scientific reports

Check for updates

OPEN

Network analysis of the intercorrelations between quality of life, trait mindfulness, and mental health among patients with breast cancer

Loan Xuan Kim[1,2], Shin Tae Kim[3], Bich Ngoc Hoang Truong[1], Dung Van Do[1], Dung Xuan Pham[4], Jee In Kang[3,5], Se Joo Kim[3,5] & Chun Il Park[3,5]✉

As cancer survival rates have improved, there is growing interest in enhancing patients' quality of life during and after treatment. Quality of life in cancer patients is a multidimensional construct encompassing physical, role, emotional, cognitive, and social functioning, along with physical symptoms and financial concerns. However, the complex interplay among these factors remains poorly understood. Mental health conditions, including anxiety, depression, and distress, are common in patients with breast cancer and significantly impair quality of life. Trait mindfulness, defined as a tendency toward present-moment awareness, is associated with reduced psychological distress and improved emotional regulation. This study aimed to examine the interrelationships among QoL domains, mental health problems, and trait mindfulness using network analysis. In particular, trait mindfulness was considered a potential factor that may enhance both quality of life and mental health in breast cancer patients. In this cross-sectional study, 196 breast cancer patients completed face-to-face interviews at various treatment phases, using structured questionnaires including the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire–Core 30, the Hospital Anxiety and Depression Scale, the Distress Thermometer, and the Mindful Attention Awareness Scale. Network analysis was conducted using a Gaussian Graphical Model optimized via the Least Absolute Shrinkage and Selection Operator and the Extended Bayesian Information Criterion, with modularity analysis applied to identify community structures. Emotional functioning and trait mindfulness emerged as central nodes, and three distinct communities were identified: mind (emotional and cognitive functioning, depression, anxiety, distress, insomnia, and trait mindfulness), body (physical and role functioning, and physical symptom burden), and socioeconomic status (social functioning and financial difficulty). The positive correlation between trait mindfulness and emotional functioning suggests that cultivating trait mindfulness may be a promising strategy to enhance quality of life in patients with breast cancer.

Keywords Trait mindfulness, Mental health, Quality of life, Breast cancer, Network analysis

Breast cancer is the most commonly diagnosed cancer and the leading cause of death in women worldwide[1]. By 2024, the global burden of breast cancer has increased significantly, with approximately three million new cases and one million deaths annually, particularly in countries with low or medium Human Development Index[2]. With significant improvements in survival rates due to advancements in cancer treatment, quality of life (QoL) is increasingly regarded as a key clinical indicator in cancer care[3]. Importantly, QoL is not only a treatment outcome but also a prognostic indicator of survival and recovery[4], highlighting the need to address it proactively in clinical practice.

[1]University of Medicine and Pharmacy at Ho Chi Minh City, Ho Chi Minh City, Vietnam. [2]MEF Fellow, Yonsei University College of Medicine, 2024 Seoul, Republic of Korea. [3]Institute of Behavioral Science in Medicine, Yonsei University College of Medicine, Seoul, Republic of Korea. [4]Ho Chi Minh City Oncology Hospital, Ho Chi Minh City, Vietnam. [5]Department of Psychiatry, Yonsei University College of Medicine, 50-1 Yonsei-ro, Seodaemun-gu, Seoul 03722, Republic of Korea. ✉email: chunil1001@yuhs.ac

Cancer treatments often cause side effects that impact both physical and mental well-being, with patients frequently reporting pain, fatigue, and nausea[5]. Chemotherapy, for instance, has been shown to impair physical and role functioning while increasing fatigue and dyspnea[5]. Furthermore, fatigue and insomnia may persist long after treatment, continuing to affect the QoL of breast cancer survivors[6]. Another study found that recurrent breast patients undergoing or not undergoing treatment experienced more severe symptoms (fatigue, pain, and appetite loss), poorer functioning, and higher levels of depression compared to the post-treatment group[7]. Treatment-related changes in appearance, such as hair loss and mastectomy, can also contribute to distress and anxiety, further diminishing overall QoL[8–10]. In addition, the prognostic role of QoL in survival outcomes has been well-documented. A meta-analysis examining the relationship between QoL and overall survival identified physical functioning, appetite loss, and pain as significant prognostic factors in cancer patients[11]. Similarly, findings from the cohort study among patients with advanced-stage cancer indicated that physical QoL symptoms such as nausea, vomiting, and dyspnea, rather than psychological QoL (anxiety, distress), provide valuable prognostic information for patient's survival[12]. The findings above highlight the importance of prioritizing the evaluation of QoL in cancer care.

QoL is a multidimensional concept encompassing various aspects. The European Organization for Research and Treatment of Cancer Quality of Life Questionnaire–Core 30 (EORTC–QLQ C30) is widely used in cancer care and research. It measures global health status; five functional domains, including physical functioning, emotional functioning, role functioning, cognitive functioning, and social functioning; three symptom scales, including fatigue, pain, and nausea; and additional symptoms, including dyspnea, appetite loss, insomnia, constipation, diarrhea, and financial difficulties[13,14]. This structure enables detailed exploration of the complex interconnections among these factors[15]. A few studies examining QoL domains have shown that better physical QoL is linked to fewer psychological symptoms and improved sleep quality, while higher emotional QoL is associated with less pain, improved sleep, and fewer gastrointestinal symptoms[16]. Additionally, fatigue has been strongly correlated with pain, insomnia, and depression[17]. However, the various dimensions of QoL are considered inconsistently across studies, and individual findings may not identify which aspects are most critical for cancer patients. Moreover, limited investigation of internal links between QoL domains may hinder a comprehensive understanding of their interrelated effects. Given its importance, reducing factors that negatively impact QoL and enhancing those that support it are essential for effective cancer care.

Depression, anxiety, and psychological distress are common among breast cancer patients and significantly reduce QoL[18]. These psychological conditions negatively affect overall QoL as well as specific domains, including emotional, physical, and social functioning[19,20]. Among breast cancer survivors, one study found that depression was strongly associated with poorer global QoL and emotional functioning[21]. Another study reported that depression, particularly when present before treatment, was a key predictor of QoL trajectories over time[22]. Furthermore, evidence suggests that depression may mediate the relationship between cognitive functioning and QoL in breast cancer patients[22]. These findings highlight the importance of understanding the interplay between psychological factors and QoL domains to enhance the overall QoL among breast cancer patients.

Given the profound impact of mental health conditions on QoL in breast cancer patients, targeting these modifiable psychological factors is crucial for improving patient outcomes. Mindfulness, an inherent trait that varies among individuals and reflects a person's ability to stay present and open-minded, has been recognized for its psychological benefits in reducing distress and stress-related symptoms in those facing physical and psychological challenges, such as cancer patients[23–25]. Evidence shows that patients with higher trait mindfulness may experience less distress and fewer stress-related symptoms[25]. Despite evidence that mindfulness-based interventions positively impact the mental health and QoL of cancer patients, the relationship between trait mindfulness and specific domains of QoL remains unclear.

The present study addresses these gaps by employing network analysis to identify central nodes that represent critical aspects of QoL and to explore the network's community structure. The primary objective was to identify key central nodes, while the secondary objective was to conduct modularity analysis to detect community structure. A holistic approach, incorporating various dimensions of QoL, mental health issues, and trait mindfulness, provides a comprehensive understanding of the interconnected factors influencing breast cancer patients' well-being. Clinically, understanding these relationships is essential for identifying targets to improve QoL in patients with breast cancer.

