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ORIGINAL RESEARCH

Network Analysis of Depressive Symptoms, Social Support, and Diabetes Distress Among Patients with Type 2 Diabetes: A Cross-Sectional Study

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Background: Diabetes distress (DD) is common in patients with type 2 diabetes (T2D). Little is known about the complex intercorrelations between different components of depressive symptoms (DS), social support (SS), and DD. This study aimed to identify the central components of DD and to examine the interconnectedness between DS, SS, and DD components.

Methods: A cross-sectional survey design was employed in this study. We investigated 886 patients with T2D from two diabetes centers. The Chinese versions of the Diabetes Distress Scale (DDS), Patient Health Questionnaire (PHQ-9), and Social Support Rating Scale (SSRS) were used. GGM was employed to estimate the network model. We identified central and bridge symptoms based on betweenness, closeness, and node strength centrality. The stability and accuracy of the network were examined using the case-dropping and bootstrapped procedures.

Results: Three items ("Do not have doctor I can see regularly", "Doctor does not give clear directions", and "Doctor does not know about diabetes") in the network of DD exhibited the highest strength centrality. The DD-DS-SS network exhibited four strong positive bridges and two strong negative bridges. The stability and accuracy tests demonstrated that the two networks were robust.

Conclusion: Physician-related distress may contribute to the development and maintenance of DD. Fatigue, diet, and social interaction summarize the complex link between DD and DS. Furthermore, subjective support and support utilization of patients with T2D were closely related to the DD. These provided more targeted theoretical guidance and a scientific basis for psychological counseling and intervention in patients with T2D.

Keywords: diabetes distress, depressive symptoms, social support, type 2 diabetes, network analysis

Introduction

Diabetes distress (DD) refers to the negative emotional impact of living with diabetes, including feelings of guilt, anxiety, and concerns about the self-management of the condition.[1] A previous study established DD as a clinically significant risk factor for suboptimal health outcomes in patients with diabetes.[2] Previous studies have demonstrated that elevated DD is associated with biological markers, including higher HbA1c[3] and lower heart rate variability.[4] Additionally, there is evidence that DD is associated with a higher mortality rate[5,6] and that elevated DD is associated with delayed medical care,[7] impaired diabetes self-management,[8–10] and lower quality of life.[11] While DD is known to complicate diabetes management, its connection to DS and SS is unclear.

For the past few decades, researchers[12,13] have focused on the association between DD and DS, which frequently occur together.[14] According to survey results, 19.6% of adults with diabetes have experienced DD and DS.[15] A longitudinal study demonstrated the persistent coexistence of DD and DS for 18 months.[16] Gastrointestinal symptoms exhibited independent associations with DD and DS in individuals with type 2 diabetes (T2D).[17] The coexistence of DD and DS increases the risk of death, poor disease management, diabetes-related complications, and a lower quality of life,

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which is a challenge to the care of patients with T2D.[18] The American Diabetes Association and other researchers agree that routine screening for DD and DS should be performed in all adults with diabetes due to comorbidity, persistence over time, and impact on health outcomes.[19–21] Therefore, establishing a link between DD and DS is critical for developing effective interventions.[22] Ehrmann et al demonstrated that higher DD predicted more DS 6 months later. Conversely, a higher DS at baseline indicated an increase in DD at the 6-month follow-up date.[23] Burns et al reported a bidirectional association between DD and DS in a follow-up study on a group of nearly 1700 patients with T2D living in the community.[24] This indicates that DD was associated with concurrent and subsequent DS, and DS, in turn, was associated with concurrent and subsequent DD. These studies demonstrate an intricate reciprocal association between DD and DS. However, the exact mechanisms of the interaction are unclear.

SS is another external factor closely associated with DD in individuals with T2D. SS is a multidimensional construct that refers to objective support, subjective support, and support utilization.[25] Previous studies have confirmed that SS buffers the impacts of DD on health-related quality of life.[26,27] A previous study has demonstrated the potential direct effects of SS in diabetes and reported that higher levels of SS were associated with lower DD, better adoption of diabetes self-management behaviors, and better diabetes-related clinical outcomes, including glycemic control.[28] Moreover, effective patient-centered communication has been indicated to buffer the effects of diabetes burden on distress levels, highlighting the importance of supportive interactions in diabetes care.[29] A previous study reported that perceived SS can alleviate feelings of distress, potentially reducing the risk of developing DS.[30] There could be a negative correlation between DD and SS. However, the mechanisms through which SS influences DD are unclear.

Previous studies on DD were primarily focused on its prevalence, instruments, and consequences.[31–33] Studies have investigated the association between DD and DS/SS, often utilizing traditional statistical methods, including regression or factor analysis.[34–36] While these methods effectively assess the association between specific predictive and outcome variables, they fail to capture the interdependencies and complex interactions among multiple variables.[37] This limitation is particularly pronounced when investigating complex phenomena, including DD in patients with T2D. Consequently, a more nuanced statistical approach is needed to investigate the association between them, including central and bridging symptoms, thereby enhancing the understanding of the complex psychopathological mechanisms associated with DD and DS/SS.

The Network Theory of Mental Disorder (NTMD) suggests that the development and maintenance of mental disorders are influenced by dynamic causal relationships among various symptoms within the disorder.[38] The network analysis, a cutting-edge approach for analyzing psychiatric disorders, aligns with the principles of NTMD and addresses this complexity by examining the correlation between specific symptoms.[39] This method elucidates the relationships among individual symptoms and, through the centrality metrics of the network, facilitates the identification of core and bridge symptoms, providing a more comprehensive perspective on exploring the connection between DD and DS/SS.

