

RESEARCH

Open Access



Application of DASS-21 in Chinese students: invariance testing and network analysis

Zheng Zhang^{1,2,11†}, Ruoheng Lin^{2†}, Andi Qiu³, Huifeng Wu¹¹, Shuo Wu^{4,5}, Le Zhang^{6,7,8}, Zijun Wu⁹, Mengna Li¹⁰, Xiangbin Zhang^{6,7,8*} and Jiansong Zhou^{2*}

Abstract

Background The Depression Anxiety Stress Scale-21 Items (DASS-21) is commonly used to assess the mental health of students, but there is a need for further clarification regarding its equivalence, structure, and core items.

Methods We conducted a confirmatory factor analysis (CFA) on a sample of 7943 Chinese students to examine the performance of the DASS-21 and assess measurement invariance. Additionally, we utilized network analysis to investigate the structure and centrality of students' mental health.

Results Our findings revealed a stable three-factor structure for the DASS-21, characterized by high correlations among depression, anxiety, and stress. The DASS-21 demonstrated strict invariance across genders and weak invariance across levels of education. Network analysis indicated that symptoms of depression, anxiety, and stress form clusters, with some symptoms exhibiting strong correlations with each other.

Conclusion Our study highlights a substantial interrelation among depression, anxiety, and stress, revealing a structurally clustered pattern. Network analysis underscores the interconnectedness and centrality of these symptoms, recommending a shorter version of the DASS, and emphasizing the imperative for targeted interventions aimed at improving the psychological well-being of students.

Keywords Students, Depression, Anxiety, Stress, Factor analysis, Network analysis

[†]Zheng Zhang and Ruoheng Lin share first authorship.

*Correspondence:

Xiangbin Zhang
208102082@csu.edu.cn
Jiansong Zhou
zhoujs2003@csu.edu.cn

¹Key Laboratory of Brain, Cognition and Education Sciences, Ministry of Education, School of Psychology, Center for Studies of Psychological Application, and Guangdong Key Laboratory of Mental Health and Cognitive Science, South China Normal University, Guangzhou, China

²Department of Psychiatry, National Clinical Research Center for Mental Disorders, and National Center for Mental Disorders, The Second Xiangya Hospital of Central South University, Changsha, China

³Faculty of Social Sciences, School of Education, The University of Sheffield, Sheffield S10 2TN, UK

⁴School of Economics, East China Normal University, Shanghai 200241, China

⁵Center for Economics and Management, East China Normal University, Shanghai 200241, China

⁶Department of Neurology, Xiangya Hospital, Central South University, Changsha, Hunan 410008, PR China

⁷National Clinical Research Center for Geriatric Disorders, Xiangya Hospital, Central South University, Changsha, Hunan, China

⁸Multi-Modal Monitoring Technology for Severe Cerebrovascular Disease of Human Engineering Research Center Xiangya Hospital, Central South University, Changsha, Hunan, China

⁹Xiangya School of Public Health, Central South University, Changsha 410083, China

¹⁰Nanmen Middle and Special Primary School in Chengxiang District, Putian 351100, China

¹¹School of Educational Science, Anhui Normal University, Wuhu, China



Introduction

Depression, anxiety, and stress are the most common emotional problems and psychological disorders across the world [1], and they have become increasingly prominent in recent years [2, 3]. Depression refers to an emotional state of helplessness and powerlessness of the self, accompanied by a variety of physiological symptoms, such as weakness and sleep disturbance [4, 5]; anxiety is a future-oriented emotional state featured by stress and worries, which may also be accompanied by physiological responses [6]; stress refers to the psychological and physiological maladjustment that occurs when the demands of the external environment exceed the limits of an individual's natural regulation, especially in unpredictable and uncontrollable situations [7]. Mental health problems represented by depression, anxiety and stress have received increasing attention from researchers in a variety of fields, including psychology [8], education [9], and economics [10].

From the perspective of education and development, students, as a physiologically or socially “immature group”, face particularly severe problems of depression, anxiety and stress [9]. A meta-analysis found that the overall prevalence of anxiety and depressive symptoms among Chinese students was 24.0% and 22.0%, respectively [11]. Stress is related to a variety of factors, the most common one being academic pressure. Prior studies have shown that Chinese students are exposed to high levels of stress over a long period of time because education in China tends to focus mainly on examinations or tests [12]. Academic pressure has been identified as an important factor contributing to health-related problems such as depression and anxiety among Chinese adolescents [13, 14]. Financial pressure has also been reported to be associated with mental health issues [15]. The impacts of stress, depression and anxiety on students include declined academic performance, sleep disturbances and even self-harming behaviors. For example, through a systematic review and meta-analysis on psychological correlates of college students' academic performance, Richardson et al. found that academic stress was significantly and negatively correlated with the students' academic performance (reflected by their grade point average [GPA]) [16]. Prior studies have found that the more stressed students are, the more likely they are to have sleep disorders [17]. One of our previous studies also found that depressive and anxiety symptoms had a mediating effect on the association of school bullying and academic stress with self-harm behaviors [18]. Although the above studies have found correlations between depression, anxiety and stress among students, they utilized different sample sources and research methodologies, resulting in a lower level of robustness in their evidence.

In clinical studies, depression, anxiety and stress are highly likely to co-exist in an individual [19, 20], and studies have also found that the three conditions are highly correlated [21]. The Depression, Anxiety and Stress Scale –21 Items (DASS-21), consisting of three subscales (i.e., depression, anxiety, and stress subscales), is a validated measurement tool widely used in studies [22]. The scale also possesses a priori theoretical concepts; therefore, it is necessary to examine its applicability and psychometric properties in diverse populations. For instance, to assess whether measurement invariance exists when applied in groups of different genders and educational levels.

This study aims to select a representative sample of Chinese students to assess the suitability and effectiveness of DASS-21 in different groups. To analyze the underlying factor structure of DASS-21, we will utilize confirmatory factor analysis from a latent variable modeling perspective. Additionally, we will employ network analysis methods to investigate the connections between different symptom nodes. By using network analysis, we can examine the relationships and key symptoms associated with psychological disorders without relying on strong prior assumptions. This approach will enable us to gain a comprehensive understanding of the connections between depression, anxiety, and stress from various perspectives. By identifying the core symptoms of depression, anxiety, and stress in the student population, this study will provide valuable evidence and resources for mental health education in schools, clinical diagnosis and counseling, and medication recommendations.