Results

Demographic and clinical characteristics

Demographic information and clinical characteristics of the participants are presented in Table 1. All the participants were women with breast cancer, with a mean age of 51.9 years. The average time since diagnosis was 18.5 months, and the majority had been diagnosed with stage II cancer (46%). Detailed descriptions are provided in Table 1.

The network structure of the functional QoL, symptom-related QoL, mental health, and trait mindfulness ability

Figure 1 depicts the network model in which nodes represent a set of variables related to global health status (QL); functional QoL, including physical (PF), role (RF), emotional (EF), cognitive (CF), and social functioning (SF); symptom-related QoL, including fatigue (FA), nausea/vomiting (NV), pain (PA), dyspnea (DY), insomnia (SL), appetite loss (AP), constipation (CO), diarrhea (DI), and financial difficulties (FI); mental health, including depression (DEP), anxiety (ANX), and distress (DT); and trait mindfulness (MAAS). The network model resulted in 19 nodes and 51 nonzero edges out of 171 possible edges, indicating 51 pairs of correlated variables. Emotional functioning was positively correlated with trait mindfulness (0.228), social functioning (0.133), and global QoL (0.105). Conversely, emotional functioning was negatively correlated with distress (−0.333) and

Age (years)	51.85 ± 10.56
Education level, N (%)	
Less than high school	129 (66%)
More than high school	67 (34%)
Stage of cancer, N (%)	
Stage 0	2 (1.0%)
Stage I	20 (10%)
Stage II	91 (46%)
Stage III	62 (32%)
Stage IV	21 (11%)
Time of disease (months)	18.53 ± 27.41
EORTC–QLQ C30	
Global health status	63.48 ± 18.14
Physical functioning	79.12 ± 17.43
Role functioning	69.64 ± 28.86
Emotional functioning	70.49 ± 26.06
Cognitive functioning	76.87 ± 23.16
Social functioning	63.18 ± 31.90
Fatigue	40.48 ± 23.83
Nausea and vomiting	14.03 ± 24.58
Pain	29.76 ± 24.72
Dyspnea	14.80 ± 25.08
Insomnia	42.69 ± 38.75
Appetite loss	42.52 ± 41.97
Constipation	9.35 ± 21.29
Diarrhea	9.18 ± 20.69
Financial difficulties	66.33 ± 33.07
HADS-D	6.67 ± 2.86
HADS-A	4.12 ± 3.89
DT	3.37 ± 2.76
MAAS	5.09 ± 0.68

Table 1. Demographic and clinical characteristics of participants (N = 196). The means ± standard deviations are provided for age, time of disease, EORTC-QLQ C30, HADS-D, HADS-A, DT, and MAAS. *EORTC-QLQ C30* European Organization for Research and Treatment of Cancer Quality of Life Questionnaire–Core 30, *HADS-D* depression subscale of the hospital anxiety and depression scale, *HADS-A* Anxiety subscale of the hospital anxiety and depression scale, *DT* distress thermometer, *MAAS* mindful attention awareness scale.

anxiety (− 0.242). The physical functioning was negatively associated with various symptoms, including pain (− 0.085), appetite loss (− 0.060), dyspnea (− 0.059), nausea, and vomiting (− 0.046), and strongly correlated with fatigue (− 0.237). Conversely, physical functioning positively correlated with role functioning (0.137). There was a strong negative association between financial difficulty and social functioning (− 0.234).

We utilized community detection to identify clusters within the network where nodes were more connected to each other than to nodes in other groups (Fig. 2). Two nodes, constipation and diarrhea which exhibited no connections, were excluded from the community network detection. The community detection algorithm results were based on the modularity score, with a score above 0.3 demonstrating a clear community structure. The Optimal algorithm achieved the highest score (0.3798), indicating the clearest community structure. In Fig. 2, the network revealed three community groups including (1) "Mind," (2) "Body," and (3) "Socioeconomic status" respectively.

We estimated bridge strength to quantify the importance of a node in connecting multiple communities (Supplementary Fig. 1). Emotional functioning was revealed to be a critical central node in the network, acting as a primary bridge between communities and influencing the overall network structure.

Edge weight accuracy

The results from 1000 bootstrap samples assessing the accuracy of the edge weights are displayed in Supplementary Figs. 2 and 3. The reliability of the correlations identified in the network estimation was confirmed. The plots revealed that the confidence intervals had a small to moderate overlap around the estimated edge weights, indicating stability across various samples.

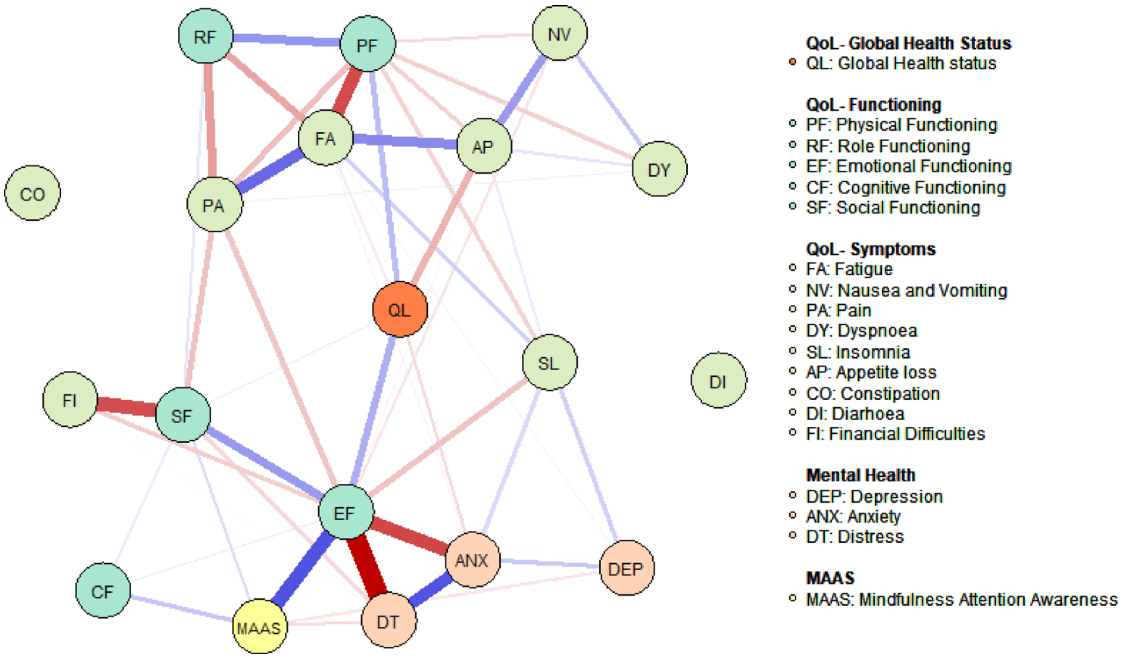

Fig. 1. Network of quality of life, depression, anxiety, distress, and trait mindfulness in patients with breast cancer. [Orange: QoL- Global Health Status; Mint: QoL- Functioning; Lime: QoL- Symptoms, Peach: Mental Health, Yellow: MAAS]. Network plot with 19 nodes and 51 undirected edge weights. The variables are represented by nodes, and the edges indicate the regularized partial correlation between the two nodes. Positive correlations are demonstrated with blue lines, whereas negative correlations are denoted with red lines. Thick and intense edges indicate strong connections.

