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ORIGINAL RESEARCH

Network Analysis of Anxiety, Insomnia, Depression, and Suicide Attempts in Chinese Outpatients with Somatic Symptom Disorder

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Background: In clinical settings, somatic symptom disorder (SSD) has a significant impact on the psychological well-being of patients and is closely related to anxiety, sleeplessness, depression, and suicide. To provide novel insights into the management and rehabilitation of patients with SSD and the early detection of suicidal behavior, this study aimed to examine the relationship among anxiety, insomnia, and depression as well as that between these symptoms and suicide attempts in patients with SSD.

Methods: A total of 899 individuals from Ganzhou People's Hospital, Gannan Medical University's First Affiliated Hospital, and Ganzhou Third People's Hospital were enrolled. The GAD-7, ISI-7, and PHQ-9 were used to evaluate the severity of anxiety, insomnia, and depression, respectively. The EBICglasso function was used to construct a network graph of the symptoms of anxiety, insomnia, and depression, and we investigated the relationship between the mental health status of the patients and whether they had attempted suicide in the past.

Results: The strongest centrality was found for "Waking up early", followed by "Irritability", "Suicide ideation", "Nervousness", and "Uncontrollable worry." The five bridge symptoms included "Irritability", "Waking up early", "Suicide ideation", "Concentration", and "Guilt." In addition, a suicide attempt was directly positively correlated with "Suicide ideation", "Sleep dissatisfaction", and "Sleep maintenance." this indicated that the worse the sleep quality, the more likely it was to be associated with suicidal behavior. There was no significant difference in network analysis between male and female patients.

Conclusion: Based on this result, we can provide psychological treatment for patients with depression and anxiety symptoms. For insomnia symptoms, appropriate clinical medicine interventions can be supplemented while adjusting sleep habits. Treatment strategies targeting specific mental symptoms are required to alleviate or prevent common and regularly recurring mental syndromes, decrease the frequency of suicide attempts, and improve treatment outcomes in patients with SSD in China.

Keywords: anxiety, insomnia, depression, suicide attempts, network analysis

Background

Patients with somatic symptom disorder (SSD) or somatoform disorder (SFD) present with a wide range of clinically significant symptoms that are not well explained by medicine. These patients have noticeable physical symptoms such as pain, discomfort, and functional impairment.[1] The prevalence of SSD in Chinese general hospitals has been reported to be 4.15%,[2] whereas that in the general population of Taiwan, China has been reported to be 5.00%.[3] These rates exceed the incidence rate of depression (2.98%) reported in the general population of China in 2021,[4] emphasizing the public health significance of SSD in China. In the European elderly population, the 12-month prevalence rate of SSD was 3.8%,[5] the pooled global prevalence rate in children and adolescents was 31.0% for somatic symptoms and 3.3% for somatic symptom disorders.[6] This data reveals that SSD has a certain disease burden at different age stages. Elderly people are more likely to exhibit clinical manifestations of SSD due to physiological decline and the presence of chronic

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diseases, while adolescents are more likely to show early expression of somatic symptoms. Nowadays SSD has been extensively investigated in clinical settings from complex psychological and social perspectives and has attracted considerable attention from researchers worldwide.[7,8]

According to some epidemiological studies on SSD or SFD, the two most common comorbidities in patients with SSD are anxiety and depression.[9,10] SSD is characterized by various frequently changing physical symptoms that can affect any system or organ in the body. The symptoms are typically persistent and fluctuating, rarely disappearing completely. Consequently, patients often seek treatment from different hospitals and doctors repeatedly. Despite long-term medication and numerous examinations, physical recovery is seldom achieved, leading to anxiety and depression. In addition to these two emotional disorders, insomnia is a common comorbidity in patients with SSD.[11] In a study on sleep disorders in adolescents and middle-aged individuals, insomnia and poor sleep quality were found to be closely related to pain and physical symptoms.[12] In addition, a survey of Japanese adults also showed a strong correlation between somatic symptoms and insomnia.[13] On the one hand, gastrointestinal, respiratory, and pain symptoms caused by SSD prevent patients from sleeping soundly, leading to issues such as early awakening and difficulty in maintaining sleep. On the other hand, inadequate sleep can increase pain sensitivity, intensifying the perception of pain[14] and hence creating a vicious cycle. A recent study reported on the relationship among somatization, sleep disorders, anxiety/depression, and the psychological effects of somatization and the mediating role of comorbid psychological disorders, such as depression and anxiety, in the relationship between somatization and sleep.[15]

Suicide attempts are closely related to SSD. A suicide attempt is defined as an individual's effort to end their life by causing some degree of self-harm.[16] Suicide is not only a significant public health concern but also a major societal problem. SSD and associated diseases are potentially related to suicidal ideation;[17] however, studies investigating this relationship are lacking. According to a survey, 55.9% of patients with SSD had thoughts of death or dying, 33.6% of the patients had current positive suicidal ideation, and 12.9% of the patients had a lifetime history of suicide attempts.[18] Several factors are related to suicidal ideation and suicide attempts, with emotional distress being an unavoidable factor. A study on Chinese adolescents showed that anxiety was independently associated with depression and suicide attempts, with sleep quality playing a mediating role in this relationship.[19] However, to date, no studies have assessed the mental health status of Chinese outpatients with SSD or its relationship with suicide attempts.

