physical and mental health [12]. In contrast, negative SPA is linked to physical and psychological decline, higher mortality, and more negative emotions, significantly affecting health in later years [13, 14]. Negative attitudes towards aging contribute to pessimistic views, especially among older adults with MCCs [15]. Therefore, understanding SPA's role in older adults with MCCs is crucial for promoting healthy aging. Examining SPA in the context of other affective disorders like depression and anxiety offers a new perspective.

Depression and anxiety are significant concerns for global healthcare, particularly in later life [16]. Studies have shown a strong link between depression and SPA in older adults, highlighting its impact [17]. In China, nearly one-third of the elderly population experiences depressive symptoms [18]. As depression becomes more severe, older adults report more negative emotions about aging, with depression worsening SPA and serving as a key predictor of it [17]. However, the relationship is bidirectional, with SPA also contributing to depression in older adults. Research by Yuan et al. found that SPA mediates the link between frailty and depression [13], while Xiao's study showed that SPA mediates the relationship between subjective age and depression [12]. Furthermore, studies [19, 20] have found high comorbidity between depression and anxiety in older adults, with both conditions often occurring together. The combined prevalence of depression and anxiety can reach 40–60% [21, 22]. Older adults with high SPA levels are more likely to experience anxiety about aging [15], indicating strong connections between SPA, depression, and anxiety. Understanding these interactions in older adults with MCCs is crucial for developing effective interventions to improve their quality of life.

While existing research confirms a strong relationship between SPA, depression, and anxiety, many studies rely on the common cause theory [23] and latent variable models [24]. These studies often treat the correlation between SPA and either depression or anxiety as the result of combined latent factors, using total scores from questionnaires to assess severity and correlation. However, they fail to capture the subtle relationships between specific dimensions of SPA and particular symptoms of depression and anxiety [24]. Clinically, it's important to understand these nuances to better assess older adults with multiple chronic conditions and detect overlapping symptoms early. By identifying common symptom profiles, healthcare providers can implement integrated treatments that address multiple disorders simultaneously, improving SPA and reducing mental health risks for patients.

Network analysis (NA) [25] is a novel method for studying the complex interactions between SPA, depression, and anxiety. Originally used in psychopathology, NA has recently been applied to chronic diseases [26]. It treats symptoms as independent nodes and explores the direct causal interactions between them by constructing a network. This approach suggests that mental symptoms result from the interaction of different symptoms, rather than being caused by a single latent variable like depression or anxiety [27]. Analyzing these interactions and identifying core symptoms—those that strongly connect with others—is crucial for developing effective interventions [20]. Core symptoms are central to the symptom network and play a key role in maintaining the overall pathological process, making them a primary focus of treatment [25]. NA also offers a new perspective on comorbidities through the concept of bridge symptoms. These are symptoms that connect different groups within the network and facilitate the spread or interaction of symptoms. For instance, in older adults with MCCs,

certain symptoms may increase the risk of developing additional conditions, acting as bridges between diseases [28, 29]. Identifying these bridge symptoms can help prevent or treat comorbidities. While previous research has used NA for depression and anxiety, this study extends the approach by including SPA, which influences psychological well-being and health outcomes in older adults with MCCs. Identifying bridge symptoms is key to preventing the dynamic transmission between SPA, depression, and anxiety.

This study aimed to use NA to build a symptom network of SPA, depression, and anxiety in older adults with MCCs. The goal was to identify core and bridge symptoms, offering insights for future interventions targeting SPA and comorbidities in this group. To our knowledge, this is the first NA study examining the relationship between SPA, depression, and anxiety in elderly Chinese individuals with MCCs living in the community.

Methods

Study design and participants

This multicenter cross-sectional study was conducted from November 2022 to May 2023, using a convenience sampling method. The sample was drawn from older adults with MCCs in the communities of four prefectural-level cities (Nanjing, Zhenjiang, Lianyungang, and Suqian) in Jiangsu province, China. The selected samples represent the regions of southern, central, and northern Jiangsu Province, providing a certain level of representativeness. The inclusion criteria were as follows: (1) age ≥ 60 years; (2) a diagnosis of two or more chronic diseases, according to the chronic disease categories provided by the Charlson Comorbidity Index [30]; (3) informed consent and voluntary participation in this study. The exclusion criteria were as follows: (1) older adults who refused to participate in the study; (2) individuals with cognitive impairments, intellectual disabilities, or other factors that could affect the validity of their informed consent; (3) non-residents of the community or residents with an unknown place of residence; (4) participation in other research projects.

According to the sample size requirement of network analysis [31], the sample size should be at least higher than the total parameters (including threshold parameter and pairwise correlation parameter).Threshold parameter = number of nodes. Pairwise correlation parameter = number of total nodes×(number of total nodes-1)/2. In this study, a total of 23 nodes need to be constructed, therefore, threshold parameter = 23,pairwise correlation parameter = 23*22/2 = 253.Therefore, the minimum sample size is 276 cases.