Methods

Participants and procedure

In this study, participants were Chinese students recruited online or through offline convenience sampling from March to September 2022, and they were from a large number of cities including Beijing, Shanghai, Guangzhou, Shenzhen, Shenyang, Huludao, Jinan, Wuhu, Shijiazhuang, Changzhou, Suzhou, Fuzhou, Linyi, Chengdu, Urumqi, Qiqihaer, Kunming, and Wuhan (in descending order regarding the number of participants). We have directly provided the number of participants for each city along with their corresponding demographic data and have included this information in Supplementary Table 1. The students were either recruited online through the Questionnaire Star platform (<https://www.wjx.cn/>) or offline from different classes, grades, and school. Written informed consent was obtained from all the participants at the beginning of the survey, and the participants could withdraw from the survey at any time without penalty. The survey was completely anonymous with no personal identifying information required. Ethical approval for this study was obtained from the

ethics committee of The Second Xiangya Hospital, Central South University.

Tools and assessments

The depression anxiety stress scale-21 items (DASS-21)

The DASS-21 is a three-factor model developed by Lovibond et al. [23] to examine common mood disorders such as depression, anxiety, and stress, and to provide auxiliary psychometric indicators for clinical diagnosis. In this study, we used the Chinese version of DASS-21 [24] to examine depression, anxiety and stress of the participants, with seven items for each condition. For instance, the subscale for depression included “I felt sad and depressed”, the subscale for anxiety included “I was aware of dryness of my mouth”, and the subscale for stress included “I found myself getting upset rather easily”. For all the subscales, higher scores indicated higher levels of depression, anxiety and stress. The scale is culturally appropriate, has been widely used in China, has shown high reliability and validity [24], and is suitable for use among primary school [25], secondary school [26], and university students [27]. In this study, the McDonald's ω coefficients for the three factors, i.e., depression, anxiety and stress, were 0.89, 0.87 and 0.86, respectively.

Demographic variables

The demographic variables used in this study included level of education (upper primary, secondary, undergraduate, and postgraduate students), gender (male and female), and age (continuous variable). The demographic variables considered in this study encompassed educational attainment (ranging from upper primary to postgraduate levels), gender (male and female), and age.

Statistical analysis

Due to the configuration of the online platform, we required participants to complete all questions before submitting the questionnaire, ensuring the completeness of the data from the online sample. Additionally, we used an attention-check question, i.e., “Please choose strongly agree,” and data from participants who selected other options were removed. For offline participants, data were directly entered by the class teachers using an Excel template provided by the researchers, and any missing data were supplemented within a week through re-interviews with the students. We acknowledge the differences in data collection methods between the online and offline samples and have therefore implemented different quality control measures. For the online sample, lacking the contextual oversight of an in-person administrator, we employed attention-check questions and lie detectors to enhance data quality control. In the offline sample, since the data collection was supervised by class teachers who were familiar with and held authority over the students,

the process was conducted under serious conditions with the principal investigator's guidance. The subsequent data entry process included manual verification of handwriting and response patterns, making the attention-check question unnecessary in the offline sample. Therefore, these questions were omitted from the offline data collection. SPSS 21.0 was used to organize the data, and participants with missing values were excluded. JASP 16.0 was used for descriptive statistics, ANOVA, correlation analysis, validation factor analysis, measurement invariance and network analysis based on EBICglasso [28, 29].

It should be noted that in the multi-group validation factor analysis, in order to simplify the model and to avoid the effect of an unbalanced sample size on the model fit, we modified the grouping of education level by combining middle school and high school students to form a group of secondary school students and combining college, undergraduate, and graduate students to form a group of university students. Additionally, in the measurement invariance analysis, according to the criteria of the invariance test indicated by Chen et al. [30], although the sample size of this study was more than sufficient, the number of participants was not balanced between groups, which led to the use of a more lenient criteria ($\Delta CFI \leq 0.01$; $\Delta RMSEA \leq 0.01$; $\Delta SRMR \leq 0.025$). When multiple criteria conflicted, the amount of change in CFI was used as the primary criterion. The network analysis functionality integrated in JASP is based on the R language, with R packages used in this study including bootnet, glasso, huge, and mgm. In the depression-anxiety-stress network, different centrality metrics can be used to explain different symptoms. Closeness centrality measures the average distance from a node to other nodes, indicating the speed and efficiency of symptom propagation for that node. Strength centrality measures the strength of connections between a node and other nodes, indicating the importance and influence of the node in symptom transmission. Betweenness centrality measures the ability of a node to act as a mediator in the network, quantifying the extent to which a node serves as a bridge in symptom transmission. Expected influence measures the influence of a node on other nodes, specifically the degree to which a node affects other nodes in symptom transmission. This study primarily focuses on exploring the comprehensive impact of symptoms. Therefore, the centrality of strength has been selected to illustrate the significance of a single symptom in the network. To prevent potential non-invariance between networks, we utilized the Network Comparison Test (NCT) package in R to conduct network comparison tests for the subgroups (primary school, middle school, and college groups).

Table 1 Descriptive statistics and ANOVA for depression, anxiety and stress (N = 7934)

	Male	Female	F	Cohen's f	Primary	Secondary	University	F	Cohen's f
Depression	0.77 ± 0.71	0.66 ± 0.66	50.83***	0.08	0.46 ± 0.58	0.64 ± 0.63	0.87 ± 0.72	152.04***	0.24
Anxiety	0.87 ± 0.71	0.73 ± 0.64	85.59***	0.10	0.65 ± 0.57	0.76 ± 0.59	0.90 ± 0.75	53.06***	0.14
Stress	0.91 ± 0.68	0.83 ± 0.65	30.68***	0.06	0.76 ± 0.59	0.88 ± 0.61	0.91 ± 0.72	18.83***	0.08

Note: Scores of depression, anxiety, and stress are the mean scores of the items; *** $p < 0.001$. Cohen's f-value indicates the effect size, and the thresholds for differentiation of small, medium, and large effect sizes are 0.1, 0.25, and 0.40, respectively

Table 2 Indicators and criteria for each DASS-21 fit

Fit indicator	CFI	TLI	NFI	IFI	GFI	RMSEA	SRMR
Total	0.934	0.925	0.932	0.934	0.915	0.065	0.038
Male	0.935	0.926	0.932	0.935	0.933	0.066	0.036
Female	0.928	0.918	0.924	0.928	0.913	0.066	0.039
Primary School Students	0.927	0.917	0.916	0.927	0.941	0.063	0.035
Secondary School Students	0.919	0.908	0.912	0.919	0.939	0.067	0.039
University Students	0.926	0.917	0.923	0.926	0.877	0.075	0.045
Standard	>0.90	>0.90	>0.90	>0.90	>0.90	<0.08	<0.05

Abbreviations: CFI=Comparative goodness-of-fit index, TLI=Tucker-Lewis index, NFI=Normative fit index, IFI=Value-added fit index, GFI=Goodness-of-fit index, RMSEA=Root mean square error of approximation, SRMR=Standardized root mean square error

Results

Descriptive statistics and analysis of variance

A total of 7934 students were enrolled in this study. They were aged 10–57 years, with a mean age of 19.08 ± 6.76 years. Among them, 4133 were male and 3801 were female. There were 1520 primary school students, 2282 secondary school students, 4132 university students.

