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Network Analysis of Urinary Incontinence–Related Quality of Life in Patients after Radical Prostatectomy

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Abstract

Objective

Urinary incontinence is a significant complication that severely impacts the quality of life of patients following radical prostatectomy for prostate cancer. This study aims to construct a symptom network of urinary incontinence–related quality of life in patients after radical prostatectomy, to analyze the network structure and the interconnections among its components, and to identify core and bridge symptoms. The findings are intended to provide a theoretical basis for the management and improvement of urinary incontinence–related quality of life in this patient population.

Methods

Convenience sampling was used to select 236 patients with urinary incontinence following radical prostatectomy for prostate cancer from two tertiary Grade A hospitals in Chongqing, China, between October 2024 and June 2025.Data were collected using a general information questionnaire and the Chinese version of Incontinence Quality of Life Questionnaire. The network was constructed using R software to describe the relationships between symptoms, and node and bridge centrality index were calculated.

Results

Symptom network analysis showed that the strength (rs = 1.21) and expected influence(rei = 1.18) were highest for the symptom "I feel depressed because of my incontinence" ,The top three symptoms with the highest bridge strength and bridge expected influence were: "I worry about wetting myself" (rbs = 1.29, rbei = 1.25), "I worry about being embarrassed or humiliated because of my incontinence" (rbs = 1.24, rbei = 1.21), and "I worry about others smelling urine on me" (rbs = 0.94, rbei = 0.85).

Conclusion

Through symptom network analysis, this study identified the core symptom of depression related to urinary incontinence, along with three bridge symptoms that connect different dimensions. Bridge symptoms are those that link distinct symptom clusters within the network. Consequently, future research can focus on developing urinary incontinence management programs targeting both core and bridge symptoms to enhance the precision and effectiveness of interventions. Clinical practitioners can then implement these programs to help alleviate the multifaceted burdens associated with urinary incontinence, including psychological distress, social embarrassment, and activity limitations, ultimately improving patients' overall quality of life.

1 Introduction

Prostate cancer (PCa) is a common malignant tumor of the urogenital system in elderly males. According to data from the International Agency for Research on Cancer (IARC), approximately 1.47 million new cases of prostate cancer and 396,800 related deaths occurred worldwide in 2022, representing 14.2% of all male cancers and 7.3% of cancer-related deaths among men[1]. This ranks prostate cancer as the second most common cancer and the fifth leading cause of cancer-related death among men globally[1]. With the accelerating global aging process and increasing life expectancy, the incidence of prostate cancer is projected to continue rising worldwide. Estimates indicate that the annual number of newly diagnosed cases will rise from approximately 1.4 million in 2020 to nearly 2.9 million by 2040[2].In China, both the incidence and mortality of prostate cancer have shown a steady upward trend, largely driven by population aging, dietary transitions, and lifestyle changes[3, 4]. As the incidence of prostate cancer continues to rise, increasing attention has been directed toward treatment outcomes and postoperative quality of life. Radical prostatectomy (RP) is the preferred treatment for localized prostate cancer. However, due to potential damage to the urethral sphincter or the nerves controlling the sphincter during surgery[5, 6], patients often experience varying degrees of urinary incontinence postoperatively[7]. A systematic review has shown that the incidence of post-prostatectomy incontinence (PPI) ranges from 2% to 87%[8].

Urinary incontinence is one of the most common and challenging complications following RP, imposing substantial physical and psychological burdens on patients and markedly reducing postoperative quality of life[9]. Studies have shown that patients with urinary incontinence exhibit significantly higher levels of depression and anxiety compared to those without urinary incontinence, indicating that its impact extends beyond purely physiological consequences[10, 11].Urinary incontinence is not merely a physiological disorder but a complex health issue encompassing multiple dimensions, including physical discomfort, psychological distress, and social functional limitations[12–14]. As a major cause of reduced quality of life in patients following RP, urinary incontinence has particularly significant negative impacts on men[15, 16]. Postoperative urinary incontinence leads to dependence on absorbent products, and the associated leakage and odor often result in embarrassment, feelings of shame, and social isolation. Patients frequently adopt social avoidance strategies due to urinary incontinence, which obstructs their ability to work and engage socially, thereby increasing the burden of the disease and affecting treatment adherence. This inability to effectively transition from the patient role to a normal social role severely hinders the recovery process and diminishes the quality of life[15, 17].

Assessing quality of life is as crucial as providing comprehensive care and treatment. Multiple studies [13, 16] have shown that patients with PPI score lower across all dimensions of quality of life, resulting in a generally reduced overall quality of life. Consequently, this population faces the considerable challenge of a substantial decline in quality of life. Current research predominantly evaluates the quality of life of PPI patients through a global score, but there is a lack of systematic, comprehensive analysis regarding the intrinsic relationships between different dimensions of incontinence-related quality of life and the

potential interactions between symptoms reflected by the questionnaire items. Network analysis models suggest that diseases are caused by interconnected and interacting symptoms, rather than being interpreted solely based on symptom scores[18]. Analyzing the symptoms and their internal structure that impact the quality of life in PPI patients from a network analysis perspective helps to identify the main distressing symptoms affecting their quality of life, as well as the symptoms that serve as key bridges connecting different dimensions. This, in turn, provides precise targets for the development of intervention strategies.