Centrality stability (CS)

We utilized a bootstrapping sample with case-dropping to evaluate the stability of the centrality indices (Supplementary Fig. 4). A CS coefficient of 0.439 for the strength indicates relatively good stability, indicating that up to 43.9% of the data can be removed while maintaining a correlation of 0.7 or higher between the original strength centrality and that of the reduced sample with a 95% probability. As the closeness and betweenness coefficients were 0.128 and 0.286, respectively, falling below the recommended thresholds, strength was prioritized as the primary centrality index.

Figures 3 and 4 present the centrality indices and expected influence based on the Z-score standardization. Centrality indices refer to the importance of a particular node relative to the other nodes in a network. The results demonstrated that emotional functioning was the most significant node in the network, as reflected by the consistently high values of the node across strength, closeness, and betweenness centrality metrics. Although emotional functioning was the node with the lowest expected influence, trait mindfulness exhibited the highest positive expected influence. These findings suggest that while emotional functioning occupies a central position in the network due to its highest direct connectivity with other nodes, trait mindfulness exerts the most significant influence when considering both its magnitude, direct and indirect effects on other nodes within the network.

Relative importance analysis

The results indicated that the factors in our model explained 77.25% of the variation in emotional well-being among patients, with trait mindfulness contributing the most at 38.68%. All predictors were identified to be statistically significant in relation to emotional functioning, with distress and anxiety having the highest relative importance among the predictors. The detailed results of the relative importance analysis are presented in Supplementary Table 1.

Discussion

QoL is an important outcome measure in medical research and clinical care and is a basis for treatment recommendations and interventions. To our knowledge, this study is the first to explore and visualize network structures of functioning and symptom domains of QoL, along with depression, anxiety, distress, and trait mindfulness in patients with breast cancer. The network analysis revealed emotional functioning and trait mindfulness as key nodes. Emotional functioning, identified as the most central node, plays a crucial role in influencing other nodes, connecting the three identified communities. Trait mindfulness also showed notable influence on QoL and mental health when considering both the magnitude and direction of its connections. Additionally, it may serve as a promising target for interventions aimed at improving QoL. As a secondary aim, this study also sought to identify closely related variables using community detection. This analysis revealed

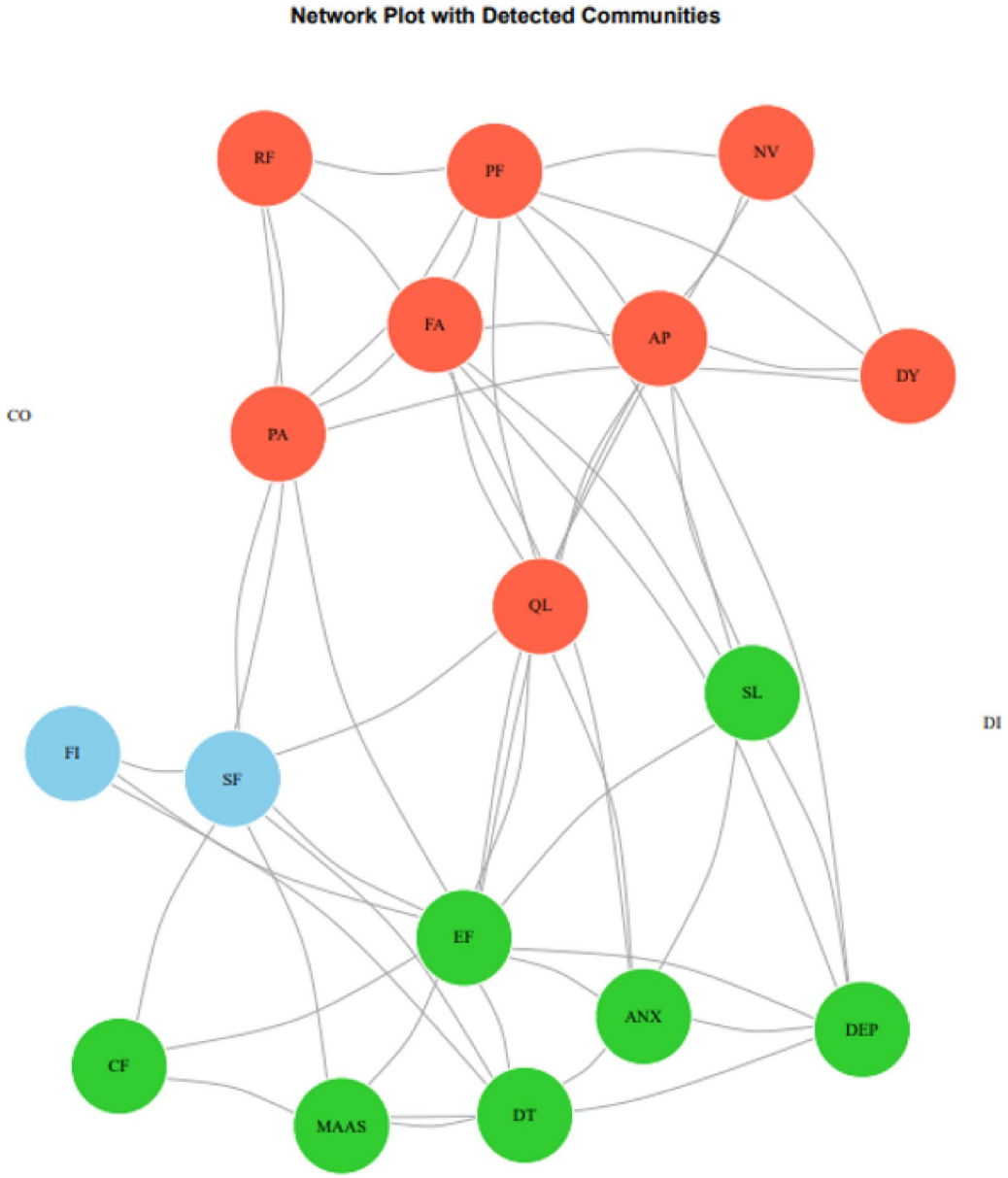

Fig. 2. Network plot with detected communities. [Detected communities – Green: Community (1), Red: Community (2), Blue: Community (3)]. Figure 2 illustrates the results of the modularity analysis. The network identified three community groups within 19 nodes and 51 undirected weighted edges: (1) "Mind": Emotional functioning—Cognitive functioning—Mindfulness—Depression—Anxiety—Distress—Insomnia; (2)"Body": Physical functioning—Role functioning—Global health-related quality of life—Pain—Fatigue—Poor appetite—Nausea and vomiting—Dyspnea; and (3)"Socioeconomic status": Social functioning—Financial difficulty.

three distinct communities including mind, body, and socioeconomic status, corresponding to the psychological, physical, and social dimensions of patient well-being.

