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Research Paper

Symptom networks analysis among people with Meniere's disease: Application for nursing care

Xuejiao Cao [a], Yue Zhou [b], Tang Li [c], Chennan Wang [a], Peixia Wu [d, *]

[a] School of Nursing, Fudan University, Shanghai, China
[b] Department of Emergency Medicine, West China Hospital, Sichuan University, Chengdu, China
[c] Business School, Nanjing University, Nanjing, China
[d] Department of Nursing, Eye and ENT Hospital of Fudan University, Shanghai, China

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ABSTRACT

Objectives: This study aimed to explore and visualize the relationships among multiple symptoms in patients with Meniere's disease (MD) and aid clinical nurses in the design of accurate, individualized interventions.

Methods: This study included 790 patients with MD at the Eye and ENT Hospital of Fudan University from October 2014 to December 2021. A self-designed symptom checklist was used to assess 15 MD-related symptoms and construct contemporaneous networks with all 15 symptoms in R software. Qgraph package and Fruchterman-Reingold layout were used for network visualization. Bootstrapping methods were performed to assess network accuracy and stability, and three centrality indices were adopted to describe relationships among symptoms.

Results: Symptom networks showed good accuracy and stability. "Anxiety and nervousness"(98.2%), "aural fullness"(84.4%) and "tinnitus"(82.7%) were the common symptom in MD patients, while "tinnitus", "aural fullness" and "decline in word recognition", were more serious. MD patients with longer disease duration had higher prevalence and severity for all symptoms ($P < 0.05$). Symptom networks showed good accuracy and stability. "Decline in word recognition," "fatigue," and "anxiety and nervousness" were at the center of the symptom networks, which had the largest strength values and closeness. "Decline in word recognition," "headache," and "spatial discrimination and poor orientation" were the symptoms with the highest betweenness with the strongest bridging effect. The ≥1-year disease group exhibited higher centralities for "drop attack" and "anxiety and nervousness," and a lower centrality for "headache" compared with the <1-year disease group.

Conclusions: The symptom networks of MD patients with varying disease durations were revealed. Clinicians and nurses must provide precision interventions tailored to modifying symptom severity and centrality. Nursing interventions should focus on word recognition issues and associated discomfort in MD patients with multiple symptoms.

What is known?

- Meniere's disease (MD) refers to a common inner ear disorder, and patients often experience multiple symptoms simultaneously, which encompass physical and psychological aspects.
- Identification of the interaction between complex symptoms in patients with MD can help clinical nurses in designing accurate and individualized interventions.

What is new?

- This study constructed symptom networks for patients with MD in the entire sample and two subgroups and analyzed their centrality properties.

* Corresponding author.
E-mail address: 13524844652@163.com (P. Wu).
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- "Anxiety and nervousness" emerged as the most common symptom and "tinnitus" as the most severe, and "decline in word recognition" occupied a central position in the symptom network despite not being the most prevalent or severe symptom.

1. Introduction

Meniere's disease (MD) is the most known vertigo disease, and it is characterized by unpredictable attacks and severely influences the quality of life of those affected [1]. The prevalence of this condition approximates 50 to 200 per 100,000 adults [2,3], and the odds of MD is marginally higher in females, the older, and the obese [4]. Endolymphatic hydrops (EH), a characteristic of MD, refers to the excessive accumulation of endolymph in the cochlea and vestibular system in the inner ear [5]. However, the association of MD symptoms with EH is not clear owing to insufficient data [6]. Some patients manifest only cochlear or vestibular symptoms regardless of having EH in the cochlea and vestibule. MD patients experienced multiple symptoms simultaneously [7]. Vertigo, hearing loss, tinnitus, and aural fullness are the most prevalent and typical symptoms [8]. These symptoms may be accompanied with gait problems, postural instability, and drop attacks. Clinical evidence indicates that initial symptoms include only one of the typical features; 41.2% of patients start experiencing vertigo with or without tinnitus and aural fullness, whereas hearing loss as the sole symptom occurs considerably less frequently [9]. Symptoms may occur abruptly; episodic attacks generally last from 20 min to 24 h and are often accompanied with imbalance, sweating, nausea, and vomiting [10]. Moreover, activity limitations and participation restrictions are important features of MD [11]. In addition to somatic symptoms, MD patients can experience psychological vulnerability, which stems from their stigma experiences [12]; drop attacks in the presence of other people are considered distressing and humiliating [13,14]. Emotional instability, anxiety, and depression are the main adverse psychological conditions observed in MD patients [15]. Identification and management of these symptoms are critical because high levels of symptom burden decrease individuals' physical and psychological function and life quality [16]. However, most studies explored symptoms independently and ignored the complex relationships among various physical and psychological symptoms [17–19].