The data were collected by a combination of online and offline methods. To collect the online data, we utilized the Wenjuanxing online survey platform (www.wjx.cn) to distribute the questionnaire. For illiterate or elderly participants who faced challenges in completing the online questionnaire, the researchers conducted face-to-face interviews and recorded their responses in the online questionnaire after ensuring their accuracy. Previous research experience has highlighted the importance of using multiple sample collection methods to mitigate the risk of overlooking crucial samples [32]. Recognizing the potential presence of elderly individuals without smartphones who desired to complete the questionnaire independently, we also prepared printed questionnaires that mirrored the online version, ensuring consistent instructions for completion. The printed questionnaires took an average of 10 min to complete, and the survey was carried out among eligible older persons in four cities. They were given some verbal guidance on healthy lifestyles during the survey, which was very practical for them. A total of 515 questionnaires were distributed in this study, of which 17 refused to be completed and 20 questionnaires were discarded as incomplete or missing key information. In the end, 478 valid questionnaires were recovered.

This research protocol adhered to the Helsinki Declaration and has received approval from the Ethics Committee of Jiangsu University (Approval No. 20221019-7).

Measurements

Demographic information and disease characteristics

The demographic and disease-related information collected in this study includes gender, age, marital status, residence, residence status, average monthly household income, number of chronic diseases, and Type of medication taken.

Self-perceived aging

The self-perceived aging level was assessed using the Chinese version of the Brief Ageing Perceptions Questionnaire (B-APQ) [9, 33]. The questionnaire consists of 17 items measuring five dimensions: Consequences and Control Negative, Consequences-Positive, Timeline-Chronic, Control-Positive, and Emotional-Representations. Participants rated their agreement on a 5-point Likert scale. The total score, ranging from 17 to 85, indicates the level of negative self-perceived aging (higher scores indicate more negative perceptions). The Chinese version of the questionnaire demonstrated good internal consistency (Cronbach's alpha = 0.758) and reliability in previous studies [12, 13]. In our study, the questionnaire exhibited high internal consistency (Cronbach's alpha = 0.883).

The depression anxiety and stress Scales-21

The Depression Anxiety and Stress Scales-21 (DASS-21) were used to measure depression and anxiety symptoms

in older adults with comorbid chronic diseases. The DASS-21 is a simplified version derived from the original DASS scale developed by Lovibond et al. [34], and it was later revised and adapted into a simplified Chinese version by Gong et al. [35]. The questionnaire consists of 21 items, with 7 items each for the depression, anxiety, and stress subscales. A 4-point Likert scale ranging from 0 (does not apply to me at all) to 3 (applies to me very much or most of the time) is used for rating in each item. Higher total scores indicate higher levels of negative emotions. In this study, the depression and anxiety subscales of the DASS-21 were primarily used. The DASS-21 has been widely used in different countries and populations, demonstrating good reliability and validity [36, 37]. In the present study, the overall DASS-21 scale showed a Cronbach's alpha coefficient of 0.936, indicating high internal consistency. The depression and anxiety subscales showed Cronbach's alpha coefficients of 0.874 and 0.884, respectively.

Statistical analysis

Descriptive statistics were analyzed using SPSS (version 26.0) in this study. The NA was conducted using different packages in R (version 4.2.0) to explore the relationships among SPA, depression, and anxiety in older adults with comorbid chronic diseases. In the network, the 5 dimensions of SPA were represented as 5 nodes, and the 14 items from the depression and anxiety scales in DASS-21 were represented as 14 nodes, resulting in a total of 19 nodes in the final network. Visualizations of all networks were generated using the Fruchterman–Reingold algorithm in the qgraph package [38].

Estimated network and model construction

The qgraph package (version 1.9.2) and bootnet package (version 1.5.0) in R were used to estimate the network and visualize the network's structure [31]. The graphical least absolute shrinkage and selection operator (gLASSO) method was used for estimating the network, which utilizes a penalty parameter to achieve sparsity. The extended Bayesian information criterion [39] (EBIC) was used to select the optimal neighborhood for each node (symptom), reducing false edges and obtaining a more realistic network structure [31]. The gamma value in EBIC determined the extent to which false edges were reduced, and the default value of 0.5 was used, as recommended in the literature [31]. In the network, each symptom (item) was treated as a node, and the connections between adjacent symptoms (nodes) were represented as edges. The color of the edges indicated the direction of the association, with dark blue representing positive correlations and red representing negative correlations [27]. The thickness of the edges reflected the strength of the correlation between two nodes. The Fruchterman-Reingold algorithm (spring layout) was used to visualize the network, allowing the central nodes to be positioned closer to the center of the network while the peripheral nodes were distributed around the network's periphery [38]. To assess and quantify the importance of each node in the network, three main centrality indices were computed: strength, closeness, and betweenness [31]. However, previous research has indicated that the centrality indices of closeness and betweenness are not reliable in psychological networks [40]. Therefore, this study primarily focused on using strength as the sole centrality index. Strength represents the sum of the weighted connections for a particular node and measures the node's importance in the network, identifying the core symptoms in the network of older adults with comorbid chronic diseases. The bridge strength centrality of each symptom was calculated using the networktools package (version 1.5.0) to identify bridge symptoms that connected SPA, depression, and anxiety [29]. Bridge symptoms refer to symptoms that connect different clusters of symptoms and reflect the degree of connectivity between the current node and other clusters of nodes. Additionally, the mgm package (version 1.2–12) was used to estimate the predictability of each node. Predictability [41] refers to the extent to which the variation in one node can be explained by the variation in its connected nodes, reflecting the controllability of the network. When a node has higher predictability, we can control it through its neighboring nodes [42]. In this study, rp was used to represent predictability.