Incorporating emotional and social factors in diabetes management may lead to improved health outcomes and enhanced quality of life for patients with T2D.[40] Further exploration of these associations is essential, as understanding the dynamics of DD and DS/SS could inform more effective interventions for individuals with T2D. This study employed a network analysis method to construct a symptom network among DD and DS/SS to investigate their interactions, aiming to establish a theoretical foundation for future interventions by identifying critical nodes with cascading effects within the network.

Methods

Design

A cross-sectional design was employed in this research. Figure 1 illustrates the study flow chart.

Setting and Sample

The study was conducted at two diabetes centers in densely populated areas of southwest China, where the prevalence of T2D is among the highest in the country.[41] One of the centers is within a large general hospital that provides outpatient and inpatient care for adults with diabetes. The other center is in a primary care facility that mainly provides outpatient

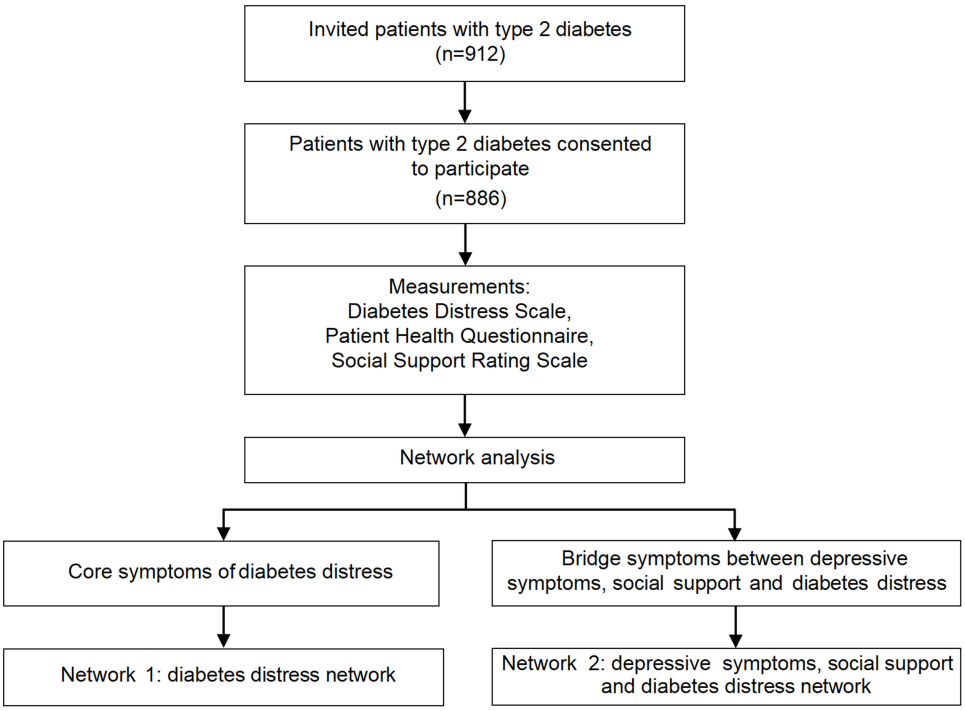

Figure 1 The flowchart of the research.

care and home visits. The two centers serve patients with T2D in various medical settings in southwest China, including outpatients, inpatients, community patients, and home care patients, ensuring the representativeness of our T2D samples. The inclusion criteria for participants were as follows: (a) Patients diagnosed with T2D, (b) patients ≥ 18 years of age, and (c) patients who had an average score > 2 points on the Diabetes Distress Scale (DDS). The exclusion criteria were as follows: (a) Patients with a history of severe dementia, psychosis, or serious neurologic disease, and (b) patients refusing to participate in the study. We invited 912 patients with T2D from the two diabetes centers to participate, and 886 consented to enroll.

Variables and Measurements

Demographic and Clinical Information

The participants self-reported their information, including their age, gender, educational background, marital status, family history of diabetes, smoking, and alcohol consumption.

Diabetes Distress

Diabetes distress was assessed using the DDS, developed by Polonsky to evaluate the distress of patients with diabetes.[42] Zhang et al[43] translated the scale into Chinese and reported that the Cronbach's alpha for the overall scale was 0.88, while the subscales ranged from 0.76 to 0.81 in Chinese adults with T2D. The Chinese DDS comprises 17 items that measure four dimensions: Emotional burden (EB, five items), physician-related distress (PD, four items), regimen-related distress (RD, five items), and diabetes-related interpersonal distress (ID, three items). These items employ a six-point Likert scale that ranges from 1 (no distress) to 6 (high distress). A total score was calculated by adding the 17 items. The higher the scores, the more significant the distress. According to the revised rating system developed by Fisher, a mean item score < 2 indicates little or no distress; 2.0–2.9 indicates moderate distress, and ≥ 3 indicates high distress.