Network analysis provides a means to evaluate complex symptoms of diseases [20]. Such approaches conceptualize diseases as systems of causally connected symptoms [21]. Network analysis provides a nuanced lens through which nursing practitioners can deepen their comprehension of the intricate interplay among various symptoms in clinical manifestations of patients [20,22] and empirical evidence for the development of personalized and precise symptom-management strategies. This method extends beyond isolated symptom descriptions or clusters for capturing complex and dynamic symptom relationships. In most conditions, symptoms can influence and exacerbate mutually, and these interactions can be overlooked in single-symptom descriptions or traditional cluster analysis. However, few studies have explored the symptom networks of multidimensional symptom experiences in MD patients. From a perspective that evaluates symptom interaction, the core symptoms in MD patients remain unclear. Thus, nursing professionals cannot tailor interventions to address symptoms that bear the utmost relevance to individual patients.

Therefore, this study aimed to 1) generate symptom networks of multidimensional symptom experiences of MD patients and 2) explore the corresponding centrality indices. Based on the symptoms network and analysis of network-centric indicators, this study explored core network symptoms to help researchers and clinicians identify interactions between symptoms and therefore help clinical nurses in designing accurate and individualized interventions.

2. Methods

2.1. Study setting and participants

We conducted a survey study at the Eye and ENT Hospital of Fudan University from October 2014 to December 2021. A total of 981 patients with MD were conveniently sampled. The participants were included if they 1) had been diagnosed with definite MD by the diagnostic criteria by the Chinese Medical Association otolaryngology Branch [23] or American Academy of Otolaryngology–Head and Neck Surgery [24], and had a diagnosis confirmed by magnetic resonance imaging of EH with gadolinium chelate as the contrast agent, 2) were followed up at the surveyed hospitals, 3) aged 18 years and over; 4) showed clear consciousness and can communicate and read normally. They were excluded if MD was observed in combination with other inner-ear diseases. A total of 191 patients were excluded due to incomplete data, which left 790 patients for the final analysis with a 19% attrition rate.

2.2. Measurement

2.2.1. Sociodemographic and clinical data

Sociodemographic and clinical data, including age, gender, marital status, and endolymphatic hydrops, were collected using a general information questionnaire.

2.2.2. Symptoms

A symptom checklist was designed via expert consultation to assess the prevalence and severity of 15 MD-related symptoms. Specifically, the symptom checklist was developed in two rounds of focus groups in June 2014 and August 2014. Before the group discussion, researchers, by reviewing literature and guidelines, outlined the main clinical symptoms of Meniere's disease. During the focus group, specialists discussed each symptom separately and ultimately identified 15 MD-related symptoms along with their severity classifications. Participants of the focus groups were 25 otolaryngology experts, focused on Meniere's disease as their main research direction. Focus group discussions were conducted in a preestablished conference room at the Eye and ENT Hospital of Fudan University. Participants were arranged to sit around a table for face-to-face discussions, and each focus group session lasted approximately 120 min. Given the extensive duration of data collection, which spanned seven years, and the update of clinical practice guidelines for MD in 2020, researchers conducted another expert consultation regarding the symptom checklist in 2020. The experts unanimously agreed that the checklist remains applicable given the absence of notable adjustments in the clinical manifestations of MD.

The final checklist covered two dimensions: psychological and physiological symptoms, with a total of 15 items. Symptoms included spatial discrimination and poor orientation, fatigue, anxiety and nervousness, feeling difficulty in memorizing and concentrating, low mood, drop attack, aural fullness, decline in word recognition, hearing loss, visual instability, dizziness, headache, tinnitus, and feeling difficult to keep balance. Except for drop attack and fatigue, the responses ranged from severe (0) to no (4). The whole checklist presented a good expert validity and the scale-level content validity index (S-CVI) was 0.92.

2.3. Ethical considerations

The Institute of ethical review board of Eye and ENT Hospital of Fudan University approved this study (reference No. 2022069). All participants signed informed consent prior to data collection.

2.4. Data collection

The investigation team of this research included two otolaryngologists and three nurses. Otolaryngologists were responsible for the diagnosis of MD and the participant's inclusion, while the nurses were responsible for the collection and organization of data. To avoid bias, this research did not change the members of the investigation team during the data collection process. Patients diagnosed with MD in the otolaryngology outpatient clinic and who met the inclusion criteria were provided with a thorough explanation of the study's objectives. Patients who expressed willingness to participate signed informed consents. Then, the nurses collected the symptoms of participants by asking the following question: "During the last six months, did you have the following symptoms? If you have, please rate the severity of these symptoms." And finally, the demographic information was collected. Each investigation duration was 30 min or so.