The mean scores and ANOVA results of different groups of participants on each scale are shown in Table 1. The post hoc test based on the LSD method showed that: (1) in terms of gender, males had significantly higher levels of depression, anxiety, and stress than females; (2) with regard to the level of education, university students had the highest levels of depression, anxiety, and stress; secondary and primary school students had relatively lower levels of depression, anxiety and stress.

Correlation analysis

Depression, anxiety and stress were significantly and positively correlated. Among them, anxiety was positively correlated with depression ($r = 0.78$, $p < 0.001$), and stress was positively correlated with both depression ($r = 0.76$, $p < 0.001$) and anxiety ($r = 0.80$, $p < 0.001$).

Multi-group validation factor analysis

A validation factor analysis was conducted to confirm the structural validity and fit metrics of the DASS-21 (see Table 2). Factor loadings for individual items were also reported for comparison with the indicators in the network analysis. The results indicated that DASS-21 met the psychometric criteria for all students overall and all groups of students. The unconstrained validation factor analysis suggests that the fit indexes of both male and female groups are acceptable. Meanwhile, the fitted indexes for the groups of primary school students,

secondary school students and university students are all acceptable. This was also a prerequisite step for the measurement invariance test.

Measurement invariance

We analyzed the measurement invariance of gender and education level (see Table 3). As shown by each model fit indicator, DASS-21 satisfied the metric invariance test ($\Delta CFI = 0.002$), the scalar invariance test ($\Delta CFI < 0.001$), and the strict invariance test ($\Delta CFI = 0.002$) between the male and female groups. Meanwhile, DASS-21 was only able to satisfy the metric invariance test ($\Delta CFI = 0.010$) between the primary, secondary and university student groups. This result indicates that the DASS-21 satisfies weak invariance between levels of education.

Network analysis

We used all the items of DASS-21 as nodes. The number of non-zero edges in the network was 171/210 with a sparsity of 0.19. The items for depression, anxiety and stress were relatively concentrated in clusters, and items *self-depreciation* and *meaninglessness* (0.36), *breathing difficulty* and *trembling* (0.25), *scare* and *uneasy* (0.24), and *arrhythmia* and *fear* (0.21) had the greatest strength of association (see Fig. 1).

We also reported the centrality of individual nodes, which measures the influence of a node within in a network. Changes in nodes with higher centrality could affect, to a greater extent, the nodes that connected to them. The results showed that *breathing difficulty* and *nervous* had higher betweenness centrality and closeness centrality, while *breathing difficulty* had higher degree centrality (see Fig. 2).

To further examine the differences and associations between the latent variable model and the theoretical

Table 3 Measurement invariance of gender and level of education (N = 7934)

		χ^2 (df)	CFI	RMSEA	SRMR	Δ CFI	Δ RMSEA	Δ SRMR	Decision
Gender	Configural invariance	6487.556 (372)	0.931	0.066	0.039				
	Metric invariance	6599.126 (390)	0.929	0.065	0.043	0.002	0.001	-0.004	Accepted
	Scalar invariance	6698.416 (408)	0.929	0.064	0.042	<0.001	0.001	0.001	Accepted
	Strict invariance	6823.257 (429)	0.927	0.063	0.042	0.002	0.001	<0.001	Accepted
Level of education	Configural invariance	7822.668 (668)	0.924	0.070	0.042				
	Metric invariance	8825.433 (594)	0.914	0.072	0.061	0.010	-0.002	0.019	Accepted
	Scalar invariance	11645.511 (630)	0.885	0.081	0.077	0.029	-0.009	-0.016	Rejected
	Strict invariance	13526.844 (915)	0.867	0.085	0.082	0.018	-0.004	-0.005	Rejected

Abbreviations: CFI=Comparative goodness-of-fit index, RMSEA=Root mean square error of approximation, SRMR=Standardized root mean square error. Configural Invariance: Confirms that the factor structure is the same across groups, with consistent factor loadings, without involving cross-group comparisons of parameters. Metric Invariance: Builds on configural invariance by requiring that factor loadings are equivalent across groups, assessing the cross-group measurement equivalence of the tool. Scalar Invariance: Adds the requirement of equal intercepts to metric invariance, indicating that both factor loadings and intercepts are the same across groups. Strict Invariance: Extends scalar invariance by also demanding that error variances or residuals are equal across groups, representing the most rigorous test for complete measurement equivalence

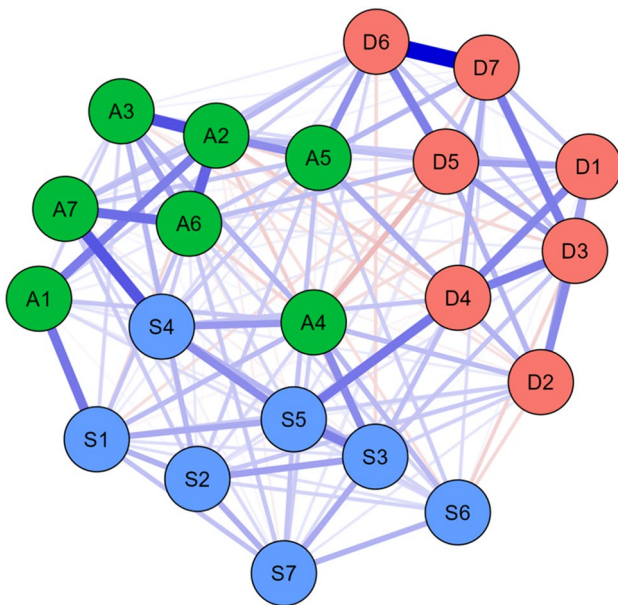


Fig. 1 Network estimates of depression, anxiety and stress symptoms. Notes: D represents depression items, A represents anxiety items, and S represents stress items. Blue lines represent positive correlations and red lines represent negative correlations, with thicker lines indicating stronger correlations. The value in the middle of the line represents the strength of the correlation between two nodes

perspective of the psychopathological network, we compared the factor loadings and expected impacts of the scale items (see Table 4). In this study, *panic*, *arrhythmia*, *self-depreciation*, *meaninglessness*, *uneasiness*, and *nervousness* had high expected impact. Factors of stress and anxiety were found to share core symptoms. *Panic*

and *arrhythmia* had high explanatory power and importance in the anxiety factor, while *uneasiness* and *nervousness* played a more central role in the stress factor. In the depression factor, the two analytical methods found inconsistent key symptoms, with *hopelessness* and *enthusiasm* having higher factor loadings in the traditional latent variable model. *Self-depreciation* and *meaninglessness* showed higher expected impacts in the network analysis. Based on this, we recommend using *self-depreciation*, *meaninglessness*, *panic*, *arrhythmia*, *blue*, and *nervousness* as a shortened version of the DASS-6. Confirmatory factor analysis results indicated that the fit indices for the DASS-6 meet psychometric standards: GFI=0.998; RMSEA=0.034; CFI=0.998; NFI=0.924; NNFI=0.994; TLI=0.994; IFI=0.998. The McDonald’s ω coefficients for the three factors of depression, anxiety, and stress were 0.816, 0.769, and 0.750, respectively, with a total McDonald’s ω of 0.905.