Estimating the accuracy and reliability of the network

In this study, the bootnet package (version 1.5.0) in R was used to validate the accuracy and stability of the network's construction [31]. Firstly, the accuracy of the edge weights was assessed by calculating the 95% confidence intervals (CIs) using non-parametric bootstrapping with 1000 samples. Narrower 95% CIs indicate a more accurate estimate of the network. Secondly, the stability of the nodes' strength and bridge strength was evaluated by computing the correlation stability coefficient, which is based on case-dropping subset bootstrapping with 1000 bootstrap samples. If the centrality measures of the nodes did not significantly change when most of the samples were excluded from the dataset, the network was considered to be stable. The coefficient of the correlations' stability should ideally be above 0.5 or at least above 0.25, with values above 0.7 being optimal [31]. The rcS notation was used to represent the coefficient of the correlations' stability. Finally, to assess whether there were significant differences between two edge weights, 1000 bootstrap difference tests ($\alpha = 0.05$) were conducted for the edge weights, node strengths, and bridge strengths.

Table 1 General characteristics of old adults with MCCs

Variables	*N*/% or Mean ± SD
Gender	
Male	263(55.0)
Female	215(45.0)
Age	71.52(7.80)
Marital Status	
Single	11(2.3)
Married	404(84.5)
Widowed	63(13.2)
Residence	
Rural	306(64.0)
Urban	172(36.0)
Residence Status	
Living alone	82(17.2)
Living with spouse	273(57.1)
Living with children	123(25.7)
Average monthly household income	
3000 CNY and below	202(42.3)
3000–5000 CNY	165(34.5)
5000–8000 CNY	91(19.0)
8000 CNY and above	20(4.2)
Number of chronic diseases	
2 kinds	270(56.5)
3 kinds	156(32.6)
4 kinds and above	52(10.9)
Type of medication taken	
None	20(4.2)
1–2 kinds	230(48.1)
3–4 kinds	167(34.9)
5 kinds and above	61(12.8)

NOTE: CNY: Chinese Yuan

Table 2 Abbreviations for each node of SPA, depression, and anxiety network

Nodes	Abbreviations
A1 I was aware of dryness of my mouth	Dry mouth
A2 I experienced breathing difficulty	Breath difficult
A3 I experienced trembling (e.g., in the hands)	Trembling
A4 I was worried about situations in which I might panic and make a fool of myself	Worried
A5 I felt I was close to panic	Panic
A6 I was aware of the action of my heart in the absence of physical exertion	Heart aware
A7 I felt scared without any good reason	Scared
D1 I couldn't seem to experience any positive feeling at all	No positive
D2 I found it difficult to work up the initiative to do things	No initiative
D3 I felt that I had nothing to look forward to	No look forward
D4 I felt down-hearted and blue	Down-hearted
D5 I was unable to become enthusiastic about anything	Not enthusiastic
D6 I felt I wasn't worth much as a person	Worthless
D7 I felt that life was meaningless	Meaningless
S1 Consequences and Control Negative	CCN
S2 Consequences-Positive	S2 CP
S3 Timeline-Chronic	S3 TC
S4 Control-Positive	S4 Ctrl-Pstv
S5 Emotional-Representations	S5 Emo-Rep

Results

General characteristics of the participants, occurrence rates, and the severity of symptoms

Table 1 shows the characteristics of participants in this study, including 263 males (55.0%) and 215 females (45.0%). The average age of the participants was 71.52 ± 7.80 years, ranging from 60 to 94. Table 2 lists the abbreviations for each symptom. Table 3 displays the occurrence rates (As described in the measurement tool, each item is scored as follows: 'Not applicable' is scored as 0, indicating absence. 'Somewhat applicable' to 'always applicable' are considered as indicating the presence of symptoms, used to calculate the prevalence.) and severity (mean) of all symptoms. We found that "Consequences and Control Negative" (17.16 ± 4.12) was the most severe symptom in the SPA cluster. "Dry mouth" (n = 349, 73.0%, 0.99 ± 0.76) had the highest occurrence rate and severity in the anxiety cluster. "Not enthusiastic" (n = 321, 67.2%, 0.88 ± 0.75) had the highest occurrence rate and severity in the depression cluster. Variables with a significance level of $P < 0.05$ in the univariate analysis, including age, marital status, place of residence, living arrangement, family monthly per capita income, number of chronic diseases, and type of medication, were included in the multiple regression analysis. Ultimately, the regression determined that the covariates were age, family monthly per capita income, medication types, and living arrangement, which were controlled for in our NA. The detailed results of the multiple stepwise regression analyses are shown in Table 4.

