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Gender differences in the network of suicidal ideation, interpersonal needs and depressive symptoms among Chinese college students

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Interpersonal needs and depression are two recognized significant risk factors for suicidal ideation. Previous studies have preliminarily revealed the gender-dependent effects of interpersonal needs and depression on suicidal ideation. However, there are very few studies that place these variables within a single framework and apply symptom-level analysis to investigate the gender-dependent relationships among them. This study applied symptom-level network analysis to construct female and male networks using data from 781 female and 628 male young adults. The networks included interpersonal needs, depressive symptoms, and suicidal ideation. Key characteristics of networks, including edge connections, bridge expected influence (BEI), and global expected influence (GEI), were compared. The results suggested that gender significantly impacts edge connections, node BEI, and GEI of the final networks. Several significantly gender-dependent connections were disclosed, such as perceived burdensomeness (PB)-suicidal ideation, hopelessness-suicidal ideation, PB-sense of failure, and PB-sadness. PB (marginally) and thwarted belongingness show significant gender differences in their impact on depressive symptoms. The GEI of the female network is significantly greater than that of the male network. These findings offer valuable insights for modern theoretical frameworks examining gender differences in the connections between suicidal ideation, interpersonal needs, and depressive symptoms. Additionally, results provide empirical support for selecting screening, prevention, and intervention strategies for suicidal ideation and depression across genders.

Keywords Suicidal ideation, Interpersonal needs, Perceived burdensomeness, Depressive symptoms, Network analysis

Suicide constitutes a serious public health concern across the globe, with more than 720,000 people dying by suicide recorded annually[1]. In 2019, there were 116,324 reported suicide deaths in China, corresponding to an age-standardized suicide rate of 6.7 per 100,000 people. This number accounted for roughly 17% of the total suicides worldwide[2]. Among individuals aged 15 to 29, suicide takes the third place in contributing to death causes[1]. Additionally, the incidence of suicide among the 10–24 age group in China experienced a growing trend from 2017 to 2021, reflecting an average yearly growth rate of 17.17%[3]. A recent meta-analysis of 54 studies revealed that the COVID-19 pandemic saw a rise in the rates of suicide ideation (10.81%), suicide attempt (4.68%), and self-harm (9.63%) compared to the rates before the pandemic, with younger people being the most vulnerable to suicidal ideation[4]. In addition, the latest survey of younger adults in China found that the rates of suicide attempt, suicidal ideation, and suicide plan were 1.78%, 23.79%, and 5.61%, respectively, among cisgender heterosexual younger adults[5]. Given that suicidal ideation is the strongest predictor of suicidal behaviors and attempts[6–8], identifying key risk factors for suicidal ideation in vulnerable populations (e.g., young adults) is crucial for developing targeted suicide prevention and intervention strategies.

Suicidal behavior rates exhibit gender differences. In most countries, suicide rates are 2–3 times higher in males than in females[7]. However, the rates of lifetime suicidal ideation, suicide plan, and suicide attempt are higher in females than in males[9]. This phenomenon is known as the "gender paradox of suicidal behavior"[10]. These gender differences in suicidal behavior may be attributable to factors such as mental health levels and social cultural factors. For instance, the higher prevalence of externalizing disorders (e.g., conduct disorders

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and substance abuse disorder) in males and the higher prevalence of internalizing disorders (e.g., depression and anxiety) in females, as well as males' reluctance to seek help and females' greater willingness to do so[11]. A thorough investigation of how these risk factors differentially impact suicidal behavior in males and females can aid in developing gender-specific suicide prevention and intervention strategies, thereby more effectively reducing the harm that suicide inflicts on individuals, families, and society.

Interpersonal needs and depression are two recognized significant risk factors for suicidal ideation[7]. Interpersonal needs arise from one of the most widely examined and empirically supported suicide theories—the interpersonal theory of suicide—and include two core constructs: perceived burdensomeness (PB) and thwarted belongingness (TB)[12–15]. PB is a mental state in which individuals experience the feeling of being a burden (i.e., 'I am a burden'), which manifests when the need for social competence is unmet. TB is a mental state in which individuals experience the feeling of not being a valuable member of the group (i.e., 'I am alone'), which manifests when the essential need for social connectedness is unmet[13,14]. Depression has been repeatedly reported as a risk factor for suicidal ideation[16–18]. Given this, depression is frequently included in suicide risk factors guidelines and structured risk assessments developed by major national and international organizations[17]. Additionally, major depressive disorder is one of the most common psychiatric diagnoses among individuals who die by suicide[19]. A recent study reported that the prevalence of suicidal ideation within the context of major depressive disorder is 37.7%[20]. In summary, interpersonal needs and depression are two key entry points for a deeper understanding of suicidal ideation.

