

Symptom Network Analysis in Patients Undergoing Chemotherapy for Colorectal Cancer: A Cross-Sectional Study

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Objective: This study aimed to construct a symptom network in patients diagnosed with colorectal cancer (CRC) undergoing chemotherapy, thereby providing a theoretical framework for optimizing symptom management strategies.

Methods: A cross-sectional survey was conducted among 261 patients with CRC receiving chemotherapy across five tertiary care hospitals in Shanghai, selected through convenience sampling. Network analysis was applied to construct the symptom network and to determine centrality indices, including strength centrality. Model accuracy and stability were evaluated using nonparametric bootstrapping techniques.

Results: Symptom prevalence ranged from 5.4% to 85.8%, with severity scores ranging from 0.51 ± 1.44 to 4.83 ± 3.23 . Fatigue was associated with the highest severity score. Depression ($r_{strength} = 2.188$), nausea ($r_{strength} = 1.290$), and anorexia ($r_{strength} = 1.223$) demonstrated the highest strength centrality values. The constructed network model exhibited high accuracy and stability, as indicated by narrow confidence intervals and Correlation Stability (CS) coefficients exceeding 0.25.

Conclusion: This study is among the first to apply network analysis to chemotherapy-related symptom interactions and potential mechanisms in CRC, highlighting central targets for intervention. These findings may inform more precise and efficient symptom management approaches in oncology care.

Keywords: chemotherapy, colorectal cancer, network analysis, symptom management, symptom network

Introduction

According to estimates by the International Agency for Research on Cancer (IARC), approximately 1.92 million new cases of colorectal cancer (CRC) and 904,000 related deaths occurred globally in 2022, positioning CRC as the third most common malignancy by incidence and second leading cause of cancer-related mortality. These figures account for nearly 10% of all cancer diagnoses and deaths worldwide (IARC, 2022).¹ Chemotherapy serves as the primary adjuvant treatment following surgical intervention in individuals diagnosed with CRC. Although this approach contributes to improved survival outcomes, it is frequently associated with the development of multiple concurrent symptoms. Findings by Pettersson et al indicated that patients receiving chemotherapy for CRC commonly experience physical symptoms such as peripheral neuropathy, fatigue, somnolence, nausea, dyspnea, and xerostomia.² Psychological symptoms, including insomnia and anxiety, were also frequently reported, with only 5% of patients remaining asymptomatic. A high symptom burden has been shown to adversely affect physical, psychological, and social functioning, substantially diminishing overall quality of life.³

Borsboom et al pointed out that the internal connections of symptoms stem from “the disease itself”, and the new “disease” is the result of causal interactions among symptoms, which may form feedback loops. Therefore, to effectively manage symptoms, it is necessary to understand the interactions among symptoms.⁴ Examining inter-relationships among symptoms and identifying central symptoms during chemotherapy for CRC may facilitate the

identification of potential targets for intervention and enhancing the effectiveness of symptom management strategies.^{5,6} However, existing literature has predominantly emphasized individual symptoms or symptom clusters.^{7–10} Some scholars have pointed out that the combinations of symptom clusters presented in different studies may vary due to differences in the selection of included symptoms, the statistical methods used, and other covariates.^{11,12} In addition, although symptom clusters can provide a general understanding of which disease-related symptoms share the same co-occurrence mechanism, the interaction mechanisms among symptoms remain unclear.¹³

Advancements in symptom science have introduced network analysis as a methodological approach in symptom management, leading to the conceptualization of “symptom networks”.¹⁴ Rooted in network theory, this approach posits that, despite variability in nodes and interactions across systems, most complex systems conform to underlying principles that govern their behavior.¹⁵ In this context, network analysis conceptualizes symptoms as interdependent nodes within a dynamic network that evolves through interactions with neighboring nodes or external influences.¹⁶ As a new technique, network analysis can visualize the interactions among complex symptoms through quantitative research on network structures and nodes. Meanwhile, it can identify central symptoms that can serve as the optimal targets for clinical intervention. Intervening in central symptoms can spread the intervention effect to surrounding nodes, leading to the alleviation or disappearance of other symptoms, and ultimately improving the efficiency and precision of symptom management.^{13–16} For instance, Bekhuis et al employed network analysis to identify the core symptoms in patients with mild to moderate depression and implemented interventions targeting these core symptoms. The results demonstrated that interventions focusing on the core symptoms led to a greater reduction in depression severity compared to other comprehensive intervention approaches.¹⁷

Previous studies have established symptom networks in different cancer patients, such as lung cancer survivors, breast cancer survivors, and liver cancer patients, to capture the complex relationships among various disease symptoms.^{18–20} However, there are relatively few current studies on the symptom network analysis of colorectal cancer patients during chemotherapy. Past research has mainly focused on the study of symptom clusters in colorectal cancer patients undergoing surgery or with colostomy, or included colorectal cancer patients during chemotherapy in mixed samples of digestive tract cancers. The use of specific assessment tools has been rather limited.^{21–23} Clinically, colorectal cancer patients during chemotherapy experience more complex symptoms and require more comprehensive research investigations. Accordingly, the present study aimed to examine the symptom profiles of patients with CRC undergoing chemotherapy and to construct a symptom network that may serve as a foundation for developing targeted and personalized symptom management strategies in this population.