In recent years, network analysis (NA) has been extensively used in various fields to understand how multicomponent systems are interconnected.[20] Because of the insights it has offered into the relationship between psychopathological symptoms and mental health, NA has been proven to be especially beneficial in psychiatry.[21] A network graph, the central aspect of NA, consists of two crucial components, "nodes" and "edges".[22] After adjustments are made for the influence of other nodes in a model, each edge reflects a partial correlation coefficient between two nodes and each node represents a single symptom.[22] The main purpose of NA is to identify core symptoms closely related to other symptoms. These core symptoms may be considered potential risk factors that warrant clinical attention and intervention. NA may help understand mental comorbidities, in which specific symptoms of one condition are associated with an increased risk of developing other disorders.[23] The symptoms that increase the risk of contagion from one condition to another are called "bridge symptoms", which can be identified via NA.[23] Clinicians can focus on these symptoms to treat or prevent comorbidities.[24]

NA of psychiatric symptoms has shown both common and unique network graphs in various samples. In a study investigating the relationship among anxiety, depression, and insomnia in Chinese college students during the COVID-19 pandemic, the key symptoms were found to be "fatigue", "restlessness", "uncontrollable worrying", "worrying too much", and "sleep insufficiency".[25] In another study, NA of Macao residents during the COVID-19 pandemic showed that the impact of "sleep maintenance", "trouble relieving", "interference with daily functioning", "irritability", and "fatigue" was more serious.[26] With regard to the NA of mental disorders, a study on the relationship between anxiety and depression in Korean patients with MDD indicated that depressive symptoms were not more important than anxiety symptoms in the estimated network graph. In addition, the correlation between irritability and nervousness indicated a potential cross-diagnostic association in MDD symptomatology.[27]

To date, no studies have reported the use of NA to assess the inter-relationships among psychiatric symptoms in Chinese outpatients with SSD. Existing studies on SSD have primarily focused on the independent relationships between

variables. Although patients with SSD have been found to have comorbid anxiety, depression, and insomnia, the inter-relationships and interactions among related symptoms of these comorbidities remain unclear. NA can be used to assess these inter-relationships and interactions, as it emphasizes that although many individuals experience symptoms of anxiety and depression, the core symptoms vary across patient populations. For instance, a study employing NA showed that "worry" was a particularly prominent symptom in college students during the COVID-19 pandemic. The findings suggested that "worry" was closely related to other symptoms and that other symptoms might result from "worry". Owing to physical discomfort, patients with SSD have unstable emotions; consequently, we speculate that "irritability" is their core symptom. This behavior differs from that of other patient groups, as each group has distinct core symptoms. Given the varying cultural backgrounds and healthcare systems across countries and ethnic groups, the patterns of symptom expression and association may vary across patients with SSD.

In this study, we constructed a network of anxiety, depression, and insomnia in patients with SSD, and also established a link with their history of attempted suicide. The history of suicide attempts can reflect the severity of the patient's past psychological crisis[26] and has a predictive value for future crises.[27] By treating attempted suicide as a binary variable, we can examine the correlation between attempted suicide and other psychological symptoms of patients with SSD. This approach can help identify symptoms that are more strongly associated with suicidal ideation in patients with SSD. These symptoms may result from attempted suicide or may indicate future psychological crises based on their presentation. Consequently, clinical intervention strategies can be optimized accordingly.

In this study, we used NA to investigate the inter-relationships among symptoms of anxiety, depression, and insomnia in Chinese outpatients with SSD. In addition to identifying central and bridge symptoms, we focused on identifying symptoms directly related to suicide attempts. Given that the incidence of SSD is higher in women,[28] we also compared the network constructions of males and females, attempting to identify the differences between them. The findings of this study provide insights not only into the management of the physical and mental health of patients with SSD but also into the prevention of suicide in these patients. Clinicians should pay close attention to the symptoms of patients and design appropriate treatment regimens. Timely psychological counseling and guidance should be provided for existing emotional disturbances. Moreover, patients without any evident emotional disturbances should be provided with support and attention to prevent emotional disturbances from hindering the recovery of the underlying disease.

Materials and Methods

Study Design and Participants

A cross-sectional survey was conducted at the First Affiliated Hospital of Gannan Medical University, the Third People's Hospital of Ganzhou, and the Ganzhou People's Hospital in Jiangxi Province, China, between January 2023 and April 2024. The study design was approved by the Institutional Review Board (IRB) of the Third People's Hospital of Ganzhou. All patients provided informed consent before participating in this study. The information of responders was kept confidential.

A total of 1068 volunteers were selected from the three centers. To be eligible to participate, individuals needed to meet the following four requirements, which were evaluated based on self-reporting: (1) Han Chinese nationality; (2) age ranging between 18 and 60 years; (3) diagnosis of SSD according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) criteria; and (4) capacity to provide written informed consent. A supervisory senior physician with years of clinical expertise cross-checked the diagnoses before confirming them during our weekly team meeting. A total of 997 patients with SSD met the inclusion criteria; of which, 98 patients were excluded owing to the following reasons: (1) ongoing pregnancy or lactation (n = 23); (2) substance use disorder (n = 25); (3) severe personality disorder (n = 13); (4) severe physical diseases (n = 12); (5) refusal to participate in the study (n = 20), and (6) other unknown reasons (n = 5).

Measurements

The 7-item Generalized Anxiety Disorder (GAD-7) scale[29,30] in Chinese was used to evaluate the severity of anxiety. This scale assesses the severity of anxiety based on the frequency of symptoms during the preceding 2 weeks. These

symptoms include nervousness, uncontrollable worry, excessive worry, trouble relaxing, restlessness, irritability, and feeling afraid. The total score varied from 0 to 21, with higher scores representing more severe anxiety.[30] Each question in the GAD-7 instrument represented a typical anxiety symptom and was scored from 0 (not at all) to 3 (almost every day).