Subgroup network analysis

The density ratios for the primary school group, middle school group, and university group were 159/210, 154/210, and 171/210, respectively. To better understand the core symptoms and structure of symptom networks among different age groups of students, we divided the student population into three groups for analysis (Fig. 3). In the network of primary school students, the highest edge weights were observed between *self-depreciation* and *meaninglessness* (0.31), *arrhythmia* and *scare* (0.26), and *nervousness* and *blue* (0.24). In the network of middle school students, the highest edge weights were observed between *self-depreciation* and *meaninglessness* (0.39), *dry*

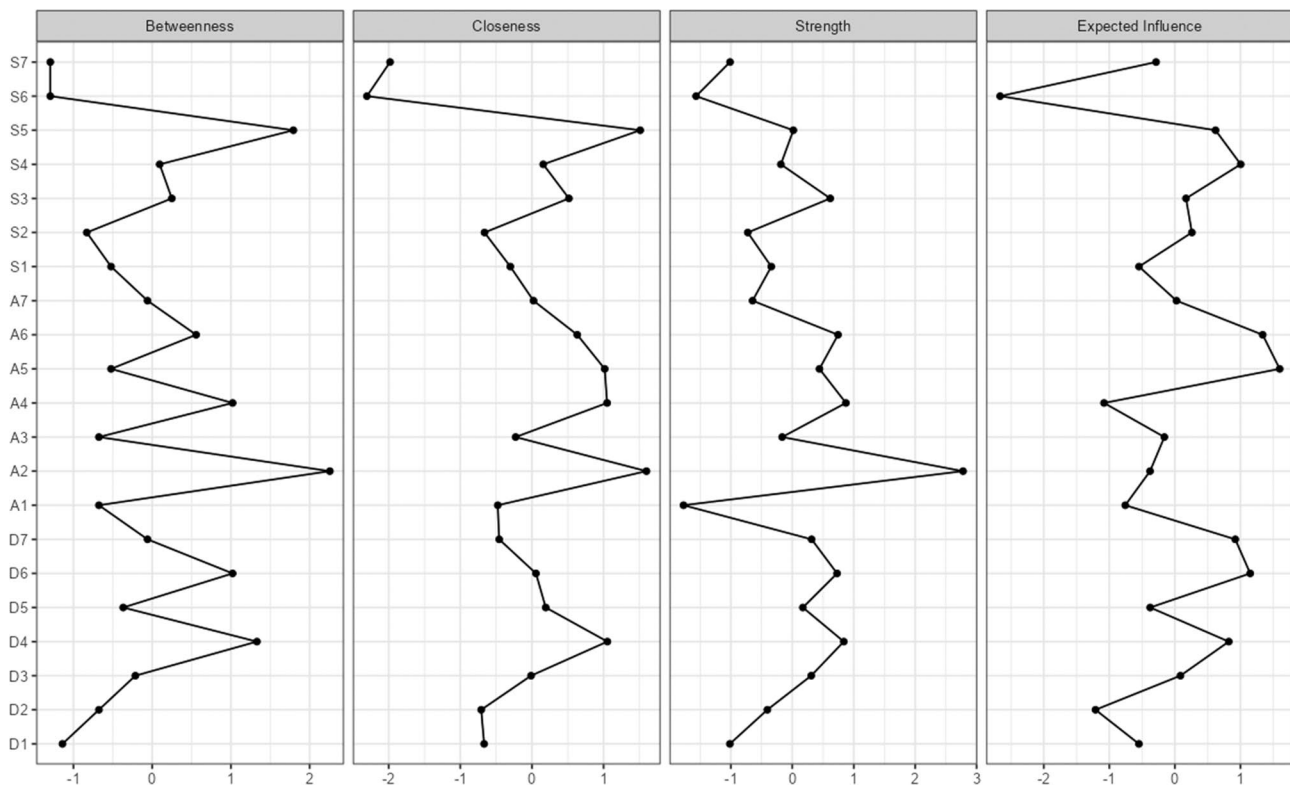


Fig. 2 Centrality graph of the network. Notes: Betweenness implies how often a node is on the shortest path between any two other nodes; closeness is the inverse of the sum of the shortest path distances from all other nodes in the network to a particular node; degree represents the number of other nodes that are directly connected to a particular node. Expected influence refers to the influence of one node on other nodes compared to the previous centrality metrics, with the edge weight directionality taken into account

mouth and *restlessness* (0.27), *no positive* and *blue* (0.25), and *hopelessness* and *meaninglessness* (0.25). Although *self-depreciation* and *meaninglessness* still maintained a high level of connectivity, there were shifts and changes in the other major edge weights, especially with close associations among other depressive symptoms. Additionally, a negative correlation was observed between *arrhythmia* and *social anxiety*, indicating an inverse relationship between *social anxiety* and *arrhythmia*. In the network of university students, the highest edge weight remained between *self-depreciation* and *meaninglessness* (0.36). There were further changes in the other major edge weights, such as *breathing difficulty* and *trembling* (0.28), *hopelessness* and *blue* (0.28), and *scare* and *uneasiness* (0.27). Furthermore, there were some symptoms that showed negative associations, such as *consumption* and *breathing difficulty* (-0.13) and *blue* and *breathing difficulty* (-0.11).

Afterwards, we utilized the NCT R package to conduct pairwise comparisons and found that there was no significant difference in overall strength between the primary and middle school groups (9.29 vs. 9.65, $p=0.07$), nor in edge weights ($p>0.05$). However, there was a significant difference in overall strength between the primary and college groups (9.29 vs. 11.04, $p<0.01$), and in edge

weights ($p<0.01$). At the same time, there was a significant difference in overall strength between the middle and college groups (9.65 vs. 11.04, $p<0.01$), and in edge weights ($p<0.01$).

In the centrality section (Fig. 4), based on considerations of statistical procedures, we decided to use strength centrality to explain the dynamics and differences in core symptoms of psychological health among students in different grade levels. The red line represented primary school students, the green line represented secondary school students, and the blue line represented university students and above.

