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Network analysis in depressed adolescents with suicidal ideation: the role of depression, anxiety, and childhood abuse

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Introduction: Adolescent depression is a global public health issue strongly associated with suicidal ideation and childhood abuse. Although family systems and ecological theories highlight the multilevel influences of family environment on mental health, most studies focus on overall symptom scores rather than examining how specific forms of abuse relate to distinct symptoms. Employing symptom network analysis, this study investigates the interactions among depressive symptoms, anxiety, and childhood abuse in adolescents diagnosed with major depressive disorder (MDD) and suicidal ideation.

Methods: We analyzed data from 733 Chinese adolescents diagnosed with MDD (mean age = 14.81 years). Symptom networks were constructed via LASSO-regularized models using the Patient Health Questionnaire-9 (PHQ-9), Generalized Anxiety Disorder-7 (GAD-7), and the Childhood Trauma Questionnaire-Short Form (CTQ-SF). Centrality (strength and bridge strength) and stability analysis identified core symptoms and bridging pathways.

Results: Depressive and anxiety symptoms showed strong comorbidity, with "Uncontrollable worry" (GAD2) and "Fatigue" (PHQ4) as central nodes. Key bridge symptoms included "Motor" (PHQ8), "Death" (PHQ9), "Restless" (GAD5), and "Emotional abuse" (EA). Childhood abuse exhibited intra-group correlations (emotional-physical abuse), and emotional abuse was directly linked to death-related thoughts. The network demonstrated strong stability.

Conclusions: Emotional abuse and bridge symptoms (e.g., fatigue and uncontrolled worry) are critical intervention targets for suicide–prevention interventions. A multimodal approach integrating cognitive-behavioral therapy for core symptom management, family-based interventions to address attachment disruptions, and policy initiatives to reduce childhood abuse is recommended.

1 Introduction

Major Depressive Disorder (MDD) is a prevalent mental health condition, affecting an estimated 280 million individuals globally (1). However, treatment rates remain notably low (2). The onset of MDD during childhood and adolescence significantly impacts physical development, academic performance, and interpersonal relationships (3). According to recent survey data, approximately 14.8% of adolescents in China are at risk of depression (4). Notably, the prevalence of depressive symptoms in this population has markedly increased compared to pre-COVID-19 levels (5). In addition, suicidal ideation is highly prevalent among adolescents with MDD (6) and may predict increased risk of suicidal behavior or progression to severe mental illness in adulthood (7). Globally, suicide ranks as the fourth leading cause of death among individuals aged 15 to 29 years (8).

Suicidal ideation, defined as thoughts of ending one's life without immediate action, is closely associated with the severity of depressive symptoms (9). In China, the prevalence of suicidal ideation among children and adolescents is reported to be 15.4% (10), with 60–70 % of adolescents experiencing depression also exhibiting suicidal ideation (11). Clinically, a frequent comorbidity between depression and anxiety is observed in adolescents, with evidence suggesting that these conditions may mutually exacerbate each other (12). A prospective study indicated that patients with MDD who also suffer from anxiety are at a higher risk of suicide compared to those experiencing depressive symptoms alone (13). Therefore, early identification of symptoms and the implementation of active treatment models for patients with comorbid depression and anxiety are critical (14). However, family functioning is critically important for adolescent mental health. Murray Bowen's Family Systems Theory posits that an individual's emotional distress does not occur alone but stems from the interactions among family members, emotional connections, and intergenerational influences (15). Research has found that an unhealthy family environment, such as parents having mental health problems or experiencing childhood abuse, can exacerbate emotional and behavioral issues in children and adolescents. These adverse factors will significantly increase their risk of developing mental illness (16). Therefore, understanding the association mechanism between childhood abuse and adolescent depression and anxiety is of great significance for formulating targeted intervention measures, improving the function of family systems, and reducing the risk of suicide (17).

Bronfenbrenner's ecological systems theory highlights the pivotal influence of environmental and familial factors in the development of adolescent mental health. This theoretical framework posits that multiple layers of an individual's environment, particularly the family unit, exert significant influence on psychological growth and adjustment. Recent empirical studies have demonstrated a robust correlation between childhood abuse and the onset of mental health disorders, including depression, anxiety, and suicidal ideation (18, 19). Childhood abuse is defined as one or more instances of physical, emotional, or sexual abuse, as well as physical or emotional neglect, perpetrated by parents or primary caregivers before the age of 18 (20). Attachment theory focuses on how early relationships affect development. It suggests that these early bonds form the basis for internal working models—mental frameworks that shape how people see themselves and relate to others (21–23). In the context of childhood abuse, children and adolescents frequently develop disorganized attachment patterns, characterized by inconsistent or inadequate caregiving. Such attachment disruptions can have profound and lasting impacts on emotional regulation and psychological functioning. Disorganized attachment is often associated with impaired emotional regulation, which heightens the risk of maladaptive behaviors and increasing susceptibility to mental health disorders such as depression and anxiety. Moreover, attachment disorganization may be linked to dissociative tendencies and attendant problems. This dissociation, a defense mechanism against overwhelming emotions, can further exacerbate psychological distress, including an elevated risk of suicidal ideation (24, 25). Integrating these theoretical perspectives can provide a more detailed and comprehensive understanding of how childhood abuse leads to the development of depression in children and adolescents. Therefore, in-depth research on child abuse is crucial for explaining the mechanisms that lead to the occurrence and development of depressive symptoms in this group. The relevant research conclusions can provide a solid theoretical basis for designing effective prevention and intervention strategies (26).