2.5. Data analysis

R software was used in all statistical analyses. Demographic variables and the prevalence of symptoms were described using frequencies, percentages, means, and standard deviations. Symptom severity was represented using median and quartiles because these data did not follow a normal distribution. Continuous variables were subjected to intergroup comparisons using *t*-tests, while chi-square (χ^2) tests were used for categorical variables.

Network analysis. 1) Symptom network construction and visualization. We constructed networks containing all 15 symptoms and visualized the network using the *graph* package. Each node represents a type of symptom, and edges denote the conditional independent relationships between two nodes. In the *Fruchterman–Reingold* algorithm, nodes with strong connections are placed close to each other at the center of the network. A subgroup analysis was performed to identify differences in networks among populations with various disease durations (< 1 year and ≥1 year) to identify real relationships among the 15 symptoms after controlling for confounding factors [25]. 2) Network indices. The absolute value of all Spearman coefficients between two nodes, which was also applied in a previous study as an indicator for long-term prognosis, was used as an indicator of network density. The accuracy and stability of the network were assessed using bootstrapping methods and the R package *bootnet*. The accuracy of estimated network connections was evaluated through the calculation of the 95% confidence intervals (CIs) of edge weight values. Stability was evaluated via calculation of the correlation stability (CS) coefficient of the expected impact of nodes. It was generally agreed that a CS coefficient greater than 0.5 represented better stability [26]. 3) Note indices. Node centrality is an indicator for the identification of core symptoms from a mechanism perspective. Centrality analysis was conducted using three centrality indices: strength, closeness, and betweenness [22]. Symptoms with high values of strength, betweenness, and closeness were regarded as important. Strength is a measure of network connectivity and refers to the capability of symptoms to affect other symptoms. The greater the strength, the higher the probability that a symptom will cooccur with other symptoms. Closeness centrality represents the average farness (inverse distance) from one node to all other nodes, and it was used to reflect the core position of network symptoms. Betweenness centrality was used to reflect the number of shortest paths through the symptoms, that is, the bridging role of network symptoms. *P* values less than 0.05 were considered statistically significant. 4) Difference tests. Finally, to identify differences in the estimations of network connections and centrality for various variables, we conducted difference tests between edge weights and centrality indices in the least absolute shrinkage and selection operator regularization of partial correlation networks based on polychoric correlation matrices.

3. Results

3.1. Participant demographics

This study included 790 participants in the analysis, representing a return rate of 81%. A total of 191 patients were excluded due to incomplete data. Table 1 shows the characteristics of the participants. Most of the participants were male ($n = 418$, 52.91%) and had vestibular and cochlear EH ($n = 553$, 70.0%). The majority were diagnosed within one year ($n_1 = 570$, 72.2%), and others within one to six years ($n_2 = 220$, 27.8%). No statistically significant difference was observed in the age, gender, and EH of those with <1 and ≥ 1-year diagnosis ($P > 0.05$) (Table 1).

3.2. Symptom prevalence and severity

Table 2 and Fig. 1 shows the prevalence and severity of symptoms. The most prevalent symptoms in the full sample included "anxiety and nervousness" (98.2%), "aural fullness" (84.4%), and "tinnitus" (82.7%). "Tinnitus" was the most serious symptom, followed by "aural fullness" and "decline in word recognition." Between the two groups, MD patients who had been diagnosed after more than one year showed higher prevalence and severity for all symptoms. The prevalence and severity score of the "<1 year" group differed from that of the group with over 1 year of MD ($P < 0.05$).

3.3. Density, accuracy, and stability of symptom networks

Fig. 2 displays the symptom network of MD patients in the full sample and two subgroups. The nonzero correlation ratios in the three network graphs reached 83/105, 92/105, and 80/105. The network densities were 0.79, 0.88, and 0.76 respectively, which refers to the ratio between the actual number of edges present and the potential number of edges in a network. Bootstrap analysis results on edge weights revealed that the bootstrapped CIs were small in the full sample and two subgroups, which indicates good network accuracy (Appendix A). In addition, the results for the bootstrap subset revealed that the correlation stability coefficients were 0.75, 0.75, and 0.75 for expected influence in the full sample and two subgroups, which imply a good stability (Appendix B).

3.4. Note centrality indices

Fig. 3 shows three centrality indices in the sample, including strength, closeness, and betweenness. "Decline in word recognition," "fatigue," and "anxiety and nervousness," which are at the core of the symptom network, had the largest strength values and closeness in the full sample, and most affect other symptoms. "Decline in word recognition," "headache," and "spatial discrimination and poor orientation" were the symptoms with the highest betweenness in the full sample with the strongest bridging effect.

