The relationships between anxiety and suicidal ideation and between depression and suicidal ideation among Chinese college students: A network analysis

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ABSTRACT

Background: Suicide is a worldwide public health problem. Evidence from previous studies has confirmed the relationship among anxiety, depression and suicidal ideation. However, the complex psychopathological pathways between anxiety and suicidal ideation and between depression and suicidal ideation require further study.
Methods: A total of 505 college students from Shanghai during COVID-19 pandemic were investigated in an online study. Anxiety, depression and suicidal ideation of the participants were investigated. R software was used to construct the anxiety-suicidal ideation and depression-suicidal ideation networks and to evaluate the bridge expected influences.
Results: The anxiety-suicidal ideation network had 28 cross-community edges, the strongest one was A7 "Afraid something will happen"–S7 "Unable to solve personal problem"; A5 "Restlessness" and S3 "Hopelessness and suicide thoughts" had the highest bridge expected influences. The depression-suicidal ideation network had 36 cross-community edges, and the strongest one was D9 "Thoughts of death"–S5 "Unable to accomplish something important"; D9 "Thoughts of death" and S3 "Hopelessness and suicide thoughts" had the highest bridge expected influences.
Conclusion: Intricate psychopathological pathways exist between anxiety and suicidal ideation and between depression and suicidal ideation. "Restlessness", "Thoughts of death" and "Hopelessness and suicide thoughts" are considered targets for suicidal ideation interventions. The present study enriches the theory of symptoms and mental disorders and provides a reliable reference for the intervention practice of suicidal ideation.

1. Introduction

Suicide is a worldwide mental and public health issue affecting social development [1,2]. According to the World Health Organization (WHO), more than 800,000 people successfully commit suicide every year, accounting for 1.4 % of the global death toll [3]. Suicidal ideation refers to the idea that an individual wants to end his or her life [4]. Research shows that the generation and reinforcement of suicidal ideation are influenced by psychological, social and biological factors. Among them, suicide caused by psychological factors, such as anxiety, depression, wrath, and sulks, is relatively high among teenagers and has become the second leading factor of death in this group [5,6].

Many scholars have studied the relationship among anxiety, depression and suicidal ideation. Bentley et al. conducted a meta-analysis of 180 cases reported in 65 studies and stated that anxiety was a prospective predictor of adolescent suicidal ideation [7]. Anxiety is independently related to the results of adolescent suicide and has been consistently confirmed by epidemiological statistics [8–10]. Studies have shown that the suicide risk of individuals with depression is approximately 20 times that of healthy people [11]. It has been found that more than 50 % of suicide completion and 20%–48 % of suicide attempts are by individuals with depression, and there is a high prevalence of suicidal ideation in depressive individuals [12,13]. Rihmer et al. deconstructed depression and found that anhedonia, as the core symptom of depression, is an important predictor of suicide [14]. The strong sense of despair experienced by depressed college students has a significant predictive effect on suicidal ideation and becomes a key mediating variable between depression and suicidal ideation [15,16]. The comorbidity of depression and anxiety may aggravate suicidal ideation. The level of suicidal ideation of depressed patients with generalized anxiety disorder was higher than that of patients with depression alone [17, 18]. Some specific symptoms of anxiety and depression have been found to be related to suicidal ideation, such as worry and anhedonia [19,20], however, considering multiple factors comprehensively may be more meaningful for predicting suicidal ideation [1]. There are complex psychopathological pathways between anxiety and suicidal ideation and between depression and suicidal ideation that still need to be further studied.

The traditional "total score model" considers different symptoms equally important and uses the total score to assess the severity of disorders, ignoring the heterogeneity of symptoms and lacking fine-grained analysis [21,22]. As a new data processing and visualization method, network analysis holds that the occurrence and development of psychological constructs and mental disorders are maintained by the interaction of symptoms [23]. In addition, network analysis provides indices to measure the importance of different symptoms, which also provides a basis for an in-depth understanding of the coexistence of multiple disorders and suggestions of potential intervention targets [24,25]. The network analysis method has been used in the studies of suicidal ideation [26,27], and this study is the first to introduce this method into the study of the relationships between anxiety and suicidal ideation, and between depression and suicidal ideation.