Network analysis has been widely applied in the fields of psychopathology and psychology[19]. In recent years, both domestic and international researchers have gradually extended its application to the management of chronic disease symptoms, long-term follow-up of cancer patients, and patient self-management[20–22].Network analysis is a research method that presents system characteristics and information in the form of a network structure, which is composed of "nodes" and "edges." Nodes can represent various variables, such as attitudes, feelings, and behaviors, while edges indicate the relationships or interactions between these variables. This method allows for the quantification of the importance and interconnections of variables and visually presents their structural characteristics through network diagrams. By calculating centrality metrics, the importance of each node within the network can be quantified, allowing for the identification of core nodes and bridging nodes, thus revealing potential complex interaction patterns within the system[23–25].

In this context, the present study moves beyond the traditional interpretation of the total score of incontinence-related quality of life. From a network analysis perspective, it constructs a symptom network related to quality of life disturbances in patients with PPI. This study delves into the intrinsic structural relationships between the various symptom items in the scale, identifying the core issues in patients' subjective experiences and revealing the bridge symptoms that facilitate the transmission of symptoms across clusters. In doing so, it offers a novel approach and perspective for managing the quality of life of PPI patients. Additionally, it provides a scientific basis for developing personalized treatment plans and making informed nursing decisions.

2 Methods

2.1 Setting and Participants

This is a cross-sectional study. A convenience sampling method was used to recruit prostate cancer patients with post-prostatectomy urinary incontinence from two tertiary Grade A hospitals in Chongqing, China, between October 2024 and June 2025. The inclusion criteria were as follows: (1) diagnosed with prostate cancer; (2) aged ≥18 years; (3) post-prostatectomy urinary incontinence; (4) informed consent obtained. The exclusion criteria were as follows: (1) presence of severe complications or serious mental disorders preventing participation in the study; (2) inability to understand or complete the questionnaire due to age, speech, or intellectual disabilities; (3) history of urinary incontinence prior to surgery. This

study was approved by the Ethics Committee of the Second Affiliated Hospital of Chongqing Medical University (Approval No. 2024-Yan Lunshen (89)).

The sample size in this study was estimated based on network analysis[26]. If the network contains N nodes, a minimum sample size of N(N-1)/2 is required to ensure the statistical power of the network. The Chinese version of the Incontinence Quality of Life Questionnaire (I-QOL) used in this study contains 22 items. According to the formula [22×(22-1)/2], the minimum required sample size was calculated to be 231 participants. Ultimately, a total of 236 participants were included in the study.

2.2 Measurements

2.2.1 Demographic and Clinical Characteristics

A general information questionnaire was developed by the research team based on a comprehensive review of relevant literature. It was designed to collect sociodemographic and clinical data from patients with PPI. The sociodemographic information included age, marital status, education level, and place of residence. Clinical information encompassed body mass index (BMI), smoking history, alcohol consumption history, comorbidities, history of transurethral resection of the prostate (TURP), clinical stage, and Gleason score.

2.2.2 Chinese version of Incontinence Quality of Life Questionnaire(I-QOL)

The original questionnaire was developed by Wagner[27] and Patrick[28] to assess the impact of urinary incontinence on patients' quality of life. The Chinese version was translated and validated by Wang Xiaoqian[29] et al., and includes three dimensions: avoidance and limiting behaviors(items 1,2,3,4,10,11,13 and 20), psychosocial impacts (items 5,6,7,9,15,16,17,21 and 22), and social embarrassment (items 8,12,14,18 and 19). Each item is scored using a 5-point Likert scale. The total score is converted to a scale of 0 to 100 according to the formula [(total score - 22) / 88] × 100, with higher scores indicating better quality of life in patients with urinary incontinence. The Chinese version of the I-QOL has been shown to have good internal consistency, with a Cronbach's alpha coefficient of 0.96. In this study, the Cronbach's alpha coefficient of the questionnaire was 0.93.

2.3 Data collection

Prior to the survey, the researchers explained the purpose of the study and important considerations to the participants, and obtained informed consent. Following this, one-on-one face-to-face or telephone follow-up interviews were conducted. If participants were unable to independently complete the questionnaire, the researcher explained the items to them without using leading language and filled out the questionnaire based on the participant’s responses. After the survey, the data were reviewed on-site, and any questions, omissions, or errors were addressed immediately to ensure accuracy and validity.

2.4 Statistical analyses

2.4.1 Descriptive Analysis

Descriptive statistical analysis of demographic, clinical information, and I-QOL scores was performed using SPSS version 27.0. Categorical data were described using frequencies and percentages, while continuous data were presented as mean ± standard deviation.