Depressive Symptoms

Depressive symptoms were assessed using the Patient Health Questionnaire (PHQ-9), a short questionnaire. The internal reliability of the PHQ-9 was excellent, with a Cronbach's alpha of 0.870 among patients with T2D.[44] The scale consists of 9 questions with response options: including "no problem" (0 points), "a few days, sometimes" (1 point), "more than 7

days" (2 points), or "almost every day" (3 points). The total score is calculated by adding the points for each response, resulting in a score range of 0 to 27. Scores from 0 to 4 indicate the absence of DS, 5 to 9 indicate mild DS (subsyndromal depression), and ≥ 10 indicate a high probability of a depressive episode, which can be classified as moderate (10 to 14), moderately severe (15 to 19), and severe depression (20 and above).

Social Support

Social support was assessed using the Social Support Rating Scale (SSRS), designed for the Chinese population by Xiao.[25] SSRS comprises three dimensions: Objective support, subjective support, and utilization of support, and has been verified to have favorable reliability and validity in patients with T2D. Chen et al[45] indicated that the Cronbach's alpha coefficient of the SSRS was 0.79. A higher score on the SSRS indicates better SS and comprehensively reflects an individual's SS status.

Data Analysis

All analyses were performed using R software (Version 4.2.3). We described continuous variables as mean (standard deviation, SD), and presented categorical variables as frequencies and percentages.

Network Estimation

We computed polychoric correlations between all nodes to examine the edges of the network. We estimated the Graphical Gaussian Model (GGM) using the graphical least absolute shrinkage and selection operator.[46] This study aimed to estimate two network structures: The first was the network structure of DD, which will help us investigate its core symptoms; the second was the network structure of DD-DS-SS, which will help us identify the bridge symptoms between DS and DD, and between SS and DD. In the network model, each symptom is represented as a "node", and the association between symptoms is defined as an "edge".[47] Thicker edges represent stronger correlations between two nodes.

Centrality Estimation

The importance of each node in the item network of DD was quantified using the centrality of strength, which is the sum of the absolute value of the edge weights attached to a node for each node. The strength indicates the network connectivity used to identify the central nodes.[48] To investigate the interconnections between DS, SS, and DD, we categorized nodes into three distinct communities: The DS community (items from PHQ-9), the SS community (items from SSRS), and the DD community (items from DDS). The bridge expected influence (BEI) was calculated to identify bridge components. The BEI of a node is the sum of its edge weights from all other communities. A higher positive BEI indicates a greater activation capacity to other communities, while a higher negative BEI indicates a greater deactivation capacity to other communities.[49]

Accuracy and Stability

The accuracy of the edge weights was confirmed by calculating 95% confidence intervals (CIs) for all edges using a nonparametric bootstrap approach with 500 bootstrap samples.[50] Additionally, the stability of the correlation (CS) coefficient for the strength/BEI was thoroughly assessed using a case-dropping subset bootstrap approach with 500 bootstrap samples. The CS coefficient must be greater than 0.25, ideally surpassing 0.5, to maintain the integrity and reliability of the results.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of the Chengdu Jinniu District People's Hospital (QYYLL-2022-011), and all procedures followed relevant guidelines and regulations. Informed consent was obtained from all subjects. As stated on the information sheet in the questionnaire packet, consent to participate was obtained by participants returning a completed survey. Participants could decide whether or not to participate and could withdraw at any time without repercussions. This study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Results

Characteristics of the Participants

The final sample comprised 886 participants with T2D, ranging from 20 to 80 years at the time of assessment. There were 562 (62.4%) male and 324 (36.6%) female participants. Of the 886 participants, 519 (58.6%) reported a family history of diabetes, while 367 (41.4%) did not. More demographic details about the participants are presented in Table 1.

Score Results of DD, DS, and SS

The means and standard deviations of all variables in the network are presented in Table 2 as indicated by the statistical description results.

Structure of the DD Network

The structure of the DD network is depicted in Figure 2A. Centrality analysis was performed to examine the importance of each symptom within the DD network, with the results depicted in Figure 2B. Due to high intercorrelations and the more reliable estimation of strength centrality and closeness (the accuracy analyses below), we will focus our interpretation of the most relevant symptoms on node strength centrality for the rest of the report. The three nodes with the

Table 1 Summary of Participants' Characteristics (N = 886)

Variables	N	%
Age (years)		
18–44	176	19.8
45–59	472	53.3
≥ 60	238	26.9
Sex		
Male	562	62.4
Female	324	36.6
Marital status		
Married	742	83.7
Other	144	16.3
Nation		
Han	683	77.1
Else	203	22.9
Education		
Illiteracy	84	9.5
Primary school	163	18.4
Junior high school	277	31.3
Senior high school	289	32.6
College degree or above	73	8.2
Family history of diabetes		
Yes	519	58.6
No	367	41.4
Smoking status		
Never	116	13.1
Used to	449	50.7
Now	321	36.2
Drinking status		
Never	178	20.1
Used to	413	46.6
Now	295	33.3

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Table 2 Mean Scores and Standard Deviations for Items of DDS, PHQ-9, and SSRS