Traditional studies using regression or structural equation modeling have primarily examined the relationships among depression, anxiety, and childhood maltreatment relationships but are unable to identify symptom-level interactions or dynamic cascades (27, 28). With multimorbidity, symptom networks grow more complex, making simple models insufficient for mapping pathological pathways. To further explore the complex interplay between the dimensions of psychological symptoms and environmental factors, network analysis has emerged as a valuable methodological tool in psychology (29, 30). In this framework, symptoms are represented as nodes, with the relationships between symptoms illustrated by edges (31). The centrality indices of nodes, such as symptom strength and intensity, are particularly crucial for identifying key symptoms, which may inform the selection of intervention targets in clinical practice (30). Consequently, this network-based approach offers a novel perspective on the comorbidity of mental health disorders. The bridge network model is especially effective in revealing the underlying connections among symptoms of comorbid mental disorders and in explaining how external environmental factors influence these symptom interactions (32). In particular, the concept of bridge strength helps identify key bridging nodes that link different symptom clusters, and it illustrates how external factors—such as childhood abuse—can impact specific symptoms across multiple disorders through these nodes (33). In this study, the bridge strength of childhood abuse symptoms clearly shows how environmental influences are directly connected to symptoms of depression and anxiety (34). This is crucial for understanding how the environment interacts with individual symptoms. By clarifying these specific bridging pathways related to childhood abuse, we can improve screening practices, enabling earlier identification of individuals at risk and supporting timely preventive interventions to reduce the long-term psychological effects of abuse (35, 36). The bridge network model, in particular, provides valuable insights into the nature of comorbidities. On one hand, it explains how multiple comorbidities of mental illnesses can arise, while on the other hand, it illustrates how specific symptoms of one disorder may increase the risk of developing another disorder. By delineating the underlying structure of symptom interaction, network analysis offers a deeper understanding of the dynamic relationships among psychological symptoms, enabling more targeted and effective interventions (29).

Currently, numerous studies have utilized network analysis to examine depression and anxiety symptoms in children and adolescents. For instance, a network study on Spanish children and adolescents identified "lfeeling lonely" and "feeling unloved" as central bridge symptoms linking depression and anxiety (37). In addition to general population studies, research has also focused on specific subgroups of children and adolescents, including those with subthreshold depression (38), panic disorder (39), obsessive-compulsive disorder (40), and autism spectrum disorder (41), to investigate the depression–anxiety network. Researchers have further sought to employ network models to elucidate the influence of environmental factors, such as childhood abuse, on depressive

symptoms in children and adolescents through specific nodes (42, 43). Given the critical importance and specificity of suicidal ideation within the symptomatology of depression, a Texas–based study explored the direct network relationship between suicidal ideation and depressive symptoms in adolescents (44). However, there is still a significant gap in the current literature. Most network analysis studies involving adolescents have focused on community samples, while there are few studies concentrating on the symptom networks of clinically depressed adolescents with suicidal ideation, especially the interaction of environmental factors (such as childhood abuse) (9). Therefore, this study aims to fill this key gap. It is necessary to investigate clinical samples of adolescents with depression and suicidal ideation, as these adolescents usually exhibit more severe symptoms, a higher incidence of suicidal ideation and more serious social dysfunction compared with the community or school population. It is worth noting that the research results based on community samples may have limitations when generalized to the clinical severe patient population. This is because there may be significant differences in the symptom network structure between the two groups of people (45). For instance, compared with healthy controls, the temporal affective networks of patients with major depressive disorder and mental illness show stronger interconnectivity, which further highlights the essential differences in symptom structure between the clinical and non-clinical populations (46). Therefore, studying this specific high-risk clinical group can provide more precise and clinically relevant insights, inform targeted interventions, and enhance clinical practice. Addressing this gap, our study investigates the network structure of depression, anxiety, and childhood abuse in clinically depressed, suicidal adolescents. Childhood and adolescence are critical periods for mental health development, making symptom-interaction analysis vital for early intervention. By including childhood abuse in our network model, we explore its interplay with depressive/ anxiety symptoms, particularly regarding suicidal ideation.

Based on the prior considerations and initial observations, this research is designed to explore three main questions. First, it explores the overall network structure involving symptoms of depression, anxiety, and childhood abuse among clinically depressed adolescents with suicidal ideation. Second, it highlights the specific symptoms occupying central positions within this comorbid symptom network, thereby elucidating potential targets for intervention. Lastly, it examines which symptoms function as critical bridge nodes that interconnect different symptom clusters (e.g., depression, anxiety, and childhood abuse). These bridge nodes may play a role in the spread of psychopathology or highlight the direct impact of environmental factors.

2 Methods

2.1 Participants and procedure

A cohort comprising 823 adolescent patients, aged between 10 to 18 diagnosed with MDD was recruited from both inpatient and

outpatient departments of the Psychiatric Department at the First Affiliated Hospital of Kunming Medical University over the period from June 2021 to December 2023. Diagnosis of MDD was conducted in accordance with DSM-5 criteria by attending psychiatrists or higher-ranking physicians (47). Each participant completed a self-assessment questionnaire, and informed consent was obtained from both participants and their guardians prior to survey administration. Participation was voluntary, and all participants and guardians were informed about the anonymity and confidentiality of the questionnaire. Exclusion criteria encompassed (1): current diagnosis of organic diseases, schizophrenia spectrum disorders, other psychiatric disorders (e.g., neurodevelopmental disorders), bipolar disorder, or psychoactive substance use disorder; (2) incomplete or invalid questionnaire data; (3) inability to understand or cooperate with the completion of questionnaires; (4) not within the specified age range of 10 to 18 years; (5) patients taking multiple psychotropic drugs for treatment.