The severity of insomnia was assessed using the validated Chinese version of the Insomnia Severity Index (ISI) questionnaire.[31] The ISI questionnaire consists of 7 items investigating different domains of insomnia, including difficulty falling asleep, sleep maintenance, waking up early, sleep dissatisfaction, interference of sleep problems with daily life, noticeability of sleep problems by others, and distress caused by sleep problems. Each item was scored from 0 (no problem) to 4 (very severe problem). The total ISI score ranged from 0 to 28, with higher scores indicating more severe insomnia. A total ISI score of ≥8 was considered indicative of insomnia.[32]

The Chinese version of PHQ-9,[33] which measures cognitive, emotional, physical, and interpersonal symptoms associated with depression, was used to assess the severity of depression. This questionnaire asks responders to report the frequency of symptoms such as anhedonia, sad mood, sleep issues, low energy, changes in appetite, feelings of guilt, difficulty in concentrating, motor agitation or retardation, and suicidal thoughts during the past 2 weeks.[34] Each question was scored from 0 (not at all) to 3 (almost every day), with higher total scores indicating more severe depressive symptoms. The validity of PHQ-9 has been robustly confirmed in Chinese populations.[35,36]

In a suicide attempt, an individual tries to end their life by harming themselves to some degree.[16,37] In this study, if the response to the question "Have you ever attempted suicide in your life?" was "yes", the patient was considered to have a history of attempted suicide. Additionally, we requested particular details regarding their suicide attempt(s), such as the number, timing, and manner of the attempts. If a patient was unable to provide a clear response, we performed follow-up interviews with family members or friends for clarification.

Network Analysis

NA was performed using the R software. According to the terminology of NA, each item is referred to as a node and the relationship between two nodes is considered an edge. Partial correlation analysis was used to evaluate the relationship between each pair of nodes while accounting for the confounding influence of every other node. To keep nodes with as few edges as possible in the network, all edges were shrunk and small correlations were set to zero using the least absolute shrinkage and selection operator (LASSO).[38] This method requires a large sample size to support and streamline the model, allowing the network graph to display the most characteristic nodes and correlations and hence reducing false associations. To make the network sparser and simpler to understand, the extended Bayesian Information Criteria (EBIC) was used to select the relevant turning parameter.[39] Subsequently, nonparanormal transformation was used to compute nonparametric correlations because of the skewed distribution of the mean item scores.[40] The network graph was constructed and visualized using the R packages *qgraph* (version 1.6.9)[22] and *bootnet* (version 1.4.3).[41] The degree of linkage was indicated by the thickness of the edge in the network. Red edges denoted negative correlations, whereas blue edges denoted positive correlations.

The *centralityPlot* function in the R package *qgraph* (version 1.6.9)[22] was used to calculate centrality indices, which measure the significance of each node in the network. An interaction network is often evaluated using various centrality indices, such as closeness, betweenness, and strength.[42] The most widely used centrality indicator, strength, was used in this study because previous studies have shown that estimates of closeness and betweenness are inconsistent.[43,44] In addition, we examined predictability, which shows how closely a node is related to its neighbors and how interconnected they are.[45] The predictability value, represented by the area of the rings surrounding each node in the network, was determined using the *predict* function in the R package *mgm* (version 1.2–11).[46]

The *bridge* function in the R package *networktools* (version 1.2.3)[47] was used to evaluate the centrality index of bridge strength to determine the significance of a node in connecting anxiety and sadness.[24] In the network, nodes with greater strength were considered more significant. Compared with bridges with lower strength, those with higher strength indicated a higher risk of spreading from one community to another.

The *flow* function in the R package *qgraph* was used to identify specific symptoms that were directly associated with suicide attempts.[22] The network structure that incorporated suicide attempts used the *mgm* hybrid network model,[46] as suicide attempts were part of a two-point scoring system.

Centrality and Stability

A case-dropping bootstrap approach was used to investigate the stability of node and bridge strengths. During this process, the centrality indices were re-estimated and a large proportion of cases were removed from the dataset. The correlation stability coefficient (CS-C)[41] is a measure of the stability of a network that indicates the number of samples that can be removed from a dataset without noticeably altering the indices. The centrality indices from subsamples are correlated with those from the original sample at a value of $r = 0.7$[41], signifying that CS-C represents the highest number of cases that can be removed from the original sample. The CS-C value should ideally be above 0.5; however, it must generally be above 0.25[41]. Based on 95% CIs, a nonparametric bootstrap method was used to evaluate the stability of edge weights. In addition, the 95% CIs were used to evaluate edge correctness, with a network with a narrower CI being considered more reliable.[41,48] Furthermore, bootstrapped tests based on the 95% CIs were used to assess differences between the strengths of two edges or those of two nodes. If zero was excluded from the CIs,[41] statistical differences were found between the strengths of two edges or those of two nodes. The R package *bootnet* (version 1.4.3)[41] was used to evaluate all stability indices of the network.

Network Comparison

Variations in network characteristics between male and female participants were investigated, considering gender-specific variations in depression and some anxiety disorders.[49] The global and local connectedness between two within-gender models were evaluated using the R package *NetworkComparisonTest* (version 2.2.1),[50] with 1000 permutations.

Results

A total of 899 patients with SSD (579 women, 320 men) were included in this study. The participants had a mean age of 34.44 years (standard deviation [SD] = 12.37 years). Regarding other demographic characteristics, 302 (33.6%) patients had a higher educational qualification (ie, undergraduate/college or above), 291 (32.4%) patients were unmarried, and 179 (19.9%) patients had attempted suicide before (Table 1). The prevalence rates of anxiety (GAD-7 score ≥ 5),

Table 1 Socio-Demographic Characteristics of the Study Population (N = 899)

Variables	N	%
Gender		
Men	320	35.6
Women	579	64.4
Education level		
Below undergraduate[a]	597	66.4
Undergraduate or higher	302	33.6
Marital Status		
Married	608	67.6
Unmarried	291	32.4
Have attempted suicide before		
Yes	179	19.9
No	720	80.1
	Mean	***SD***
Age (years)	34.44	12.37

Notes: [a] Below undergraduate = less than 12 years of education.

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insomnia (ISI score ≥ 8), and depression (PHQ-9 score ≥ 5) were 80.4% (95% CI, 77.6–82.9%), 85.3% (95% CI, 82.8–87.5%), and 83.7% (95% CI, 81.0–86.0%), respectively.