In this study, emotional functioning affected all other nodes within the network, highlighting a series of interconnected pathways. The negative correlation between emotional functioning and anxiety and distress implies that increased anxiety and distress may impair patients' ability to regulate emotions, which in turn impairs their emotional functioning[26]. Patients with cancer often experience elevated anxiety and distress when confronted with their illness and throughout their treatment[27]. Research has demonstrated that up to 30–60% of patients with breast cancer experience emotional distress, yet fewer than 30% receive appropriate psychological support[28]. In addition, patients with cancer with comorbid psychological conditions, such as depression and anxiety, tend to have significantly lower emotional functioning than those without these conditions[29]. Findings from several studies indicate that emotional functioning scores are generally lower than physical and cognitive functioning scores[30,31]. This suggests that, even when other functions are relatively preserved, declines in

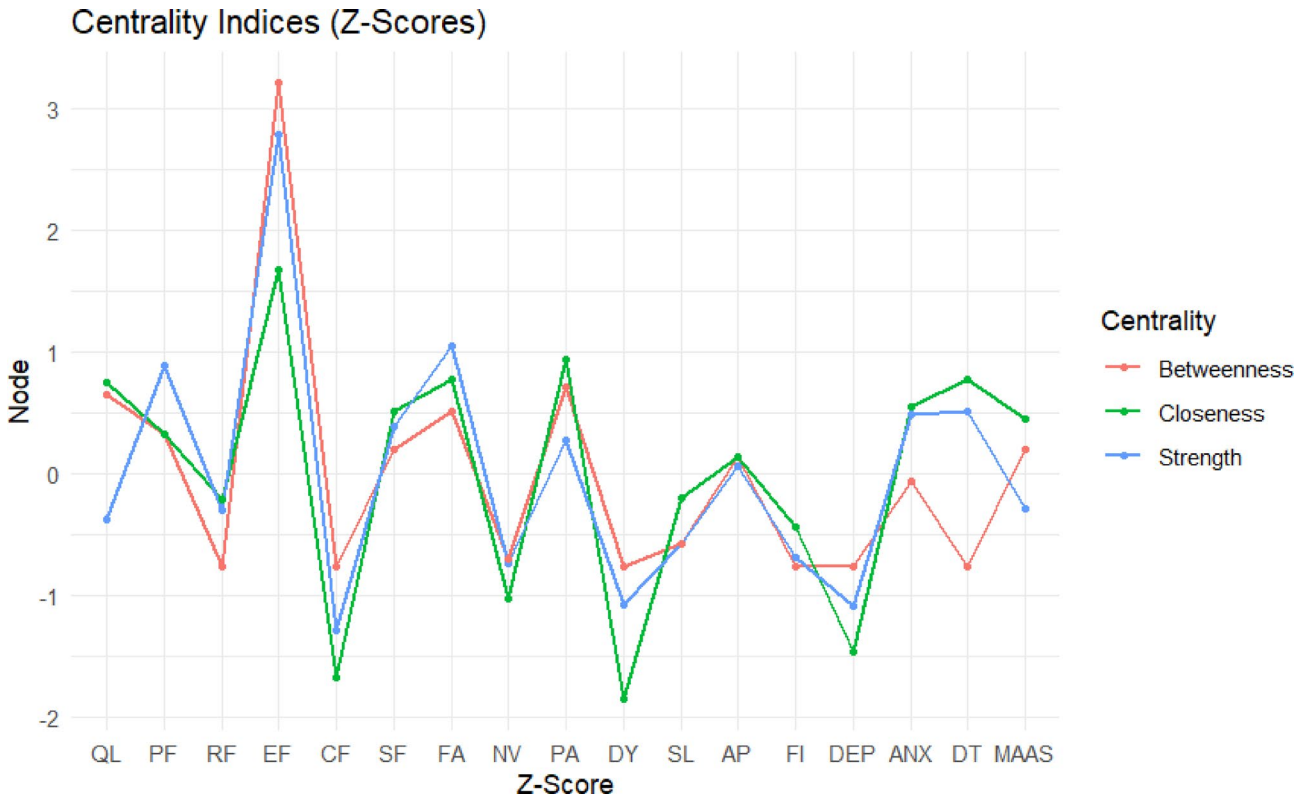

Fig. 3. Centrality indices plot. [*QL* global health status, *PF* physical functioning, *RF* role functioning, *EF* emotional functioning, *CF* cognitive functioning, *SF* social functioning, *FA* fatigue, *NV* nausea and vomiting, *PA* pain, *DY* dyspnea, *SL* insomnia, *AP* appetite loss, *FI* financial difficulty, *DEP* depression, *ANX* anxiety, *DT* distress, *MAAS* mindfulness attention awareness].

emotional functioning can significantly reduce overall QoL. Therefore, prioritizing the assessment of emotional functioning may be essential for enhancing QoL in cancer patients.

Our findings indicate that emotional functioning and trait mindfulness are not only key components of the overall network but also play significant roles within the mind community. Notably, this community reveals complex interrelationships among trait mindfulness, emotional functioning, distress, and depression. Specifically, trait mindfulness had a significant positive relationship with emotional functioning, while emotional functioning demonstrated an inverse relationship with distress. Our results also indicate a direct negative association between trait mindfulness and depression. These findings support the hypothesis that individuals with high trait mindfulness tend to exhibit improved psychological well-being, fewer stress-related symptoms, and better emotional regulation[32–34]. Furthermore, the results of a study suggesting that mindfulness could mediate the relationship between stress and QoL, influencing QoL either directly or indirectly[35], align with our findings. Considering that regularly increasing state mindfulness through meditation enhances trait mindfulness[36], mindfulness-based interventions may reduce distress and improve QoL by strengthening trait mindfulness.

The psychological mechanism by which mindfulness practice reduces symptoms of anxiety, depression, and distress while enhancing emotional functioning is based on attention and acceptance of emotional states[37]. Augmenting trait mindfulness and emotional regulation can reduce the impact of negative thinking patterns including rumination and self-criticism, which often contribute to depressive symptoms[38,39]. Furthermore, self-regulation of attention training encourages individuals to acknowledge and accept their emotions, reduce automatic reactions, and respond to stressors adaptively through emotional regulation rather than by suppressing or avoiding negative emotions[34,39,40].

Physical functioning is a key indicator of overall health and reflects independence in daily activities[41,42]. Consistent with the outcomes of the previous studies, the body community network in our analysis identified that the symptom burden is closely linked to physical functioning[43,44]. In addition, our study indicated that symptoms such as appetite loss, nausea and vomiting, and dyspnea form a cluster of interrelated symptoms that collectively impair physical functioning, with fatigue exhibiting the strongest correlation with physical functioning. This finding aligns with previous studies demonstrating a significant correlation between fatigue and physical functioning[45,46]. Moreover, our findings emphasize the interconnectedness between physical and role functioning, with the latter defined as the ability to engage in work, daily activities, and leisure pursuits[47]. A strong correlation between these two aspects indicates that a decline in physical health, especially with fatigue and pain, can substantially hinder a patient's ability to perform daily tasks and participate in meaningful