In summary, in this study, we used network analysis to explore the relationships between anxiety and suicidal ideation and between depression and suicidal ideation in Chinese college students. Network models were constructed to deepen the understanding of the psychopathological pathways between anxiety and suicidal ideation and between depression and suicidal ideation, and bridge centrality indices were calculated to quantify the roles of symptoms on the comorbidity of mental disorders. This study enriched the comorbidity theory of mental disorders and provided potential targets for suicide prevention.

2. Materials and methods

2.1. Participants

From April to May 2022, 505 students from 3 colleges in Shanghai and Xi'an, China, were recruited for an investigation powered by the www.wjx.cn. The informed consents were obtained from the participants or their legal guardians before investigation. The inclusion criteria were: (1) between the ages of 17 and 25; (2) Clear consciousness and normal perception; (3) Voluntary participation. The exclusion criteria were: (1) incomplete questionnaire responses; (2) Incorrect basic information.

2.2. Measurements

2.2.1. Positive and negative suicide ideation inventory (PANSI)

We used PANSI [28] to measure suicidal ideation. PANSI includes two dimensions: positive ideation and negative ideation. To examine the overall risk of anxiety or depression on suicidal ideation, we conducted reverse scoring for positive ideation items. PANSI contains 14 items rated on a Likert scale ranging from 1 "none of the time" to 5 "most of the time". A higher score of the scale indicates more frequent suicidal ideation. In this study, the Cronbach's α coefficient of the scale was 0.88; the McDonald's coefficient ω was 0.90.

2.2.2. Generalized anxiety Disorder-7 (GAD-7)

As a self-assessment scale, GAD-7 was used to assess the severity of anxiety symptoms [29]. GAD-7 contains 7 items, and each item has a score from 0 to 3, representing "not at all" to "almost every day". The total GAD-7 score is between 0 and 21; a higher score indicates more serious anxiety symptoms. A total score of GAD-7 greater than 5 indicates possible anxiety, with 5–9 being mild anxiety, 10–14 being moderate anxiety, and 15–21 being severe anxiety [30]. The GAD-7 results of this study showed high reliability (Cronbach's α coefficient = 0.90; McDonald's coefficient ω = 0.90).

2.2.3. Patient health Questionnaire-9 (PHQ-9)

PHQ-9 is a self-screening tool for assessing the severity of depression during the immediately preceding 2 weeks [31]. PHQ-9 contains 9 items, and each item is scored on a scale of 0–3, representing "not at all" to "almost every day". The PHQ-9 total score ranges from 0 to 27; a higher score indicates more severe depression symptoms. A total score of PHQ-9 greater than 5 indicates possible depression, with 5–9 being mild depression, 10–14 being moderate depression, and 15–27 being severe depression [30]. In this study, the Cronbach's α coefficient of the scale was 0.88; the McDonald's coefficient ω was 0.86.

2.3. Procedure

GAD-7, PHQ-9 and PANSI were selected to anonymously investigate the anxiety, depression and suicidal ideation of the participants. Questionnaires that were not completely answered were considered invalid, and 29 questionnaires were excluded, for an effective rate of 94.57 %. This study was approved by the Ethics Committee of the Xijing Hospital of Air Force Medical University (NO. CHiCTR1800019761).

2.4. Statistical analysis

The Cronbach's α coefficients, means, and standard deviations of the scales were calculated by

SPSS software; the McDonald's ω coefficients of the scales were calculated by Jamovi software; R software was used to construct the anxiety-suicidal ideation and depression-suicidal ideation network models and evaluate the bridge expected influence (BEI) indices of the nodes in the two networks.

2.4.1. Network model construction

The R qgraph package [32] was used to construct 2 networks, namely, the anxiety-suicidal ideation and depression-suicidal ideation networks of college students during the COVID-19 pandemic. The extended Bayesian information criterion (EBIC) [33] and least absolute shrinkage and selection operator (LASSO) [34] regularization were applied jointly to punish the trivial edges exactly to zero [35]. As suggested by Foygel and Drton [36], the EBIC hyperparameter was set to 0.5. The network construction was based on the Spearman correlation. In the networks, the nodes represented symptoms of suicidal ideation, anxiety and depression and were grouped into different communities. The edges reflected the partial correlations between the symptoms, and the edge weight of each node pair was estimated after statistical control to reduce interference from other nodes [37]. The Fruchterman-Reingold algorithm was used to build the network layout [38]. The goldbricker function of the R package networktools [39] was used to examine the node redundancy. If two nodes have a correlation stronger than 0.70 and have less than 20 % unique correlations with other nodes, they were considered to be conceptual overlapped. We did not identify potentially redundant nodes in the anxiety-suicidal ideation network

Table 1
The means, standard deviations and bridge expected influences of the items in the anxiety-suicidal ideation network.