Among primary school students, the three nodes with the highest centrality were *meaninglessness* (1.527), *blue* (1.312), and *arrhythmia* (1.128). For middle school students, it was *social anxiety* (1.717), *meaninglessness* (1.597), and *arrhythmia* (1.524). And for university students, it was *breathing difficulty* (3.337), *self-depreciation* (1.163), and *consumption* (0.954). In primary school students, the primary symptoms observed were depression. In middle school students, the symptoms were predominantly anxiety. However, in university students, the symptoms exhibited greater complexity.

In terms of changes across grade levels, as age increased, the importance of *low patience* gradually rose,

Table 4 Factor loadings and expected impact of symptoms (N=7934)

Code	Symptom	Factor loading	Expected impact
D1	No positive	0.66	-0.55
D2	Initiation	0.57	-1.21
D3	Hopelessness	0.70	0.09
D4	Blue	0.65	0.82
D5	Enthusiasm	0.67	-0.38
D6	Self-depreciation	0.65	1.15
D7	Meaninglessness	0.65	0.92
A1	Dry mouth	0.58	-0.76
A2	Breathing difficulty	0.68	-0.38
A3	Trembling	0.61	-0.16
A4	Social anxiety	0.54	-1.08
A5	Panic	0.69	1.60
A6	Arrhythmia	0.71	1.34
A7	Scare	0.67	0.03
S1	Restlessness	0.56	-0.55
S2	Allergy	0.64	0.26
S3	Consumption	0.64	0.17
S4	Uneasiness	0.70	1.01
S5	Nervousness	0.69	0.62
S6	Low patience	0.45	-2.67
S7	Irritability	0.64	-0.29

Note: Bold numbers indicate that the item has a high Factor loading or Expected impact in that factor

approaching a central position within the symptom network. In contrast, the importance of *blue* declined year by year.

Discussion

This study explored the internal associations and structure of depression, anxiety and stress among Chinese students based on the latent variable model and psychopathological network theory [31]. Greater depression, anxiety, and stress have been found among males than

females, and prior studies [32] also suggested that this might be because Chinese males tended to take on more social responsibility and project a strong image, and this cultural pressure may affect the mental health of Chinese males. Chinese males also have a lower level of collateral social support, which may lead to their difficulty in relieving stress through the social system. The mental health of students is also getting worse with increased level of education. This may be due to the gradual increase in academic pressure, the increasing social responsibilities, and increased self-awareness and awareness of emotions [11]. Prior studies also found that depression, anxiety and stress are highly likely to co-exist [19, 20] and the importance of different symptoms or symptom clusters varies [33]. The correlation and network analyses in the present study showed that depression, anxiety and stress were positively and strongly correlated not only at the variable level but also at the symptom level.

The confirmatory factor analysis indicated excellent fit of the three-factor structure for depression, anxiety and stress, which has been supported by existing studies [24]. The multi-group confirmatory factor analysis found measurement invariance of the DASS-21, which was in line with prior studies [34, 35], and the DASS-21 met strict equivalence in gender. However, the DASS-21 only satisfies weak equivalence in the level of education, which might be due to the fact that the studied population covered primary, secondary, and tertiary school students, and that there were differences in the understanding of scale items between the groups [34]. Therefore, it is not recommended to use the same set of scales on the whole student population. Subsequent research can focus on the revise of a version specifically for primary school students, which should be more relevant to their daily life.

The network analyses indicated that *self-depreciation* was most strongly associated with *meaninglessness* in

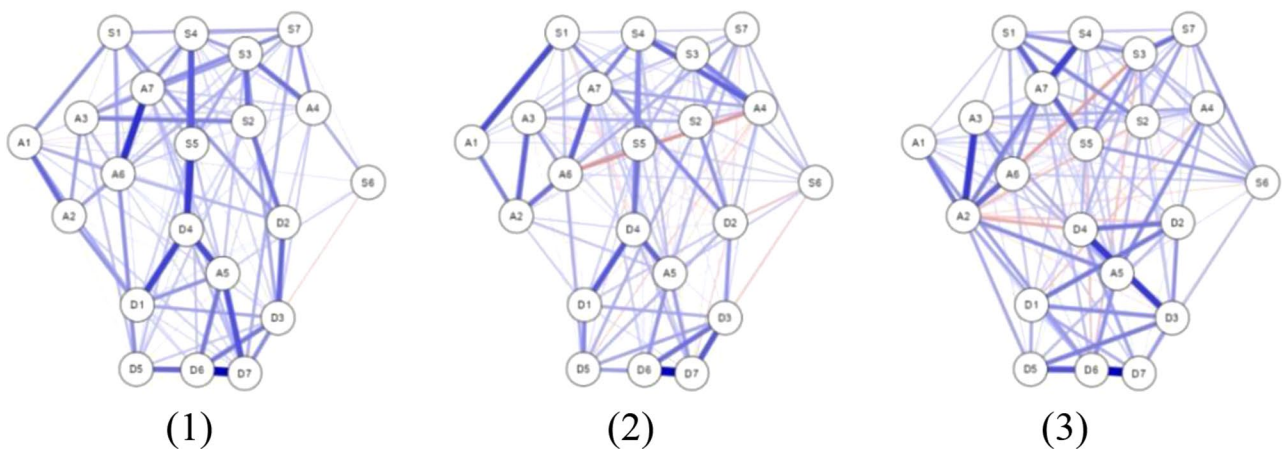


Fig. 3 Edge structure of mental health network of students at different educational levels. Note: (1) (2) (3) respectively represent the primary school group, the middle school group and the university group