Materials and Methods

Study Population

Patients diagnosed with CRC and receiving chemotherapy were recruited from the oncology and general surgery departments of five tertiary care hospitals in Shanghai between January 2022 and February 2023, using a convenience sampling approach. Inclusion criteria were as follows: (1) histopathologically confirmed diagnosis of CRC; (2) currently receiving chemotherapy and having completed at least one cycle; (3) age ≥ 18 years; (4) alert mental status and the ability to communicate effectively; and (5) provision of written informed consent. Exclusion criteria included: (1) presence of major comorbidities unrelated to CRC; (2) diagnosis of synchronous primary malignancies; and (3) patients whose families had requested nondisclosure of the diagnosis.

The required sample size for network analysis was calculated using the formula $n = P(P - 1)/2$,²⁴ where P denotes the number of nodes. Based on an initial plan to include 25 symptom nodes, the estimated sample size was 300. Ultimately, analysis was conducted on 23 symptoms, yielding a revised minimum sample size of 253. A total of 261 valid responses were included in the final analysis.

Instruments

General Information Questionnaire

A structured questionnaire was developed based on a review of existing literature and expert consultation. It included two domains: (1) Demographic characteristics: sex, age, ethnicity, place of residence, marital status, living arrangement, education level, employment status, monthly per capita household income, health insurance status, and perceived financial burden; and (2) Clinical characteristics: tumor site, histological type, clinical stage, time since diagnosis, presence of comorbid conditions, treatment modalities received, and the number of chemotherapy cycles completed.

Chinese Version of M.D. Anderson Symptom Inventory with CRC Module

The M.D. Anderson Symptom Inventory (MDASI), developed by the University of Texas M.D. Anderson Cancer Center in 2000, is a validated tool for assessing symptom severity in oncology settings.²⁵ The Chinese version (MDASI-C) has demonstrated adequate psychometric properties for use among individuals in China, with Cronbach's α coefficients of 0.86 for the symptom severity subscale and 0.84 for the symptom interference subscale.²⁶ The MDASI-C includes two sections: The first section assesses the severity of 13 commonly reported cancer-related symptoms (eg, pain, fatigue, somnolence, distress, sadness) using an 11-point scale ranging from 0 (no symptom) to 10 (as severe as imaginable). Symptom severity is categorized as mild (1–3), moderate (4–6), or severe (≥ 7). The second section evaluates the extent to which symptoms interfere with daily activities. Higher scores in either section indicate greater symptom burden or interference.

A CRC-specific module, aligned with the MDASI-C's structural and item framework, was developed to capture additional symptoms relevant to CRC. This module, designed by the research team, includes 12 additional symptom items relevant to CRC.²⁷ In the current study, internal consistency reliability was satisfactory, with Cronbach's α coefficients of 0.871 for the core MDASI-C and 0.726 for the CRC-specific module.

Data Collection

Researchers provided unified training to the investigators. During the survey, a standardized set of instructions was used to introduce the research purpose, significance, methods, and the time required to the patients. After obtaining the patients' informed consent, they signed the informed consent form. The researchers used consistent language to explain any questions raised by the patients, avoiding any leading statements. They also informed the patients of their right to withdraw from the study at any time. For patients unable to self-complete the questionnaire due to physical limitations, trained investigators conducted face-to-face interviews, reading each item aloud and recording responses. Completed questionnaires were reviewed immediately upon submission to ensure completeness and accuracy. Missing responses were resolved on-site, and any identified errors were corrected in real-time. Of the 272 questionnaires distributed, 261 were deemed valid, resulting in a completion rate of 96.0%.

Statistical Analysis

All statistical analyses were performed using JASP version 0.15.0.0.²⁸ Continuous variables were summarized as means \pm standard deviations or medians with interquartile ranges, while categorical variables were presented as frequencies and percentages. Symptom networks were constructed based on symptom severity scores and estimated with the EBICglasso method within the network analysis module of JASP, based on the bootnet package in R. Network visualization was performed using the qgraph package. The Graphical Least Absolute Shrinkage and Selection Operator (GLASSO) method with regularization was applied, and model selection was optimized using the Extended Bayesian Information Criterion (EBIC) to enhance network sparsity and interpretability.²⁹ In the resulting network graphs, nodes represented individual symptoms, and edges indicated pairwise associations. The strength of these associations was visually represented by edge thickness and color intensity: thicker, darker lines indicated stronger associations, while edge color distinguished direction—blue for positive correlations and red for negative correlations.^{14,30} Clusters of symptoms with strong internal connections and weak external connections were interpreted as distinct communities.³¹