Numerous studies have demonstrated gender differences in the risk factors for suicidal ideation[21–23]. An in-depth understanding of these gender differences may provide potential gender-specific targets for selecting screening, prevention, and intervention strategies for suicide. Regarding interpersonal needs and depression, previous studies have found that PB increases the risk for suicidal ideation, particularly in males[24]. Additionally, depression is a significant risk factor for suicide in females but not in males[23,25]. These studies preliminarily reveal the gender-dependent effects of interpersonal needs and depression on suicidal ideation.

However, most previous studies investigating the gender differences in the effect of depression on suicidal ideation were based on the total score model (i.e., latent variable model). This model overlooks the fact that depression is essentially a heterogeneous syndrome (i.e., including various cognitive, affective, and physical symptoms), leading to a lack of gender-dependent insights at the symptom level. For example, sadness or hopelessness, which are typical affective symptoms of depression, are more strongly associated with suicidal ideation in females than in males[21,22]. In summary, studying the gender-dependent effects of depression on suicide at the symptom level may significantly enhance our understanding of this field. Furthermore, most studies either consider the impact of interpersonal needs on suicidal ideation or the effect of depression on suicidal ideation, with very few studies placing these three variables within a single framework. In fact, there is a close relationship between interpersonal needs and depression[6,26,27]. A recent study indicates that depression mediates the relationship between interpersonal needs and suicidal ideation[28]. Therefore, as suggested by previous research, exploring the impact of interpersonal needs on suicidal ideation should consider clinically relevant variables such as depression[13]. By placing interpersonal needs, depression, and suicidal ideation within a single framework, it is possible to control for the interactions between these two key risk factors for suicidal ideation, thereby deepening the understanding of their independent risk contributions to suicidal ideation in females and males[29]. At the same time, this approach can expand the potential gender-dependent patterns of association between interpersonal needs and depression at the symptom level, making an important contribution to this research domain.

Considering the aforementioned issues, this study applies symptom-level network analysis to explore the gender-dependent network characteristics among suicidal ideation, interpersonal needs and depressive symptoms. Compared with traditional statistical models, network analysis offers the following methodological advantages for investigating the relationships among these three variables: 1) Network comparison. For the current study, this is the most significant methodological advantage of using network analysis. The network comparison test allows us to detect differences between female and male networks in terms of edge connections, node bridge expected influence (BEI) and global expected influence (GEI)[30–33]. These gender differences in network characteristics will provide an important contribution to the research in this field; 2) Visualization. By inspecting the network structure, researchers can identify, from a very intuitive visual perspective, which variables are directly associated with suicidal ideation and the extent of their association in females and males[34]; 3) Statistics. Within a network, edges are usually statistically depicted using regularized partial correlations. These correlations, obtained after controlling for other variables and employing statistical regularization techniques, represent purer, more parsimonious, and interpretable connections among multivariate data[35,36]; 4) BEI index. Network analysis also offers a BEI index to analyze how relevant variables may co-occur target clusters[37]. Specifically, the BEI can quantify to what extent PB and TB may activate (i.e., transmit positive effects to) the symptoms cluster of depression. Such information could be valuable for identifying potential targets for the prevention and intervention of depression.

Using network analysis, this study has two main aims: 1) to investigate edge connections and their differences among suicidal ideation, interpersonal needs, and various depressive symptoms within female and male networks; 2) to explore edge connections, BEI, and their differences between various dimensions of interpersonal needs and depressive symptoms within female and male networks. Based on the two main aims of this study, we put forward the following two primary hypotheses. Hypothesis 1: There are gender differences in the connections between suicidal ideation, interpersonal needs, and depressive symptoms. Hypothesis 2: There are gender differences in the impact of PB and TB on the symptoms cluster of depression. By testing these hypotheses, we aim to enhance existing theoretical frameworks concerning gender-dependent relationships among these variables and provide empirical evidence for developing screening, prevention, and intervention strategies for suicidal ideation and depression across different genders.

Method

Participants

Data were collected through paper-and-pencil tests administered in two universities in Shaanxi province, China. The inclusion criteria were: 1) participants aged 18 years or older; 2) provision of written informed consent. The exclusion criteria were: 1) a history of mental disorders or psychiatric medication use; 2) incorrect responses to any attention detection items (there were 2 attention detection items in this investigation). One hundred and one participants (6.69%) were excluded due to failing the attention detection items (e.g., participants did not choose the third option when responding to "Please choose the third option for this question"). The final sample included 781 female participants (Mean age = 20.16, SD = 1.07) and 628 male participants (Mean age = 20.13, SD = 1.07).