Item	Mean	SD
Diabetes Distress Scale (DDS)		
DDS1. Feeling that diabetes is taking up too much of my mental and physical energy every day.	2.3	0.9
DDS2. Feeling angry, scared, and/or depressed when I think about living with diabetes.	2.2	0.7
DDS3. Feeling that diabetes controls my life.	2.3	0.8
DDS4. Feeling that I will end up with serious long-term complications, no matter what I do.	2.3	0.7
DDS5. Feeling overwhelmed by the demands of living with diabetes.	2.3	1.0
DDS6. Feeling that my doctor does not know enough about diabetes and diabetes care	1.8	0.9
DDS7. Feeling that my doctor does not give me clear enough directions on how to manage my diabetes	1.8	0.8
DDS8. Feeling that my doctor does not take my concerns seriously enough	2.0	0.9
DDS9. Feeling that I do not have a doctor whom I can see regularly enough about my diabetes	2.0	1.0
DDS10. Feeling that I am not testing my blood sugars frequently enough.	2.2	0.9
DDS11. Feeling that I am often failing with my diabetes.	2.2	1.0
DDS12. Not feeling confident in my day-to-day ability to manage diabetes.	2.3	0.9
DDS13. Feeling that I am not sticking closely enough to a good meal plan.	2.3	1.0
DDS14. Not feeling motivated to keep up my diabetes self-management.	2.1	0.8
DDS15. Feeling that friends or family are not supportive enough of self-care efforts (for example, planning activities that conflict with my schedule, encouraging me to eat the "wrong" foods).	2.3	1.2
DDS16. Feeling that friends or family do not appreciate how difficult living with diabetes can be.	2.3	1.1
DDS17. Feeling that friends or family do not give me the emotional support that I would like.	2.2	1.0
The Patient Health Questionnaire (PHQ-9)		
PHQ1. Little interest or pleasure in doing things.	1.6	1.0
PHQ2. Feeling down, depressed, or hopeless.	1.3	1.0
PHQ3. Trouble falling or staying asleep, or sleeping too much.	1.5	1.0
PHQ4. Feeling tired or having little energy.	1.3	0.9
PHQ5. Poor appetite or overeating.	1.2	0.8
PHQ6. Feeling bad about myself, or that I am a failure, or have let myself or my family down.	1.2	1.0
PHQ7. Trouble concentrating on things, such as reading the newspaper or watching television.	1.8	0.8
PHQ8. Moving or speaking so slowly that other people could have noticed? Or the opposite—being so fidgety or restless that I have been moving around a lot more than usual.	1.7	0.7
PHQ9. Thoughts that I would be better off dead or hurting myself in some way.	1.2	1.0
Social Support Rating Scale (SSRS)		
SSRS1. Objective support	10.7	1.3
SSRS2. Subjective support	18.0	1.1
SSRS3. Support utilization	5.8	1.1

Note: DDS-17 is used with permission from © Behavioral Diabetes Institute.
Abbreviation: SD, Standard deviations.

highest node strength centrality were PD4 (Do not have doctor I can see regularly), PD2 (Doctor does not give clear directions), and PD1 (Doctor does not know about diabetes).

Structure of the DD-DS-SS Network

We estimated the network structures of the DD, DS, and SS. The resulting network is displayed in Figure 3. The nodes between DD and DS were positively connected within the network, and particularly strong connections were between DDS1 (diabetes taking up too much energy)-PHQ4 (tired or little energy), DDS13 (not sticking closely enough to meal plan)-PHQ5 (poor appetite/ overeating), DDS16 (Friends/family do not appreciate difficulty of diabetes)-PHQ2 (feeling down, depressed, or hopeless), and DDS17 (friends/family do not give emotional support)-PHQ6 (Failure). These three dimensions of SS were inversely related to DD, especially between DDS17-SSRS2 (subjective support) and DDS17-SSRS3 (support utilization).