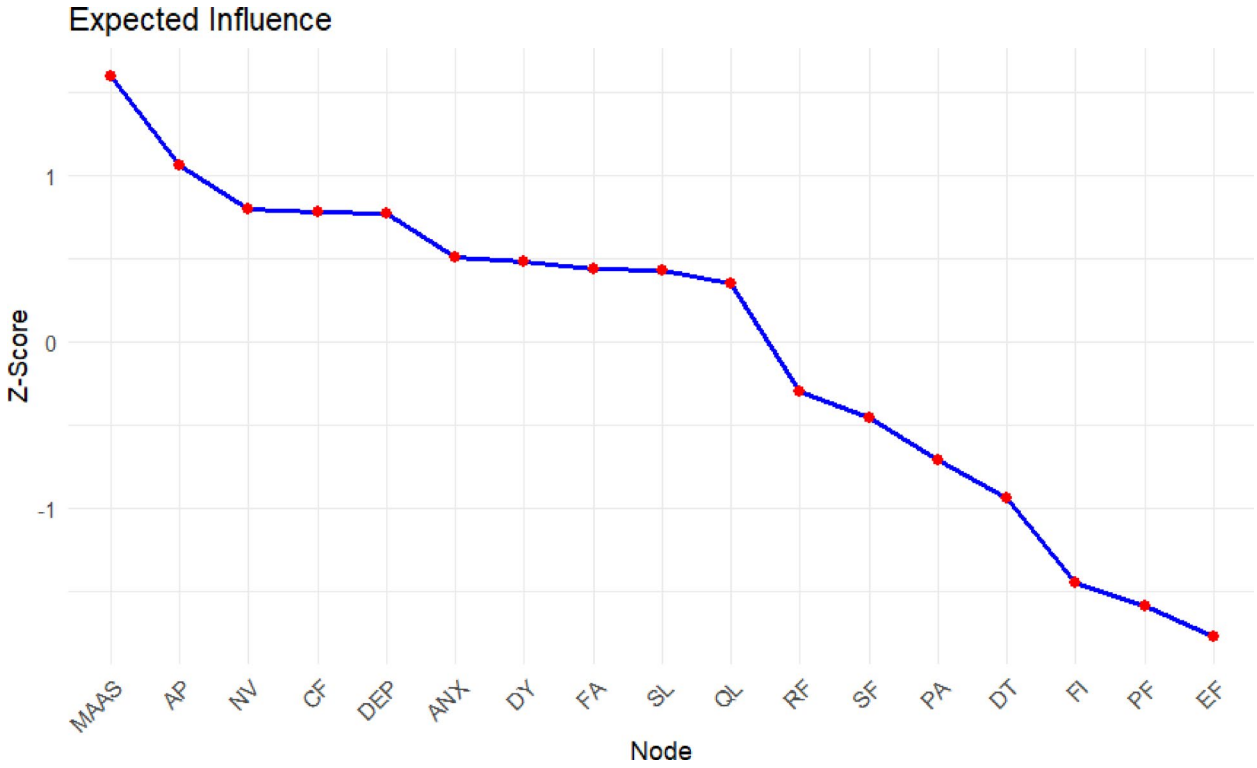

Fig. 4. Expected influence plot. [*MAAS* mindfulness attention awareness, *AP* appetite loss, *NV* nausea and vomiting, *CF* cognitive functioning, *DEP* depression, *ANX* anxiety, *DY* dyspnea, *FA* fatigue, *SL* insomnia, *QL* global health status, *RF* role functioning, *SF* social functioning, *PA* pain, *DT* distress, *FI* financial difficulty, *PF* physical functioning, *EF* emotional functioning]. The Y-axis represents the Z-scores of expected influence, while the X-axis displays the nodes arranged in descending order of the expected influence values.

activities. Based on this finding, we suggest a multi-symptom management approach that targets interrelated symptoms collectively rather than individually, to enhance patient care and improve QoL.

Consistent with previous research[48], our study found that the socioeconomic status community revealed a strong negative association between financial instability and social functioning. Therefore, treatment-related financial difficulties can create significant barriers to patient participation in social activities. Additionally, our network analysis showed that the socioeconomic status community was closely linked to the mind community, particularly through emotional functioning. This suggests that, beyond limiting social activity, financial difficulty also negatively affects mental health, primarily by impairing emotional functioning. Our findings align with those of studies indicating that women with breast cancer experiencing financial difficulty have poor emotional QoL[49]. Another study revealed that emotional distress mediates the relationship between financial difficulty and overall distress[50]. These findings highlight the importance of efforts to reducing patients' financial burdens, as improving financial conditions may positively influence both mental health and emotional functioning.

Our network analysis of QoL in breast cancer patients revealed significant interconnections among emotional functioning, trait mindfulness, and other domains, organized into three distinct yet interconnected communities: mind, body, and socioeconomic status. Emotional functioning and trait mindfulness emerged as central nodes within the mind community, both influencing and being influenced by other domains. The body community primarily reflected physical functioning and symptom burden, whereas the socioeconomic community represented social and economic influences on well-being. Notably, the observed linkage between the mind and body communities aligns with Taoist philosophy, which conceptualizes the mind and body as harmoniously interdependent and balanced, as illustrated by the concept of Yin and Yang[51]. This view is echoed in broader Eastern philosophies, which regard physical, emotional, and spiritual health as integrated foundations of mental well-being[52]. However, our findings should be interpreted with caution, as the analysis reflects associations rather than causal relationships.

Our study has several limitations that should be acknowledged. First, the use of a weighted, undirected network based on cross-sectional data limits the interpretation of observed associations as correlational rather than causal. Second, the correlation stability coefficients for strength centrality in our analysis demonstrate that moderate stability can provide valuable insights into the network structure. However, the betweenness and closeness centralities are more sensitive to data variations, likely reflecting sample size constraints. Larger sample sizes in future studies may enhance the robustness of these centrality indices. Third, the focus on women with breast cancer in this study restricts generalizability to other cancer types. Future studies should include a broad range of cancer populations to gain a comprehensive understanding of how these correlations vary across diverse patient demographics. Finally, assessments were conducted across all cancer stages and treatment phases, the

potential confounding effect of cancer stage and timing of assessment on QoL and mental health issues was not controlled. Future research should recruit a sufficient number of participants from each cancer stage to explore possible differences in network structures according to cancer stage.

This study applied network analysis to explore the complex interrelations among QoL domains, mental health problems, and trait mindfulness in patients with breast cancer. Emotional functioning and trait mindfulness emerged as central nodes. Emotional functioning showed the highest centrality, bridging psychological, physical, and socioeconomic dimensions, while trait mindfulness exhibited the strongest expected influence. These findings underscore the potential benefits of targeting emotional functioning and enhancing trait mindfulness to improve QoL. Future research should examine the role of emotional functioning and its relationship with trait mindfulness in diverse cancer populations. Longitudinal network analyses are required to clarify causal pathways in QoL and guide personalized psychosocial interventions.

Methods

Participants

A cross-sectional study was performed in March 2024 in two specialized oncology Units in Ho Chi Minh City. Women with breast cancer were screened according to predefined recruitment criteria using consecutive sampling. The eligibility criteria included women aged 18 years or older with a confirmed breast cancer diagnosis and receiving treatment, including surgery, chemotherapy, hormone therapy, or radiation therapy, at the study hospitals. Patients with severe medical conditions, such as postoperative status or uncontrolled pain, which made it impossible for them to participate in interviews, as well as those previously diagnosed with any psychiatric disorder by a psychiatrist, were excluded. A total of 196 patients were enrolled in the study.

Following ethical approval and collaboration with the hospital departments, final-year public health students from the University of Medicine and Pharmacy at Ho Chi Minh city were granted permission to approach potential participants, provide information about the study, and screen patients for eligibility. Research team members responsible for conducting the interview were trained by the principal investigator on standardized face-to-face interview techniques, using a structured questionnaire to ensure consistency throughout the interview process. The interviews were conducted when patients were deemed eligible to participate in the study and took place across various treatment phases, ranging from early to late stages. Written informed consent was obtained from all participants prior to the interviews. The study was approved by the Ethics Committee of the University of Medicine and Pharmacy at Ho Chi Minh City (No.390/HĐĐĐ) and Ho Chi Minh City Oncology Hospital (No.323/BVUB- HĐĐĐ). All study protocols were conducted in accordance with the approved guidelines.