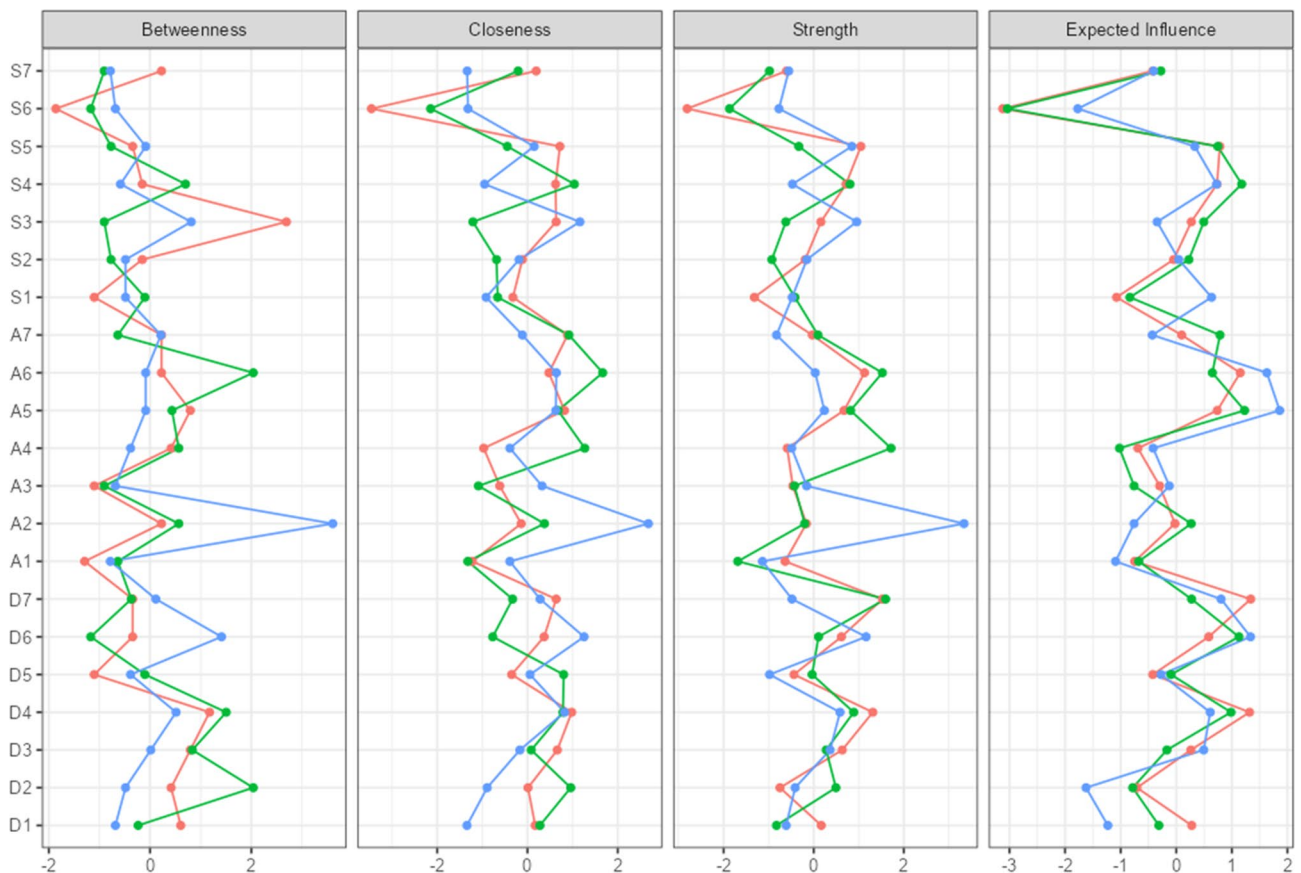


Fig. 4 Mental health network centrality map of students at different educational stages

the network of depressive symptoms. Studies based on a phenomenological hermeneutic approach suggest that the association of these two symptoms may be related to an imbalance between the real and ideal selves [36]. Within the anxiety symptom network, *breathing difficulty* and *trembling* had the strongest association, followed by *arrhythmia* and *scare*. The above four symptoms tend to co-occur in one individual, as neurotransmitters such as norepinephrine, a key factor for anxiety, may simultaneously affect the heart rate, respiration and sympathetic nervous system [37]. We also found a strong association between *scare* and *uneasiness*, which has been reported in prior clinical studies [38]. Although it was assumed that they belonged to different factors in the latent variable model, the network analysis showed a stronger association. With regard to centrality, *breathing difficulty*, *nervousness*, *panic*, *arrhythmia*, *self-depreciation*, *meaninglessness*, and *uneasiness* played a more important role in their symptom clusters. Therefore, we believe that these core symptoms can constitute the items of a shorter version of the DASS, which is further supported by psychometric testing. We are confident that the DASS-6 can serve as a quicker and more convenient screening tool within the Chinese student population.

The advantage of network analyses is that more information can be obtained from cross-sectional data than from latent variable models. A better understanding of the interplay between all the symptoms and the identification of key symptom nodes in the network structure [39, 40], may help us find ways to improve the mental health of students.

In our study, we used the NetworkComparisonTest to analyze the characteristics of depression, anxiety, and stress symptom networks among students at different educational stages (elementary, middle, and college) [41]. The results showed that while there were no significant differences in the overall intensity and edge weights of symptoms between elementary and middle school students, both groups exhibited significantly lower levels compared to college students. This may reflect the increasing academic pressures and social responsibilities that come with age, thereby leading to higher levels of mental health symptoms [42]. These findings provide an important perspective for understanding changes in the mental health status of students across different educational stages, and also highlight potential psychological health issues that may need attention during the educational process.

Recently, several studies among Chinese populations have validated the DASS-21 scale [43–45]. This study confirms previous research and, with a representative large sample of student data, revealed a stable three-factor structure for the DASS-21, characterized by high correlations among depression, anxiety, and stress. Our research observed differences and variations in core symptoms between different age groups, which helps to better understand the mental health status of students at various age levels. At the same time, we also proposed a brief version of the DASS-6 and assessed its reliability and validity, providing a potentially more efficient tool for mental health assessment, which has not been explored in existing literature.

Integrating the perspectives of latent variable theory and psychopathological network theory, we found that *panic* and *arrhythmia*, and *uneasy* and *nervous* had superior performances in terms of factor loadings and expected impacts in anxiety and stress networks, suggesting that there is consistency across theoretical perspectives for key symptoms of anxiety and stress. However, in the depression network, there was inconsistency between factor loadings and expected impacts, which might be due to the fact that depressive symptoms are more biased towards internal mechanisms compared to anxiety and stress, with greater discrepancy between outward symptoms and underlying constructs [46]. Intervention for depression, anxiety and stress, such as counselling or medications, may be more effective with the identification of the right targets. At present, the development and selection of medications for depression and anxiety has still been challenging due to unclear pathogenesis of the mental illnesses [47]. Through network analyses, the relationships between individual symptoms can be organized to find the key symptoms in the network [39, 48], which may provide a reference for subsequent empirical interventions and pharmacotherapy.

Our findings should be interpreted in light of certain strengths and limitations. The strengths of the study include the use of consistent measurement tools and the availability of a large sample size of representative data for analysis. Limitations of the study include two aspects. Firstly, network models have drawbacks, such as model overfitting or excessive complexity [49]. Secondly, the present study used cross-sectional data, and despite the introduction of a penalty factor in the network model, the associations we obtained remained correlational rather than causal. Thus, we emphasized the relative importance of a symptom for mental disorders, but such an assumption might be less likely due to “missing in the hypothesis”. Considering the differences in depression, anxiety, and stress between groups of different genders and ages, subsequent studies can focus on the differences in the DASS-21 network using different grouping methods,

identification of symptom nodes that are more suitable for interventions based on the differences in the centrality of nodes, and development of intervention strategies that are more relevant to the characteristics of the studied population [50].