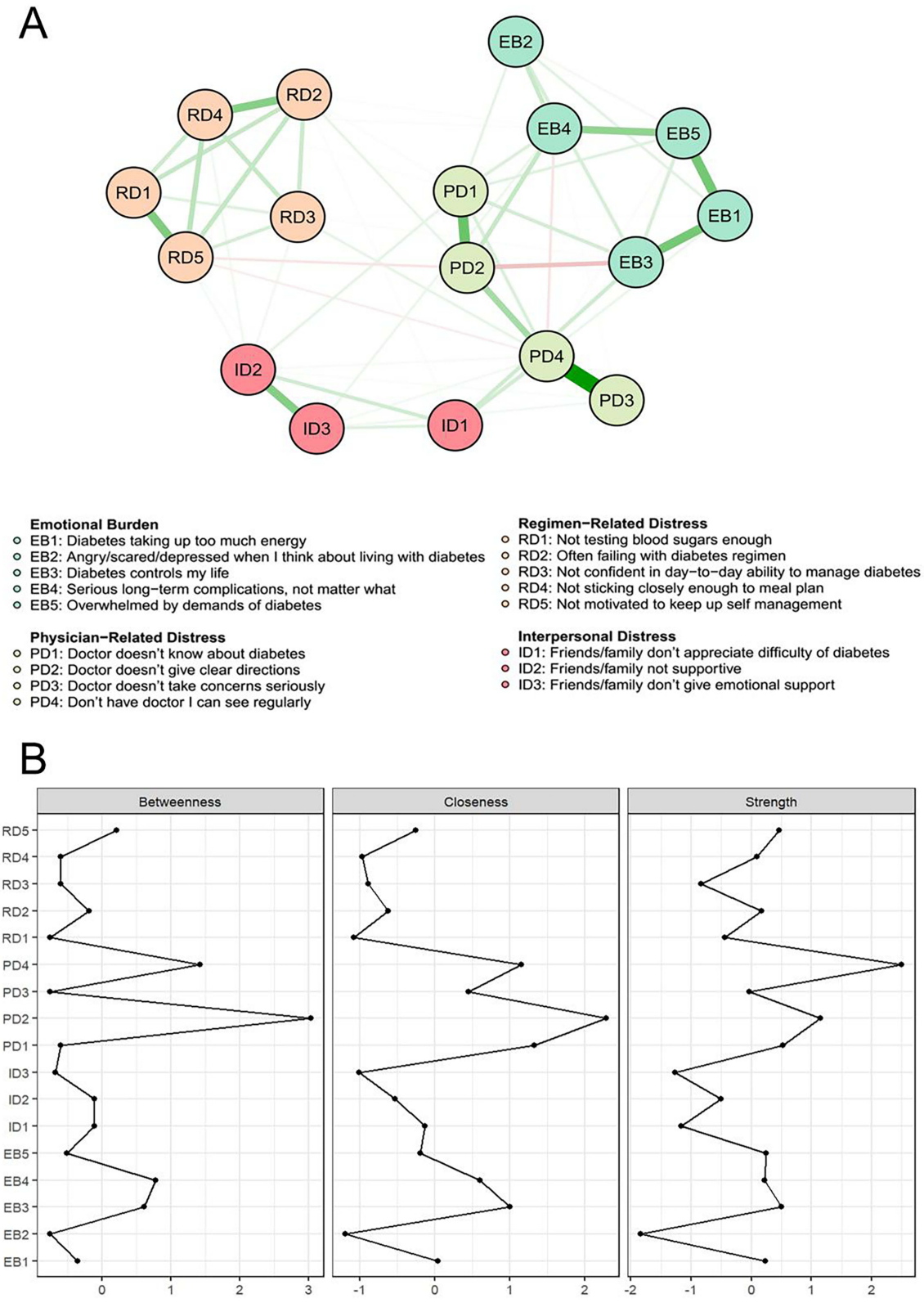

Figure 2 Network structure of the DD (**A**) and centrality index of the DD network (**B**).

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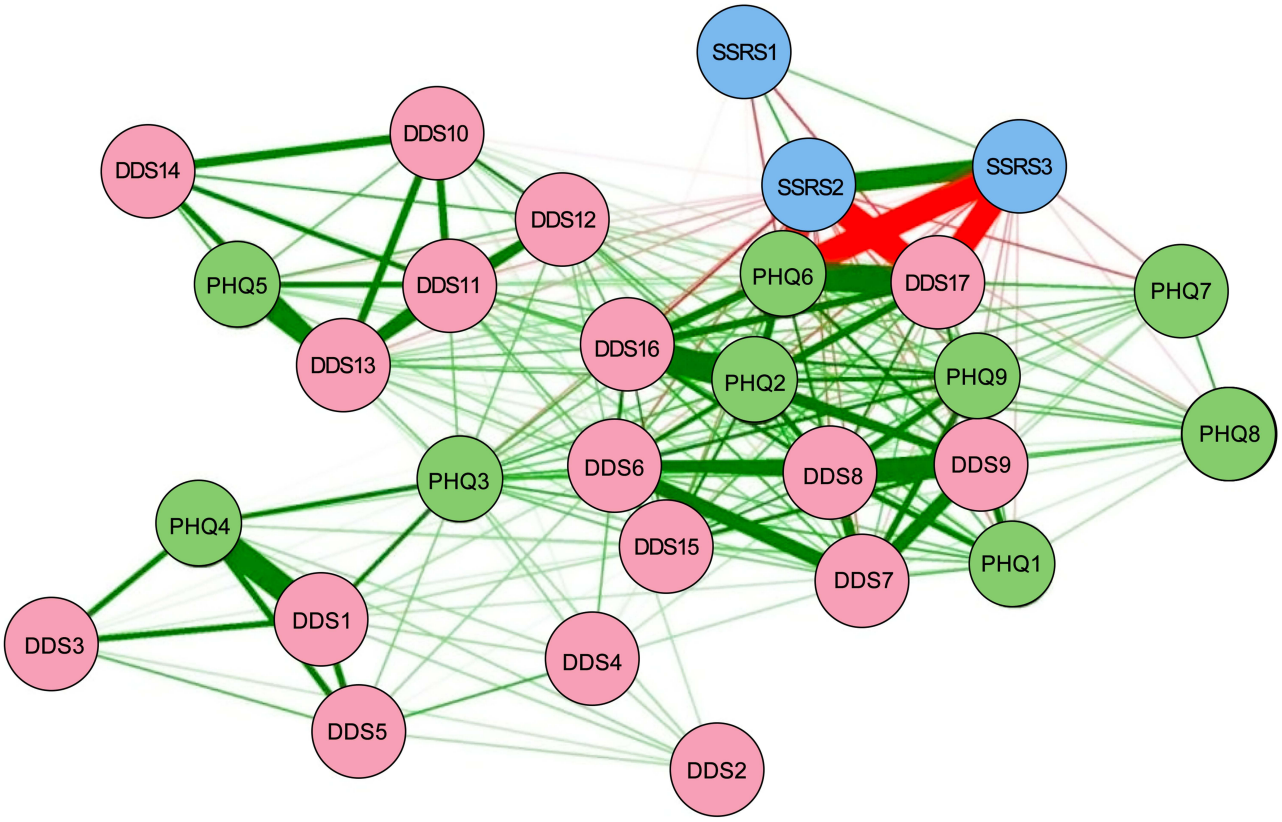