Measurements

The participants completed interviews using a structured questionnaire that included standardized questions on sociodemographics (age and education level) and disease-related characteristics (disease duration and cancer stage).

European organization for research and treatment of cancer quality of life questionnaire–core 30 (EORTC–QLQ C30)

The EORTC QLQ-C30, developed by the EORTC QoL group, is a 30-item scale designed to assess various aspects of QoL in patients with cancer[53]. The scale used to assess QoL includes several components: global health-related QoL, five functional scales (physical, role, cognitive, emotional, and social), three symptom scales (fatigue, pain, and nausea/vomiting), and six additional items (dyspnea, insomnia, appetite loss, constipation, diarrhea, and financial difficulty). Raw scores were obtained by averaging item responses and standardized scores were linearly transformed to a 0–100 scale to facilitate comparability across different domains. The QLQ C30 demonstrated high internal consistency, with a Cronbach's alpha of 0.8514[54].

Distress thermometer (DT)

The DT, recommended by the National Comprehensive Cancer Network for screening distress in patients with cancer, involves a single question: "How distressed have you been over the past week, including today?" Participants rated the number on a Likert scale ranging from 0 (not distressed) to 10 (extremely distressed). The DT was translated and employed to screen for psychological distress in a previous study involving Vietnamese patients with cancer[55].

Hospital anxiety and depression scale (HADS)

The HADS is one of the most commonly used instruments in cancer-related contexts. This 14-item self-report questionnaire was utilized to screen for anxiety (HADS-A) and depressive states (HADS-D) in patients in nonpsychiatric settings. Each subscale consists of seven items with a 4-point response, with scores ranging from 0 to 21 for each subscale. We employed the Vietnamese version of the HADS used in previous studies[56]. In this study, the Cronbach's alpha for the HADS was 0.7955, indicating adequate internal consistency[54,57].

Mindful attention awareness scale (MAAS)

The MAAS was developed to evaluate critical aspects of trait mindfulness, characterized by awareness of and attention to the present moment[58]. The 15-item self-response scale assesses how often individuals experience mindfulness in daily life, using a Likert scale ranging from 1 (almost always) to 6 (almost never). The average score of all 15 items was used to calculate the MAAS. This scale has been widely used across various groups, including patients with cancer, to demonstrate its suitability and applicability in assessing the role of trait

mindfulness in psychological health. In this study, Cronbach's alpha for the MAAS was 0.8791, indicating adequate internal consistency[57].

Statistical analysis

Network analysis was performed using the open-source R software. As all variables did not meet the assumption of normal distribution, the nonparanormal transformation method ("huge.npn" function) was applied to align the data with Gaussian Graphical Model (GGM) assumptions[59].

Network estimation

The network was visualized using the "qgraph" package, where each node represented a variable, and edges reflected partial correlations between nodes. To optimize the model selection for the GGM, we applied graphical the Extended Bayesian Information Criterion (EBIC) with regulated LASSO (Least Absolute Shrinkage and Selection Operator) ($\lambda = 0.4$). This approach ensures a sparse and interpretable network that captures crucial relationships without omitting critical connections. Edge weights indicated the strength of conditional dependencies between nodes, accounting for the influence of other nodes in the network[60].

Modularity analysis

In this study, after estimating the network using the "qgraph" package and extracting the weighted matrix, all edge weights in the network were converted to absolute values to ensure consistency in the calculation of centrality measures[61,62]. Next, we performed community detection using the "igraph" package in R to evaluate the community structure of the graph. Community detection identifies clusters of nodes within the network that exhibit higher internal connection density compared to their connections with nodes outside the group[61]. Three main algorithms have been applied for community detection: optimal, spin-glass, and walktrap[62–64]. The results of these algorithms were compared by selecting the algorithm with the highest modularity scores. As a rule of thumb, a modularity value greater than 0.3 indicates a significant community structure[65]. In addition, after community detection, bridge strength is calculated using the "igraph" package in R. It quantifies the importance of a node in connecting multiple communities by summing the edge weights between the node and those in different communities[61].

Edge weight accuracy and stability

The accuracy of the edge weights in the network was evaluated using the "bootnet" package. We performed 1000 bootstrap samples to assess the values surrounding the edge weight, estimating 95% confidence intervals across multiple samples generated by randomly resampling the original data with replacements. If the confidence intervals do not include zero values, this indicates that the edge weights are highly reliable, and the correlations between nodes in the network are stable[59].

Centrality indices, CS, and expected influence

The centrality indices employed in this analysis were node strength, betweenness, and closeness. Node strength reflected connectivity; closeness measured how quickly a node reached others; and betweenness indicated how often a node acted as a bridge. These indices were standardized to z-scores to compare node importance.

CS, estimated using the CS coefficients, assessed the accuracy of these indices. We used bootstrapping with CS via the R package "bootnet" to evaluate how much data could be excluded while maintaining a correlation of at least 0.7 with the original sample. CS coefficients above 0.25, and ideally above 0.5, were recommended[60].

Expected influence, as an extension of strength centrality, measures the total impact of a node in a network by considering both the magnitude and direction of the connection. Unlike other centrality indices, this approach evaluates not only the direct influence between nodes but also their indirect influences. Therefore, it enables the determination of whether a given node plays a central role within the entire network. This is particularly useful in psychological and social networks, where the influence helps identify the most impactful nodes and guide effective interventions[66].

Relative importance analysis

The node with the highest centrality index was selected as the dependent variable for the relative importance analysis. To evaluate the relative importance of each node concerning emotional functioning, we utilized the "relaimpo" R package. This approach focused only on the nodes that exhibited significant correlations with emotional functioning in the stepwise final model. The contribution of each independent variable was measured using the "lmg" metric, which allocated explained variance (R^2) among predictors The "always" parameter was applied to the trait mindfulness variable, based on its highest expected influence, to explore its inclusion in every model subset. Variables with high "lmg" values were identified as significant contributors, while those with low values had minimal impact. To confirm the robustness of these "lmg" estimates, we calculated bootstrap confidence intervals; if the confidence interval for the difference between two "lmg" values did not include zero, it indicated a meaningful difference in their contributions[67,68].