The ≥ 1 year subgroup patients had a higher closeness and betweenness among "drop attack" and higher strength and betweenness of "anxiety and nervousness." Thus, the centrality of

Table 1
The characteristics of patients ($N = 790$).

Characteristics	Full Sample ($N = 790$)	< 1 year ($n = 570$)	≥1 year ($n = 220$)	t/χ^2	P
Age	54.77 ± 13.13	54.96 ± 13.09	54.28 ± 13.25	0.658	0.511
Gender				0.131	0.702
Male	418 (52.91)	304 (53.33)	114 (51.82)		
Female	372 (47.09)	266 (46.67)	106 (48.18)		
Marital status				20.030	0.001
Married	252 (31.90)	160 (28.07)	92 (41.82)		
Unmarried	180 (22.78)	135 (23.68)	45 (20.45)		
Otherwise	358 (45.32)	275 (48.25)	83 (37.73)		
Endolymphatic hydrops				1.354	0.716
Vestibular hydrops	131 (16.58)	95 (16.67)	36 (16.36)		
Cochlear hydrops	56 (7.09)	44 (7.72)	12 (5.46)		
Both	553 (70.0)	396 (69.47)	157 (71.36)		
Otherwise	50 (6.33)	35 (6.14)	15 (6.82)		

Note: Data are *n* (%) and *Mean* ± *SD*.

Table 2
Prevalence and severity of symptoms among patients and the comparison of prevalence between the two groups ($N = 790$).

Symptoms	Full Sample ($N = 790$)		< 1 year ($n = 570$)		≥1 year ($n = 220$)		χ^2	P
	Prevalence (%)	Severity *Median* (P_{25}, P_{75}), *Mean*	Prevalence (%)	Severity *Median* (P_{25}, P_{75}), *Mean*	Prevalence (%)	Severity *Median* (P_{25}, P_{75}), *Mean*		
A. drop attack	15.1	-	15.1	-	15.1	-	0.017	0.898
B. aural fullness	84.4	2 (1, 3), 2.14	82.6	2 (1, 3), 2.22	89.1	2 (1, 3), 1.91	11.650	0.020
C. spatial discrimination and poor orientation	38.7	4 (3, 4), 3.41	35.6	4 (3, 4), 3.45	46.8	4 (3, 4), 3.30	10.949	0.027
D. decline in word recognition	79.4	3 (2, 3), 2.57	75.6	3 (2, 3), 2.68	89.1	3 (1, 3), 2.31	23.465	< 0.001
E. hearing loss	71.0	3 (2, 4), 2.59	67.4	3 (2, 4), 2.66	80.5	2 (1, 3), 2.41	15.259	0.004
F. visual instability	50.5	3 (3, 4), 3.21	43.9	4 (3, 4), 3.34	67.7	3 (2, 4), 2.85	50.211	< 0.001
G. fatigue	49.6	-	44.7	-	62.3	-	19.961	< 0.001
H. anxiety and nervousness	98.2	3 (2, 4), 2.89	98.2	3 (2, 4), 2.91	98.2	3 (2, 4), 2.83	17.876	0.001
I. dizziness	35.3	4 (2, 4), 3.13	32.3	4 (2, 4), 3.21	43.2	4 (2, 4), 2.91	11.179	0.025
J. headache	73.7	3 (3, 4), 3.03	71.2	3 (3, 4), 3.06	78.6	3 (3, 3), 2.97	3.900	0.272
K. tinnitus	82.7	1 (1, 3), 1.84	80.0	1 (1, 3), 1.93	89.5	1 (1, 2), 1.60	12.756	0.013
L. feeling difficult in memorizing	53.8	3 (3, 4), 3.30	52.3	3 (3, 4), 3.32	57.7	3 (3, 4), 3.24	2.520	0.472
M. feeling difficult to keep balance	9.9	4 (4, 4), 3.85	8.1	4 (4, 4), 3.88	14.5	4 (4, 4), 3.77	7.886	0.048
N. feeling difficult in concentrating	53.0	3 (3, 4), 3.32	50.5	3 (3, 4), 3.36	59.5	3 (3, 4), 3.23	5.700	0.127
O. low mood	47.5	4 (3, 4), 3.24	44.2	4 (3, 4), 3.27	55.9	3 (3,4), 3.15	17.430	0.002

Note: The scores did not conform to the normal distribution, which was represented by *Median* (P_{25}, P_{75}), and the *Mean* was used as auxiliary data to evaluate.