Centrality indices were calculated to assess each symptom's importance within the network: Strength centrality reflected the sum of absolute edge weights directly connected to a node; Closeness centrality represented the inverse of the sum of shortest path lengths to all other nodes; Betweenness centrality measured the frequency with

which a node lies on the shortest path between two other nodes.^{14,30} Model accuracy and stability were evaluated using nonparametric bootstrap methods. Edge weight accuracy was assessed using 95% confidence intervals (CIs) derived from 1,000 bootstrap samples; narrower CIs indicated greater reliability. Network stability was quantified using the Correlation Stability (CS) coefficient. A CS coefficient above 0.25 were considered acceptable, while values exceeding 0.50 reflected high stability.²⁶ Symptoms with a prevalence of less than 10% were excluded from the final network analysis due to the limited representation and potential interference with network estimation and interpretability.^{10,32} Statistical significance was determined using a threshold of $p < 0.05$.

Results

General Characteristics

A total of 261 patients with colorectal cancer (CRC) receiving chemotherapy were included in the analysis. Participant ages ranged from 25 to 82 years (mean: 63.47 ± 10.59 years). Of the total sample, 151 (57.9%) were male and 110 (42.1%) were female. The largest proportion of participants ($n = 108$, 41.4%) reported a monthly per capita household income between 3,000 and 4,999 RMB. The majority (96.2%) were covered by medical insurance, while 113 patients (43.3%) reported experiencing significant financial stress. Demographic characteristics are presented in Table 1.

Disease Characteristics

The duration of CRC ranged from 1 to 91 months (mean: 11.87 ± 13.68 months). The number of completed chemotherapy cycles varied from 1 to 34 (mean: 9.63 ± 7.60). The most frequently reported primary tumor sites were the rectum (34.9%) and the sigmoid colon (27.2%). Adenocarcinoma was the predominant histological type, identified in 246 patients (94.3%). Disease staging demonstrated that 92 patients (35.2%) were classified as stage III and 84 patients (32.2%) as stage IV. Clinical characteristics are presented in Table 2.

Table 1 Demographic Characteristics of Patients with CRC Receiving Chemotherapy ($n = 261$)

Variables		Frequency (n)	Proportion (%)
Sex	Male	151	57.9
	Female	110	42.1
Age	18–29 years	4	1.5
	30–39 years	6	2.3
	40–49 years	16	6.1
	50–59 years	41	15.7
	60–69 years	119	45.6
	70–79 years	70	26.8
	≥ 80 years	5	1.9
Ethnicity	Han	259	99.2
	Tujia	2	0.8
Marital status	Married	229	87.7
	Single	32	12.3
Residence	Urban	192	73.6
	Rural	69	26.4
Living situation	Living alone	15	5.7
	Living with family	245	93.9
	Living with friends	1	0.4

(Continued)

Table 1 (Continued).

Variables		Frequency (n)	Proportion (%)
Education	Illiterate	15	5.7
	Primary school	58	22.2
	Middle school	102	39.1
	High school/Technical school	55	21.1
	University/College	29	11.1
	Master's degree and above	2	0.8
Employment status	Unemployed	12	4.6
	Retired	215	82.4
	Employed	26	10.0
	Farming	5	1.9
	Other	3	1.1
Monthly household income per capita	< RMB 1,000	5	1.9
	RMB 1,000–2,999	40	15.3
	RMB 3,000–4,999	108	41.4
	RMB 5,000–6,999	69	26.4
	RMB 7,000–9,999	27	10.3
	≥ RMB 10,000	12	4.6
Healthcare payment method	Self-pay	1	0.4
	Medical insurance	251	96.2
	Commercial insurance	9	3.4
Financial stress	Light	20	7.7
	Moderate	128	49.0
	Heavy	113	43.3

Table 2 Clinical Variables in Patients with CRC Receiving Chemotherapy (n = 261)

Variables		n (%) / Mean ± SD (Min, Max)
Primary tumor sites	Transverse colon	18 (6.9)
	Descending colon	30 (11.5)
	Ascending colon	51 (19.5)
	Sigmoid colon	71 (27.2)
	Rectum	91 (34.9)
Histological type	Adenocarcinoma	246 (94.3)
	Mucinous adenocarcinoma	10 (3.8)
	Signet ring cell carcinoma	3 (1.1)
	Other	2 (0.8)
Clinical stage	Stage I	9 (3.7)
	Stage II	76 (29.1)
	Stage III	92 (35.2)
	Stage IV	84 (32.2)
Number of comorbidities	0	134 (51.3)
	1	95 (36.4)
	2	24 (9.2)
	3	7 (2.7)
	4	1 (0.4)

(Continued)

Table 2 (Continued).