Data availability

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

Received: 12 November 2024; Accepted: 27 June 2025
Published online: 08 July 2025

References

1. Bray, F. et al. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA: A cancer J. Clin.* **74**, 229–263 (2024).
2. Arnold, M. et al. Current and future burden of breast cancer: Global statistics for 2020 and 2040. *The Breast* **66**, 15–23 (2022).
3. Sloan, J. A. et al. The clinical significance of quality of life assessments in oncology: A summary for clinicians. *Support. Care Cancer* **14**, 988–998 (2006).
4. Montazeri, A. Quality of life data as prognostic indicators of survival in cancer patients: An overview of the literature from 1982 to 2008. *Health Qual. Life Outcomes* **7**, 102. https://doi.org/10.1186/1477-7525-7-102 (2009).
5. Arahori, H. et al. Symptomatic adverse events of chemotherapy in breast cancer patients: Using CTCAE, PRO-CTCAE, and EORTC QLQ-C30. *J. Med. Invest.* **71**, 82–91 (2024).
6. Baussard, L. et al. Network analyses applied to the dimensions of cancer-related fatigue in women with breast cancer. *Cancer Med.* **13**, e70268. https://doi.org/10.1002/cam4.70268 (2024).
7. Lee, M. K. et al. Factors affecting health-related quality of life in women with recurrent breast cancer in Korea. *Qual. Life Res.* **16**, 559–569 (2007).
8. İzci, F., İlgün, A. S., Fındıklı, E. & Özmen, V. Psychiatric symptoms and psychosocial problems in patients with breast cancer. *J. Breast Health* **12**, 94–101. https://doi.org/10.5152/tjbh.2016.3041 (2016).
9. Ozkan, M. Psychosocial adaptation during and after breast cancer. In *Breast Disease: Management and Therapies* Vol. 2 (eds Aydiner, A. et al.) 705–727 (Springer International Publishing, 2019).
10. Grusdat, N. P. et al. Routine cancer treatments and their impact on physical function, symptoms of cancer-related fatigue, anxiety, and depression. *Support. Care Cancer* **30**, 3733–3744. https://doi.org/10.1007/s00520-021-06787-5 (2022).
11. Quinten, C. et al. Baseline quality of life as a prognostic indicator of survival: A meta-analysis of individual patient data from EORTC clinical trials. *Lancet Oncol.* **10**, 865–871. https://doi.org/10.1016/S1470-2045(09)70200-1 (2009).
12. Vigano, A. et al. Quality of life and survival prediction in terminal cancer patients. *Cancer* **101**, 1090–1098. https://doi.org/10.1002/cncr.20472 (2004).
13. Kim, S. *World Health Organization Quality of Life (WHOQOL) Assessment* 1–2 (2020).
14. Quinten, C. et al. The effects of age on health-related quality of life in cancer populations: A pooled analysis of randomized controlled trials using the European Organisation for Research and Treatment of Cancer (EORTC) QLQ-C30 involving 6024 cancer patients. *Eur. J. Cancer* **51**, 2808–2819 (2015).
15. Efficace, F. et al. Patient-reported outcomes as independent prognostic factors for survival in oncology: Systematic review and meta-analysis. *Value Health* **24**, 250–267. https://doi.org/10.1016/j.jval.2020.10.017 (2021).
16. Bardwell, W. A. et al. Health-related quality of life in women previously treated for early-stage breast cancer. *Psychooncology* **13**, 595–604. https://doi.org/10.1002/pon.768 (2004).
17. Bower, J. E. et al. Fatigue in breast cancer survivors: Occurrence, correlates, and impact on quality of life. *J. Clin. Oncol.* **18**, 743–743 (2000).
18. Alagizy, H., Soltan, M., Soliman, S., Hegazy, N. & Gohar, S. Anxiety, depression and perceived stress among breast cancer patients: Single institute experience. *Middle East Curr. Psychiatry* **27**, 1–10 (2020).
19. Park, J.-H., Jung, Y. S., Kim, J. Y. & Bae, S. H. Determinants of quality of life in women immediately following the completion of primary treatment of breast cancer: a cross-sectional study. *PLoS ONE* **16**, e0258447 (2021).
20. Park, J. H., Jun, E.-Y., Kang, M.-Y., Joung, Y.-S. & Kim, G.-S. Symptom experience and quality of life in breast cancer survivors. *J. Kor. Acad. Nurs.* **39**, 613–621 (2009).
21. Kim, S. H. et al. Fatigue and depression in disease-free breast cancer survivors: Prevalence, correlates, and association with quality of life. *J. Pain Symptom Manage.* **35**, 644–655 (2008).
22. Visser, M. & Smets, E. Fatigue, depression and quality of life in cancer patients: How are they related?. *Support. Care Cancer* **6**, 101–108 (1998).
23. Sala, M., Rochefort, C., Lui, P. P. & Baldwin, A. S. Trait mindfulness and health behaviours: A meta-analysis. *Health Psychol. Rev.* **14**, 345–393 (2020).
24. Brown, K. W. & Ryan, R. M. Perils and promise in defining and measuring mindfulness: Observations from experience (2004).
25. Tamagawa, R. et al. Trait mindfulness, repression, suppression, and self-reported mood and stress symptoms among women with breast cancer. *J. Clin. Psychol.* **69**, 264–277 (2013).
26. Cole, P. M., Michel, M. K. & Laureen O'Donnell, T. The development of emotion regulation and dysregulation: A clinical perspective. *Monograph. Soc. Res. Child Dev.* **59**, 73–100. https://doi.org/10.2307/1166139 (1994).
27. Van Noyen, L., Markovitz, S., Broers, N. J. & Peters, M. L. Prevalence and predictors of psychological distress in women diagnosed with breast cancer and women without breast cancer: A prospective study of psychological risk and resilience factors. *J. Psychosoc. Oncol. Res. Pract.* **4**, 1–10 (2022).
28. Sanchez, L. et al. Long-term treatment for emotional distress in women with breast cancer. *Eur. J. Oncol. Nurs.* **42**, 126–133 (2019).
29. Mystakidou, K. et al. Assessment of anxiety and depression in advanced cancer patients and their relationship with quality of life. *Qual. Life Res.* **14**, 1825–1833 (2005).
30. Rogers, S. N. et al. Quality of life, cognitive, physical and emotional function at diagnosis predicts head and neck cancer survival: Analysis of cases from the Head and Neck 5000 study. *Eur. Arch. Otorhinolaryngol.* **277**, 1515–1523. https://doi.org/10.1007/s00405-020-05850-x (2020).
31. Giesinger, J. M. et al. Thresholds for clinical importance for four key domains of the EORTC QLQ-C30: Physical functioning, emotional functioning, fatigue and pain. *Health Qual. Life Outcomes* **14**, 1–8 (2016).
32. Van Gordon, W., Shonin, E. & Griffiths, M. D. Mindfulness in mental health: a critical reflection. *J. Psychol. Neuropsychiatr. Disord. Brain Stimulat.* **1** (2015).
33. Kaya, F. & Odacı, H. Subjective well-being: Self-forgiveness, coping self-efficacy, mindfulness, and the role of resilience?. *Br. J. Guid. Couns.* **52**, 628–644 (2024).
34. Keng, S.-L., Smoski, M. J. & Robins, C. J. Effects of mindfulness on psychological health: A review of empirical studies. *Clin. Psychol. Rev.* **31**, 1041–1056 (2011).
35. Dehghan, M. et al. Stress and quality of life of patients with cancer: The mediating role of mindfulness. *J. Oncol.* **2020**, 3289521 (2020).
36. Kiken, L. G., Garland, E. L., Bluth, K., Palsson, O. S. & Gaylord, S. A. From a state to a trait: Trajectories of state mindfulness in meditation during intervention predict changes in trait mindfulness. *Personal. Individ. Differ.* **81**, 41–46. https://doi.org/10.1016/j.paid.2014.12.044 (2015).
37. Grecucci, A., Pappaianni, E., Siugzdaite, R., Theuninck, A. & Job, R. Mindful emotion regulation: Exploring the neurocognitive mechanisms behind mindfulness. *Biomed. Res. Int.* **2015**, 670724 (2015).
38. Bernstein, E. E., Heeren, A. & McNally, R. J. Reexamining trait rumination as a system of repetitive negative thoughts: A network analysis. *J. Behav. Ther. Exp. Psychiatry* **63**, 21–27 (2019).
39. Paul, N. A., Stanton, S. J., Greeson, J. M., Smoski, M. J. & Wang, L. Psychological and neural mechanisms of trait mindfulness in reducing depression vulnerability. *Soc. Cognit. Affect. Neurosci.* **8**, 56–64. https://doi.org/10.1093/scan/nss070 (2012).
40. Lutz, A., Slagter, H. A., Dunne, J. D. & Davidson, R. J. Attention regulation and monitoring in meditation. *Trends Cogn. Sci.* **12**, 163–169 (2008).