Items	Abbreviation	M	SD	BEI
Anxiety items				
A1: Feeling nervous, anxious, or on edge	Nervousness or anxiety	0.74	0.78	0.00
A2: Not being able to stop or control worrying	Uncontrollable worry	0.69	0.84	0.15
A3: Worrying too much about different things	Worry too much	0.75	0.82	0.01
A4: Trouble relaxing	Trouble relaxing	0.61	0.79	0.06
A5: Being so restless that it is hard to sit still	Restlessness	0.53	0.76	0.25
A6: Becoming easily annoyed or irritable	Irritable	0.72	0.85	0.08
A7: Feeling afraid as if something awful might happen	Afraid something will happen	0.59	0.81	0.22
Suicidal ideation items				
S1: Felt frustrated because you were not doing well at school or at work	Frustrated at work	3.04	1.13	0.08
S2: Felt that you were not in control of most situations in your life	Unable to control the situation	3.00	1.09	0.07
S3: Felt Hopelessness and suicide thoughts and you wondered if you should kill yourself	Hopelessness and suicide thoughts	1.65	0.96	0.20
S4: Felt so unhappy about your relationship with someone you wished you were dead	Unhappy about relationships	1.45	0.91	0.07
S5: Thought about killing yourself because you could not accomplish something important in your life	Unable to accomplish something important	1.47	0.94	0.07
S6: Felt hopelessness and had suicide thoughts because things were not working out well for you	Things were not working out well	2.66	1.27	0.00
S7: Thought about killing yourself because you could not find a solution to a personal problem	Unable to solve personal problem	1.45	0.92	0.12
S8: Seriously considered killing yourself because you could not live up to the expectations of other people	Unable to meet expectations	1.43	0.87	0.03
S9: Felt unconfident about your ability to cope with most of the problems in your life	No confidence in life problems	2.71	1.31	0.00
S10: Thought that your problems were so overwhelming that suicide was seen as the only option to you	Overwhelming problems	1.44	0.92	0.03
S11: Felt so lonely or sad you wanted to kill yourself so that you could end your pain	Felt lonely or sad	1.38	0.81	0.02
S12: Thought about killing yourself because you felt like a failure in life	Felt like a failure	1.41	0.89	0.07
S13: Felt that life was not worth living	An unworthy life	2.30	1.45	−0.02
S14: Felt unconfident about your plans for the future	No confidence in future plan	2.50	1.37	0.02

and the depression-suicidal ideation network.

We conducted an accuracy test of edge weights by nonparametric bootstrapping (2000 bootstrapped samples), and a relatively narrow 95 % confidence interval (CI) of edge weights represents an accurate estimation [40]. We also conducted a difference test of the edge weights of node pairs by bootstrapping (2000 bootstrapped samples, α = 0.05). The R bootnet package [35] was used to perform these operations.

2.4.2. BEI evaluation

To explore the bridges between different communities in the two networks, the R networktools package [39] was used to evaluate the BEIs of the nodes. BEI indicates a given node's sum connectivity with other communities [39] and is appropriate to networks with both positive and negative edges. A high BEI reflects the critical role of a symptom in the mutual contagion of different mental disorders [41].

We conducted the stability test of BEIs by the case-dropping bootstrapping method (2000 bootstrapped samples) and estimated the correlation stability coefficient (CS coefficient) to quantify the stability. For ideal stability, this coefficient needs to be greater than 0.5 [39]. We conducted a difference test of the BEIs of the nodes by bootstrapping (2000 bootstrapped samples, α = 0.05). The R bootnet package [35] was used to perform these operations.

3. Results

3.1. Descriptive statistics

The average age of the participants recruited in our study was 19.99 ± 1.11 years. Among the participants, 33.47 % were male, 31.09 % were single children, 34.85 % were from rural areas, and 11.88 % were from single-parent families. Tables 1 and 2 display the means, standard deviations and BEIs of the items in the anxiety-suicidal ideation and depression-suicidal ideation networks, respectively. The average value of the GAD-7 total score was 4.64, 47.12 % of participants were considered to have anxiety with a GAD-7 total score greater than 5; the average value of the PHQ-9 total score was 6.90, 64.55 % of participants were considered to have depression with a PHQ-9 total score greater than 5; and the average value of the PANSI total score was 27.90.