Network Structure

The left panel of Figure 1 shows networks of symptoms of anxiety, insomnia, and depression. With regard to the fundamental properties of the networks, 175 of the 253 available edges (69.2%) were not zero and showed a significant degree of connection across symptoms. Furthermore, 9 of the 10 strongest edges were found within the communities of specific mental health issues (5 in the depression community, 3 in the anxiety community, and 1 in the insomnia community), whereas the remaining edge linked the communities of anxiety and depression. The edge between GAD1 "Nervousness" and GAD4 "Trouble relaxing" was strongest, followed by the edges between ISI3 and ISI7 ("Waking up early" and "Distress caused by sleep problems"), GAD2 and GAD7 ("Uncontrollable worry" and "Feeling afraid"), PHQ2 and PHQ4 ("Sad mood" and "Energy"), PHQ5 and PHQ8 ("Appetite" and "Motor"), PHQ7 and PHQ8 ("Concentration" and "Motor"), GAD6 and PHQ7 ("Irritability" and "Concentration"), PHQ1 and PHQ6 ("Anhedonia" and "Guilt"), PHQ5 and PHQ6 ("Appetite" and "Guilt"), and GAD3 and GAD6 ("Excessive worry" and "Irritability") (Figure 1). GAD6 and PHQ7 were negatively correlated, whereas the nodes in all other edges were positively correlated.

The node predictability values ranged from 87.3% to 96.3%, with an average of 91.9%, indicating that 91.9% of the variance in the nodes could be explained by their neighboring nodes (Figure 1, Table 2). PHQ8 "Motor" and PHQ7 "Concentration" (depressive symptoms) had the highest predictability value in the model, whereas PHQ4 "Energy", which is also a symptom of depression, had the lowest predictability value. In the network of anxiety, insomnia, and depression, ISI3 "Waking up early" had the highest node strength, followed by GAD6 "Irritability", PHQ9 "Suicide", GAD1 "Nervousness", and GAD2 "Uncontrollable worry". In terms of bridge symptoms, GAD6 "Irritability" showed the highest bridge strength, followed by ISI3 "Waking up early", PHQ9 "Suicide ideation", PHQ7 "Concentration", and PHQ6 "Guilt" (Figure 2).

Figure 3 shows a flow diagram demonstrating the relationship between suicide attempts and the symptoms of anxiety, insomnia, and depression in the network. The four distinct symptoms in the center of the diagram had a direct correlation

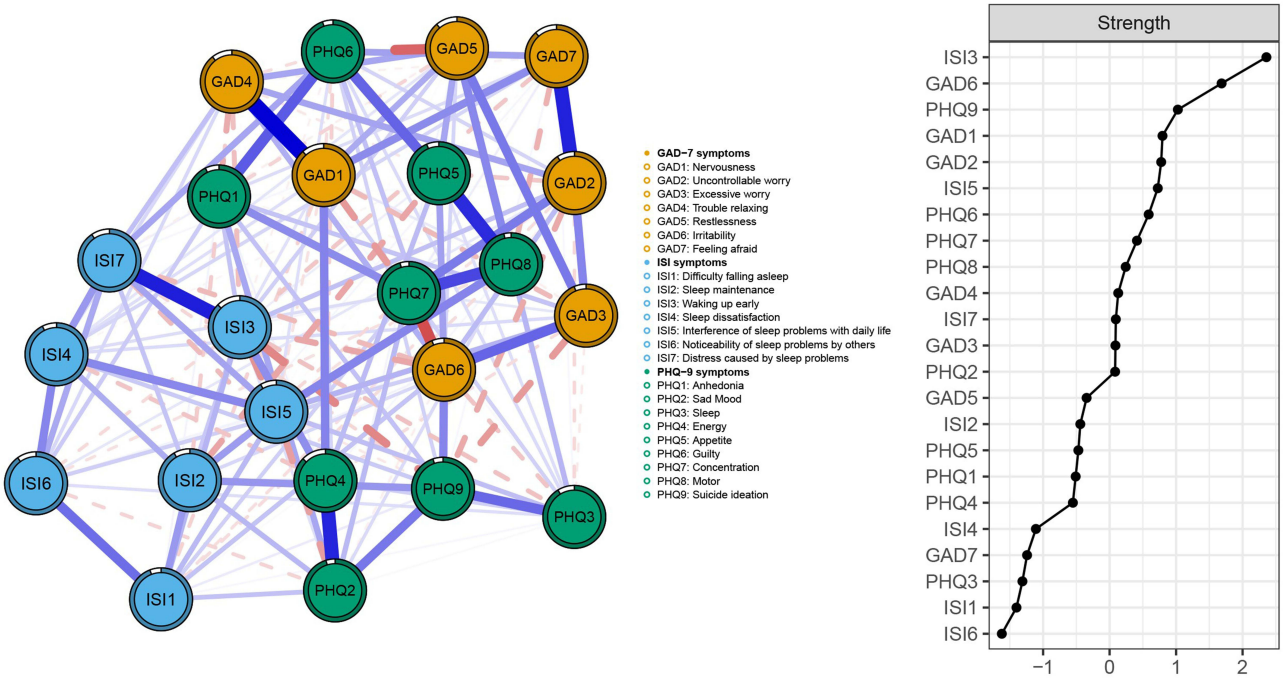

Figure 1 Network structure of anxiety, insomnia and depressive symptoms in Chinese outpatients with somatic symptom disorder.