For this study, the Suicidal Behavior Questionnaire-Revised (SBQ-R) (48), assessed past-year suicidal ideation frequency, specifically querying participants on the frequency of suicidal thoughts in the past year. The response options for this item were: "Never," "Rarely (1 time)," "Sometimes (2 times)," "Often (3–4 times)," and "Very often (5 or more times)." Participants reporting "never" were excluded. Suicidal ideation occurring 1–2 times was classified as lower frequency, while 3 or more times was categorized as higher frequency. Previous research has demonstrated that this item from the SBQ-R serves as a robust clinical screening tool, aiding in the identification of individuals at elevated risk for suicide and informing subsequent evaluation and intervention strategies (49, 50). The network analysis included 733 MDD-diagnosed children/adolescents with suicidal ideation. Ethical approval was obtained from the Ethics Committee of the First Affiliated Hospital of Kunming Medical University (2021 Ethical Approval L No. 25).

2.2 Measures

2.2.1 Childhood trauma

The Child Trauma Questionnaire (CTQ) (51), was utilized in its Chinese version, CTQ-SF Scale, as adapted by FU-wenqing (52), to assess childhood trauma. This instrument comprises 28 items rated on a five-point scale ranging from 1 ("never") to 5 ("always"), where higher scores indicate greater severity of childhood trauma. The internal consistency of the scale, assessed by Cronbach's α coefficient in this study, was 0.82, indicating good reliability.

2.2.2 Depression

The Patient Health Questionnaire (PHQ-9) (53), a nine-item tool using a four-point Likert scale, assessed depressive symptoms in children and adolescents. This clinically validated measure demonstrated excellent internal consistency (Cronbach's α = 0.86) in our study (54).

2.2.3 Anxiety

The Generalized Anxiety Disorder Scale (GAD-7) (55), a seven-item instrument using a four-point Likert scale, assessed participants' anxiety symptoms. This scale has demonstrated strong psychometric properties and effectiveness for screening anxiety in Chinese adolescents (56). In our study, the GAD-7 showed excellent internal consistency (Cronbach's α = 0.89).

2.3 Analysis

Descriptive statistics were computed using SPSS, and the network structure estimation was conducted in R (version 4.4.1) employing several dedicated packages, namely *bruceR*, *qgraph*, *networktools*, *bootnet*, and *mgm*.

2.4 Network construction

2.4.1 Network estimation

Network analyses were performed using R 4.4.1. Considering our sample size, data type, and research objectives, we estimated network models and calculated connection weights using the graphical LASSO method with EBIC model selection at first, implemented through the estimateNetwork function with EBICglasso option (57). In the resulting networks, nodes represent variables connected by edges whose thickness reflects connection strength (30). Node predictability (how well each node is predicted by others) was assessed using the mgm package (45).

2.4.2 Centrality and bridge estimation

In the exploration of network structure, three key centrality indicators are considered: strength, closeness, and betweenness (58). Centrality indices for each node were calculated using the centralityPlot function from the graph package in R (59).

Strength refers to the sum of the absolute values of the weights of the edges connected to a node. Prior research has highlighted the relevance of node strength in the study of psychopathology, noting its greater stability compared to other centrality measures like closeness and betweenness (31, 60).

A bridge analysis was conducted to identify key pathways linking depressive symptoms and environmental factors. Bridge nodes, critical connections between network domains, were assessed using bridge strength (networktools package in R). Bridges are shared dimensions that facilitate symptom transmission across domains (61). Bridge strength, the most effective index (62), was estimated with an 80th percentile cutoff (61), revealing influential pathways and network dynamics.

2.4.3 Network accuracy and stability

Given the influence of sampling variability on the estimation of network models, we employed the bootstrap method to assess the accuracy and stability of both edge weights and centrality measures. This was accomplished using the bootnet package in R. To evaluate

the accuracy of the edge weights, we calculated the 95% confidence intervals (CI) for the edge-weight bootstrap. For assessing the stability of centrality measures, we utilized the centrality stability coefficient (CS coefficient). This coefficient serves as a reference index for determining the robustness of the centrality measures against sampling variability.

3 Results

3.1 Descriptive statistics

The study enrolled a total of 733 subjects (N = 733), with a mean age of 14.81 years ± standard deviation of 1.63 years. Among the 733 individuals in this cohort, 548 (74.8%) were of Han ethnicity. Among the 548 people in this cohort, 74.8% are of Han ethnicity. In addition, 536 participants (73.1%) were urban residents, and 341 participants (46.5%) were only children. Detailed demographic characteristics are presented in Table 1.

3.2 Network structure

Figure 1 illustrates the network structure of depression, anxiety, and childhood abuse in Depressed Adolescents with suicidal ideation. Out of 210 possible edges, 109 (51.90%) non-zero edges were observed, with an average weight of 0.04. The network demonstrated overall positive correlations among symptoms. Predictability of the symptoms is represented in Figure 1 as a ring pie chart, with an average predictability score of 0.46. This indicates that adjacent nodes in the model can explain 46% of the variance of each node on average.

In the network model, as depicted in Figure 1, the nodes representing "emotional neglect" (EN) and "physical neglect" (PN) exhibited the strongest direct relationship within the childhood abuse symptom group (r = 0.48). This was followed by the association between "emotional abuse" (EA) and "physical abuse" (PA) (r = 0.32), and between EA and EN (r = 0.31). Meanwhile, within the depressive symptom group, the node representing "anhedonia" (PHQ1) and the node "sad mood" (PHQ2) were most directly connected (r = 0.31). This was followed by connections between the PHQ1 and the "fatigue" node (PHQ4) (r = 0.28), the PHQ4 and the "appetite" node (PHQ5) (r = 0.25), and the "worthless" node (PHQ6) and the "Death" node (PHQ9) (r = 0.23). In the anxiety symptom group, the connection between node "nervous" (GAD1) and node "Control worry" (GAD2) (r = 0.36) is the most direct. This is followed by the connection between node GAD2 and node "worry too much" (GAD3) (r = 0.31), and the connection between GAD3 and node "relax" (GAD4) (r = 0.19). Furthermore, there are numerous interconnections between symptoms across the three communities. For instance, the node "restless" (GAD5) is most closely associated with the node "motor" (PHQ8) (r = 0.23). Additionally, there is a notable connection between PHQ9 and

TABLE 1 Demographic characteristics of the sample (N = 733).