Variables		n (%) / Mean \pm SD (Min, Max)
Treatment modalities	1	2 (0.8)
	2	48 (18.4)
	3	151 (57.9)
	4	45 (17.2)
	5	10 (3.8)
	6	4 (1.5)
	7	1 (0.4)
Chemotherapy cycles	1	52 (19.9)
	2	178 (68.2)
	3	29 (11.1)
	4	2 (0.8)
Disease duration (months)		11.87 \pm 13.68 (1, 91)
Chemotherapy cycles		9.63 \pm 7.60 (1, 34)

Symptom Prevalence and Severity

Symptom prevalence ranged from 5.4% to 85.8%, with mean severity scores ranging from 0.51 ± 1.44 to 4.83 ± 3.23 (see [Table 3](#)). Among the total sample, 19.5% reported experiencing at least one symptom classified as severe, 14.2% reported two severe symptoms, and 29.1% reported three or more severe symptoms.

Table 3 Prevalence and Severity of Symptoms in Patients with CRC Receiving Chemotherapy (n = 261)

Symptoms	Symptom Prevalence (%)	Symptom Severity (Mean \pm SD)
Pain	43.7	1.40 \pm 2.01
Fatigue	85.8	4.83 \pm 3.23
Nausea	53.3	2.31 \pm 2.80
Sleep disturbance	75.1	3.70 \pm 3.19
Distress	77.8	2.98 \pm 2.41
Dyspnea	29.1	0.97 \pm 1.88
Forgetfulness	58.2	2.40 \pm 2.68
Anorexia	71.6	3.51 \pm 3.10
Somnolence	49.4	2.15 \pm 2.88
Xerostomia	60.5	2.59 \pm 2.83
Sadness	57.1	1.62 \pm 1.95
Vomiting	34.9	1.37 \pm 2.33
Peripheral neuropathy	64.0	3.02 \pm 2.96
Diarrhea	40.6	1.70 \pm 2.57
Constipation	49.0	2.20 \pm 2.79
Abdominal distension	56.7	2.14 \pm 2.49
Change in stool characteristics (bloody/mucous stool)	14.6	0.51 \pm 1.44
Altered bowel habits (thin stools/increased frequency)	53.3	2.20 \pm 2.58
Alternation of diarrhea and constipation	21.1	0.69 \pm 1.61
Weight loss	55.2	2.36 \pm 2.84
Tenesmus	36.8	1.41 \pm 2.40
Fear	68.6	2.15 \pm 1.93
Depression	80.8	2.88 \pm 2.19
Peristomal skin changes	6.5	1.20 \pm 1.75
Stoma abnormalities	5.4	0.97 \pm 1.62

Symptom Network Construction

A total of 23 symptoms were included in the network analysis. The resulting symptom network revealed substantial interconnectivity. Based on edge thickness, the three most prominent symptom communities were identified as follows: Community 1: nausea (3), vomiting (12), anorexia (8); Community 2: depression (23), fear (22), distress (5), sadness (11); Community 3: tenesmus (21), diarrhea (14), altered bowel habits (thin stools/increased frequency) (18). The symptom network is presented in Figure 1.

Network Centrality Indices

Among the 23 symptoms analyzed, depression demonstrated the highest strength centrality ($r_{strength} = 2.188$), followed by nausea ($r_{strength} = 1.290$), and anorexia ($r_{strength} = 1.223$), indicating their central roles within the network. For closeness centrality, the highest values were observed for depression ($r_{closeness} = 1.178$), distress ($r_{closeness} = 1.212$), and somnolence ($r_{closeness} = 1.087$), indicating that these symptoms maintained the shortest average distance to other nodes. Betweenness centrality was highest for abdominal distension ($r_{betweenness} = 2.542$), anorexia ($r_{betweenness} = 2.051$), and distress ($r_{betweenness} = 1.121$), reflecting their importance as bridge symptoms mediating interactions across the network. Centrality metrics are presented in Figure 2.

Network Model Accuracy and Stability

CI for edge weights are presented in Figure 3. The relatively narrow CIs observed indicate a high level of model accuracy. As presented in Figure 4, nonparametric bootstrapping procedures demonstrated that the CS coefficients for both strength and closeness centrality exceeded 0.50, indicating high stability. The CS coefficient for betweenness centrality was consistently above 0.25, meeting the threshold for acceptable stability. Overall, the network model demonstrated satisfactory accuracy and stability.