Ethical statement

The data collection process for the present sample was approved by the Ethical Committee of Chengdu University (Approval No. 2023CDU866656) and was carried out in compliance with the Declaration of Helsinki. All participants willingly participated in this data collection process and provided written informed consent. Participants reporting distress were provided with immediate referrals to campus counseling services and a list of local mental health resources. The financial expenses required for this process are covered by the research funds.

Measurements

Interpersonal needs

The interpersonal needs were assessed using the 15-item Interpersonal Needs Questionnaire[13,38]. This questionnaire consists of two dimensions: the first dimension, PB, which is measured by 6 items, and the second dimension, TB, measured by 9 items. Each item is ranked on a 7-point Likert scale, ranging from 1 to 7. Higher total scores in each dimension reflect higher levels of PB and TB. The Cronbach's alpha coefficients for PB were 0.75 for females and 0.73 for males, while for TB they were 0.73 for females and 0.71 for males.

Depressive symptoms

The Beck Depression Inventory, a well-known self-report tool for depression assessment, has two subscales: the cognitive-affective (items 1 to 13) and somatic-performance subscales (items 14 to 21). We used the cognitive-affective subscale (i.e., the Beck Depression Inventory-Short Form (BDI-SF)) to evaluate participants' symptoms of depression[39]. We chose this subscale for two main reasons. First, it's widely accepted in clinical and research settings, effectively differentiating participants' depression levels[40]. Prior studies have validated the BDI-SF's good psychometric properties in Chinese populations, with a Cronbach's alpha of 0.94[41]. Second, due to network analysis statistical power considerations (more nodes mean more parameters to estimate and require more participants for stable results) and our preference for stability, we selected the BDI-SF. This subscale includes 13 items depicting different domains of depressive symptoms[39]. Each item is ranked using the Likert 4-point scale, ranging from 0 to 3. A higher score indicates a greater severity of depression. The Cronbach's alpha coefficients for this scale were 0.87 for females and 0.85 for males.

Suicidal ideation

Building on previous studies, this study utilized Item 7 from the BDI-SF as a measure of suicidal ideation[42,43]. This approach may offer three potential advantages: 1) it is straightforward and easy to administer; 2) compared to suicidal ideation questionnaires with multiple items, a single-item measure may pose a lower risk of ethical harm to participants; 3) it facilitates comparison with other network analysis studies related to suicidal ideation, such as those employing the Patient Health Questionnaire-9 scale, where Item 9 is used to measure suicidal ideation[42].

Data analysis

We utilized SPSS software (version 27.0) for conducting descriptive statistical analysis. The Shapiro–Wilk test was applied to assess the normality of the data, and the results indicated that all variables of both females and males were non-normally distributed ($ps < 0.001$). Therefore, we employed the Mann–Whitney U test to test the differences between female and male samples in terms of various dimensions of interpersonal needs and depressive symptoms (including suicidal ideation).

Before constructing female and male networks, we utilized unique variable analysis (UVA) with a weighted topological overlap metric to identify redundant nodes[44]. This method has been suggested as the best performing local dependence detection method in the network analysis. UVA results showed that no redundant nodes were identified in the two networks mentioned above. UVA was conducted using the R-package EGAnet[45].

In the present study, female and male networks were constructed using the graphical Least Absolute Shrinkage and Selection Operator (gLASSO) combined with the Extended Bayesian Information Criterion (EBIC)[35]. Within each network, the edges denote the partial correlation between two linked nodes, accounting for the influence of other nodes[35,46]. To account for the ordinal nature of the questionnaires used in the current study, the nonparametric Spearman rho correlations were used when estimating the network structure[35,46]. The gLASSO technique punishes the small correlation coefficients to zero and leads to a sparser and more interpretable network[47]. The EBIC tuning parameter (gamma) was adjusted to 0.5[48]. Gamma controls the severity of the model selection, with higher values indicating that simpler models are preferred. When gamma is set to 0.5, most spurious edges can be avoided. Therefore, this more conservative approach makes the results of network structure more likely to be stable and reproducible[48]. The EBICglasso function introduces gamma = 0.5 as "generally a good choice" and sets it as the default value[49]. The network visualization was generated using

the Fruchterman-Reingold algorithm and R-package qgraph[49,50]. In order to more intuitively present the relationships between suicidal ideation and other variables, as well as the gender differences in the network structure of interpersonal needs and depressive symptoms, we used the flow and average layout approaches to visualize the male and female networks[51].

BEI was calculated for nodes within female and male networks through the R-package networktools[37]. A higher positive value of BEI indicates greater ability to activate the opposite community[52,53]. For the both female and male networks, two communities were predetermined: one community includes two dimensions of interpersonal needs and the other community consists of thirteen depressive symptoms (including suicidal ideation).