Network analysis

Network structure

Figure 1A displays the network among SPA, depression, and anxiety symptoms, constructed with the EBICglasso model. Out of 171 possible edges, 105 (61.4%) were non-zero edges, and the majority of edges, except those connected to Symptoms S2 and S4 symptoms, showed positive correlations. The predictability of symptoms is presented in the form of a circular pie chart in Fig. 1A; Table 3. The average predictability value of symptoms was 0.55.

Figure 1B presents the centrality index of the network, namely strength. We found that among the 19 items in the constructed network, the five symptoms with the greatest strength were "Meaningless" (strength = 1.58), "No look forward" (strength = 1.46), "Emotional-Representations" (strength = 1.25), "Panic" (strength = 1.18),

Table 3 Strength, bridging strength, and predictability of SPA, depression, and anxiety scales notes: A: anxiety; D: depression; S: Self-Perceived aging

Nodes	Mean	SD	Prevalent	Predictability	Strength	Bridge strength
A1 Dry mouth	0.99	0.76	73.00%	0.44	-0.71	0.37
A2 Breath difficult	0.74	0.77	56.10%	0.54	0.49	0.56
A3 Trembling	0.83	0.82	60.30%	0.50	-0.42	0.45
A4 Worried	0.83	0.80	61.70%	0.52	0.03	0.57
A5 Panic	0.69	0.77	51.90%	0.61	1.18	0.79
A6 Heart aware	0.85	0.77	64.40%	0.53	-0.24	0.49
A7 Scared	0.85	0.77	63.80%	0.67	0.84	0.73
D1 No positive	0.79	0.72	62.80%	0.49	-0.52	0.51
D2 No initiative	0.78	0.77	59.20%	0.53	0.16	0.49
D3 No look forward	0.83	0.78	61.50%	0.61	1.46	0.65
D4 Down-hearted	0.82	0.73	64.40%	0.54	0.21	0.59
D5 Not enthusiastic	0.88	0.75	67.30%	0.49	-0.89	0.49
D6 Worthless	0.50	0.73	37.70%	0.56	-0.54	0.33
D7 Meaningless	0.72	0.76	54.80%	0.71	1.58	0.80
S1 CCN	17.16	4.12	-	0.64	0.48	0.06
S2 CP	11.01	2.57	-	0.50	-0.70	0.06
S3 TC	10.45	2.86	-	0.45	-1.90	0.08
S4 Ctrl-Pstv	10.82	2.61	-	0.47	-1.73	0.06
S5 Emo-Rep	9.31	2.84	-	0.66	1.25	0.05

Table 4 Multiple linear Stepwise regression analysis with SPA as dependent variable

Independent variable	β	Standard Error (SE)	Standardized β	t-value	*P*-value
Constant	39.794	4.451	-	8.940	<0.001
Age	0.230	0.054	0.176	4.236	<0.001
Average monthly household income	-2.016	0.488	-0.172	-4.127	<0.001
Type of medication taken	4.195	0.566	0.314	7.417	<0.001
Residence Status	-2.175	0.644	-0.138	-3.377	0.001

Notes: $R^2 = 0.304$, Adjusted $R^2 = 0.298$, $F = 51.558$, $P < 0.001$

and "Scared" (strength = 0.84). Figure 1B; Table 2, respectively, show the plot of centrality in terms of strength and the specific values of the network.

Additionally, we identified some strong edge connections in the network, including "Consequences-Positive" and "Control-Positive" (S2-S4, weight = 0.62), "Consequences and Control Negative" and "Emotional-Representations" (S1-S5, weight = 0.53), "Scared" and "Meaningless" (A7-D7, weight = 0.48), "Consequences and Control Negative" and "Timeline-Chronic" (S1-S3, weight = 0.25), and "Worthless" and "Meaningless" (D6-D7, weight = 0.24). The values of the edge weights between each network node excluding the covariates are presented in Supplementary Table S1 and the specific values of the edge weights including the covariates are presented in Supplementary Table S2. Table 3 presents the top 5 symptoms with the highest predictability, which are "Meaningless" (rp = 0.71), "Scared" (rp = 0.67), "Emotional-Representations" (rp = 0.66), "Consequences and Control Negative" (rp = 0.64), and "No look forward" (rp = 0.61).

Network accuracy and stability

According to this estimation, we obtained a central stability coefficient of *rc*S = 0.59, which is greater than 0.50, indicating that our results are relatively stable. The bootstrap difference test of the edge weights revealed that most of the edges were statistically significant ($P < 0.05$), as shown in Supplementary Figure S1.

Core symptoms in the network

To account for the influence of covariates on the network, this study used stepwise regression analysis to determine the demographic factors of age, monthly per capita household income, type of medication, and living arrangement as the influencing factors for SPA. The results showed that after including the covariates, some core symptoms in the network underwent changes, and the core role of "Emotional-Representations" (strength = 1.67), "Consequences-Positive" (strength = 1.25), "Consequences and Control Negative" (strength = 1.24) in SPA, as well as "Meaningless" (strength = 1.34) and "Worthless" (strength = 1.12) in the depression dimension became more pronounced, and they were finally determined as core symptoms (Fig. 2).