Discussion

High Symptom Prevalence and Significant Symptom Burden

Symptom severity scores in the present sample ranged from 0.51 ± 1.44 to 4.83 ± 3.23 , with fatigue identified as the most severe symptom. Symptom prevalence varied from 5.4% to 85.8%, with fatigue also being the most frequently reported. These findings are consistent with previous studies conducted by Pettersson et al and O’Gorman et al^{2,7} More than half of the assessed symptoms were reported by over 50% of participants, and more than half of patients experienced at least one symptom categorized as severe. Furthermore, 29.1% of patients reported experiencing three or more severe symptoms, indicating a substantial impact on daily functioning. The symptoms analyzed in this study are commonly observed among

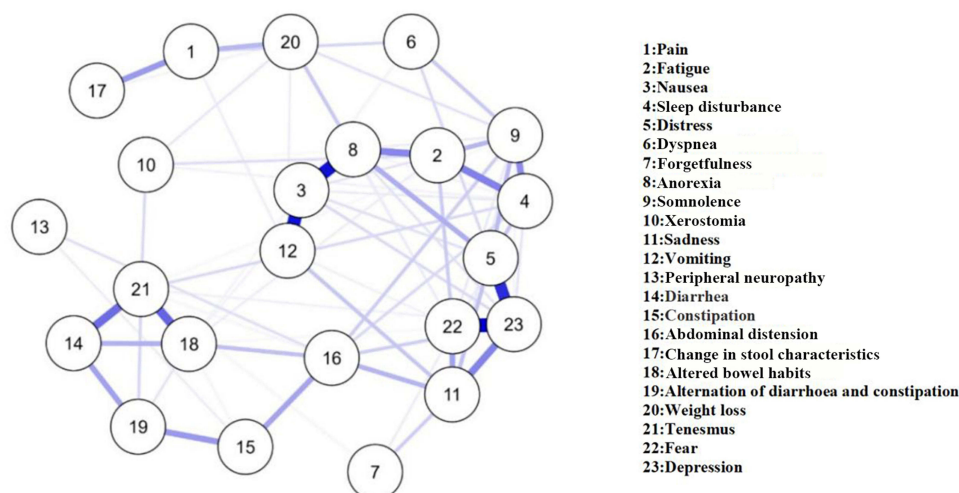


Figure 1 Symptom network among patients with CRC receiving chemotherapy.

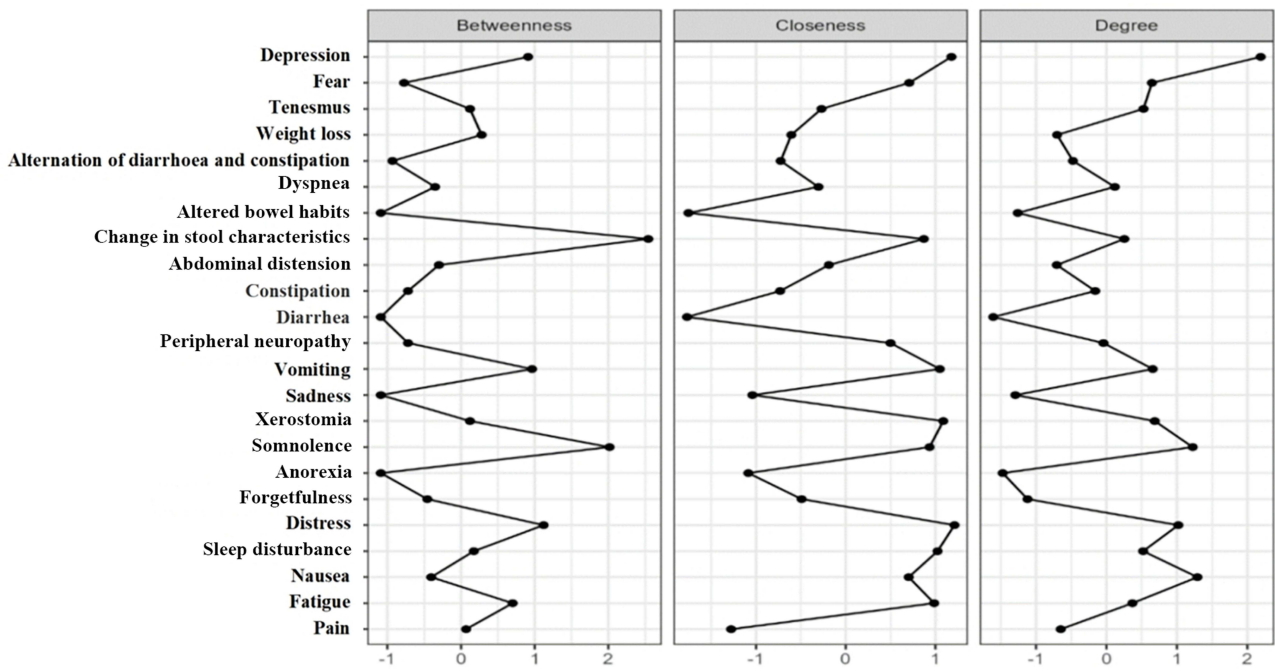


Figure 2 Centrality indices of the symptom network in patients with CRC receiving chemotherapy.