Variable	Mean (SD) or N (%)
Age (years)	14.81 (1.63)
Sex	
Male	190 (25.9%)
Female	543 (74.1%)
Only child: Yes	341 (46.5%)
Current residence region	
City	536 (73.1%)
Rural	197 (26.9%)
Ethnicity	
Han	548 (74.8%)
Bai	117 (16.0%)
Yi	37 (5.0%)
Hui	9 (1.2%)
Others	22 (3.0%)
Live with mother: Yes	631 (86.1%)
Live with father: Yes	490 (66.8%)
Frequency of suicidal ideation	
1 time	94 (12.8%)
2 times	162 (22.1%)
3–4 times	182 (24.8%)
5 or more times	295 (40.2%)

EA (r = 0.13). Supplementary Table 1 details all edge weights within the network.

3.3 Network central and bridge symptoms

The intensity of nodes in children and adolescents with MDD and suicidal ideation is depicted in Figure 2. Among these nodes, GAD2 emerges as the most robust, with nodes PHQ4 and EA also demonstrating statistically significant strength compared to most other nodes in the network. This indicates that these nodes are more central to the overall network structure. Additional centrality indicators can be found in Supplementary Figure 1.

To gain a deeper understanding of the relationships between different symptom communities, the bridge strength of each node was calculated, resulting in the bridge network illustrated in Figure 1. According to the bridge strength analysis shown in Figure 3, the nodes PHQ8, PHQ9, GAD5, and EA exhibit higher bridge strength compared to most other nodes. This signifies that these four nodes serve as critical bridging symptoms, linking various symptom communities within the network. Table 2 presents the raw values for the strength of all symptoms and their
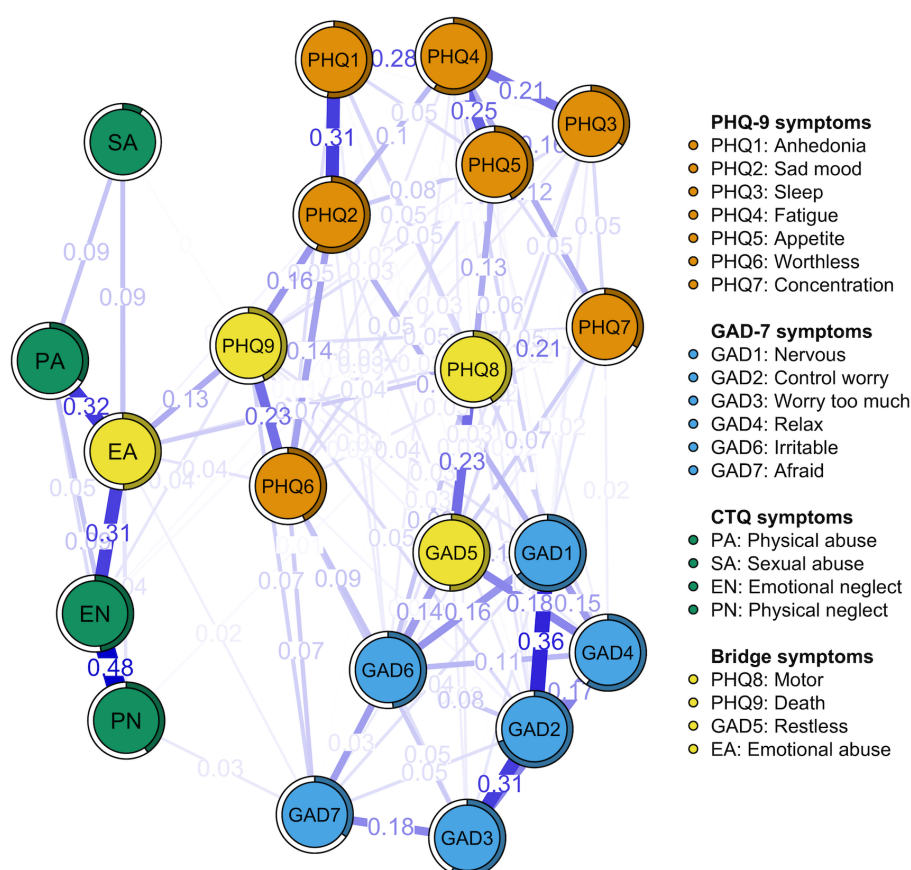
FIGURE 1
The network displaying the relationship between depression, anxiety, and childhood abuse symptoms. Nodes of different colors represent distinct network communities. Specifically, yellow nodes denote bridge nodes. The specific meanings and values of each node are shown in Table 2. Nodes are connected by edges, with thicker edges indicating stronger connections between symptom nodes.

respective bridge strengths. We estimated networks for the Han and urban subgroups, and their network structurekey, central symptoms and bridge symptoms were largely consistent with the overall sample (Supplementary Figures 5, 6).

3.4 Network accuracy and stability

As illustrated in Supplementary Figure 2, the bootstrap 95% CI is narrow, indicating that the estimates of edge weights are both accurate and stable. Results from the bootstrap difference test for edge weights (Supplementary Figure 3) reveal that the strongest edges in the network are found between items from the childhood abuse scale. Supplementary Figure 4 shows the difference test of node strength. The stability of the CS for node strength and bridge strength is reflected in a CS coefficient of 0.75 and 0.67, indicating that these estimates are sufficiently stable (see Figure 4). Additionally, the CS coefficients for the remaining centrality indicators are all greater than 0.25 (see Supplementary Figure 7). Additionally, the subgroup networks showed good stability (Supplementary Figures 8, 9). Given that the estimates of node strength are more reliable, the

interpretation of the results in this study primarily focuses on node strength.