2.4.2 Network Analysis

2.4.2.1 Network Construction

Statistical analysis and network construction were performed using R version 4.5.1. The "qgraph" package in R was employed to generate the symptom network, with Spearman's rank correlation used to describe the relationships between symptoms. The Fruchterman–Reingold force-directed layout was applied to position the most strongly correlated nodes at the center of the network[30] . Symptoms were represented as nodes, and the edges between them reflected their relationships. The thickness and color intensity of the edges were proportional to the strength of the correlation between symptoms.

2.4.2.2 Centrality analysis

Centrality analysis was performed using the "qgraph" package. The centrality metrics calculated for the model included Strength, Closeness, Betweenness, and Expected Influence (EI). Strength centrality refers to the sum of the absolute weights of all edges connected to a node. Expected Influence is similar to Strength centrality, but it also considers the nature of the edges in the network and the directional relationships between symptoms[31,32]. In this study, Strength centrality and Expected Influence were used as the node centrality indicators[33]. To identify key nodes that connect different symptom dimensions within the network, bridge centrality analysis was further conducted. Bridge strength and Bridge Expected Influence (BEI) were calculated using the bridge function from the "Networktools" package in R. Bridge strength is defined as the sum of the absolute weights of all edges connecting a node to other nodes in different communities. It has been reported as the most effective bridge centrality index for identifying bridge nodes. It also assesses their intermediary role and influence in linking different groups [34,35].This metric served as the primary basis for identifying bridge symptoms in the present study. In this study, bridge symptoms were operationally defined as nodes with Bridge Expected Influence (BEI) values ranking in the top 20% (highest) of all nodes. These nodes are considered to play a critical role in facilitating the spread of activation between different symptom communities .

2.4.2.3 Network Stability and Accuracy Analysis

Network stability and accuracy were assessed using the "bootnet" package. The case-dropping bootstrap method was applied to remove subsets (1,000 bootstrap samples) to estimate the stability coefficient of node Expected Influence, known as the correlation stability coefficient (CS). A CS > 0.25 indicates an acceptable level of stability for the network model, while a CS > 0.5 indicates good

stability[26]. Non-parametric bootstrap was used to evaluate network accuracy. The accuracy of edge weights was calculated by performing 1,000 bootstrap resamples on the dataset and computing the 95% confidence interval (95% CI) for the edge weight accuracy[26].

3 Results

3.1 Characteristics of the participants

The average age of participants was 70.57±6.89 years, ranging from 48 to 85.Other demographic information is shown in Table 1. Table 2 presents the mean values and standard deviations of all items. The I-QOL score for PPI patients was 55.89±12.69. Among these, the item with the lowest score was "Because of my incontinence, it’s important to plan every detail in advance (I11)," with a score of 2.26±0.92.

Table 1. Characteristics of the participants(n=236).

Variables		Number/N（%）
BMI	（24	117（49.6）
	≥24	119（50.4）
Marital status	Unmarried	2（0.8）
	Married	226（95.8）
	Widowed	5（2.1）
	Divorced	3（1.3）
Place of residence	Urban area	170（72）
	Rural area	66（28）
Educational level	Elementary school and below	86（36.4）
	Junior high school	61（25.8）
	High school or technical secondary school	49（20.8）
	Junior college or above	40（16.9）
Smoking history	No	142（60.2）
	Yes	94（39.8）
Alcohol consumption history	No	167（70.8）
	Yes	69（29.2）
Comorbid chronic diseases	No	95（40.3）
	Yes	141（59.7）
History of TURP	No	217(91.9)
	Yes	19(8.1)
Clinical stage	≤T2a	134（56.8）
	T2b	14（5.9）
	≥T2c	88（37.3）
Gleason score	≤6	67（28.4）
	7	86（36.4）
	8	39（16.5）
	≥9	44（18.6）

Table 2. Statistical results of the mean and standard deviation of items

Item	Mean	SD
I1.I worry about not being able to get to the toilet on time	3.04	0.80
I2.I worry about coughing or sneezing because of my incontinence	2.85	0.67
I3.I have to be careful standing up after I've been sitting down because of my incontinence	3.22	0.83
I4.I worry about where toilets are in new places	2.75	1.01
I5.I feel depressed because of my incontinence	3.36	0.77
I6.Because of my incontinence, I don't feel free to leave my home for long periods of time	2.57	1.08
I7.I feel frustrated because my incontinence prevents me from doing what I want	3.47	0.80
I8.I worry about others smelling urine on me	3.32	0.79
I9.Incontinence is always on my mind	2.64	0.73
I10.It's important for me to make frequent trips to the toilet	2.79	0.76
I11.Because of my incontinence, it's important to plan every detail in advance	2.26	0.92
I12.I worry about my incontinence getting worse as I grow older	3.80	0.67
I13.I have a hard time getting a good night of sleep because of my incontinence	3.38	0.86
I14.I worry about being embarrassed or humiliated because of my incontinence	3.29	0.78
I15.My incontinence makes me feel like I'm not a healthy person	3.78	0.61
I16.My incontinence makes me feel helpless	3.30	0.80
I17.I get less enjoyment out of life because of my incontinence	3.45	0.74
I18.I worry about wetting myself	2.56	0.66
I19.I feel like I have no control over my bladder	3.80	0.67
I20.I have to watch what I drink because of my incontinence	3.28	0.80
I21.My incontinence limits my choice of clothing	4.13	0.78
I22.I worry about having sex because of my incontinence	4.15	0.73

3.2 Network structure

In the symptom network diagram of this study (Figure 1), there are a total of 22 nodes and 118 edges. The strongest connection is between the items "I worry about coughing or sneezing because of my

incontinence(I2)" and "I have to be careful standing up after I’ve been sitting down because of my incontinence (I3)" (r = 0.42). The second strongest connection is between "I feel depressed because of my incontinence (I5)" and "I feel frustrated because my incontinence prevents me from doing what I want (I7)" (r = 0.34).