Table 2 Descriptive Statistics of Measurement Items

Item Abbreviation	Item Content	Item Mean (SD)	Node Strength[a]	Predictability
GAD1	Nervousness	1.43 (0.80)	2.216	0.885
GAD2	Uncontrollable worry	1.41 (0.83)	2.210	0.909
GAD3	Excessive worry	1.71 (0.92)	1.992	0.938
GAD4	Trouble relaxing	1.64 (1.04)	2.005	0.895
GAD5	Restlessness	1.72 (0.94)	1.855	0.889
GAD6	Irritability	1.57 (0.86)	2.496	0.937
GAD7	Feeling afraid	1.57 (0.99)	1.572	0.885
ISI1	Severity of sleep onset	1.78 (0.90)	1.522	0.942
ISI2	Sleep maintenance	1.83 (1.14)	1.825	0.917
ISI3	Early morning wakening problems	1.90 (0.82)	2.709	0.877
ISI4	Sleep dissatisfaction	1.89 (1.13)	1.614	0.926
ISI5	Noticeability of sleep problems by others	2.14 (1.35)	2.193	0.917
ISI6	Distress caused by the sleep difficulties	1.89 (0.90)	1.453	0.901
ISI7	Interference with daytime functioning	2.01 (1.18)	1.994	0.905
PHQ1	Anhedonia	1.17 (1.18)	1.803	0.929
PHQ2	Sad Mood	1.18 (1.06)	1.991	0.953
PHQ3	Sleep	1.41 (0.86)	1.550	0.913
PHQ4	Energy	1.25 (1.02)	1.790	0.873
PHQ5	Appetite	1.35 (0.89)	1.816	0.937
PHQ6	Guilt	1.42 (1.03)	2.150	0.946
PHQ7	Concentration	1.57 (0.86)	2.094	0.954
PHQ8	Motor	1.33 (0.91)	2.041	0.963
PHQ9	Suicide	0.92 (1.25)	2.289	0.948

Notes: [a]The values of node strength were raw data from the network.
Abbreviations: ISI, Insomnia Severity Index; PHQ-9, the 9-item Patient Health Questionnaire; GAD-7, 7-item Generalized Anxiety Disorder Scale; SD, standard deviation.

with suicide attempts, whereas the other symptoms had an indirect correlation. The symptoms that exhibited the strongest direct correlations with suicide attempts included PHQ9 "Suicide ideation", ISI4 "Sleep dissatisfaction", ISI2 "Sleep maintenance", and GAD4 "Trouble relaxing". Suicide attempts were negatively correlated with GAD4 but positively correlated with the other 3 nodes, with sleep maintenance (an insomnia symptom) being the most prominent.

Network Stability

Both node strength and bridge strength values (both CS-coefficients = 0.75) (Figure 4) demonstrated an exceptional degree of stability, indicating that 75% of the participants could be removed from the analysis without altering the structure of the network. According to the bootstrapped stability test for strength, the central symptoms considerably differed from other nodes (Figure S1).

Comparison of Networks Constructed for Women and Men

Figure S2 shows the network graphs separately constructed for men and women. The global strength of the network (men, 23.648; women, 23.378; S = 0.270; p = 0.661) and edge weight distribution (M = 0.163, p = 0.644) did not significantly differ between the networks constructed for men and women (Figure S3).

Discussion

To the best of our knowledge, this study is the first to conduct a network analysis of symptoms related to anxiety, insomnia, and depression in Chinese outpatients with SSD. In the network of anxiety, insomnia, and depression constructed in this study, 9 of the 10 strongest edges were dispersed throughout the communities of specific mental

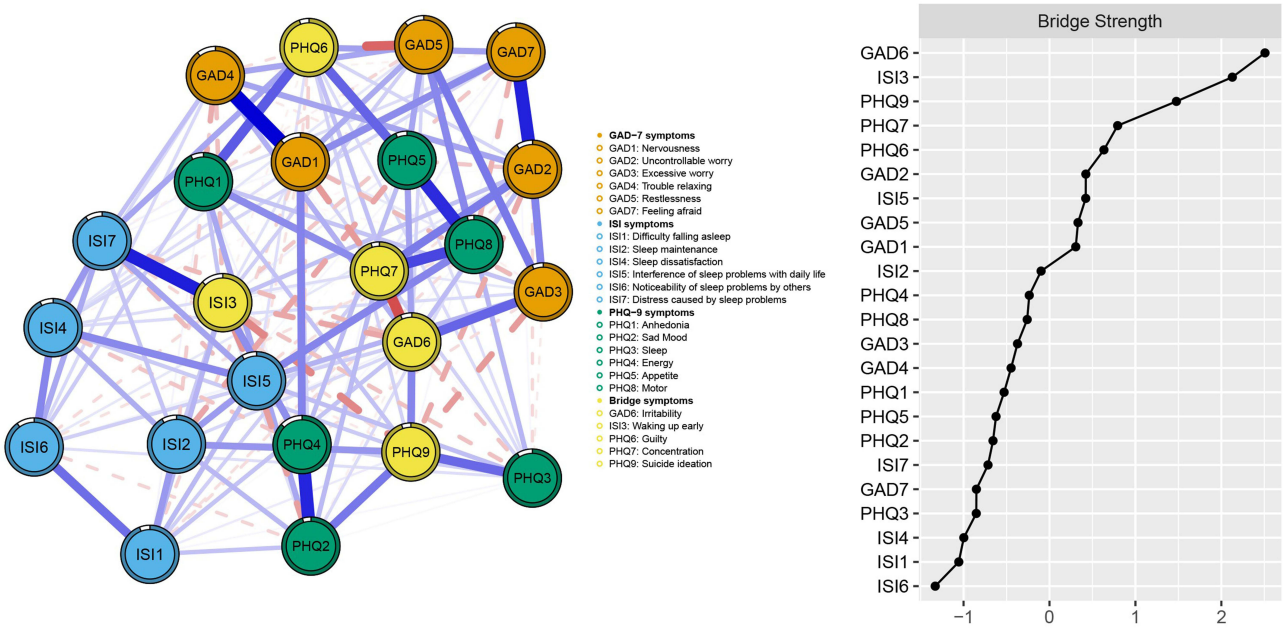

Figure 2 Network structure of anxiety, insomnia and depressive symptoms showing bridge symptoms in Chinese outpatients with somatic symptom disorder.