Table 2
The means, standard deviations and bridge expected influences of the items in the depression-suicidal ideation network.

Items	Abbreviation	M	SD	BEI
Depression items				
D1: Little interest or pleasure in doing things	Anhedonia	0.96	0.81	0.06
D2: Feeling down, depressed, or hopeless	Depressed or sad mood	0.87	0.74	0.05
D3: Trouble falling/staying asleep or sleeping too much	Sleep difficulties	0.91	0.90	0.04
D4: Feeling tired or having little energy	Fatigue	0.89	0.80	0.03
D5: Poor appetite or overeating	Appetite changes	0.77	0.85	0.03
D6: Feeling bad about yourself—or that you are a failure or have let yourself or your family down	Feeling of worthlessness	0.76	0.78	0.11
D7: Trouble concentrating on things, such as reading the newspaper or watching television	Concentration difficulties	0.67	0.84	0.11
D8: Moving or speaking so slowly that other people could have noticed? Or the opposite—being so fidgety or restless that you have been moving around a lot more than usual	Psychomotor agitation/ retardation	0.60	0.79	0.13
D9: Thoughts that you would be better off dead or of hurting yourself in someway	Thoughts of death	0.47	0.80	0.58
Suicidal ideation items				
S1: Felt frustrated because you were not doing well at school or at work	Frustrated at work	3.04	1.13	0.10
S2: Felt that you were not in control of most situations in your life	Unable to control the situation	3.00	1.09	0.08
S3: Felt hopelessness and suicide thoughts and you wondered if you should kill yourself	Hopelessness and suicide thoughts	1.65	0.96	0.23
S4: Felt so unhappy about your relationship with someone you wished you were dead	Unhappy about relationships	1.45	0.91	0.08
S5: Thought about killing yourself because you could not accomplish something important in your life	Unable to accomplish something important	1.47	0.94	0.16
S6: Felt hopelessness and suicide thoughts because things were not working out well for you	Things were not working out well	2.66	1.27	0.00
S7: Thought about killing yourself because you could not find a solution to a personal problem	Unable to solve personal problem	1.45	0.92	0.11
S8: Seriously considered killing yourself because you could not live up to the expectations of other people	Unable to meet expectations	1.43	0.87	0.01
S9: Felt unconfident about your ability to cope with most of the problems in your life	No confidence in life problems	2.71	1.31	0.05
S10: Thought that your problems were so overwhelming that suicide was seen as the only option to you	Overwhelming problems	1.44	0.92	0.07
S11: Felt so lonely or sad you wanted to kill yourself so that you could end your pain	Felt lonely or sad	1.38	0.81	0.11
S12: Thought about killing yourself because you felt like a failure in life	Felt like a failure	1.41	0.89	0.01
S13: Felt that life was not worth living	An unworthy life	2.30	1.45	0.01
S14: Felt unconfident about your plans for the future	No confidence in future plan	2.50	1.37	0.10

3.2. Network analysis

3.2.1. The network structures

The anxiety-suicidal ideation network model of the college students is shown in Fig. 1(a). There were 99 edges in the anxiety-suicidal ideation network. There were 28 edges bridging different communities, and the strongest were A7 "Afraid something will happen"–S7 "Unable to solve personal problem" (edge weight = 0.10), A2 "Uncontrollable worry"–S5 "Unable to accomplish something important" (edge weight = 0.07) and A5 "Restlessness"–S4 "Unhappy about relationships" (edge weight = 0.06). The details of the edge weights in the network are provided in Table S1 of the supplemental material. A narrow bootstrapped 95 % CI proved acceptable edge weight accuracy (Fig. S1 of the supplemental material). See Fig. S2 of the supplemental material for the results of the difference test of the edge weights.