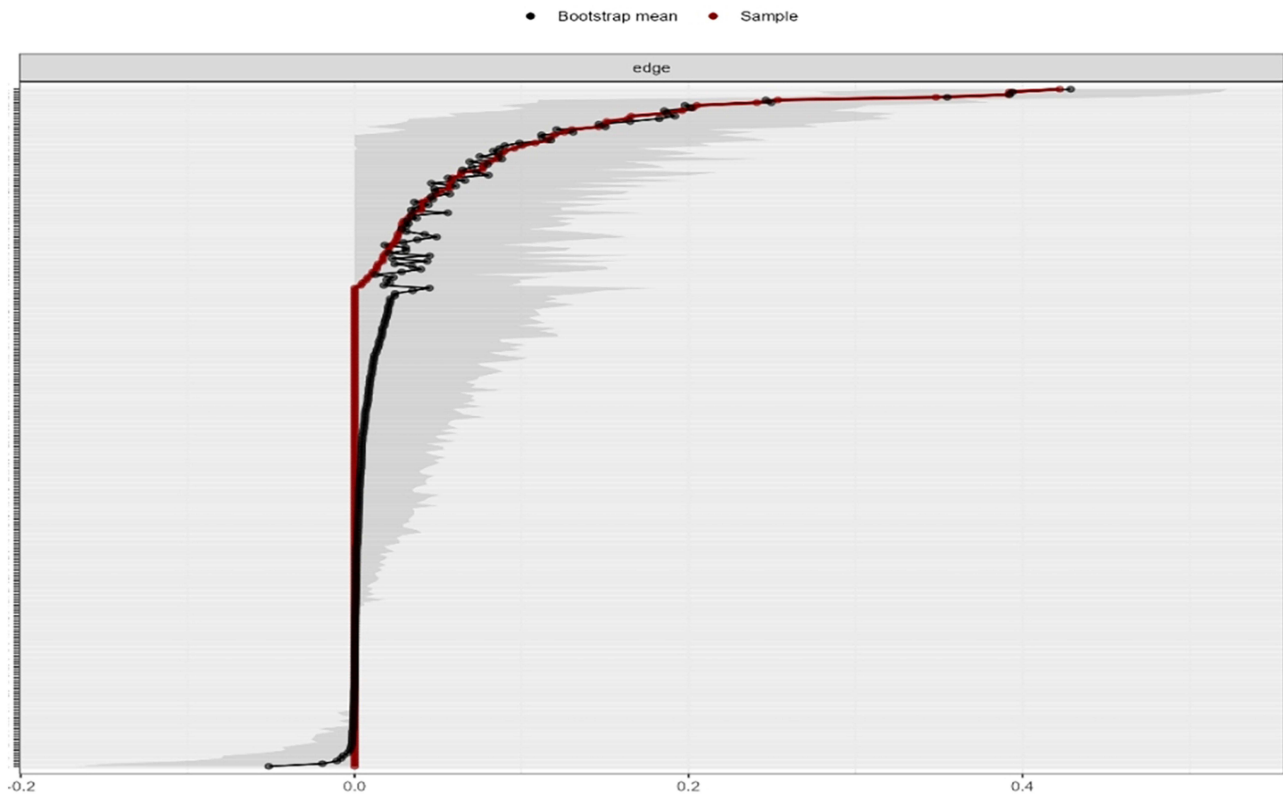


Figure 3 Bootstrap confidence intervals for edge weights in the symptom network.