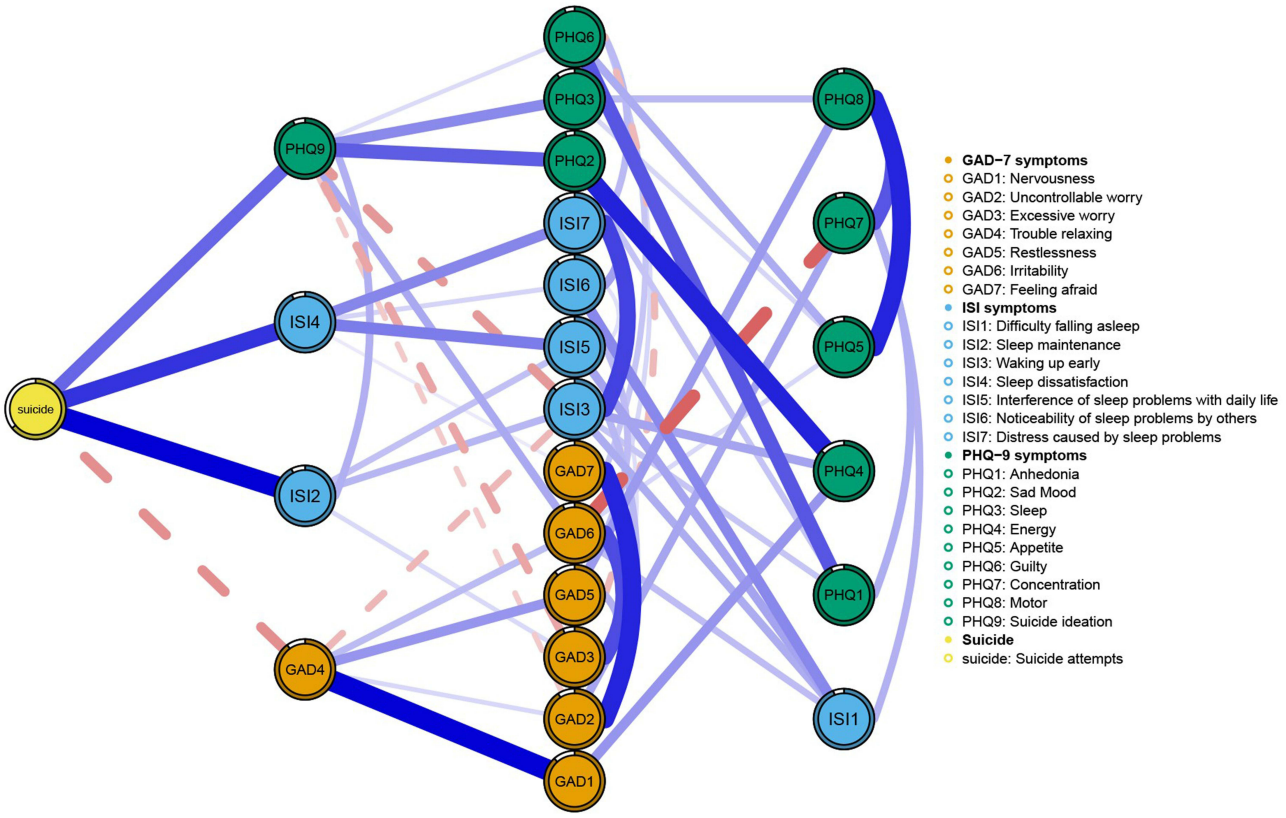

Figure 3 Flow network of suicide attempts.

health issues, whereas the remaining one edge connected the communities of depression and anxiety. In particular, GAD1 "Nervousness" and GAD4 "Trouble relaxing" (anxiety symptoms) formed the strongest edge in the entire network. Long-term discomfort and pain are more likely to make patients feel trouble relaxing.[51] Given that pain is positively correlated