4 Discussion

In contrast to many studies that utilize samples from adult populations within communities, this research adopts a network analysis approach to investigate the relationships between childhood maltreatment, depression, and anxiety among outpatient or inpatient pediatric and adolescent patients with suicidal ideation. This methodological approach is relatively uncommon in existing research. By employing this method, we aim to elucidate the complex interconnections among various community clusters, as well as the intricate interactions and associations between environmental factors and symptoms. Specifically (1): Among the symptoms across the three communities, the node GAD5 exhibits the strongest connection with the node PHQ8; (2) The nodes GAD2, PHQ4, and EA are the most central symptoms within the comorbid network model; (3) The node with the highest bridging strength in the comorbid network is PHQ8, which will be further discussed in detail below.
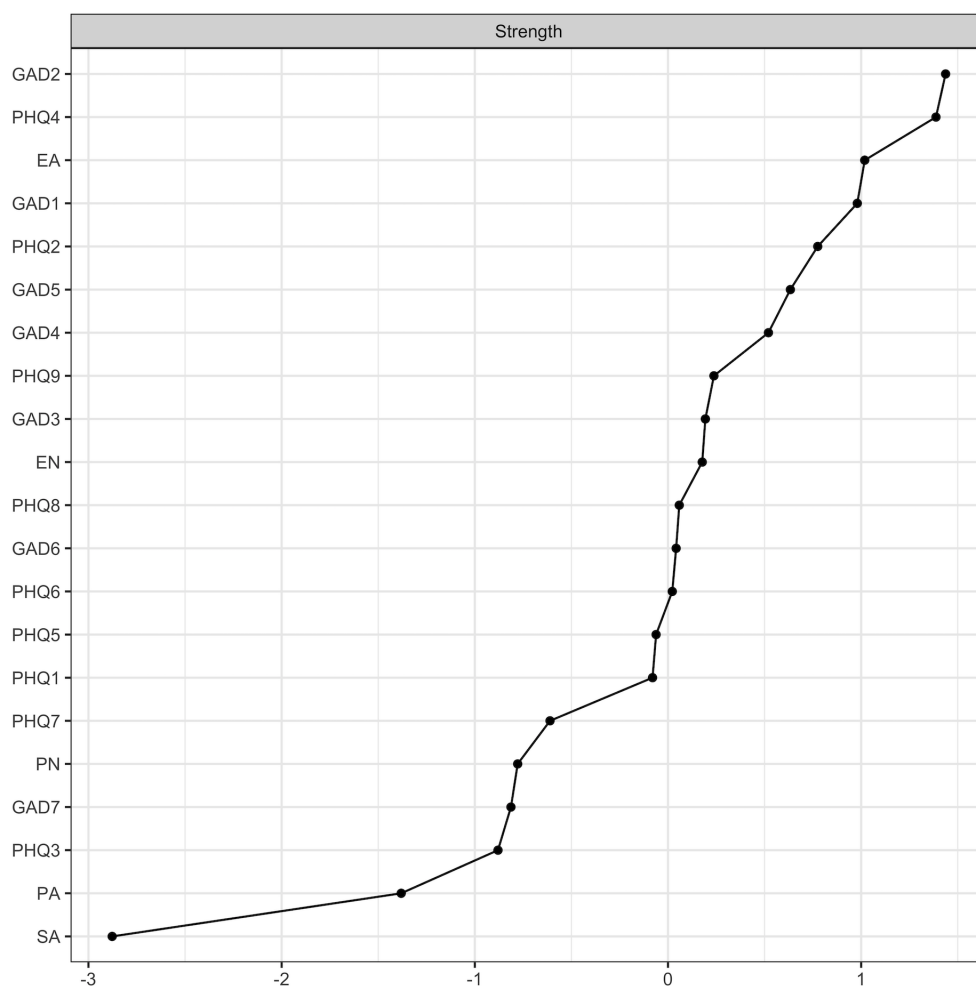
FIGURE 2
Node strength centrality estimates of the present network.

4.1 Central nodes and edges in the depression-anxiety-childhood abuse network

We have found that depression and anxiety symptoms in adolescents with suicidal ideation are highly interconnected and form a cluster. Within the depression and anxiety network, we observed that "control worry" and "fatigue" show high strength, making them core symptoms of the network, which is consistent with previous research conducted in child and adolescent populations (63, 64). Fatigue not only serves as one of the important symptoms for the diagnostic criteria of depression (47), but has also been mentioned in numerous studies of depressive symptoms. For instance, a depression symptom network study involving 3,463 outpatients with depression in the United States revealed that lack of energy has the strongest node centrality (65). Another survey conducted among college students demonstrated that fatigue is associated with more severe depressive symptoms and a higher risk of suicidal and anxiety tendencies (66).

Empirical evidence indicates that adolescents with depression exhibit a distinct depressive symptom profile characterized by pronounced fatigue, in contrast to adult populations (67). From a developmental psychopathology perspective, this phenomenon may be attributed to the interplay of multiple biological and psychosocial factors, including pubertal hormonal fluctuations and circadian rhythm dysregulation, which collectively predispose adolescents to increased vulnerability to persistent fatigue and energy depletion (68, 69). This finding prompts us to investigate the sensation of fatigue in depressive symptoms, which may uncover the complex relationships between depression, anxiety, and suicide. Interestingly, related neuroimaging studies have also shown that reduced neuronal activity in relevant brain regions of individuals with depression may explain the symptom of fatigue (70).