DDS

- DDS1: Diabetes taking up too much energy
- DDS2: Angry/scared/depressed when I think about living with diabetes
- DDS3: Diabetes controls my life
- DDS4: Serious long-term complications, not matter what
- DDS5: Overwhelmed by demands of diabetes
- DDS6: Doctor doesn't know about diabetes
- DDS7: Doctor doesn't give clear directions
- DDS8: Doctor doesn't take concerns seriously
- DDS9: Don't have doctor I can see regularly
- DDS10: Not testing blood sugars enough
- DDS11: Often failing with diabetes regimen
- DDS12: Not confident in day-to-day ability to manage diabetes
- DDS13: Not sticking closely enough to meal plan
- DDS14: Not motivated to keep up self-management
- DDS15: Friends/family not supportive
- DDS16: Friends/family don't appreciate difficulty of diabetes
- DDS17: Friends/family don't give emotional support

PHQ

- PHQ1: Little interest or pleasure
- PHQ2: Feeling down, depressed, or hopeless
- PHQ3: Sleep problems
- PHQ4: Tired or little energy
- PHQ5: Poor appetite/ overeating
- PHQ6: Failure
- PHQ7: Trouble concentrating
- PHQ8: Moving/speaking slowly or being restless
- PHQ9: Suicidal thoughts

SSRS

- SSRS1:Objective support
- SSRS2: Subjective support
- SSRS3: Support utilization

Figure 3 Network structure of the DD-DS-SS.

Accuracy and Stability of the Two Networks

We assessed the accuracy and stability of the estimated networks. Figure 4 illustrates the accuracy of the bootstrap method in obtaining edge weights. The narrow confidence interval indicates that the edge weights possess sufficient accuracy. The subset bootstrap (Figure 5) indicates that the centrality of node strength and closeness had good stability, with a decrease in sample size. Meanwhile, coefficients of 0.7 signify adequate stability in centrality of strength and closeness.

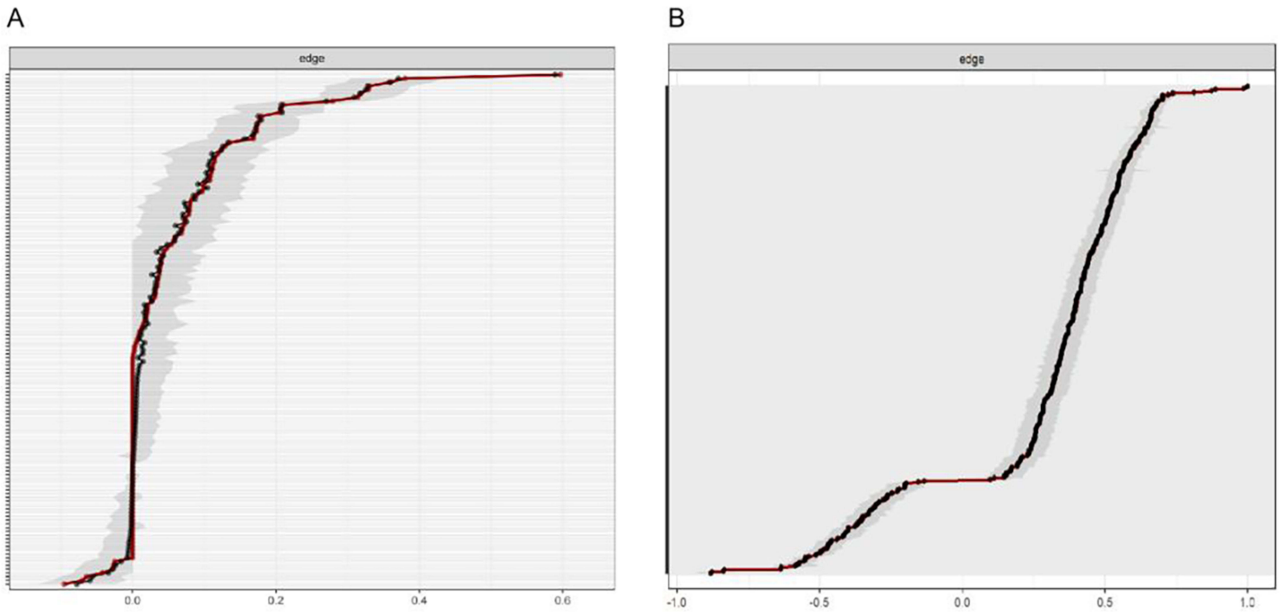

Figure 4 Bootstrapped confidence intervals of the edge weights in the DD network (**A**) and DD-DS-SS network (**B**).