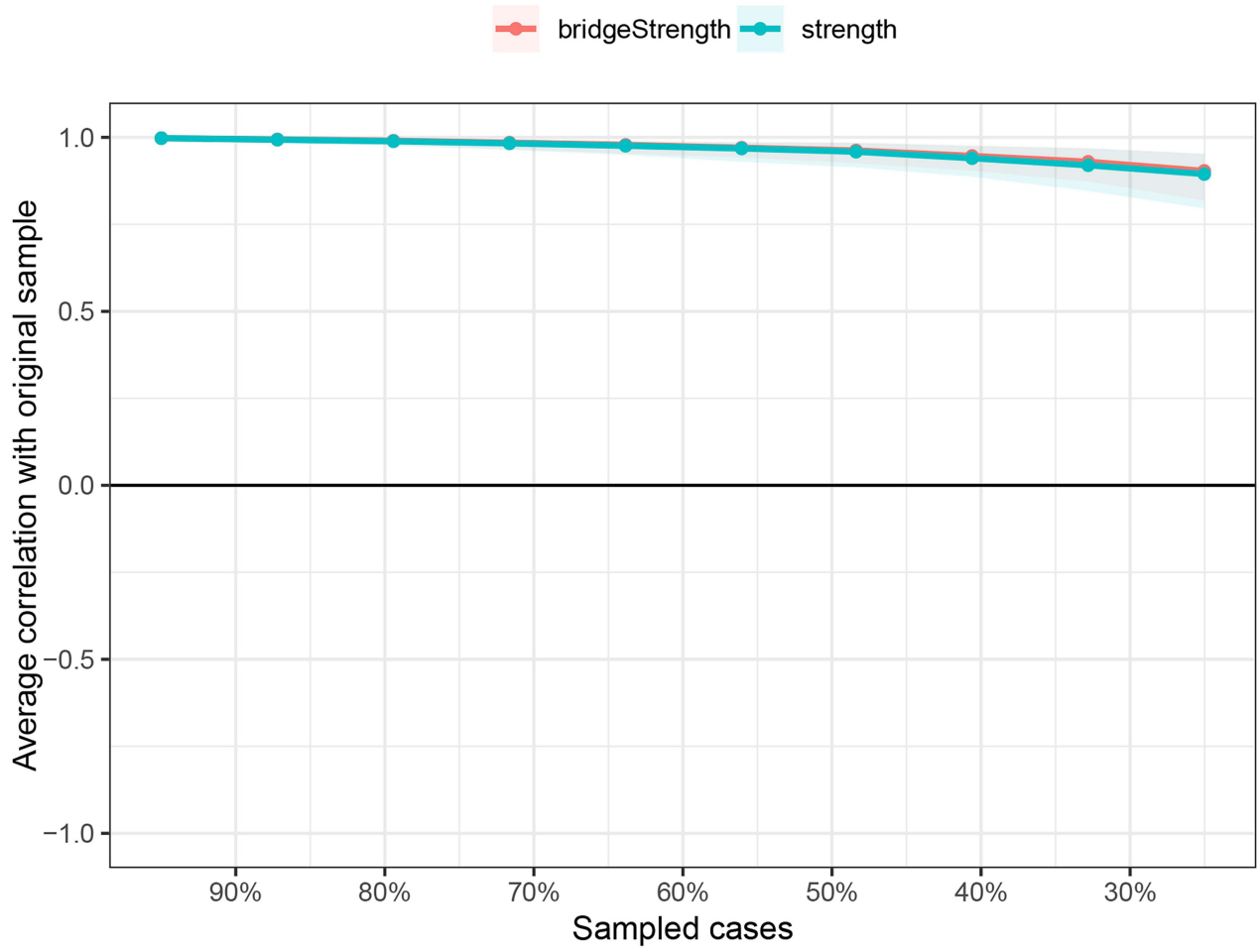

Figure 4 The stability of centrality and bridge centrality indices using case-dropping bootstrap.

with nervousness,[52] patients with SSD naturally have a more pronounced state of nervousness. Therefore, the relationship between tension and difficulty relaxing is also more evident in patients with SSD. In this study, we focused more on the negative correlation between the scores of GAD6 "Irritability" and PHQ7 "Concentration", which indicated that higher levels of irritability led to more focused attention. Moreover, the edge weight of the two factors was relatively high. Studies[53] have shown that patients with SSD have high trait anger[54] and that the more irritable one is, the less focused their attention becomes, which is contradictory to the results of this study. We speculate that the negative correlation between GAD6 "Irritability" and PHQ7 "Concentration" scores may be related to the decrease in serotonin levels caused by anger expression.[55] Studies have shown that serotonin stimulation may impair sustained attention;[56] From a psychological perspective, patients with SSD may subconsciously transform psychological conflicts into physical symptoms in order to avoid difficult emotional issues. Irritability can be seen as another manifestation of psychological conflict, while concentration can be seen as a "rationalized" defense against physical symptoms, by focusing attention on physical discomfort to avoid facing more complex psychological conflicts, thus demonstrating a special connection between irritability and attention. This correlation may be unique to the particular sample in this study, and further research is warranted to verify it. Focusing on the edge weight and the inter-relationships between symptoms suggests that clinicians should pay attention to the adverse effects caused by the co-occurrence of symptoms. Furthermore, we found that the dominant edge in the network connected the symptoms of anxiety and depression, which highlights the need to pay attention to the relationship and interaction between the symptoms of depression and anxiety in patients with SSD in clinical practice.

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The strength centrality of nodes performed well in identifying specific symptoms that most strongly contributed to the overall network of psychopathological symptoms. Specifically, an insomnia symptom, ISI3 "Waking up early", had the highest strength centrality value, indicating its crucial role in maintaining the entire network. Waking up early is a sign of sleep deprivation[57] and one of the manifestations of insomnia. However, the aforementioned finding is not consistent with that of existing studies. In a survey of Chinese fire service recruits, the most intense symptom in the network graph was ISI4 "Sleep dissatisfaction".[58] Additionally, in a survey of the general Korean population, the core symptom in the network was ISI7[59] "Distress caused by sleep problems" during the COVID-19 pandemic. The reason for these inconsistent findings may be that the physical discomfort or pain experienced by patients with SSD can interfere with sleep and prompt waking up early, which is less likely to occur in the general population.[60] As ISI3 "Waking up early" was identified as the core symptom, the appropriate clinical treatment of this symptom may also alleviate other symptoms in the network. Furthermore, anxiety accounted for three of the top five strongest symptoms, namely, GAD6 "Irritability", GAD1 "Nervousness", and GAD2 "Uncontrollable worry", indicating the importance of anxiety in the network. We speculate that anxiety-related symptoms affect the entire symptom network in two ways. First, in terms of physiology, anxiety occurs when patients pay excessive attention to their physical discomfort. Anxiety triggers the autonomic nervous system,[61] resulting in physical symptoms such as palpitations and muscle tension. These symptoms, in turn, intensify the excessive focus of patients on their physical health, creating a vicious cycle of anxiety, physical symptoms, and worsening anxiety. On the psychological level, catastrophic thinking caused by anxiety[62] can worsen a patient's misinterpretation of bodily sensations, establishing another vicious cycle. Therefore, anxiety-related symptoms were highly correlated with other nodes in the network.

In the insomnia–anxiety–depressive symptom network in this study, the key bridge symptom based on the node bridge strength was GAD6 "Irritability". This symptom has been mentioned multiple times before, either as a core symptom or as a symptom related to other symptoms. As a bridge symptom, irritability has a significant impact on network construction, and many studies have reported the same conclusion. In a study investigating the comorbidity network of clinicians during the later stages of the COVID-19 pandemic, irritability was identified as the most influential bridge symptom.[63] Another study on the general population of China reported anger as an important bridge symptom.[64] In patients with SSD, emotional management is impaired,[65] leading to a stronger expression of negative emotions,[66] especially irritability.[67] Irritability manifests as episodes of explosive anger due to sustained emotional distress. At the cognitive level, the perception of threats increases,[68] triggering sustained psychological stress and expanding anxiety-related emotions. Long-term emotional instability can affect intimate relationships and social functioning. An outbreak of interpersonal conflicts can deepen negative experiences,[69] exacerbate the sense of helplessness, and aggravate depressive symptoms. Therefore, irritability is an important predictor of anxiety and depression.[70] Furthermore, studies have indicated an association between irritability and sleep.[71,72] Irritability can trigger stress in patients,[72] and stress can activate the endocrine system, increasing its activity. This increased activity can affect various functions of the body, causing significant damage to sleep patterns.