Furthermore, we found that "control worry" consistently exhibits high node centrality across almost all network models studying depressive and anxiety symptoms. Despite using a sample of patients with depression in this study, we obtained similar results.
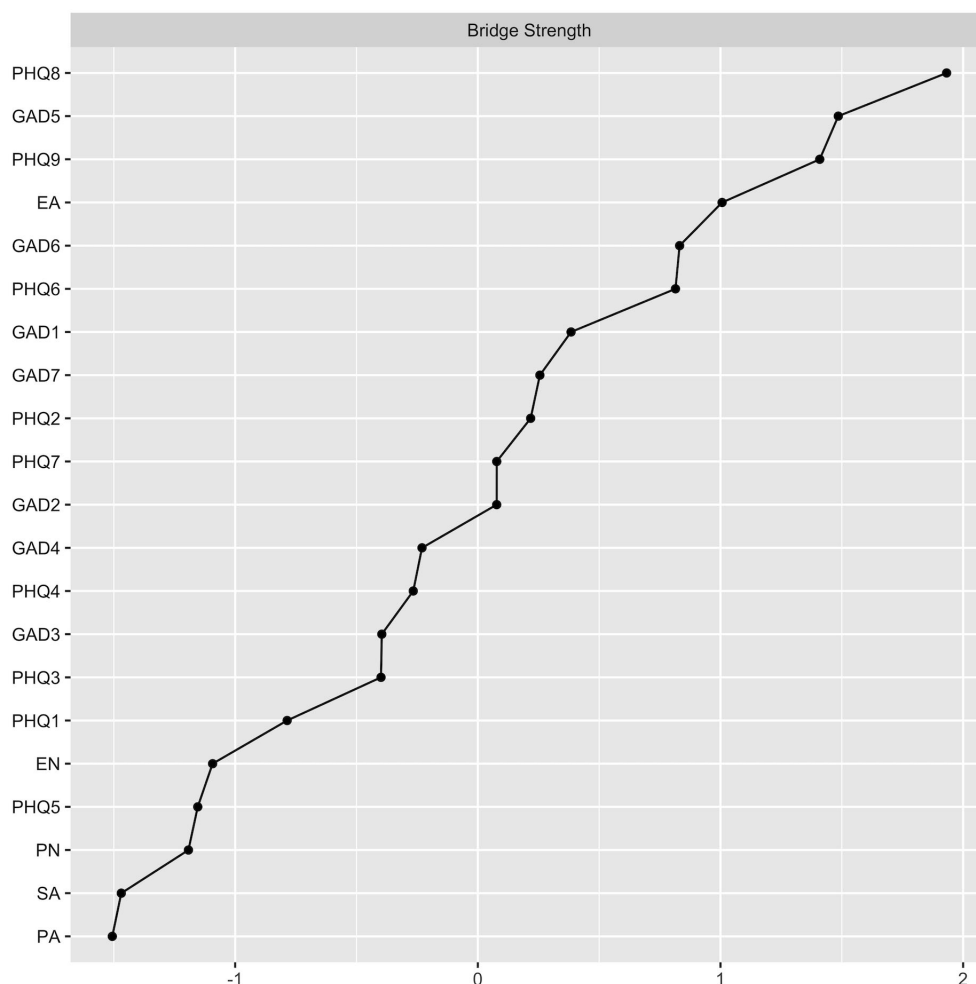
FIGURE 3
Bridge strength of each node in the present network.

Childhood and adolescence are critical periods for brain structural changes and development (71), potentially related to cognitive formation. According to the cognitive theory of suicide (72), the occurrence of suicidal behavior is associated with negative cognitions among individuals with depression. Children and adolescents with depression often have negative self-cognitions, manifested as pessimistic expectations about themselves, their environment, and the future, which may lead to persistent tension and worry, and subsequently, suicidal ideation.

Within the overarching framework of the depression-anxiety-childhood abuse network, EA emerges as a node with greater strength, alongside "control worry" and "fatigue", echoing analogous findings in prior research on childhood trauma networks (42). A deeper exploration reveals that the most pronounced edges are predominantly observed among the various forms of childhood maltreatment, with a notable emphasis on EA. Our findings well with those reported in earlier studies (73). Indeed, previous scholars have documented the frequent coexistence of psychological abuse with PA (74). This concurrence supports our

research conclusions and further substantiates the intricate interplay between diverse manifestations of childhood maltreatment. We postulate that, within the familial sphere, the occurrence of childhood maltreatment, including sexual abuse, may exacerbate familial conflicts. Both the familial milieu and maltreatment experiences have the potential to impact children's depressive and anxiety symptoms (75). A comprehensive meta-analysis indicates that individuals exposed to childhood maltreatment exhibit a twofold increased risk of recurrent depressive episodes compared to those without such histories (76). Hence, irrespective of the maltreatment type, any such experience poses a significant threat to the mental health of children and adolescents.

Conversely, in the realm of psychiatric symptoms, the strongest edges are predominantly found within the respective communities of depressive and anxiety symptoms, rather than between them, aligning with extensive prior research. Across these investigations, we consistently identify the most robust edges within depressive or anxiety symptom clusters, using PHQ-9 and GAD-7 scales to

TABLE 2 Descriptive statistics of depression, anxiety, and childhood abuse symptoms in depressed adolescents.