"drop attack" and "anxiety and nervousness" increased along with the disease process, but that of "headache" showed a decrease. In the overall observation, the centrality of symptom intensity in the ≥ 1 year group was greater than or equal to that of the <1 year group. The above results revealed the evolution of symptoms over time.

3.5. Difference tests of symptom networks

In the full sample, the bootstrapped difference test for edge weights indicated that the two strongest edge weights, namely, "L (feeling difficult in memorizing) and N (feeling difficult in concentrating)" and "H (anxiety and nervousness) and J (headache)," significantly differed from the other edge weights (Appendix C). In the results of the bootstrapped node difference test, "decline in word recognition" significantly differed from other nodes (DTs = 1.80). The results were not significantly different in the various subgroup samples (Appendix D).

4. Discussion

This research extensively investigated and analyzed the complex symptoms reported by MD patients. We observed that "anxiety and nervousness" was the most common symptom, and "tinnitus" was deemed the most severe. "Decline in word recognition" was the core symptom. MD patients with a long disease duration had a high prevalence and severity for all symptoms. In the ≥1-year disease group, "drop attack" and "anxiety and nervousness" showed a higher centrality, whereas "headache" had a lower centrality in the < 1-year disease group. These findings can serve as valuable references and offer important considerations for clinical practices and nursing care.

First, we observed that the vast majority of MD patients suffered from varying levels of anxiety and nervousness. These conditions were in part attributed to the unpredictability of vertigo and drop attacks [27]. Vertigo in MD arises due to abnormal excitability or cessation of sensory input from the affected ear caused by fluid disturbance in the inner ear [28]. Serious drop attacks occurred in

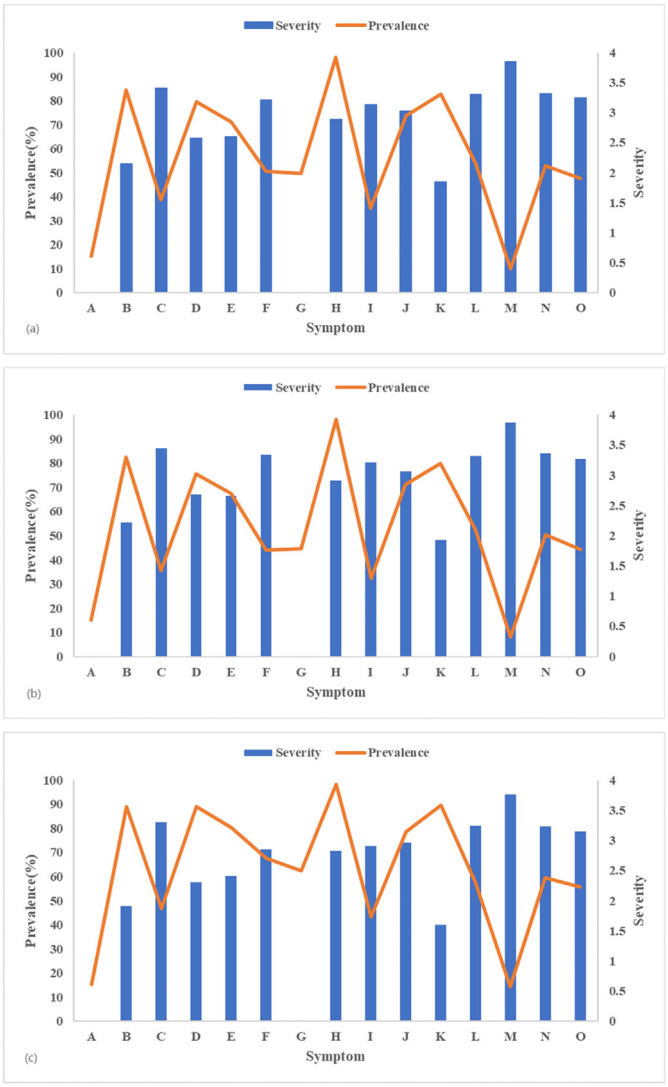

Fig. 1. Prevalence and severity of Meniere's disease-related symptoms. A = drop attack. B = aural fullness. C = spatial discrimination and poor orientation. D = decline in word recognition. E = hearing loss. F = visual instability. G = fatigue. H = anxiety and nervousness. I = dizziness. J = headache. K = tinnitus. L = feeling difficult in memorizing. M = feeling difficult to keep balance. N = feeling difficult in concentrating. O = low mood. (a) Full sample; (b) <1 year; (c) ≥1 year.