Conclusion

Factor and network analyses showed that depression, anxiety and stress were closely related among Chinese students. DASS-21 has varying degrees of measurement invariance across genders and grades. The DASS-6 has a satisfactory reliability and validity. There are also differences and changes in core symptoms among different age groups, which provide reference for subsequent intervention.

List of Abbreviations

Code	Symptom	Question
D1	No positive	I couldn't seem to experience any positive feeling at all.
D2	Initiation	I found it difficult to work up the initiative to do things.
D3	Hopelessness	I felt that I had nothing to look forward to.
D4	Blue	I felt down-hearted and blue.
D5	Enthusiasm	I was unable to become enthusiastic about anything.
D6	Self-depreciation	I felt I wasn't worth much as a person.
D7	Meaninglessness	I felt that life was meaningless.
A1	Dry mouth	I experienced dryness of my mouth.
A2	Breathing difficulty	I experienced breathing difficulty (e.g., excessively rapid breathing).
A3	Trembling	I experienced trembling (e.g., in the hands).
A4	Social anxiety	I was worried about situations in which I might panic and make a fool of myself.
A5	Panic	I felt I was close to panic.
A6	Arrhythmia	I was aware of the action of my heart in the absence of physical exertion (e.g., sense of heart rate increase, heart missing a beat).
A7	Scare	I felt scared without any good reason.
S1	Restlessness	I found it hard to wind down.
S2	Allergy	I tended to over-react to situations.
S3	Consumption	I felt that I was using a lot of nervous energy.
S4	Uneasiness	I found myself getting agitated.
S5	Nervousness	I found it difficult to relax.
S6	Low patience	I was intolerant of anything that kept me from getting on with what I was doing.
S7	Irritability	I felt that I was rather touchy.

Abbreviations

Abbreviations	Full Name
DASS-21	Depression Anxiety Stress Scale – 21 Items
CFA	Confirmatory Factor Analysis
NCT	Network Comparison Test
CFI	Comparative Goodness-of-Fit Index
TLI	Tucker-Lewis Index
NFI	Normative Fit Index
IFI	Incremental Fit Index
GFI	Goodness-of-Fit Index
RMSEA	Root Mean Square Error of Approximation
SRMR	Standardized Root Mean Square Error
GPA	Grade Point Average
ω	McDonald's Omega
LSD	Least Significant Difference
NNFI	Non-Normed Fit Index
EBIC	Extended Bayesian Information Criterion
glasso	Graphical Lasso

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12889-024-20123-6>.

Supplementary Material 1

Acknowledgements

We sincerely thank the participating schools and students for their support, and we are also grateful to the anonymous reviewers for their valuable feedback, which has greatly enhanced this study.

Author contributions

Zheng Zhang and Ruoheng Lin designed the study and wrote the first draft of manuscript. Hui Feng Wu and Shuo Wu collected and organized the primary data. Le Zhang conducted the statistical analyses. Zijun Wu and Mengna Li managed the literature searches. Xiangbin Zhang and Jiansong Zhou provided supervision in the implementation of the study. All authors approved the final manuscript.

Funding

This research was funded by STI2030-Major Projects-2021ZD0200700, Major Science and Technology Projects in Changsha, China (kq2301008) and the Hunan Provincial Natural Science Foundation of China (2023JJ60144).

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The study was approved by the Ethics Committee for Research of the Second Xiangya Hospital of Central South University. All participants will provide informed written consent prior to commencing the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 30 November 2023 / Accepted: 18 September 2024

Published online: 23 October 2024

References

- O'Leary K. Global increase in depression and anxiety. *Nat Med*. 2021;d41591–021.
- Racine N, McArthur BA, Cooke JE, Eirich R, Zhu J, Madigan S. Global prevalence of depressive and anxiety symptoms in children and adolescents during COVID-19: a Meta-analysis. *JAMA Pediatr*. 2021;175:1142–50.
- Zhan H, Zheng C, Zhang X, Yang M, Zhang L, Jia X. Chinese College Students' stress and anxiety levels under COVID-19. *Front Psychiatry*. 2021;12.
- Velikova SA. A contemporary view of depressive symptomatology. *Revista geintec-gestao Inovacao e Tecnologias*. 2021;11:50–60.
- Bibring E. The mechanism of depression. 1953.
- Shedletsky R, Endler NS. Anxiety: the state-trait model and the interaction model. *J Pers*. 1974;42:511–27.
- Koolhaas JM, Bartolomucci A, Buwalda B, de Boer SF, Flügge G, Korte SM, et al. Stress revisited: a critical evaluation of the stress concept. *Neurosci Biobehavioral Reviews*. 2011;35:1291–301.
- Vaughan RS, Edwards EJ, MacIntyre TE. Mental health measurement in a post Covid-19 world: psychometric properties and invariance of the DASS-21 in athletes and non-athletes. *Front Psychol*. 2020;11:590559.
- Welford P, O'Brien A. Improving student mental wellbeing. *BMJ*. 2019;366:l2421.
- Knapp M, Wong G. Economics and mental health: the current scenario. *World Psychiatry*. 2020;19:3–14.
- Zhang Y, Bao X, Yan J, Miao H, Guo C. Anxiety and depression in Chinese students during the COVID-19 pandemic: a Meta-analysis. *Front Public Health*. 2021;9:697642.
- Li J-h, Feng X, -I, Mei SL, Yao DL. Investigation of study pressure effects on mental health of junior high school students in Changchun. *Med Soc*. 2007;20:56–7.
- Giota J, Gustafsson J-E. Perceived academic demands, peer and teacher relationships, stress, anxiety and mental health: changes from grade 6 to 9 as a function of gender and cognitive ability. *Scandinavian J Educational Res*. 2021;65:956–71.
- Zhang C, Shi L, Tian T, Zhou Z, Peng X, Shen Y et al. Associations between academic stress and depressive symptoms mediated by anxiety symptoms and hopelessness among Chinese college students. *Psychol Res Behav Manage*. 2022;15:547–56.
- Schröpfer K, Schmidt N, Kus S, Koob C, Coenen M. Psychological stress among students in health-related fields during the COVID-19 pandemic: results of a cross-sectional study at selected Munich universities. *Int J Environ Res Public Health*. 2021;18:6611.
- Richardson M, Abraham C, Bond R. Psychological correlates of university students' academic performance: a systematic review and meta-analysis. *Psychol Bull*. 2012;138:353.
- Bodys-Cupak I, Czubek K, Grochowska A. Stress and Sleep disorders in Polish nursing students during the SARS-CoV-2 Pandemic—Cross Sectional Study. *Front Psychol*. 2022;12:814176.
- Chen H, Guo H, Chen H, Cao X, Liu J, Chen X, et al. Influence of academic stress and school bullying on self-harm behaviors among Chinese middle school students: the mediation effect of depression and anxiety. *Front Public Health*. 2023;10:1049051.
- Kieseppä V, Holm M, Jokela M, Suvisaari J, Gissler M, Lehti V. Depression and anxiety disorders among immigrants living in Finland: Comorbidity and mental health service use. *J Affect Disord*. 2021;287:334–40.
- Bystritsky A, Kronemyer D. Stress and anxiety: counterpart elements of the stress/anxiety complex. *Psychiatric Clin*. 2014;37:489–518.
- Yalçın İ, Can N, Mançe Çalısır Ö, Yalçın S, Çolak B. Latent profile analysis of COVID-19 fear, depression, anxiety, stress, mindfulness, and resilience. *Curr Psychol*. 2021;41(1):459–69.
- Mellor D, Vinet EV, Xu X, Mamat NHB, Richardson B, Román F. Factorial invariance of the DASS-21 among adolescents in four countries. *Eur J Psychol Assess*. 2015;31:138–42.
- Lovibond PF, Lovibond SH. The structure of negative emotional states: comparison of the Depression anxiety stress scales (DASS) with the Beck Depression and anxiety inventories. *Behav Res Ther*. 1995;33:335–43.
- Gong X, Xie X, Xu R, Luo Y. Psychometric properties of the Chinese versions of DASS-21 in Chinese college students. *Chin J Clin Psychol*. 2010;18:443–6.
- Szabó M. The short version of the Depression anxiety stress scales (DASS-21): factor structure in a young adolescent sample. *J Adolesc*. 2010;33:1–8.
- Willemsen J, Markey S, Declercq F, Vanheule S. Negative emotionality in a large community sample of adolescents: the factor structure and