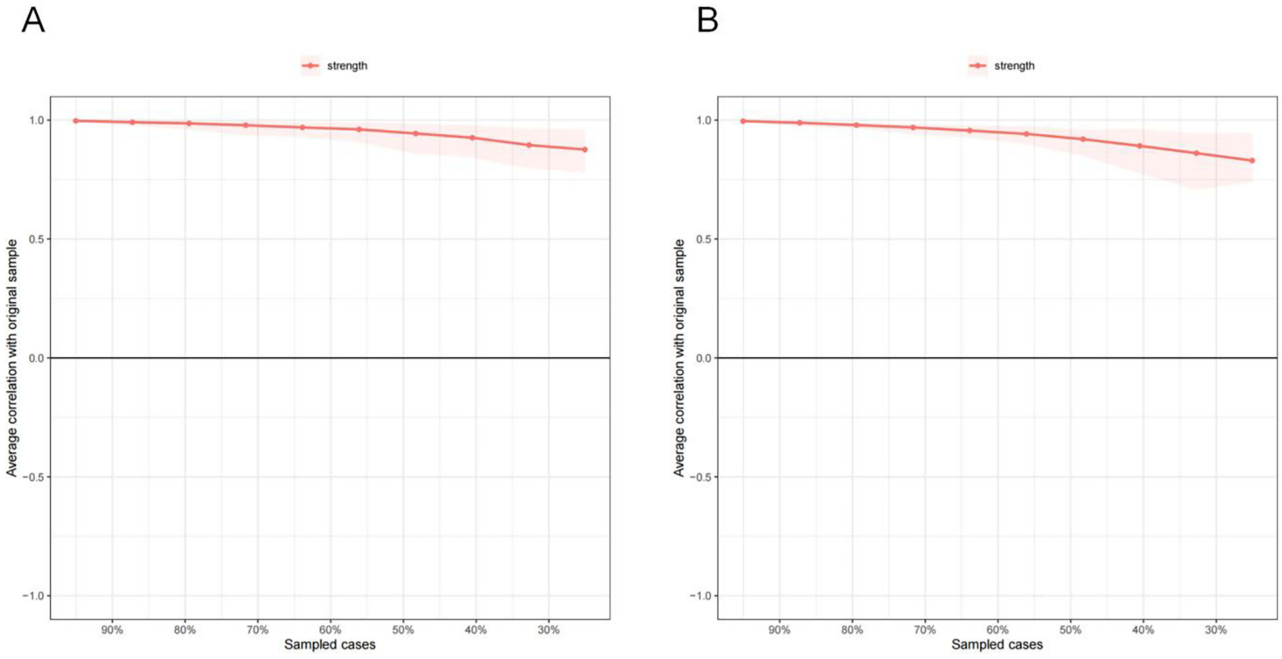

Figure 5 Subsetting bootstrap for DD network (**A**) and DD-DS-SS network (**B**).

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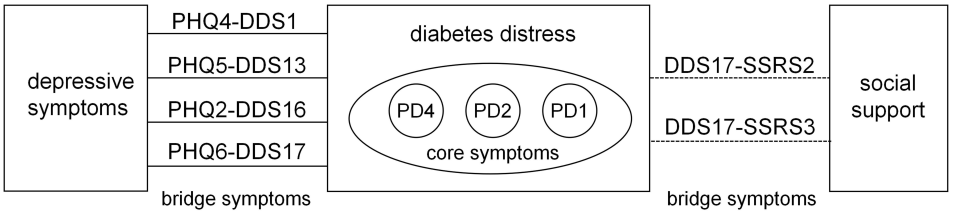

PD4: Don't have doctor I can see regularly
PD2: Doctor doesn't give clear directions
PD1: Doctor doesn't know about diabetes
DDS1: Diabetes taking up too much energy
DDS13: Not sticking closely enough to meal plan
DDS16: Friends/family don't appreciate difficulty of diabetes
DDS17: Friends/family don't give emotional support

PHQ2: Feeling down, depressed, or hopeless
PHQ4: Tired or little energy
PHQ5: Poor appetite/ overeating
PHQ6: Failure
SSRS2: subjective support
SSRS3: support utilization
——: represent positive correlations
------: represent negative correlations

Figure 6 Summary of key findings.

Discussion

This is the first study to investigate the interconnections among components of DD and the correlations between DS, SS, and DD constructs in patients with T2D using network analysis, to the best of our knowledge. We performed a network analysis of DD to identify its core symptoms, followed by another analysis that included DS and SS to uncover key connections between them. The principal findings of this study were systematically delineated in Figure 6, which graphically elucidates the core symptoms of diabetes DD and its bridge symptoms between DS/SS. By assessing the stability and accuracy of these networks, we gained insights into the complex association between DD and DS/SS, which helped to provide a focus for the psychological care of people with T2D.

The observed clustering pattern of DD items, illustrated in Figure 1, corresponds closely with the four subscales of DDS-17: Emotional burden, physician-related distress, regimen-related distress, and interpersonal distress.[51] In the DD item network, the three nodes with the highest node strength centrality were PD4 (Do not have doctor I can see regularly), PD2 (Doctor does not give clear directions), and PD1 (Doctor does not know about diabetes). Highly central nodes in a cross-sectional network were indicated to predict the correlation between changes in one node and other network symptoms.[52] A Canadian cross-sectional survey identified physician-related distress as a core symptom of DD.[53] The findings indicated that while diabetes management primarily falls on the patient, healthcare professionals play a crucial role. Previous studies indicate that the involvement of healthcare professionals—including doctors, nurses, and dietitians—enhances patient self-management and compliance and reduces the risk of complications, particularly cardiovascular ones.[54,55] Moreover, medical personnel are instrumental in setting individualized treatment goals and monitoring progress, which is essential for achieving optimal glycemic control.[56] Although there are several treatment options available, many patients struggle to manage their condition effectively due to factors including a lack of support and low health literacy.[57] The findings underscored the need for medical professionals to engage in open communication with their patients, to help them understand their condition and the importance of adherence to treatment plans.[58] This dependence on medical professionals has become the primary source of DD in T2D patients and an essential part of psychological care. Similar evidence was reported in other interventional studies. Psychological interventions provided by nursing staff,[59] integrating nurse counseling with mobile health technologies,[60] and nurse-administered mindfulness-based stress reduction programs[61] have all demonstrated significant positive effects on self-efficacy, self-management capabilities, and DD in patients with T2D. A focus group interview revealed favorable responses from patients with T2D toward nurse-physician collaborative care, with participants expressing feelings of empowerment.[62] Therefore, we recommend incorporating healthcare professional support into psychological interventions for patients with T2D to optimize disease management outcomes.