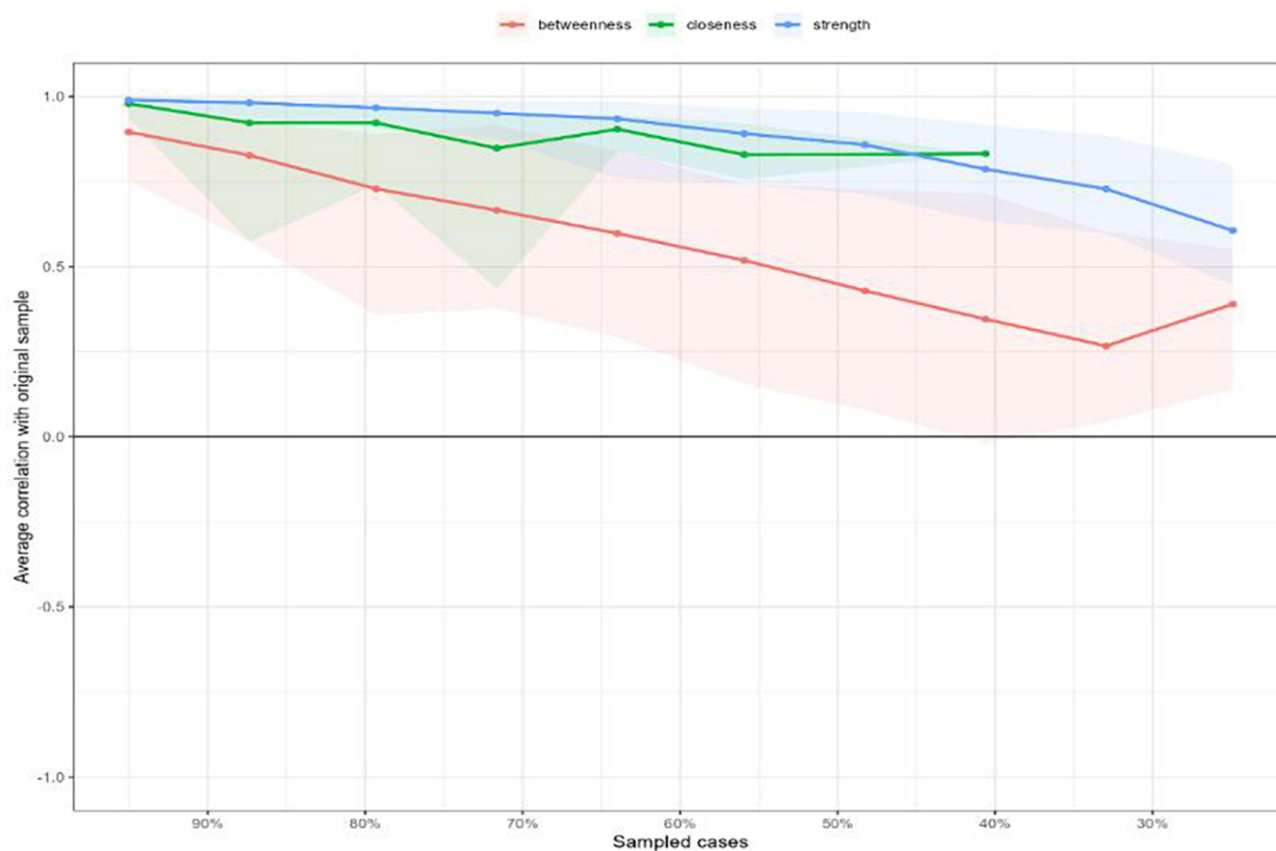


Figure 4 Stability analysis of centrality indices in the symptom network.

patients with CRC undergoing chemotherapy, and the overall findings underscore a high prevalence and burden. Fatigue, sleep disturbance, anorexia, and distress ranked among the highest in both prevalence and severity. These results highlight the necessity for comprehensive physical and psychological assessments in clinical practice. Early identification and timely intervention targeting symptoms with both high prevalence and severity may contribute to a reduction in overall symptom burden and improvement in patient well-being.

Depression, Nausea, and Anorexia as Core Symptoms and Targets for Intervention

The constructed symptom network, comprising 23 symptoms, revealed extensive interconnectivity. Depression, nausea, and anorexia demonstrated the highest strength centrality values, identifying them as core symptoms within the network. Depression, distress, and somnolence exhibited the highest closeness centrality, indicating close associations with other symptoms. Abdominal distension, anorexia, and distress demonstrated the highest betweenness centrality, indicating pivotal roles as bridge symptoms in the transmission of symptom effects.

These findings position depression, nausea, and anorexia as central targets for symptom management in patients undergoing chemotherapy for CRC. Interventions focused on reducing psychological distress and alleviating upper gastrointestinal symptoms may indirectly reduce the severity or incidence of other symptoms within the network. Previous evidence has demonstrated that patients with CRC are susceptible to psychological distress.² Han et al identified psychological and gastrointestinal symptoms as primary concerns among CRC survivors.³³ Factors contributing to psychological distress may include the presence of severe physical symptoms, financial hardship, and challenges associated with social reintegration.^{34–36} These contextual factors are consistent with the present sample, which demonstrated high physiological symptom burden and financial stress. Nausea and anorexia, common upper gastrointestinal symptoms during chemotherapy, are largely associated with treatment-induced emetic reflexes.³⁷ Prioritizing the

management of these symptoms may not only alleviate gastrointestinal discomfort but also reduce their cascading effects on other symptom domains. A clinically integrated approach focusing on psychological and gastrointestinal symptom control may therefore represent a critical strategy in reducing overall symptom burden. This approach should incorporate sustained intervention, monitoring of associated symptoms, and regular reassessment to ensure timely adjustments in symptom management strategies.