The depression-suicidal ideation network model of the college students is shown in Fig. 2(a). There were 119 edges (edge weight ranging from −0.02 to 0.46) in this network. There were 36 edges across the communities in the network, and the strongest were D9 "Thoughts of death"–S5 "Unable to accomplish something important" (edge weight = 0.14), D9 "Thoughts of death"–S3 "Hopelessness and suicide thoughts" (edge weight = 0.11) and D9 "Thoughts of death"–S11 "Felt lonely or sad" (edge weight = 0.10). Table S2 of the supplemental material displays the details of the edge weights in the network. Acceptable edge weight accuracy was proven by a narrow bootstrapped 95 % CI (Fig. S5 of the supplemental material). Fig. S6 of the supplemental material displays the results of the difference test of the edge weights.

3.2.2. The BEIs

The BEIs of the nodes in the anxiety-suicidal ideation network are shown in Fig. 1(b). A5 "Restlessness" (BEI = 0.25) and S3 "Hopelessness and suicide thoughts" (BEI = 0.20) had the highest BEIs of their communities and thus were identified as bridges in the network. As Fig. S3 of the supplemental material shows, the BEIs of A5 "Restlessness" and S3 "Hopelessness and suicide thoughts" were significantly larger than those of most other nodes in the network ($P < 0.05$). The CS coefficient of BEI in the network was 0.60, which indicated ideal stability (Fig. S4 of the supplemental material).

As shown in Fig. 2(b), D9 "Thoughts of death" (BEI = 0.58) and S3 "Hopelessness and suicide thoughts" (BEI = 0.23) had the highest BEIs of their communities and were considered bridges between depression and suicidal ideation. In addition, the BEIs of D9 "Thoughts of death" and S3 "Hopelessness and suicide thoughts" were significantly larger than those of most other nodes in the network ($P < 0.05$, Fig. S7 of the supplemental material). The CS coefficient of BEI in the network was 0.75, which was larger than 0.5 and indicated sufficient stability (Fig. S8 of the supplemental material).
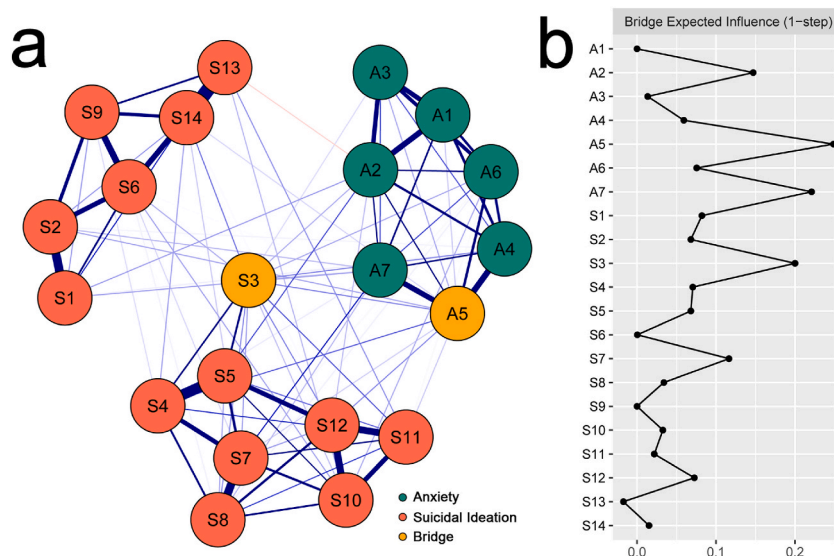