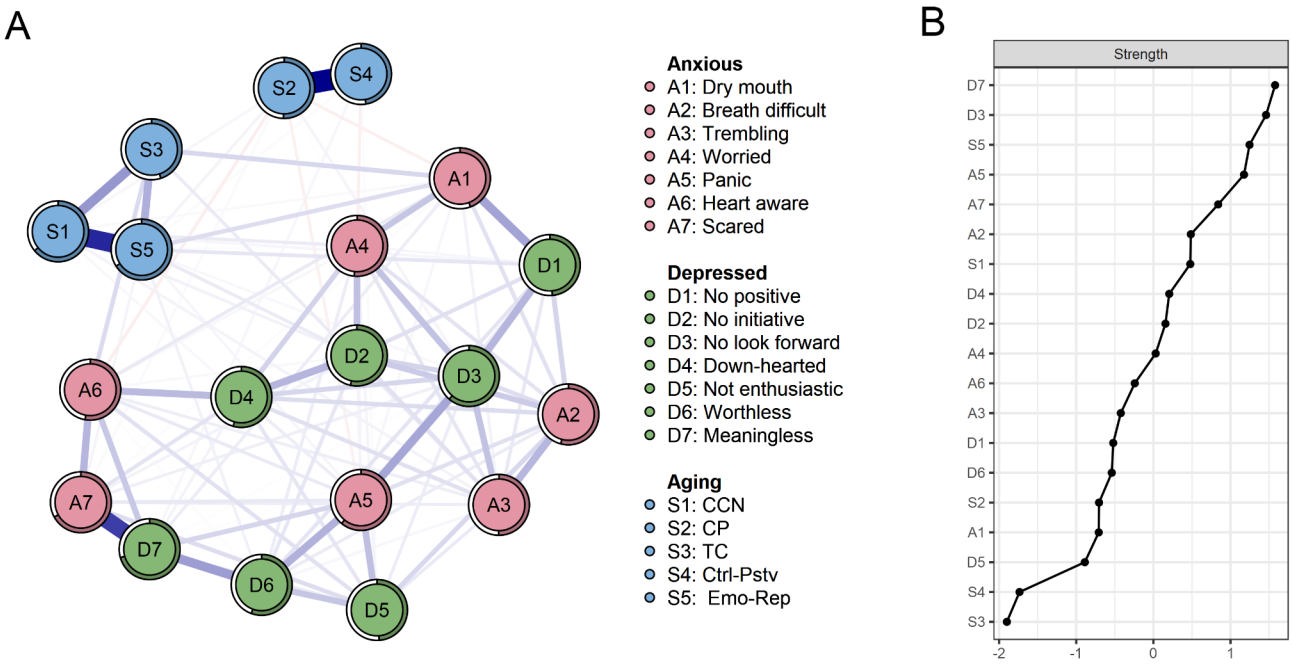

Fig. 1 (**A**) Network structure diagram of SPA, depression, and anxiety in older adults with MCCs (*N* = 478). (**B**) Strength centrality graph of the network structure. CCN: Consequences and Control Negative; CP: Consequences-Positive; TC: Timeline-Chronic; Ctrl-Pstv: Control-Positive; Emo-Rep: Emotional-Representations

Notes: The edge color shows correlation: dark blue means positive, red means negative. Edge thickness indicates strength: thicker edges show stronger correlations