- measurement invariance of the short version of the depression anxiety stress scales (DASS-21). *Stress Health*. 2011;27:e120–8.
27. Coker AO, Coker OO, Sanni D. Psychometric properties of the 21-item depression anxiety stress scale (DASS-21). *Afr Res Rev*. 2018;12:135–42.
 28. JASP TEAM.
 29. Tang H, Zhang Z, Chen H, Chen H, Chen X, Li S, et al. Core items selection and psychometric properties of the adult attention-deficit hyperactivity disorder self-report scale-chinese short version (ASRS-CSV). *Asian J Psychiatry*. 2024;99:104136.
 30. Chen FF. Sensitivity of goodness of fit indexes to lack of measurement invariance. *Struct Equation Modeling: Multidisciplinary J*. 2007;14:464–504.
 31. Borsboom D. A network theory of mental disorders. *World Psychiatry*. 2017;16:5–13.
 32. Guo K, Zhang X, Bai S, Minhat HS, Nazan AINM, Feng J, Saliluddin. Assessing social support impact on depression, anxiety, and stress among undergraduate students in Shaanxi province during the COVID-19 pandemic of China. *PLoS ONE*. 2021;16:e0253891.
 33. Van den Bergh N, Marchetti I, Koster EH. Bridges over troubled waters: mapping the interplay between anxiety, depression and stress through network analysis of the DASS-21. *Cogn Therapy Res*. 2021;45:46–60.
 34. Putnick DL, Bornstein MH. Measurement invariance conventions and reporting: the state of the art and future directions for psychological research. *Dev Rev*. 2016;41:71–90.
 35. Lu S, Hu S, Guan Y, Xiao J, Cai D, Gao Z, et al. Measurement invariance of the Depression anxiety stress Scales-21 across gender in a sample of Chinese university students. *Front Psychol*. 2018;9:2064.
 36. Arvidsdotter T, Marklund B, Kylén S, Taft C, Ekman I. Understanding persons with psychological distress in primary health care. *Scand J Caring Sci*. 2016;30:687–94.
 37. Mah L, Szabuniewicz C, Fiocco AJ. Can anxiety damage the brain? *Curr Opin Psychiatry*. 2016;29:56–63.
 38. Midtbust MH, Alnes RE, Gjengedal E, Lykkeslet E. A painful experience of limited understanding: healthcare professionals' experiences with palliative care of people with severe dementia in Norwegian nursing homes. *BMC Palliat Care*. 2018;17:25.
 39. Borsboom D, Deserno MK, Rhemtulla M, Epskamp S, Fried EI, McNally RJ, et al. Network analysis of multivariate data in psychological science. *Nat Rev Methods Primers*. 2021;1:1–18.
 40. Borsboom D, Deserno MK, Rhemtulla M, Epskamp S, Fried EI, McNally RJ, et al. Reply to 'Critiques of network analysis of multivariate data in psychological science'. *Nat Rev Methods Primers*. 2022;2:1–2.
 41. van Borkulo C, Boschloo L, Borsboom D, Penninx BWJH, Waldorp LJ, Schoevers RA. Association of Symptom Network structure with the course of [corrected] Depression. *JAMA Psychiatry*. 2015;72:1219–26.
 42. R RB, N, M M, D R, M L, M C. The prevalence and correlates of depression, anxiety, and stress in a sample of college students. *J Affect Disord*. 2015;173.
 43. Chen I-H, Chen C-Y, Liao X-L, Chen X-M, Zheng X, Tsai Y-C, et al. Psychometric properties of the Depression, anxiety, and stress scale (DASS-21) among different Chinese populations: a cross-sectional and longitudinal analysis. *Acta Psychol (Amst)*. 2023;240:104042.
 44. Cao C-H, Liao X-L, Gamble JH, Li L-L, Jiang X-Y, Li X-D, et al. Evaluating the psychometric properties of the Chinese depression anxiety stress scale for Youth (DASS-Y) and DASS-21. *Child Adolesc Psychiatry Ment Health*. 2023;17:106.
 45. Cao C-H, Liao X-L, Jiang X-Y, Li X-D, Chen I-H, Lin C-Y. Psychometric evaluation of the depression, anxiety, and stress scale-21 (DASS-21) among Chinese primary and middle school teachers. *BMC Psychol*. 2023;11:209.
 46. Mascaró N, Rosen DH. Existential meaning's role in the enhancement of hope and prevention of depressive symptoms. *J Pers*. 2005;73:985–1014.
 47. Schafer KM, Lieberman A, Sever AC, Joiner T. Prevalence rates of anxiety, depressive, and eating pathology symptoms between the pre-and peri-COVID-19 eras: a meta-analysis. *J Affect Disord*. 2022;298:364–72.
 48. CAI Y, DONG S. HU C-P. Network analysis and its applications in psychology. *Adv Psychol Sci*. 2020;28:178.
 49. Neal ZP, Forbes MK, Neal JW, Brusco MJ, Krueger R, Markon K, et al. Critiques of network analysis of multivariate data in psychological science. *Nat Reviews Methods Primers*. 2022;2:90.
 50. McNally RJ. Can network analysis transform psychopathology? *Behav Res Ther*. 2016;86:95–104.

Publisher's note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.