Fatigue as a Sentinel Symptom with Warning Value

A high symptom prevalence but low centrality implies that the symptom may be a sentinel symptom of other symptoms. Sentinel symptoms, serving as early warning signals indicating the occurrence or exacerbation of other symptoms, play a crucial role in disease prevention.³⁸ Although fatigue was the most prevalent and severe symptom reported in the sample, it did not exhibit high centrality indices, indicating that it was not a core symptom in the context of chemotherapy for CRC. Fatigue is a sentinel symptom within the entire symptom network. Previous studies indicate that fatigue has been identified as one of the most common and burdensome symptoms among patients diagnosed with cancer.^{2,39,40} A meta-analysis by Maqbali et al reported that the prevalence of fatigue among patients with cancer ranges from 11% to 99% across studies.⁴¹ Despite its widespread occurrence, the relatively low centrality of fatigue in this analysis indicates a role as a sentinel symptom rather than a core symptom.⁴² This finding is consistent with the results of the longitudinal study by Rha et al, which evaluated the symptoms of cancer patients receiving adjuvant chemotherapy over 2 cycles. The results showed that fatigue was a sentinel symptom during the entire chemotherapy process for patients.⁹ Other studies have also noted a diminishing centrality of fatigue as patients transition into survivorship.^{13,43} Different from the findings of this study, Zhang et al identified fatigue as a core symptom in the sickness behavior symptom cluster of colorectal cancer patients receiving postoperative chemotherapy.⁴⁴ It is speculated that a substantial proportion of patients in the current sample received traditional Chinese medicine as part of their treatment regimen, which may have contributed to symptom relief and lower centrality values associated with fatigue. As a sentinel symptom, fatigue may serve as an early indicator of other developing symptoms within the network. In this analysis, fatigue demonstrated strong associations with both sleep disturbance and anorexia. Identification and early management of fatigue may prevent the exacerbation of these associated symptoms. Therefore, routine clinical assessment of fatigue and prompt intervention may provide opportunities for early symptom control and contribute to improved outcomes in symptom management during chemotherapy.

Limitations

This study represents a preliminary exploration into symptom networks among patients undergoing chemotherapy for CRC. However, certain limitations should be acknowledged. (1) Firstly, as a data-driven approach, network analysis is sensitive to sample size variability. The sample size in the present study only met the minimum threshold for analysis, and the survey was conducted in select hospitals in Shanghai, China, limiting the generalizability of the findings. Future studies should aim to recruit larger patient cohorts across multiple centers to enhance external validity. (2) We did not perform subgroup analyses by cancer stage (eg, differences between stage III and stage IV cases) due to sample size constraints. Future studies with larger samples should explore whether symptom networks differ across disease stages. (3) Furthermore, the cross-sectional design employed in this study restricted the ability to assess symptom dynamics over time. Subsequent research should incorporate longitudinal designs to construct dynamic or temporal symptom networks. Such designs would allow for the exploration of potential causal pathways and the identification of time-sensitive intervention targets to further optimize symptom management strategies. (4) Although we provided a detailed methodological description, the use of convenience sampling and a single-time assessment may limit the replicability of our findings in other settings.

Implications for Clinical Practice and Research

Symptom experience represents patients' perception of symptoms and the impact of symptoms on them. Therefore, strengthening symptom management is of particular importance. Network centrality provides a symptom - level indicator that enables medical staff to identify core symptoms from a mechanistic perspective. By using symptom

networks to analyze the patterns among symptoms, medical staff can prevent the occurrence of potential symptoms, intervene and monitor existing symptoms, and predict the possible subsequent symptoms, thus improving the effectiveness of symptom management. For example, the study by Atreya et al found that audio - based mindfulness meditation can effectively improve the distress and fatigue symptoms of colorectal cancer patients during chemotherapy.⁴⁵ In future clinical practice, researchers can develop more personalized physical and mental intervention measures based on symptom networks. It is hoped that such cost - effective intervention measures can not only improve core symptoms but also, like a “domino effect”, improve other symptoms in the symptom network. In addition, in clinical work, medical staff should be familiar with the core symptoms and sentinel symptoms of colorectal cancer patients during chemotherapy. When a certain symptom occurs, they should further assess other related symptoms in the symptom network.

Conclusions

Symptom network analysis offers a valuable framework for identifying mechanisms underlying complex symptom interactions, guiding the selection of intervention targets, and supporting the development of individualized symptom management strategies. By leveraging the synergistic effects among symptoms within identified clusters, as revealed through network analysis, healthcare professionals may improve the efficiency of symptom management—preventing the onset of new symptoms, addressing existing ones, and anticipating future symptom trajectories.

Abbreviations

IARC, International Agency for Research on Cancer; MDASI, M.D.Anderson Symptom Inventory; GLASSO, Graphical Least Absolute Shrinkage and Selection Operator; EBIC, Extended Bayesian Information Criteria.

Data Sharing Statement

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Ethics Approval and Consent to Participate

The study was approved by Ethics Committee of Shanghai University of Traditional Chinese Medicine. This study was conducted in accordance with the declaration of Helsinki. Written informed consent was obtained from the participants.

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Disclosure

The authors declare that they have no conflict of interests.

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