Item	Item abbreviation	Mean (SD)	Strength	Bridge strength	Predictability
PHQ1	Anhedonia	2.41 (0.73)	0.83	0.09	0.53
PHQ2	Sad mood	2.35 (0.74)	1.02	0.22	0.57
PHQ3	Sleep	2.20 (0.94)	0.66	0.14	0.35
PHQ4	Fatigue	2.39 (0.79)	1.15	0.16	0.59
PHQ5	Appetite	2.17 (0.93)	0.84	0.04	0.42
PHQ6	Worthless	2.27 (0.89)	0.86	0.29	0.44
PHQ7	Concentration	1.88 (1.07)	0.72	0.20	0.34
PHQ8	Motor	1.74 (1.07)	0.86	0.43	0.41
PHQ9	Death	1.94 (0.97)	0.90	0.37	0.43
GAD1	Nervous	2.30 (0.85)	1.07	0.24	0.65
GAD2	Control worry	2.20 (0.92)	1.17	0.20	0.70
GAD3	Worry too much	2.13 (0.90)	0.89	0.14	0.57
GAD4	Relax	2.11 (0.90)	0.96	0.16	0.60
GAD5	Restless	1.73 (1.01)	0.99	0.38	0.51
GAD6	Irritable	2.36 (0.82)	0.86	0.29	0.48
GAD7	Afraid	1.62 (1.08)	0.67	0.22	0.35
EA	Emotional abuse	11.88 (4.87)	1.07	0.32	0.50
PA	Physical abuse	7.62 (3.42)	0.55	0.00	0.34
SA	Sexual abuse	5.53 (1.73)	0.22	0.00	0.09
EN	Emotional neglect	15.85 (4.97)	0.89	0.05	0.48
PN	Physical neglect	9.46 (3.50)	0.68	0.04	0.41

identify connections such as GAD1-GAD2, GAD2-GAD3, and PHQ1-PHQ2 (77, 78). However, differences in the pattern of strongest edges become evident when our findings are compared with certain studies (79), potentially attributed to our focus on healthcare workers. In the post-pandemic era, the frequent revisions of infection control protocols and guidelines have introduced an element of uncertainty. Compared with the general populace, healthcare workers confront unique challenges, including the implementation of infectious disease prevention measures and the management of critically ill patients (80), which may manifest in distinct depressive and anxiety profiles.

Nonetheless, among the top ten strongest edges identified, only one bridges the depressive and anxiety symptom communities, specifically PHQ8 and GAD5, resonating with prior research (77). This cross-community edge underscores the potential of these symptoms as candidate bridge symptoms within the entire network. From a clinical standpoint, the strong association between the "Motor" and "Restless" nodes suggests that interventions targeting the somatic manifestations of internal distress, particularly psychomotor agitation, may simultaneously alleviate symptoms of both depression and anxiety.

4.2 Bridge symptoms in the depression-anxiety-childhood abuse network

Regarding the connection between adverse childhood experiences and depressive and anxiety symptoms in adolescents, we found nodes within the communities of childhood trauma, depression, and anxiety that collectively serve as crucial bridges. Specifically, PHQ8, PHQ9, GAD5, and EA exhibit the highest bridge strength. As illustrated in Figure 1, PHQ9 and EA link the two communities of depression and childhood maltreatment (81). Previous researchers posited that emotional abuse constitutes a persistent, repetitive, and inappropriate emotional response to children's emotional expressions and their accompanying behaviors.

According to the cumulative risk hypothesis, negative events in early childhood, such as maltreatment, may have a cumulative effect, leading to increased internalizing and externalizing behavior problems in the future (82), which may ultimately result in suicidal ideation. The despair theory is often utilized by researchers to explain the linkage between negative events, emotions, and suicide (83). On one hand, individuals with depressive disorders may develop suicidal ideation due to cognitive changes that lead to feelings of hopelessness
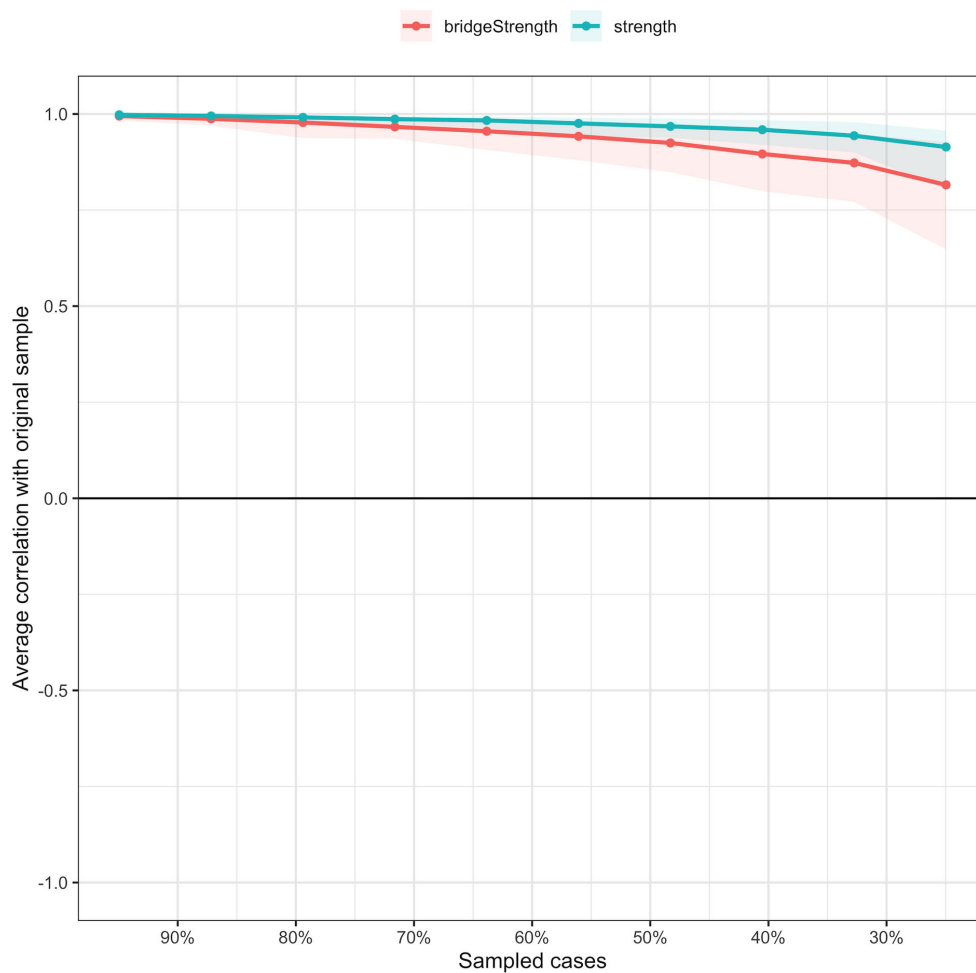
FIGURE 4
The stability of centrality and bridge centrality indices using case-dropping bootstrap.

and diminished Reasons for Living (84). On the other hand, individual negative life events, such as emotional abuse, can also induce feelings of despair. Specifically, despair mediates the relationship between emotional abuse and depressive symptoms, and negative life events combined with negative cognition can predict despair and depressive symptoms (85), potentially leading to the emergence of suicidal ideation. Our network analysis identified cognitive-affective symptoms as central mediators that transmit the impact of emotional abuse toward suicidal ideation, highlighting a potential psychopathological pathway underlying this association.