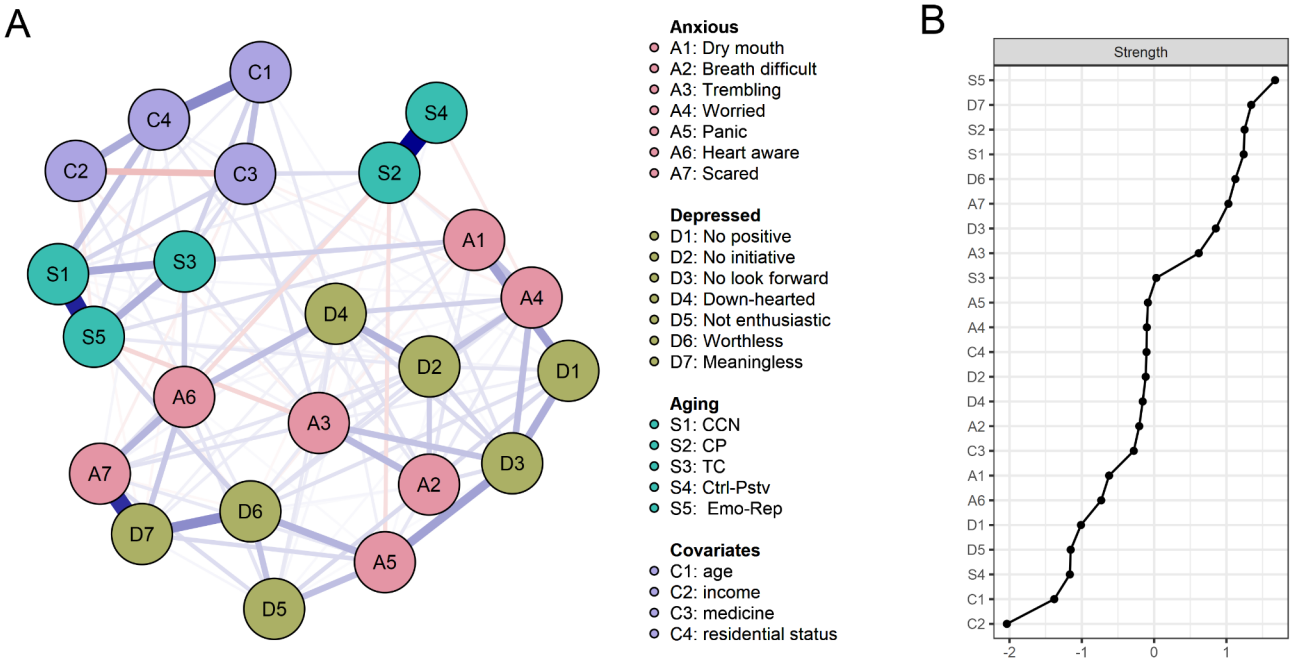

Fig. 2 (**A**) Network structure diagram of SPA, depression, anxiety, and covariates after inclusion (*N* = 478); (**B**) Strength centrality graph of the network structure. CCN: Consequences and Control Negative; CP: Consequences-Positive; TC: Timeline-Chronic; Ctrl-Pstv: Control-Positive; Emo-Rep: Emotional-Representations

Notes: The edge color shows correlation: dark blue means positive, red means negative. Edge thickness indicates strength: thicker edges show stronger correlations

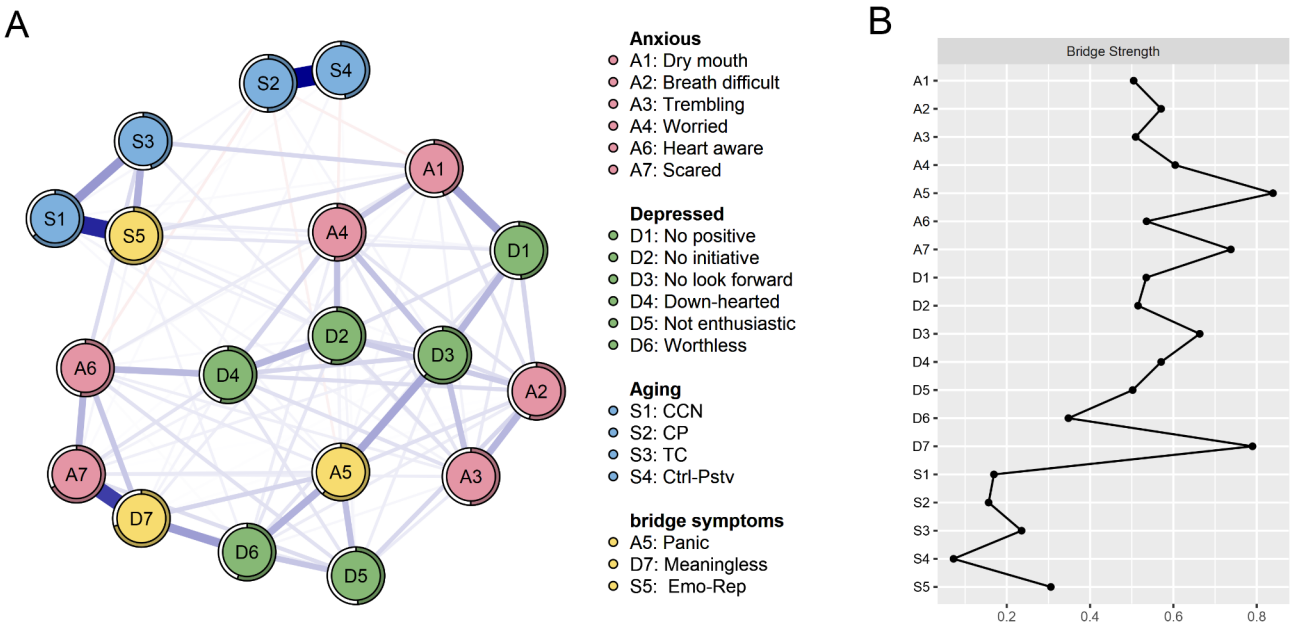

Fig. 3 (**A**): Network structure diagram with bridge symptoms. (**B**): Centrality indices of bridge symptoms. CCN, Consequences and Control Negative; CP, Consequences-Positive; TC, Timeline-Chronic; Ctrl-Pstv, Control-Positive; Emo-Rep, Emotional-Representations
Notes: The edge color shows correlation: dark blue means positive, red means negative. Edge thickness indicates strength: thicker edges show stronger correlations