We observed the link paths between DD and DS/SS in the second network. We analyzed the more microscopic relationship between DD and DS as depicted in Figure 3. Although a previous study suggested that DD and DS overlap with each other,[53] the exact overlap is not fully reported. Through network analysis, this study found the exact part of DD

and DS duplication, which is of significant help in understanding the differences and connections between DD and DS. A previous study suggested that the scientific debate about the overlap between DD and DS may stem from shared etiological pathways and symptoms,[63] and our study demonstrated that DDS1-PHQ4, DDS13-PHQ5, DDS16-PHQ2, and DDS17-PHQ6 have strong positive bridges in terms of their network structure. The DDS1 item addresses the energy expenditure associated with diabetes, while the PHQ4 item addresses the fatigue caused by the disease.[64] The two focused on the negative emotions associated with the long-term illness. It is therefore not difficult to understand that the diabetes management of DD-positive patients is generally poor. DDS13 and PHQ5 items were focused on understanding the impact of diabetes on the diet of patients.[65] Diet is a key modifiable factor in the management and prevention of T2D.[66] This result is consistent with a previous study in which DD and DS were independently associated with gastrointestinal symptoms in patients with T2D.[17] The other pairs of bridging symptoms (DDS16-PHQ2 and DDS17-PHQ6) were associated with inadequate support from family or friends, whether emotional support or dietary help. The above analysis of bridging symptoms summarizes the connection between DD and DS into three aspects: Fatigue, diet, and social interaction. For patients with DD and DS comorbidity, these three aspects may serve as effective intervention targets to sever the connection and comorbidity of DD and DS, representing a significant finding of this study. Based on evidence that dietary management,[67] peer support,[68] and family-focused interventions[69] have independently demonstrated significant benefits for psychological well-being in patients with T2D, we recommend developing a comprehensive intervention package that integrates these approaches to address DD and DS simultaneously.

The second network structure demonstrated the relationship between DD and SS. A strong negative bridge appeared in SSRS2/SSRS3-DDS17. In contrast to the objective support represented by SSR1, the subjective support represented by SSRS2 indicated a negative association with DDS17. This indicates that emotional support from family or friends is more important for patients with T2D than material and financial support and may directly affect patients' self-cognition. This is consistent with the results of several systematic reviews, where low SS was reported to increase the risk of depression among people with T2D,[70] and increased SS was inversely associated with emotional distress.[71] More importantly, SS is more linked to the self-management of people with T2D than T1D.[72] Similarly, the support utilization represented by SSRS3 is equally significant for patients with T2D. This implies that even when subjective and objective support are sufficient, the failure of the patient to perceive or utilize this support may, however, impact the success of their disease management. Few studies have noted this, with only one qualitative study[73] examining how adolescents with T2D understand and use SS, indicating that their use of SS is restricted to close friends and family due to fear of disclosing their diabetes to others. Several randomized controlled trials have demonstrated that different SS technologies, including mobile health-enhanced peer support intervention[74] and peer-led diabetes self-management support intervention,[75] effectively reduce DD among patients with T2D. Our findings revealed that effective SS must incorporate emotional support components and actively encourage patient engagement with available resources, as interventions limited to offering disease-specific knowledge and skill training are insufficient for comprehensive SS.

Certain limitations must be addressed. First, using cross-sectional data made identifying direct effects between symptoms impossible. Consequently, it is unclear whether the most central symptoms activate other symptoms, are activated by other symptoms, or are the case for both. To examine this causal relationship, longitudinal study data are necessary to provide new insights into the dynamic relationship between DD-DS/SS. Second, our survey was conducted during the COVID-19 pandemic. Therefore, it is impossible to rule out the possibility that the prevalence of the virus influenced the psychological state of people with T2D. Finally, although the sample size of this study is sufficient for network analysis, it is inadequate to support network comparison tests between different subgroups.[49] Future studies should expand the sample size to more comprehensively investigate the differences in the co-occurrence networks of DD, DS, and SS among different samples.

Conclusions

Our study investigated the interconnections between components of DD and the correlations between constructs of DS, SS, and DD in patients with T2D using network analysis. Our findings from the DD network indicated that physician-related distress may significantly contribute to the development and maintenance of DD. From the DD-DS-SS network, the first significant finding is that the complex link between DD and DS can be summarized in three aspects: Fatigue,

diet, and social interaction. Another significant finding is that the subjective support and utilization of support in patients with T2D are closely related to managing their disease. The findings provided more targeted theoretical guidance and a scientific basis for psychological counseling and interventions aimed at alleviating DD in patients with T2D. However, all the above conclusions require more confirmatory studies in the future for validation.

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of the Chengdu Jinniu District People's Hospital (QYYLL-2022-011), and written informed consent was obtained from every participant.

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Disclosure

The authors report no conflicts of interest regarding this manuscript.

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