In China, parents often see their children as "private property" and believe they have the right to beat their children when they try to educate and "regulate" them (86). Therefore, it is necessary to fundamentally change this concept and phenomenon. In addition, the incidence of child abuse can be reduced to some extent through training (87). Target adolescents exposed to childhood abuse to develop positive personality traits and improve emotional regulation skills (88). This measure is essential for children who have already been diagnosed with mdd. It is important to note that when children experience more abuse, even more positive experiences (such as social support, peer care, etc.) do not significantly improve the exposure of adverse experiences to mental health problems (89), so it is very possible to prevent childhood abuse. However, there are documented reasons why child abuse has not yet been recognized as a social problem worthy of public attention in China (90), and this phenomenon needs to be greatly changed. On the one hand, correct guidance of public opinion can be established through media and Internet to reduce the occurrence of childhood abuse. On the other hand, strengthen the formulation of relevant laws and regulations, restrict the parenting behavior, and maximize the protection of children and adolescents from domestic abuse.

This study identified key bridge nodes linking depression, anxiety, and childhood abuse through bridge network analysis, offering a new perspective for clinical identification and intervention. PHQ8, GAD5, and EA emerged as important hubs connecting different psychological problems. In outpatient screening, elevated scores on these bridge nodes may indicate the presence of comorbid depression and anxiety as well as a history of childhood abuse, warranting further assessment of suicide risk (91). In terms of treatment, for individuals with high scores on bridge nodes such as EA and GAD5, different strategies may be applied. For example, targeting restlessness (GAD-5) directly may be effective, as studies have shown that early improvement in restlessness is associated with remission in major depression (92). For patients with high EA scores, it is essential to assess for a potential history of childhood trauma. Interventions focusing on trauma and family functioning may help reduce the mutual reinforcement between depression and anxiety, potentially lowering overall suicide risk (93).

4.3 Strengths, limitations and future direction

The strength of this study lies in its focus on clinically diagnosed depressive populations, where it identifies children with high-risk suicidal ideation and incorporates childhood maltreatment, along with depressive and anxiety symptoms, into the model analysis.

However, the study also has certain limitations. Firstly, it only includes childhood maltreatment as an environmental factor in the network model, neglecting other risk factors. Confounding variables (e.g., socioeconomic status, pharmacologic treatment, or trauma recency) were not controlled, which may subtly influence certain symptom-to-symptom associations. Nonetheless, we believe the core findings—such as the strong bridge connections between abuse and symptoms—are robust. We recommend future studies include more risk factors and control for confounders to further validate these associations. Secondly, as a cross-sectional study, we cannot establish the temporal sequence and causal relationship between childhood maltreatment experiences and depressive/anxiety symptoms. Results from a single time point are inadequate for understanding the entire process. Future studies should conduct dynamic observations of variables, with longitudinal data and cross-lagged network models potentially providing better explanations. Thirdly, The SBQ-R was used for measurement. However, the information obtained from individual item scores is relatively limited, as the screening was based solely on questions related to suicidal ideation. Future research could further investigate the causal inference of abuse and depressive symptoms on suicidal ideation within network structures (94). We also considered combining the SBQ-R with the Columbia Suicide Severity Rating Scale to assess different dimensions of suicidality. Lastly, as our sample was drawn from a single hospital, the generalizability of our findings is limited to similar clinical populations. Future studies will aim to recruit adolescents with depression from multiple hospitals and diverse regional backgrounds.

5 Conclusion

In conclusion, this study employed symptom network analysis to examine interactions between depression and anxiety symptoms and childhood adversity in suicidal adolescents with depressive disorders. The network revealed strong depression-anxiety comorbidity, with "control worry" and "fatigue" as central nodes. Bridge centrality identified transdiagnostic bridge symptoms (e.g., "motor", "death"), which may amplify suicide risk through cognitive-affective pathways. Childhood maltreatment subtypes showed strong intra-correlations, with EA directly linked to "death", suggesting it indirectly fuels suicidal ideation through negative schemas (e.g., hopelessness). To safeguard adolescent mental health and reduce suicide risk, interventions are needed at family, psychological, and policy levels. Our findings highlight the importance of a holistic approach, considering the complex links between childhood abuse, suicidality, and psychiatric symptoms.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Ethics Committee of the First Affiliated Hospital of Kunming Medical University. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

ZH: Formal analysis, Writing – original draft, Methodology, Conceptualization, Software. LA: Writing – original draft, Methodology, Software, Conceptualization, Formal analysis. KY: Writing – original draft, Investigation. HR: Investigation, Writing – original draft. YC: Writing – original draft, Investigation. RY: Investigation, Writing – original draft. LJ: Writing – original draft, Investigation. RX: Investigation, Writing – original draft. RZ: Investigation, Writing – original draft. TL: Investigation, Writing – original draft. YiX: Writing – original draft, Investigation. YuX: Funding acquisition, Writing – review & editing, Conceptualization. JL: Conceptualization, Writing – review & editing, Funding acquisition.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2025.1645303/full#supplementary-material

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