3.3 Results of node centrality indices and bridge centrality indices

The centrality and bridge centrality indicators of the symptom network for incontinence-related quality of life in PPI patients are shown in Figure 2. Node centrality analysis (Figure 2A) revealed that "I feel depressed because of my incontinence (I5)" had the highest node strength (rs =1.21) and expected influence (rei =1.18) in the network, indicating that I5 is the core symptom influencing the quality of life of PPI patients. I5 plays a key role in the network through its extensive direct connections and exerts significant influence on other nodes. Regarding the bridge centrality indicators (Figure 2B), the top three symptoms for bridge strength and bridge expected influence were "I worry about wetting myself (I18)" (rbs = 1.29, rbei = 1.25), "I worry about being embarrassed or humiliated because of my incontinence(I14)" (rbs = 1.24, rbei = 1.21), and "I worry about others smelling urine on me(I8)" (rbs = 0.94, rbei = 0.85).

3.4 Network stability and accuracy

The network stability test is shown in Figure 3A. The results indicate that the correlation stability coefficient for strength centrality, expected influence, bridge strength centrality, and bridge expected influence are all above 0.5, suggesting that the results of the network analysis exhibit high stability. The edge weight accuracy is shown in Figure 3B. The non-parametric bootstrap results indicate that the confidence intervals are relatively narrow, demonstrating that the edge weight estimates are precise. Although a formal centrality difference test was not explicitly conducted, the high stability coefficient (CS > 0.5) for Expected Influence confirms that the centrality ranking of the nodes is robust. Specifically,"I feel depressed because of my incontinence (I5) "consistently demonstrated the highest centrality across the bootstrap samples, statistically supporting its status as the significantly dominant core symptom in the network.

4 Discussion

Urinary incontinence is one of the primary symptoms affecting the quality of life in patients after radical prostatectomy for prostate cancer[36]. The results of this study showed that patients with PPI had an I-QOL score of 55.89 ± 12.69, indicating an overall low level of quality of life. Notably, the item "Because of my incontinence, it’s important to plan every detail in advance (I11)"received the lowest score. This reflects a significant 'perceived behavioral burden,' indicating the immense cognitive effort patients must

exert to plan their daily activities around their incontinence. This finding is consistent with previous research[37], which indicates that the most frequent and severe symptoms are not necessarily the core symptoms within the symptom network. The centrality of a symptom depends on its influence on other symptoms and its role in activating the overall network[38], rather than on its individual severity. The high score for I11 reflects patients'strong subjective perception of behavioral restriction, but it may essentially represent a response triggered by other core or bridge symptoms.

The symptom network analysis revealed that the items "I worry about coughing or sneezing because of my incontinence (I2)" and "I have to be careful standing up after I've been sitting down because of my incontinence (I3)" showed the strongest association (r = 0.42). This robust connection finds a clear physiological basis in the mechanism of Stress Urinary Incontinence (SUI), which is the predominant form of incontinence following radical prostatectomy. Surgical damage to the external urethral sphincter compromises its ability to maintain sufficient urethral closure pressure. Both coughing/sneezing and the physical act of standing up from a seated position serve as mechanical triggers that cause a sudden elevation in intra-abdominal pressure. In the absence of an intact sphincter mechanism, this pressure is transmitted directly to the bladder, overcoming urethral resistance and resulting in involuntary urine leakage [39]. Consequently, these two symptoms are statistically bonded by a shared physiological trigger. This suggests that patients develop a specific guarding behavior pattern, becoming hyper-vigilant toward these specific physical movements to prevent leakage episodes. In future clinical interventions and rehabilitation guidance, in addition to the fundamental components of pelvic floor muscle training and bladder training, greater emphasis should be placed on lifestyle modifications and the use of assistive devices. Educating patients to control body weight, avoid behaviors that elevate abdominal pressure, and appropriately use absorbent pads or other protective products can effectively reduce the triggers of urinary incontinence, alleviate psychological distress and anxiety, and thereby enhance patients' quality of life in a multidimensional manner.