In addition to irritability, other symptoms with a high bridge strength included ISI3 "Waking up early", PHQ9 "Suicide ideation", PHQ7 "Concentration", and PHQ6 "Guilty". Similar findings have been reported in previous studies.[53,73–75] We found that three out of the five selected bridge symptoms were related to depression. Unlike the high intensity of anxiety symptoms, depression, as a diffuse emotional state, affects various aspects of psychological well-being. The three bridge symptoms, namely, "Suicidal ideation", "Concentration", and "Guilt", reflect cognitive impairment, which has a negative impact on other psychological aspects of patients.

Bridge symptoms connect the communities of different mental disorders. Bridge symptoms in different groups of mental disorders can lead to comorbid mental illnesses.[26] Therefore, in clinical practice, close attention and prompt intervention are required to control the mutual influence of different mental disorders. In particular, irritability is a key symptom that requires close attention, as it was important in terms of the overall network strength and bridge strength in the network constructed in this study. At present, exposure-based cognitive behavioral therapy (CBT) is considered an effective treatment for irritability,[76] and the combination of CBT and PMT has shown good efficacy in treating irritability in adolescents. Meanwhile, CBT is also one of the validated and effective clinical intervention methods for SSD.[77]

Antidepressants have also been proven properties.[78] Antidepressants regulate emotions by modulating neurotransmitters, which can effectively address the anxiety and depression symptoms mentioned earlier.

Epidemiological studies have shown that patients with SSD have a high suicide attempt rate.[18] In the network constructed in this study, the insomnia symptom ISI2, "Sleep maintenance", was most strongly correlated with suicide attempts. Difficulty in sleep maintenance refers to waking up one or more times at night. After waking up, it takes 20–30 minutes or even longer to return to sleep, indicating a problem with resuming sleep.[79] Sleep disruption caused by physical symptoms is particularly evident in patients with SSD.[11,12,14,80,81] "Waking up early" is the core symptom affecting the severity of anxiety, depression, and other symptoms, whereas sleep maintenance and satisfaction are strongly correlated with attempted suicide in patients with SSD. These findings emphasize that clinicians should remain vigilant about patients' insomnia, not only for predicting suicide attempts but also for maintaining the overall mental health of the patients. To date, no studies have reported a negative correlation between suicide attempts and trouble relaxing. We speculate that the more anxious individuals are about their situation, the more difficult it is to relax. This anxiety may result from an individual's survival instinct. The more one concentrates on and worries about their physical condition, the more it reflects their fear of death. Individuals with this trait are more likely to opt for alternatives to suicide. However, this speculation cannot be generalized. For patients with health issues that may lead to suicidal ideation, other potential factors should be considered and additional investigations should be performed. In China, the overall age-standardized suicide rate decreased from 10.88 to 5.25 per 100,000 population from 2010 to 2021; however, the suicide rate among young individuals significantly increased during this period.[82] Moreover, the suicide rate can reach 312.8 per 100,000 person-years among patients with severe mental illnesses.[83] These statistics suggest that suicide remains a serious public health concern. In this study, we attempted to explore the psychological characteristics of patients with SSD through network analysis to provide valuable insights into the prevention of suicide attempts in this patient population. In particular, symptoms of insomnia warrant more clinical attention. Based on the multiple characteristics mentioned earlier, antidepressants with sedative properties (eg, doxepin, mirtazapine, trazodone)[84] can be used in moderation in clinical practice. Relieve anxiety, depression, and insomnia symptoms through medication and psychotherapy to control suicidal behavior and ultimately promote the recovery of patients with SSD.

Limitations

One of the strengths of this study is its large sample size, which is unusual in studies involving patients with SSD. However, this study has some limitations that should be acknowledged. First, because this study had a cross-sectional design, we could not prove causation or identify dynamic interactions between the variables. And in this study, we cannot rule out the influence of Bergson bias[85] on the results of network analysis. Second, this study included only patients with SSD; therefore, the results cannot be generalized to patients with other mental health issues, such as major depressive disorder, bipolar disorder, and personality disorders. At the same time, we were unable to provide detailed information on the specific manifestations and comorbidities of patients with SSD. Third and last, to reduce the burden of unpaid research volunteers, we did not assess potential confounding factors, especially for participants who had attempted suicide. These limitations emphasize the necessity of conducting additional investigations in future research.

Conclusions

In conclusion, the anxiety–insomnia–depression network constructed in this study revealed insomnia- and anxiety-related symptoms as most crucial in terms of the node and bridge centrality strengths in Chinese outpatients with SSD. Furthermore, insomnia-related symptoms were closely related to suicidal ideation and attempted suicide, suggesting that clinicians should pay more attention to these symptoms. The aforementioned psychological symptoms may be potential targets for intervention. In addition, medications should be integrated with cognitive behavioral therapy to dynamically monitor patients with SSD and alert them against the manifestation of core symptoms, thereby reducing the risk of suicide, particularly in patients with a history of attempted suicide. Future research in this field should focus on enhancing treatment outcomes for patients with SSD.

Data Sharing Statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics Approval and Consent to Participate

The ethical review of this study is strictly enforced in accordance with the *declaration of Helsinki*. The studies involving human participants were reviewed and approved by the *Ethics Committee of the Institute of Third People's Hospital of Ganzhou*. The patients/participants provided their written informed consent to participate in this study. (IRB: Ethics Committee of the Institute of Third People's Hospital of Ganzhou, Ethical code: gzsyy2024044).

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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