Fig. 1. The anxiety-suicidal ideation network model and the bridge expected influence indices among Chinese college students. Note: (a) Anxiety-suicidal ideation network model among Chinese college students during the COVID-19 pandemic. The nodes represent symptoms, and the edges represent the correlations. Red and blue edges represent negative and positive correlations, respectively, and wide edges and saturated colors indicate strong correlations. (b) Bridge expected influence indices in the anxiety-suicidal ideation network (raw score). A1 = Nervousness or anxiety, A2 = Uncontrollable worry, A3 = Worry too much, A4 = Trouble relaxing, A5 = Restlessness, A6 = Irritable, A7 = Afraid something will happen, S1 = Frustrated at work, S2 = Unable to control the situation, S3 = Hopelessness and suicide thoughts, S4 = Unhappy about relationships, S5 = Unable to accomplish something important, S6 = Things were not working out well, S7 = Unable to solve personal problem, S8 = Unable to meet expectations, S9 = No confidence in life problems, S10 = Overwhelming problems, S11 = Felt lonely or sad, S12 = Felt like a failure, S13 = An unworthy life, S14 = No confidence in future plan. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)
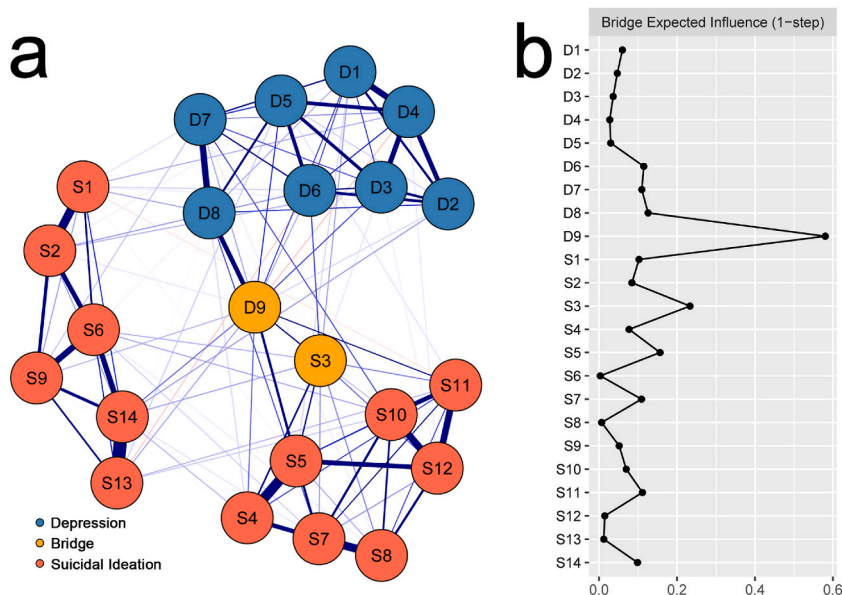
Fig. 2. The depression-suicidal ideation network model and the bridge expected influence indices among Chinese college students.
Note: (a) Depression-suicidal ideation network model among Chinese college students. The nodes represent symptoms, and the edges represent the correlations. Red and blue edges represent negative and positive correlations, respectively, and wide edges and saturated colors indicate strong correlations. (b) Bridge expected influence indices in the depression-suicidal ideation network (raw score). D1 = Anhedonia, D2 = Depressed or sad mood, D3 = Sleep difficulties, D4 = Fatigue, D5 = Appetite changes, D6 = Feeling of worthlessness, D7 = Concentration difficulties, D8 = Psychomotor agitation/retardation, D9 = Thoughts of death, S1 = Frustrated at work, S2 = Unable to control the situation, S3 = Hopelessness and suicide thoughts, S4 = Unhappy about relationships, S5 = Unable to accomplish something important, S6 = Things were not working out well, S7 = Unable to solve personal problem, S8 = Unable to meet expectations, S9 = No confidence in life problems, S10 = Overwhelming problems, S11 = Felt lonely or sad, S12 = Felt like a failure, S13 = An unworthy life, S14 = No confidence in future plan. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

4. Discussion

4.1. The psychopathological pathways between anxiety and suicidal ideation, depression and suicidal ideation

There are two different theories for the diagnosis of mental disorders. One is the classification diagnosis perspective [42], the other is the dimension perspective [43,44]. However, these two theories ignore the interactions between symptoms, which is common in the development of mental disorders [45]. Psychopathology network theory proposes that symptoms are not passive indicators of mental disorders but interacting components in mental disorder pathology [46,47]. Although some previous studies explored the relationship between suicidal ideation and its related influencing factors [48,49], these studies treated suicidal ideation as a node in the network, ignoring the interaction among different symptoms of suicidal ideation. This study is the first to explore the relationships between anxiety and suicidal ideation and between depression and suicidal ideation at the symptom level. The edges bridging different communities represent the psychopathological pathways between mental disorders, which helps understand the underlying interaction mechanism of comorbidity [50,51]. In view of this, we discuss the key cross-community edges in the network models.

In the anxiety-suicidal ideation network, "Afraid something will happen" was positively correlated with "Unable to solve personal problem". Unlike most previous traumatic events, the threats brought by the COVID-19 pandemic can be anywhere and close to us; thus, individuals are prone to experience a high level of uncertainty over the future [52]. The inconvenience caused by the epidemic hinders the solution of personal problems, and persistent negative experiences form the basis of fear of the future. "Uncontrollable worry" was positively correlated with "Unable to accomplish something important", cognitive avoidance theory suggests that negative emotional arousal can be inhibited by the conversion from the visual presentation of danger to the verbal presentation of worry; thus, uncontrollable worry is negatively reinforced [53,54]. This negative coping strategy may come from a sense of powerlessness. "Restlessness" was positively correlated with "Unhappy about relationships". Exploratory analysis indicated that restlessness co-occurred primarily with argumentation and disturbance to others [55], which undoubtedly leads to interpersonal problems.