In this study, we identified "I feel depressed because of my incontinence" (I5) as the core symptom within the symptom network of quality of life for PPI patients, serving as a key node that influences the overall network level. Radical prostatectomy may damage pelvic nerves, directly affecting monoaminergic micturition control pathways dependent on spinal serotonin (5-HT) and norepinephrine (NA) inputs. This weakens the facilitation of the urethral sphincter contraction reflex, thereby leading to urinary incontinence. Concurrently, as a chronic stressor, urinary incontinence can disrupt the function of these same monoaminergic neurotransmitter systems within the limbic system, attenuating central inhibition of pelvic discomfort and directly impacting emotional regulation[40], thus creating a vicious cycle between incontinence and depressive mood. Notably, a significant association was found between "I feel depressed because of my incontinence (I5)" and "I feel frustrated because my incontinence prevents me from doing what I want (I7)". This may be attributed to the psychological gap resulting from patients' limited understanding of postoperative incontinence, as well as the depression stemming from an inability to effectively cope with the condition.

Urinary incontinence, as an event of physiological loss of control, not only triggers shame and self-denial but also causes patients to rely long-term on continence care products and endure persistent concerns about leakage and odor. According to Bandura's Self-Efficacy Theory[41], an individual's confidence in their ability to cope with challenges is a crucial foundation for psychological adaptation. However, repeated failures to effectively cope with incontinence erode the patient's self-efficacy and sense of control. Driven by this reduced self-efficacy and illness-related stigma, patients often consciously restrict daily activities such as going out or exercising, and adopt avoidance behaviors like concealing their condition or withdrawing from social interactions. Such behavioral withdrawal further intensifies psychological distress, creating a vicious cycle [42, 43]. Furthermore, patients with prostate cancer dominated by such negative emotional states often tend to adopt avoidant coping strategies[17], reinforcing the centrality of depressive symptoms. Particularly for male patients, the persistent loss of control caused by urinary incontinence stands in sharp contrast to traditional masculine ideals of strength and autonomy, directly threatening their sense of masculinity and self-identity. Consequently, men tend to internalize the pressure rather than express emotional distress. In the specific cultural context of China, this phenomenon is further amplified by the traditional concept of self-esteem. The potential public exposure of incontinence is often perceived not merely as a health issue but as a profound loss of moral status and dignity, driving patients to adopt extreme social isolation strategies to preserve their public image[44]. This study reveals that the decline in quality of life among PPI patients is less related to the severity or frequency of leakage, and more to the psychosocial consequences and gender-specific stigma it entails.

At present, most clinical interventions focus primarily on the physiological aspects, such as pelvic floor muscle rehabilitation, while the psychological dimension remains insufficiently addressed. Previous research[45]has shown that implementing comprehensive psychological interventions for PPI patients,including education on disease understanding, training in emotional regulation skills, pelvic floor exercises combined with psychological encouragement, and support from peers and family members,can significantly reduce negative emotions such as anxiety, depression, and shame. These interventions enhance patients’self-efficacy in symptom management and ultimately improve their quality of life.Therefore, to effectively disrupt these bridge connections, we propose a specific integrated protocol in which Cognitive Behavioral Therapy (CBT) techniques are embedded into routine Pelvic Floor Muscle Training (PFMT) sessions. Clinicians should utilize cognitive restructuring to help patients identify and challenge catastrophic thoughts related to intermediate symptoms. Simultaneously, graded exposure techniques should be applied through behavioral experiments that encourage patients to engage in short, low-risk social activities with appropriate safety measures. This approach serves to desensitize patients to the fear of accidents, thereby, severing the pathological link between social embarrassment and avoidance behaviors.

Findings from this study indicate that the decline in quality of life among PPI patients is often not primarily determined by the severity or frequency of leakage, but rather by the psychosocial consequences associated with incontinence. This underscores the need to establish an integrated

clinical intervention model that simultaneously addresses both physical and psychological health. By enhancing patients'psychological adaptability and self-management capacity, such a model could provide effective support for achieving optimal recovery and an improved quality of life.

Bridge symptoms, which serve as connectors between different symptom clusters or disease subgroups, increase the risk of symptom transitions from one problem domain to another[34]. In this study, "I worry about wetting myself (I18)" ,"I worry about being embarrassed or humiliated because of my incontinence (I14)" and "I worry about others smelling urine on me (I8)" ranked highest in both bridge strength and bridge expected influence. These highly influential bridge symptoms were primarily concentrated within the dimension of social embarrassment, playing a pivotal bridging role in linking distinct clusters of psychosocial symptoms. These high-influence bridge symptoms reveal the critical pathway transitioning from internal psychological distress to external behavioral avoidance. Patients do not limit activities solely due to the physical act of leakage, but rather due to anticipatory anxiety regarding social embarrassment, such as visible wetness or odor. This specific fear of negative social evaluation acts as a cognitive stressor, driving preventative safety behaviors such as social withdrawal and perpetuating a recursive feedback loop between perceived stigmatization and maladaptive avoidance. Consequently, internal feelings of shame are translated into external limiting behaviors, as patients prioritize avoiding potential humiliation over social participation.