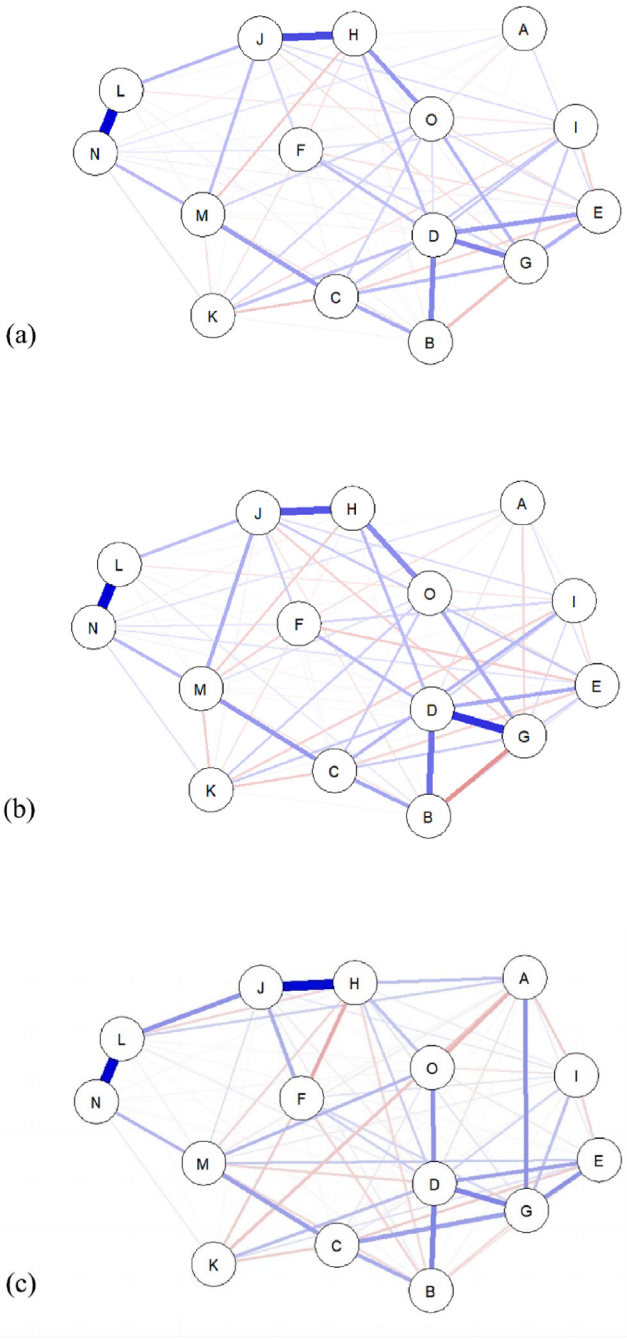

Fig. 2. Symptom networks of Meniere's disease patients with different disease durations. A = drop attack. B = aural fullness. C = spatial discrimination and poor orientation. D = decline in word recognition. E = hearing loss. F = visual instability. G = fatigue. H = anxiety and nervousness. I = dizziness. J = headache. K = tinnitus. L = feeling difficult in memorizing. M = feeling difficult to keep balance. N = feeling difficult in concentrating. O = low mood. (a) Full sample; (b) < 1 year; (c) ≥1 year. The thicker edge represents the closer relationship between two nodes, indicating a stronger interaction. Blue edge represents a positive interaction, while red represents a negative correlation.

6% of MD patients [29], and some milder types of drop attack occurred in 72% of MD patients [30], usually with advanced-stage disease. Vertigo and drop attack are considered a loss of bodily control competence for patients [31], which has a negative and long-lasting effect on their sense of themselves and may be accompanied with anxiety and nervousness. According to researchers, MD patients suffering from anxiety can negatively affect disease progression; in addition, psychological factors play a major role during the whole disease course [31,32]. Similarly, "anxiety and nervousness" is one of the core symptoms of MD patients at all durations of the disease in this study. This finding indicates that for long-term patients, early detection and psychological adjustments that relieve emotional distress should be crucial components of long-term management. Negative perceptions and fear of somatic symptoms can be subject to modification in cognitive psychotherapy [33]. For patients with vertigo, the psychological impact of vestibular rehabilitation, which can foster cognitive habituation to symptoms and instill confidence in the predictability and controllability of symptoms, has also been proven [34]. Monitoring and addressing symptoms effectively are also crucial in managing patients with vestibular disorders to prevent the development or exacerbation of secondary depressive and anxiety symptoms. Future nursing practice should delve deeper into cognitive behavioral therapy, integrate them into nursing care, and pay attention to