Bridge symptoms in the network

As shown in Fig. 3; Table 3, we found that "Panic" (A5, bridge strength = 0.84), "Meaningless" (D7, bridge strength = 0.79), and "Emotional-Representations" (S5, bridge strength = 0.31) had the highest bridge strengths within their respective clusters, indicating that they are bridge symptoms in the SPA, depression, and anxiety networks. Based on the edge weight relationships, we observed strong connections between the bridge symptom "Panic" (A5) in the anxiety cluster and "No look forward" (A5-D3, weight = 0.21) and "Worthless" (A5-D6, weight = 0.19) in the depression cluster. The bridge symptom "Meaningless" (D7) in the depression cluster exhibited close associations with "Scared" (D7-A7, weight = 0.48) and "Heart aware" (D7-A6, weight = 0.14) in the anxiety cluster. The bridge symptom "Emotional-Representations" (S5) in the SPA cluster demonstrated a close relationship with "Dry mouth" (S5-A1, weight = 0.08) in the anxiety cluster and "No positive" (S5-D1, weight = 0.06) in the depression cluster. By estimating the stability of bridge strengths, we obtained a bridge strength stability coefficient of rcS = 0.75, which is greater than 0.7, indicating that our estimate results are sufficiently stable.

Discussion

Our study utilized NA to examine the interplay among SPA, depression, and anxiety in older adults with comorbid chronic conditions. It has also pioneered the consideration of covariates in a NA of comorbid chronic diseases in older adults. Overall, the stability coefficients of both centrality (strength) and bridge centrality met the required standards [31], lending credibility and reliability to the preliminary findings and the subsequent implications of this study.

The results showed that "Emotional-Representations" was the most central symptom in the network, meaning it is closely connected to other symptoms and plays a key role. This finding contrasts with previous studies that, based on total scores, found weaker associations between "Emotional-Representations" and SPA severity in older adults [43]. However, in network analysis, the most common symptom is not always the most central [44–46]. Similarly, "Emotional-Representations," while not the most severe symptom, can activate other symptoms, including depression and anxiety. Therefore, older adults with MCCs who score high on Emotional-Representations should be prioritized for interventions aimed at helping them express emotions and improving emotional resilience, which could enhance their self-perception of aging and overall quality of life.

"Emotional-Representations" refers to emotional experiences related to aging, such as feeling sad or worried about the impact of aging on daily activities and relationships [9]. Studies show that chronic conditions and comorbidities in older adults can lead to social isolation and loneliness, which worsens feelings of sadness and worry [47]. Concerns about disease progression, treatment, and future challenges often contribute to these emotions [4], further intensifying worries about

aging [48]. Previous research [12, 15] has linked these emotional representations to negative emotions like depression and anxiety, emphasizing the central role of "Emotional-Representations." This underscores the need for community healthcare professionals to assess and address negative emotions, especially depression and anxiety, in older adults with comorbid conditions, while also considering their "Emotional-Representations." This study found that "Emotional-Representations" and "Consequences and Control Negative" were strongly linked, indicating they often co-occurred and interacted in older adults with comorbid chronic conditions. Older adults with higher levels of negative emotions tend to focus on the drawbacks of aging, such as physical decline and limited mobility, and often engage in maladaptive attributions, leading to fear and distress [17, 49]. This negative mindset prevents them from developing positive attitudes toward aging and coping effectively [50]. Additionally, these emotional representations can impair self-regulation, resulting in poor self-management and negative outcomes [6, 51]. Psychologically, these factors interact through cognitive appraisals and emotional responses to health challenges. Clinically, addressing the co-occurrence of these symptoms is essential, as it highlights the link between emotional perceptions of aging and negative outcomes. Interventions could focus on cognitive restructuring, emotional regulation, and improving coping mechanisms to foster a more positive perception of aging and enhance well-being in older adults with MCCs.

This study also identified "Consequences and Control Negative" as a core symptom in the network and the most severe symptom in SPA. Together with "Emotional-Representations," they form a dual core in the network [20]. Therefore, interventions should target both symptoms simultaneously. Notably, both "Emotional-Representations" and "Consequences and Control Negative" had high predictability and the strongest connection between them, suggesting that addressing one symptom would also reduce the impact of the other, highlighting the need for interventions that target both.

Meaninglessness was identified as a core symptom in the original network and remained a significant factor even after including covariates, highlighting its stable core role [20]. "Worthless" and "Meaningless" symptoms, both related to depression, showed a strong connection. Research suggests that older adults are more focused on the meaning of life than younger individuals [52, 53]. Older adults with comorbid chronic conditions may struggle with role changes, such as losing work or family responsibilities, leading to feelings of worthlessness and meaninglessness [54, 55]. These feelings can be intensified by psychological challenges, such as accepting their illness and anxiety about the future [4]. These factors can hinder role adaptation and worsen perceptions of self-worth and life meaning [56]. Therefore, in assessing depression in older adults with MCCs, it's important to address feelings of meaninglessness and worthlessness. However, since our study excluded those with cognitive impairment, these findings may not apply to that population, and further research is needed to explore this.