Social embarrassment resulting from urinary incontinence can readily give rise to psychological disorders such as social anxiety, interpersonal withdrawal, and social phobia, which in turn trigger emotional disturbances including anxiety, depression, frustration, and diminished self-worth[46]. For example, anxiety stemming from the concern "I worry about wetting myself (I18)" may lead to psychological impact symptoms such as "Incontinence is always on my mind(I9)", "Because of my incontinence, I don't feel free to leave my home for long periods of time (I6)" and "I feel depressed because of my incontinence (I5)." Items I18, I14, and I8 essentially reflect a profound fear of social exclusion and negative evaluation. This fear itself constitutes a form of intense psychological distress that can directly exacerbate symptoms of psychological impact.At the same time, social embarrassment exerts a direct influence on avoidance and limiting behaviors. To avoid potentially humiliating situations such as wetting their clothes, losing control in public, or emitting unpleasant odors due to urinary incontinence, patients tend to engage in meticulous planning before any activity. They often restrict fluid intake, remain hyperaware of restroom locations in unfamiliar environments, and frequently empty their bladders to minimize the risk of accidents.Sun et al.[44] reported that embarrassment and shame associated with urinary incontinence foster negative self-perceptions, prompting individuals to deliberately avoid public situations. Moreover, the fear of leakage, combined with the practical challenges of managing incontinence during outings, collectively contributes to reduced social participation, ultimately leading to diminished social roles and decreased enjoyment in social interactions.Concerns about social embarrassment thus serve as a central driver of avoidance and limiting behaviors. To prevent these concerns from becoming reality, patients often actively modify their daily routines. However, such behavioral adjustments in turn intensify the distress associated with

avoidance and limiting behaviors. This transformation from worry to preventive action identifies social embarrassment as the most influential bridge symptom leading to the development of avoidance and limiting behaviors.

Comprehensively, patients’concerns about the potential social consequences of urinary incontinence, such as wetting clothes, experiencing embarrassing situations, feelings of shame, or exposure to unpleasant odors, serve as a core driving force affecting the quality of life among individuals with PPI. These concerns not only constitute a direct source of psychological distress but also represent a key contributor to behavioral restriction. During social activities, patients exhibit pronounced difficulties in maintaining bodily control and managing self-image; compared with general nervousness, these manifestations are characterized by greater intrusiveness and avoidance tendencies, influencing multiple domains of psychological functioning and behavioral adaptation. Such experiences reflect an underlying vulnerability in self-esteem maintenance, situational coping, and social confidence. This sustained state of hypervigilance compels patients to adopt self-restrictive strategies when participating in activities, engaging in interpersonal interactions, or entering public settings, thereby exacerbating the vicious cycle between social isolation and psychological burden and substantially increasing the risk of comorbid emotional disorders, such as anxiety and depression.

Therefore, these findings suggest that healthcare professionals, while addressing core symptoms, should also consider bridge symptoms as potential intervention targets. By doing so, they can develop tailored strategies to disrupt the cascading interactions among symptoms, promote deactivation of the symptom network, and ultimately enhance patients’symptom management outcomes and overall quality of life.In clinical practice, healthcare providers should guide patients to select incontinence management products that correspond to the individual severity of leakage and that possess high absorbency, effective leakage prevention, and odor control. Such physical measures can offer a reliable sense of security and reduce patients’concerns regarding leakage and odor exposure. At the same time, patients should be instructed in standardized pelvic floor muscle rehabilitation and other behavioral interventions to strengthen bladder control and restore confidence in their bodily functions.Furthermore, psychological interventions such as CBT and self-esteem restoration should be implemented to help patients identify and reframe catastrophic cognitions related to social failure. Family education and public awareness initiatives can also provide essential social support and help reduce illness-related stigma, thereby mitigating anticipatory anxiety and minimizing maladaptive avoidance behaviors. Ultimately, these efforts can facilitate a shift from passive worry to active self-management, promoting better rehabilitation outcomes and improved quality of life.

Several limitations of this study should be acknowledged. First, the use of cross-sectional data prevents the capture of dynamic changes in urinary incontinence-related quality of life over time and precludes the determination of causal directions between symptoms. Future research could adopt longitudinal designs to construct dynamic networks that capture the evolution of symptoms during the critical post-operative recovery period. Unlike static models, such dynamic networks could differentiate temporal feedback loops and shifting symptom centralities that accompany rapid physiological recovery during

the first year. Additionally, this study relied on self-reported measures. The absence of objective clinical data, such as 24-hour pad tests or urodynamic parameters, limits the assessment of physiological severity, and future network models should incorporate these as external covariates.

5 Conclusion

This study employed network analysis to examine the interconnections among symptoms that influence the quality of life in patients with PPI. The results revealed that “I feel depressed because of my incontinence (I5)” emerged as the core symptom influencing the quality of life among PPI patients. Meanwhile, “I worry about wetting myself (I18),” “I worry about being embarrassed or humiliated because of my incontinence(I14),” and “I worry about others smelling urine on me (I8)” were identified as bridge symptoms connecting different dimensions within the network, serving as crucial mediators and conduits of symptom transmission.These findings provide new insights into the role of key symptoms and their underlying mechanisms of interaction, facilitating the identification of priority targets for clinical intervention and offering an empirical basis for developing precision rehabilitation strategies. Targeting these pivotal symptoms in interventions may help disrupt the mutually reinforcing cycle among symptoms, thereby achieving more effective and holistic symptom management and improving patients’overall quality of life.