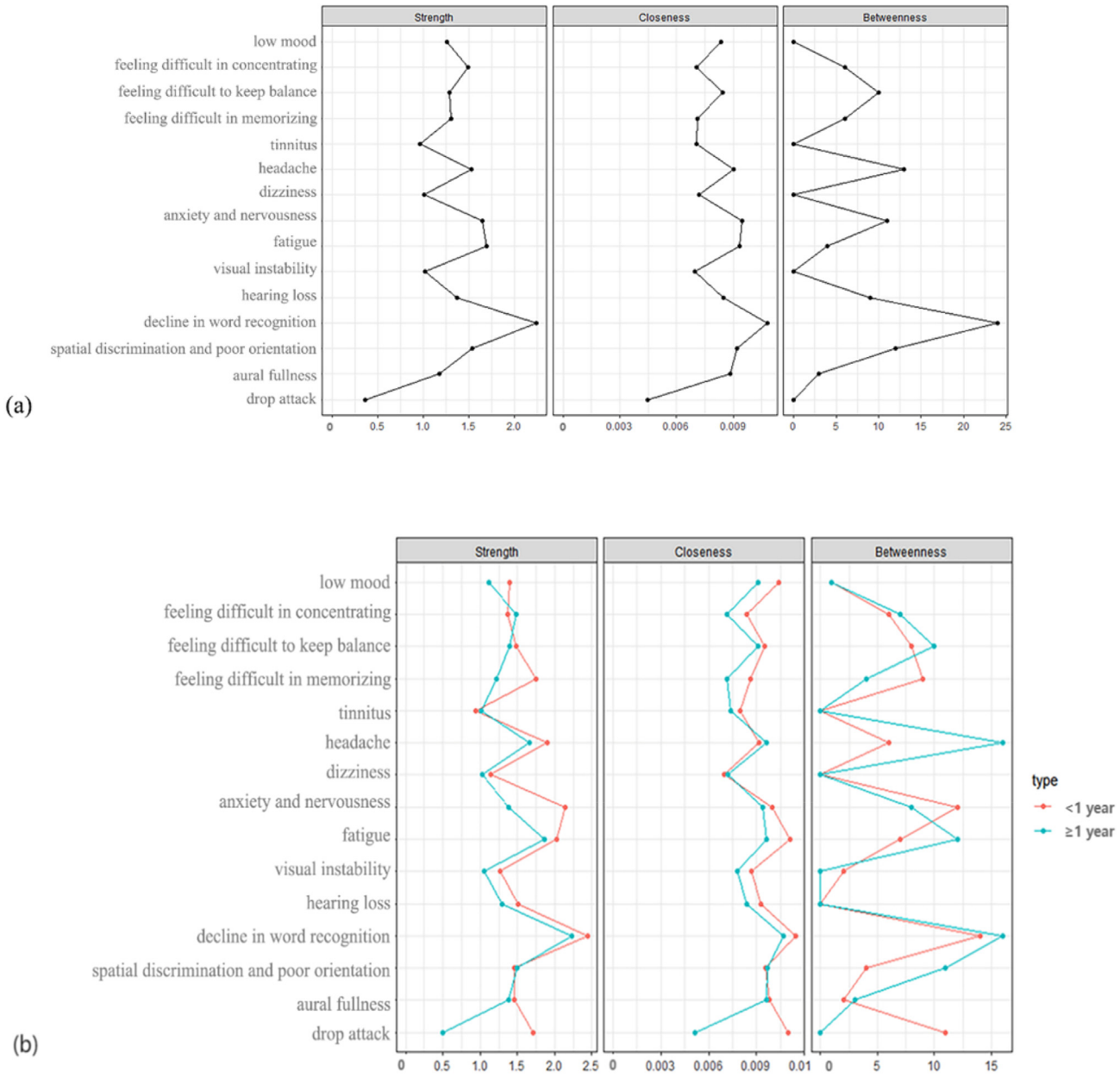

Fig. 3. Centrality of symptom networks of Meniere's disease patients with different disease durations. (a) Full sample; (b) < 1 year and ≥1 year.

the psychological effects of vestibular rehabilitation to help MD patients cope better with their anxiety and nervousness.

We also observed that tinnitus was one of the most serious symptoms, especially in patients with long disease duration, whereas the centrality of tinnitus was lower than that of the majority of other symptoms. Tinnitus is one of the most common nonvertigo symptoms observed in MD in remission and can substantially affect the patient's quality of life [35]. However, our results indicate that tinnitus may not be the central symptom despite its high prevalence. The possible reason was that some patients became habituated to their tinnitus gradually and did not complain regarding any disturbance, a condition called compensated tinnitus [36]. This result was in line with that of previous study showing that some patients can adapt to tinnitus, especially those with a long disease duration [37]. Therefore, tinnitus in these patients no longer seriously affects their daily life and did not interact with other symptoms. Based on the above findings, guidance must be provided to patients to foster adaptability to tinnitus. Clinical practice needs the promotion and implementation of nurse-led sound therapy within the clinical setting and through outpatient care, which can facilitated by electronic health technologies to provide personalized guidance and interventions and avoid the anxiety and depression caused by tinnitus.