SPA in older adults is not always negative. Our results showed that "Consequences-Positive" emerged as a core symptom after controlling for covariates, ranking third in the network. "Consequences-Positive" and "Control-Positive" also had the strongest connection. This may reflect individual differences in emotional regulation, resilience, and adaptability [49, 51]. Some older adults effectively regulate their emotions, using strategies like seeking social support, actively addressing problems, and engaging in enjoyable activities [57, 58]. This helps them maintain a positive attitude despite challenges. Therefore, encouraging older adults with comorbid chronic conditions to adopt a positive view of aging could enhance healthy aging. Additionally, the significant changes in "Consequences-Positive" with covariates suggest that future research should categorize covariates more precisely to identify the most influential variables, leading to a clearer understanding of psychological issues in older adults [42].

SPA often interacts with depression and anxiety, appearing together or in sequence. This study identified bridge symptoms in the network of SPA, depression, and anxiety, suggesting that intervening in these symptoms may help prevent comorbidities in older adults with chronic diseases [29]. Three bridge symptoms were identified: "Panic," "Meaningless," and "Emotional-Representations." "Panic" and "Meaningless" connect the anxiety and depression clusters, while "Emotional-Representations" links SPA with both clusters. In older adults with chronic diseases, comorbid anxiety and depression are more prominent, consistent with previous studies [21, 22]. "Panic" affects depressive symptoms through connections with "No look forward" (A5-D3, weight = 0.21) and "Worthless" (A5-D6, weight = 0.19) in the depression cluster. Chronic illness increases irritability, panic, and fear of the future, which, if unresolved, can lead to worthlessness and depressive symptoms [59, 60]. Therefore, regular assessments of panic levels and targeted interventions, such as cognitive behavioral therapy or relaxation techniques, are important. "Meaningless" is a bridge symptom connecting depression and anxiety, with strong connections to "Scared" and "Heart aware" in the anxiety cluster. Addressing "Meaningless" in interventions could reduce symptom intensity across the network [20] and potentially weaken the connection between depression and anxiety [29].

Although the connection between "Emotional-Representations" and the depression and anxiety clusters is weaker than the connections within the clusters, its bridging role is still important. In Fig. 1A, "Emotional-Representations" connects anxiety and depression through "Dry mouth" and "No positive." To support this visually, we provided numerical edge weights. "Dry mouth" is common in elderly patients with anxiety, partly due to medication effects [61], but it may also have a psychogenic component [62]. Anxiety can increase sensitivity to bodily sensations, like dry mouth, and activate the sympathetic nervous system, reducing saliva production [63]. In older adults with chronic diseases, "Emotional-Representations" often manifest as sadness, worry, and anxiety, which can influence anxiety through "Dry mouth." "No positive," a key depression symptom, also aligns with previous research [64, 65]. This study shows that SPA mainly exacerbates depression symptoms in older adults with chronic diseases through "Emotional-Representations," especially targeting "No positive." Healthcare professionals should consider this in their care strategies, and further research is needed to promote active aging in older adults with MCCs [66].

Limitations

Firstly, the study used convenience sampling, which may limit the representativeness of the sample. Health data from older adults who declined participation were not collected, which affects the generalizability of the results. Secondly, excluding individuals with cognitive impairments or issues with informed consent limits the applicability of the findings to this group. Additionally, the combination of data collection methods may have influenced responses, with differences in education and socioeconomic status between online and paper respondents not analyzed. The uneven age distribution may have also impacted perceptions of self-aging, anxiety, and depression across age groups. Only 17% of participants lived alone, mostly in rural areas, limiting the findings' relevance to those in large cities or living alone. Finally, factors like participants' functioning, disability, and medication use, which may affect symptoms like dry mouth, were not thoroughly analyzed, which could impact the interpretation and generalizability of the results.

Conclusion

Our study identified core and bridge symptoms in the network of SPA, depression, and anxiety in older adults with MCCs. "Emotional - Representations" was the most core symptom, and "Panic," "Meaningless," and "Emotional - Representations" were bridge symptoms. These symptoms can be primary treatment and intervention targets. However, these findings need further validation in future research studies.

Abbreviations

SPA	Self-perceived aging
MCCs	Multiple chronic conditions
NA	Network analysis
CNY	Chinese Yuan

Supplementary Information

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Supplementary Material 1

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Author contributions

Bin Shang and Caifeng Luo jointly designed this study. Yinan Wang, Fei Lv, Jing Wu, and Xiao Shao were responsible for data collection. Bin Shang conducted the data analysis and drafted the initial manuscript, which was reviewed and revised by Yinan Wang and Caifeng Luo. All authors reviewed the manuscript and approved the final submitted version.

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Data availability

The dataset for this study will not be made publicly available due to ethical restrictions. The dataset will be personally available if there is reasonable request. Readers and all interested researchers may contact Bin Shang (Sevenage007@163.com).

Declarations

Ethics approval and consent to participate

This study was conducted in compliance with the principles outlined in the Declaration of Helsinki. The research protocol was approved by the Medical Ethics Committee of Jiangsu University (No. 20221019-7). Prior to their participation, written informed consent was obtained from all subjects involved in the study.

Consent for publication

Not applicable.

Competing interests

All authors report that they do not have any potential conflicts of interest.

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