Declarations

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the Second Affiliated Hospital of Chongqing Medical University (Approval No. 2024-Yan Lunshen (89)).

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Author Contribution

Study design and manuscript drafting: Xin Huang, Yiqin Shi, Wang Li and Xiaoqin Huang.Data collection: Xin Huang and Guihong Zheng. Analysis and interpretation: Xin Huang. Critical revision of the

manuscript:Xin Huang, Yiqin Shi, Wang Li and Xiaoqin Huang. All authors approval of the final version for publication.

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Data Availability

The datasets generated and/or analyzed during the current study are not publicly available due to the inclusion of sensitive participant information and institutional restrictions, but are available from the corresponding author on reasonable request.

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Figures

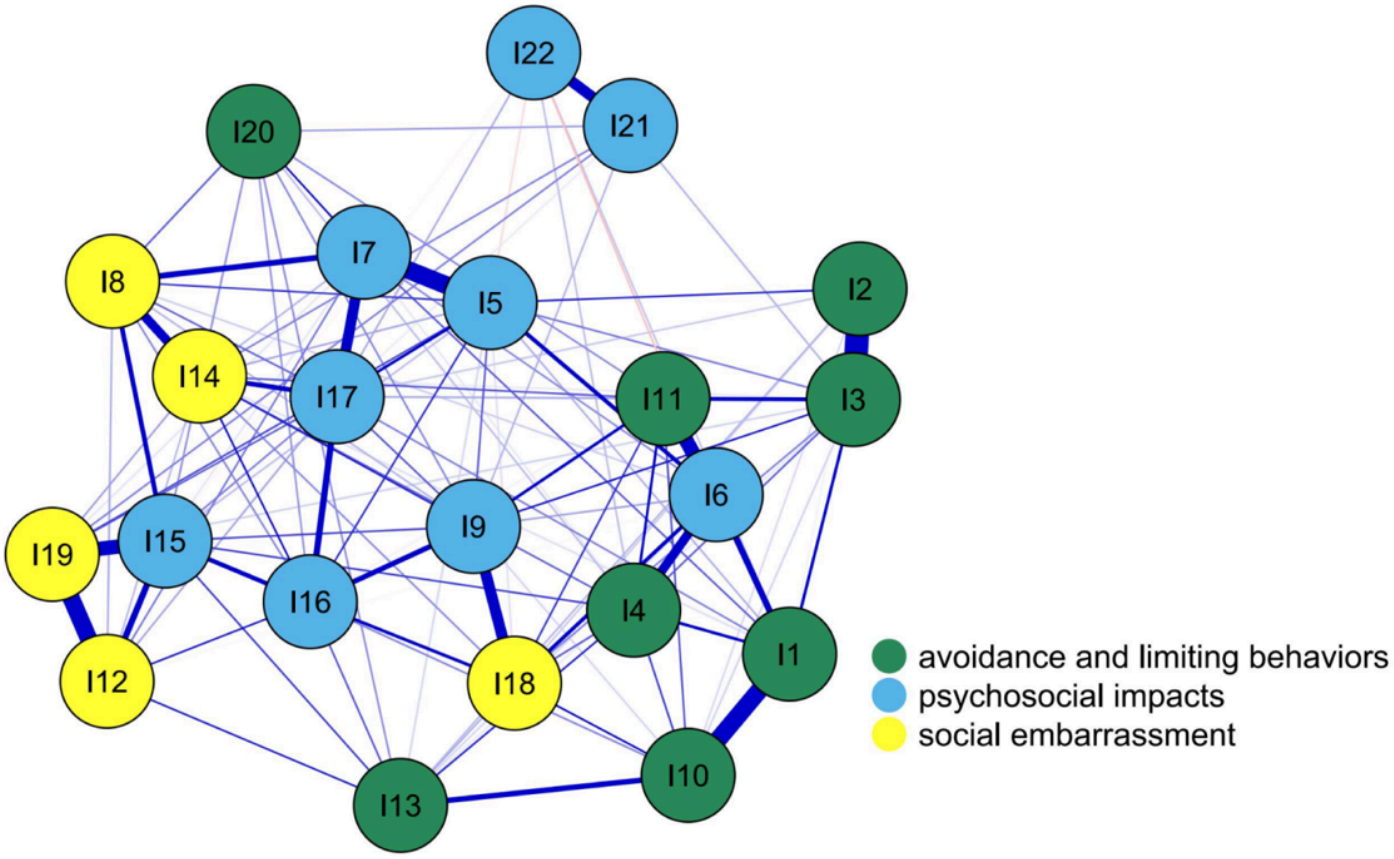


Figure 1

The symptom network of incontinence-related quality of life. Three different colors represent three dimensions. Blue edges indicate positive correlations, and red edges represent negative correlations. The thickness of the edges reflects the strength of the connection between symptoms.