41. Nekhlyudov, L. et al. Cancer-related impairments and functional limitations among long-term cancer survivors: Gaps and opportunities for clinical practice. *Cancer* **128**, 222–229 (2022).
42. National Academies of Sciences, E. & Medicine. *Diagnosing and Treating Adult Cancers and Associated Impairments* (The National Academies Press, 2021).
43. Ebbestad, F. E. et al. The long-term burden of a symptom cluster and association with longitudinal physical and emotional functioning in breast cancer survivors. *Acta Oncol.* **62**, 706–713 (2023).
44. Park, J. H. et al. Latent profile analysis for assessing symptom clusters in women with breast cancer. *J. Cancer Surviv.* https://doi.org/10.1007/s11764-024-01648-6 (2024).
45. Poikonen-Saksela, P. et al. A graphical LASSO analysis of global quality of life, sub scales of the EORTC QLQ-C30 instrument and depression in early breast cancer. *Sci. Rep.* **12**, 2112 (2022).
46. Abrahams, H., Gielissen, M., Verhagen, C. & Knoop, H. The relationship of fatigue in breast cancer survivors with quality of life and factors to address in psychological interventions: A systematic review. *Clin. Psychol. Rev.* **63**, 1–11 (2018).
47. Michels, F. A. S., Latorre, M. D. R. D. D. O. & Maciel, M. D. S. Validity, reliability and understanding of the EORTC-C30 and EORTC-BR23, quality of life questionnaires specific for breast cancer. *Rev. Bras. Epidemiol.* **16**, 352–363 (2013).
48. Chen, M.-H. et al. Associations of financial hardship and health status, social functioning, and mental health among cancer survivors in the United States: Findings from a nationally representative study. *JCO Oncol. Pract.* **21**, 78–88 (2025).
49. Perry, L. M. et al. Financial strain and physical and emotional quality of life in breast cancer. *J. Pain Symptom Manage.* **58**, 454–459 (2019).
50. Meeker, C. R. et al. Relationships among financial distress, emotional distress, and overall distress in insured patients with cancer. *J. Oncol. Pract.* **12**, e755-764. https://doi.org/10.1200/jop.2016.011049 (2016).
51. Hartley, L. *Wisdom of the Body Moving: An Introduction to Body-Mind Centering* (North Atlantic Books, 1995).
52. Lee, M. Y., Chan, C. C., Chan, C. L., Ng, S.-M. & Leung, P. P. *Integrative Body-Mind-Spirit Social Work: An Empirically Based Approach to Assessment and Treatment* (Oxford University Press, 2018).
53. Aaronson, N. K. et al. The European organization for research and treatment of cancer QLQ-C30: A quality-of-life instrument for use in international clinical trials in oncology. *JNCI J.: Natl. Cancer Inst.* **85**, 365–376 (1993).
54. Cronbach, L. J. Coefficient alpha and the internal structure of tests. *Psychometrika* **16**, 297–334 (1951).
55. Nguyen, T. Q., Do, T. M. & Pham, T. A. Screening for psychological distress in Vietnamese cancer patients: An evaluation of the distress thermometer. *Cancer Med.* **10**, 7793–7803 (2021).
56. Ha, L. et al. Utilization of hospital anxiety and depression scale to measure mental disorders of patients with lung cancer in Vietnam: A cross-sectional study. *Int. J. Healthc. Manag.* https://doi.org/10.1080/20479700.2024.2331914 (2024).
57. Bland, J. M. & Altman, D. G. Statistics notes: Cronbach's alpha. *BMJ* **314**, 572 (1997).
58. MacKillop, J. & Anderson, E. J. Further psychometric validation of the mindful attention awareness scale (MAAS). *J. Psychopathol. Behav. Assess.* **29**, 289–293 (2007).
59. Epskamp, S., Borsboom, D. & Fried, E. I. Estimating psychological networks and their accuracy: A tutorial paper. *Behav. Res. Methods* **50**, 195–212 (2018).
60. Hevey, D. Network analysis: a brief overview and tutorial. *Health Psychol. Behav. Med.* **6**, 301–328 (2018).
61. Radicchi, F., Castellano, C., Cecconi, F., Loreto, V. & Parisi, D. Defining and identifying communities in networks. *Proc. Natl. Acad. Sci.* **101**, 2658–2663 (2004).
62. Rodrigues, F. A. Network centrality: An introduction. *A mathematical modeling approach from nonlinear dynamics to complex systems*, 177–196 (2019).
63. Traag, V. A. & Bruggeman, J. Community detection in networks with positive and negative links. *Phys. Rev. E: Stat. Nonlinear Soft Matter Phys.* **80**, 036115 (2009).
64. Pons, P. & Latapy, M. Computing communities in large networks using random walks. in *Computer and Information Sciences-ISCIS 2005: 20th International Symposium, Istanbul, Turkey, October 26–28, 2005. Proceedings 20* 284–293 (Springer, 2005).
65. Newman, M. E. Analysis of weighted networks. *Phys. Rev. E: Stat. Nonlinear Soft Matter Phys.* **70**, 056131 (2004).
66. Robinaugh, D. J., Millner, A. J. & McNally, R. J. Identifying highly influential nodes in the complicated grief network. *J. Abnorm. Psychol.* **125**, 747 (2016).
67. Brusco, M., Watts, A. L. & Steinley, D. A modified approach to fitting relative importance networks. *Psychol. Methods* **29**, 1 (2024).
68. Grömping, U. Relative importance for linear regression in R: The package relaimpo. *J. Stat. Softw.* **17**, 1–27 (2007).

Acknowledgements

This study was supported by a MEF Fellowship conducted as part of "Education and Research capacity building project at University of Medicine and Pharmacy at Ho Chi Minh City" implemented by the Korea International Cooperation Agency (KOICA) in 2024 (No. 2021-00020-3), and a faculty research grant of Yonsei University College of Medicine (6-2024-0065).

Author contributions

LXK and CIP contributed to the study's conception and design. BNHT and DXP collected the clinical data. LXK and STK performed the analysis. LXK and CIP interpreted the results and wrote the manuscript. DVD, JIK, SJK, and CIP reviewed and supervised the study. All authors read and approved the final manuscript.

Declarations

Competing interests

The authors declare no competing interests.

Ethics approval

The study received ethical approval from the Ethics Committee of the University of Medicine and Pharmacy at Ho Chi Minh City (No.390/HĐĐĐ) and Ho Chi Minh City Oncology Hospital (No.323/BVUB- HĐĐĐ).

Consent to participate/publish

Written informed consent was obtained from all participants before the interviews.

Additional information

Supplementary Information The online version contains supplementary material available at https://doi.org/1

0.1038/s41598-025-09550-6.

Correspondence and requests for materials should be addressed to C.I.P.