In the depression-suicidal ideation network, "Thoughts of death" was positively correlated with "Unable to accomplish something important", "Hopelessness and suicide thoughts", and "Felt lonely or sad". The increase in confirmed cases and deaths, the blockade caused by the epidemic, the severe economic burden, and the fear of disease consequences exacerbated feelings of powerlessness, hopelessness and loneliness in students during the epidemic [56–58], and these three feelings have been confirmed as important predictors of suicidal ideation [16,59–61].

4.2. The intervention targets of suicidal ideation

Psychopathology suggests that bridge symptoms activate and maintain the coexistence of multiple disorders [62]. Consequently, when one disorder appears, the identification and intervention of potential bridge symptoms may help prevent the occurrence of comorbid disorders [39].

In the anxiety-suicidal ideation network, "Restlessness" and "Hopelessness and suicide thoughts" were identified as bridge symptoms, while "Thoughts of death" and "Hopelessness and suicide thoughts" were considered bridge symptoms in the depression-suicidal ideation network. Previous studies have proposed that the risk of suicidal ideation is directly increased by anxiety rather than being a simple byproduct of comorbid depression [17,63], and "Restlessness" may be the link between anxiety and suicidal ideation. Restlessness in anxiety is caused by autonomic arousal and subjective worry; can manifest in trembling, twitching, and loud complaints of inner turmoil [64]; and reflects intolerable psychological distress and tends to induce the emergence of extreme thoughts. In addition, although "Thoughts of death" differ from suicidal ideation in terms of the risk of adverse consequences [65], different from the thinking about the meaning of death that usually appears in elderly individuals, "Thoughts of death" in college students tends to manifest as a passive death wish or an active suicide plan [42]. Suicidal ideation is associated with depression severity [66], and the common increase in the two in college students during the COVID-19 pandemic has been confirmed by previous studies [67]. "Thoughts of death" may build a bridge in the interaction between depression and suicidal ideation. Furthermore, according to the suicide psychological model, the psychological factors that are crucial to suicide include feelings of being hopeless, trapped and defeated [68], and hopelessness occupies centrality in suicidal ideation development [69]. In the current study, "Hopelessness and suicide thoughts" played a bridge role between anxiety and suicidal ideation and between depression and suicidal ideation; thus, interventions targeting "Hopelessness and suicide thoughts" can simultaneously minimize the effects of anxiety and depression on suicidal ideation.

4.3. Limitations

There are several limitations that should be pointed out. First, a cross-sectional design was used in our research, thus the causality and temporality in the relationships of anxiety, depression and suicidal ideation symptoms can not be determined. Second, the sample scope was limited to Chinese college students, and generalizing the results to a larger population remains to be considered. Finally, the intervention effect of the targets on suicidal ideation still needs to be tested in practice.

5. Conclusion

This study represents the first utilization of network analysis to explore the relationships between anxiety and suicidal ideation and between depression and suicidal ideation in Chinese college students. The visual network models helped us develop a delicate understanding of the psychopathological pathways between anxiety and suicidal ideation and between depression and suicidal ideation. The BEI evaluation helped to determine the bridge symptoms that maintain comorbidity and suggested the potential targets for interventions of suicidal ideation. The present study enriches the theory of symptoms and mental disorders and provides a reliable reference for the practice of psychological intervention.

Data availability statement

Data will be made available on request.

CRediT authorship contribution statement

Tianqi Yang: Writing – original draft, Investigation, Formal analysis, Data curation, Conceptualization. **Yang He:** Writing – original draft. **Lin Wu:** Writing – original draft. **Lei Ren:** Supervision, Software, Methodology. **Jiaying Lin:** Project administration, Investigation. **Chaoxian Wang:** Software, Resources, Project administration. **Shengjun Wu:** Writing – review & editing, Funding acquisition, Conceptualization. **Xufeng Liu:** Writing – review & editing, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e20938.

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