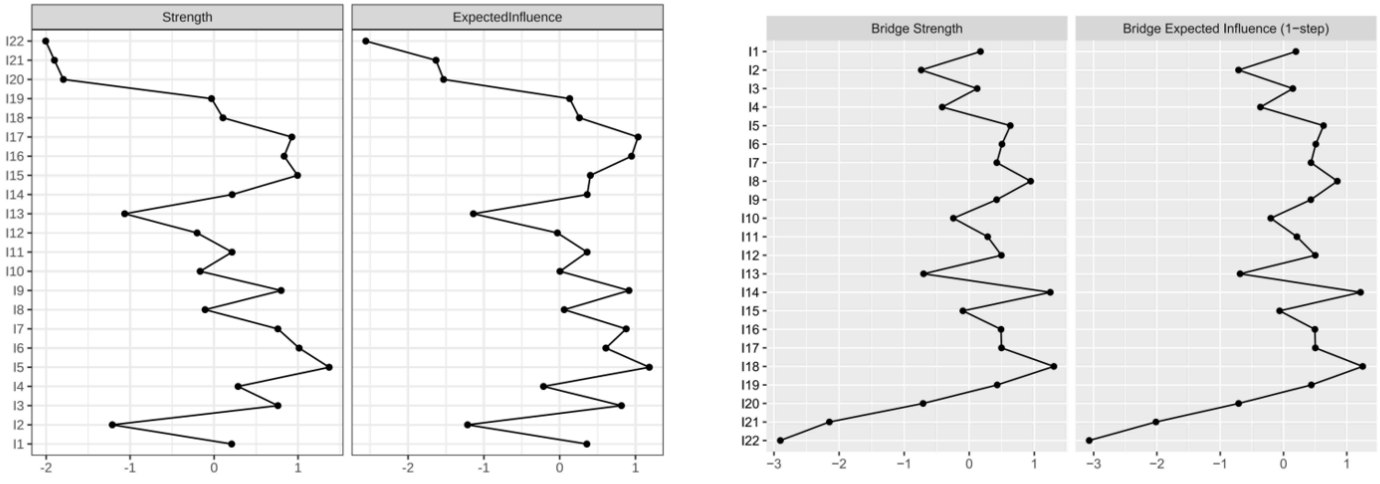


Figure 2

Centrality indices of symptom networks.(A)Node strength centrality and expected influence coefficient. (B)Bridge strength centrality and bridge expected influence coefficient.

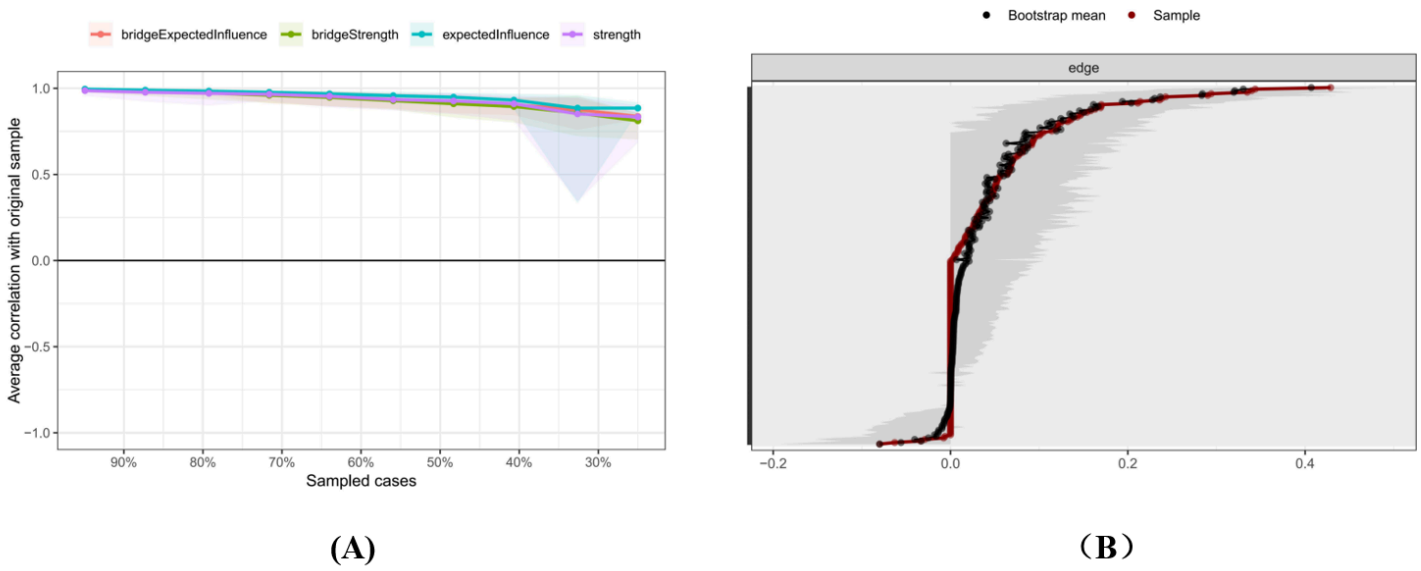


Figure 3

Stability and accuracy of the network structure.(A)Correlation stability coefficients of the symptom network.(B)Accuracy analysis of edge weights.

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