The results show that the decline in word recognition affected other symptoms of MD patients as an important bridging symptom. Although decline in word recognition is not the symptom with the highest incidence and severity, it played a central role in bridging MD-related symptoms and symptom clusters, which is also an effective target for disease treatment, and intervention. The mechanism of word recognition decline in MD is multifaceted. MD often precipitates sensorineural hearing loss, a type of auditory impairment that stems from the damage incurred by delicate

sensory hair cells within the cochlea and auditory nerve [38]. This pathophysiological aspect adversely affects one's ability to perceive, decipher, and process auditory signals. Thus, individuals with MD may encounter formidable challenges in the recognition and discernment of words, especially in environments characterized by ambient noise [39]. The bridging effect of a decline in word recognition is attributable to its close association with other MD-related symptoms. Studies have shown that the decline in word recognition score depends largely on the degree of hearing loss [40]. Tinnitus can also divert a patient's attention away from spoken language, which exacerbates word recognition difficulties [41]. A previous comparative study demonstrated that MD patients exhibited lower word recognition capabilities compared to the general population and this kind of cognitive function in MD patients were found to be associated with depression scores [42]. Another study also found that word recognition score is not only related to acoustic and physiological factors but also phonetics and psychology [43]. Therefore, we suggest that by incorporating psychological support from medical means, nursing personnel should help patients cope with speech perception. Nurses can play a supportive and collaborative role in offering social support to patients facing challenges with word recognition, especially in the development of personalized communication strategies and fostering understanding and patience among family members and peers. If necessary, patients can also benefit from various assistive listening devices [44].

Furthermore, we conducted a comparative analysis of symptom networks among patients with varying disease durations and observed that the centrality of symptom intensity of the ≥1-year group was greater than or equal to that of the <1-year group, which indicates that the influence of symptoms on other symptoms gradually deepened with disease development. Despite the largely similar network structures across the two samples, several significant differences were observed in the node centrality and edge weight. Headache had a greater centrality in the <1-year group only, whereas "drop attack" and "anxiety and nervousness" had a higher centrality among people with a long disease duration. These findings suggest the possible role of drop attack and psychological disorders in the activation of other symptoms during disease progression. Despite their rarity in MD patients, imbalance and drop attack often lead to serious injury. After multiple attacks, patients' anxiety and fear seriously affect their confidence in diseases, which can exacerbate the situation. Early vestibular rehabilitation effectively reduces the risk of fall and obtains better prognosis via improved vestibular function. Therefore, caregivers should commence vestibular rehabilitation in the early stages of the disease while concurrently improving accessibility and compliance of vestibular rehabilitation in MD patients and pay more attention to the drop attack situation and psychological status of patients with a long disease duration.

Overall, this study is the first to explore symptom networks among patients with MD in China. Concrete conclusions were drawn using sufficient sample size and adequate statistical power to draw. However, this study encountered several limitations. First, this is on a survey study sample. The design limited our conclusions. Our results should be extended using a longitudinal cohort design to test for causality. Next, we used the sample from a tertiary ENT specialized hospital that may not be representative of the entire population. Third, the majority of patients involved in the research had short disease duration, which engendered an imbalance in the sample sizes between the two subgroups and possibly imparted bias to the study outcomes. In the future, we explore the causality among symptoms and markers of interventions hope to develop dynamic symptom networks and follow the trajectories of centrality indices in longitudinal data.

5. Conclusions

This study revealed symptom networks in 790 MD patients with various diseases durations. We suggested the need to provide precision intervention targeting MD patients based on their changing symptom severity and centrality. Nursing interventions should focus on word recognition issues and associated discomfort in MD patients presenting multiple symptoms.

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The funding organization hasn't had any roles in the survey's design, implementation, and analysis.

Data availability statement

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

CRediT authorship contribution statement

Xuejiao Cao: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing - original draft, Writing - review & editing, Project administration. **Yue Zhou:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing - review & editing, Supervision, Project administration. **Tang Li:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing - review & editing. **Chennan Wang:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Writing - review & editing. **Peixia Wu:** Conceptualization, Methodology, Validation, Formal analysis, Funding acquisition, Writing - review & editing, Supervision, Project administration.

Declaration of competing interest

The authors have no relevant financial or non-financial interests to disclose.

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Appendices. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijnss.2024.03.014.

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