We assessed the robustness of each network by examining the accuracy of edge weights and the stability of BEI using the R-package bootnet[54]. To evaluate the edge weights' accuracy, a 95% confidence interval (1,000 samples) was plotted for each edge. The BEI's stability was determined by calculating the correlation stability coefficient (CSC) using the case-dropping bootstrap method (1,000 samples). The CSC measures the maximum proportion of data that can be dropped to retain, with 95% certainty, a correlation of at least 0.7 with the centralities of the original network[54]. As recommended by Epskamp et al., the ideal CSC is considered to be higher than 0.5 and not lower than 0.25[54]. Additionally, we carried out bootstrapped difference tests (1,000 samples) for edge weights and node bridge centrality.

To investigate gender differences in above network characteristics, the R-package NetworkComparisonTest was employed with 1,000 permutations[30]. We primarily concentrated on four key network characteristics: 1) edges between suicidal ideation and interpersonal needs and depression; 2) edges between interpersonal needs and depression; 3) BEI of interpersonal needs and depression; and 4) GEI (the sum of all edges in male and female networks). In the context of this exploratory analysis, no corrections for multiple comparisons were utilized[30,55].

Results

Table 1 presents the descriptive statistical results for each variable in the female and male samples. The nonparametric Spearman correlation matrix for variables in the female and male samples is provided in the Supplemental Material (Figure S1). The female sample shows significantly higher scores in TB, Dep1, Dep4, Dep10 and Dep13, and significantly lower scores in Dep6 and Dep9 compared to the male sample. It is noted that there is no significant difference between the female and male samples in suicidal ideation (Dep7).

In the female network (see left of Fig. 1), suicidal ideation is directly related to 11 variables, with the strongest connections being Dep7-Dep6 (weight = 0.13), Dep7-Dep2 (weight = 0.13), Dep7-Dep10 (weight = 0.11), and Dep7-Dep1 (weight = 0.09). It is noted that the connections Dep7-PB (weight = 0.07) and Dep7-TB (weight = 0.03) are relatively weak. While in the male network (see right of Fig. 1), Dep7 is also directly related to 11 variables, with the strongest connections being Dep7-PB (weight = 0.20), Dep7-Dep11 (weight = 0.09), Dep7-Dep10 (weight = 0.08), and Dep7-Dep1 (weight = 0.06). The connection Dep7-TB (weight = 0.01) is very weak. Weights, accuracy and difference test results of all edges within two networks can be found in the Supplementary Materials (Table S1 and S2, Figure S2 and S3). The results of the network comparison test reveal that there are significant gender differences in the connections between Dep7 and three other nodes: Dep7-PB ($p = 0.007$), Dep7-Dep2 ($p = 0.02$), and Dep7-Dep11 ($p = 0.05$). These results supported Hypothesis 1 by revealing significant

Variables	Female		Male		p
	Mean	SD	Mean	SD	
Interpersonal needs (PB and TB)					
Perceived burdensomeness (PB)	11.94	6.54	11.26	5.95	0.10
Thwarted belongingness (TB)	29.73	9.79	28.53	9.20	0.03
Depressive symptoms (Dep1-Dep13)					
BDI-SF1: Sadness (Dep1)	0.65	0.73	0.48	0.61	< 0.001
BDI-SF2: Hopelessness (Dep2)	0.44	0.64	0.47	0.61	0.15
BDI-SF3: Sense of failure (Dep3)	0.61	0.75	0.62	0.65	0.21
BDI-SF4: Dissatisfaction (Dep4)	0.65	0.76	0.51	0.68	< 0.001
BDI-SF5: Feel guilty (Dep5)	0.72	0.63	0.75	0.56	0.22
BDI-SF6: Self-hate (Dep6)	0.46	0.70	0.51	0.66	0.03
BDI-SF8: Social withdrawal (Dep8)	0.39	0.65	0.40	0.62	0.57
BDI-SF9: Indecisiveness (Dep9)	0.43	0.76	0.60	0.84	< 0.001
BDI-SF10: Self-image change (Dep10)	0.35	0.80	0.29	0.79	0.02
BDI-SF11: Work inhibition (Dep11)	0.72	0.83	0.72	0.85	0.75
BDI-SF12: Fatigue (Dep12)	0.67	0.67	0.64	0.63	0.46
BDI-SF13: Appetite change (Dep13)	0.62	0.81	0.51	0.78	0.002
Suicidal ideation (Dep7)					
BDI-SF7: Suicidal ideation (Dep7)	0.20	0.56	0.18	0.62	0.25

Table 1. Descriptive statistics results. M, mean; SD, standard deviation.

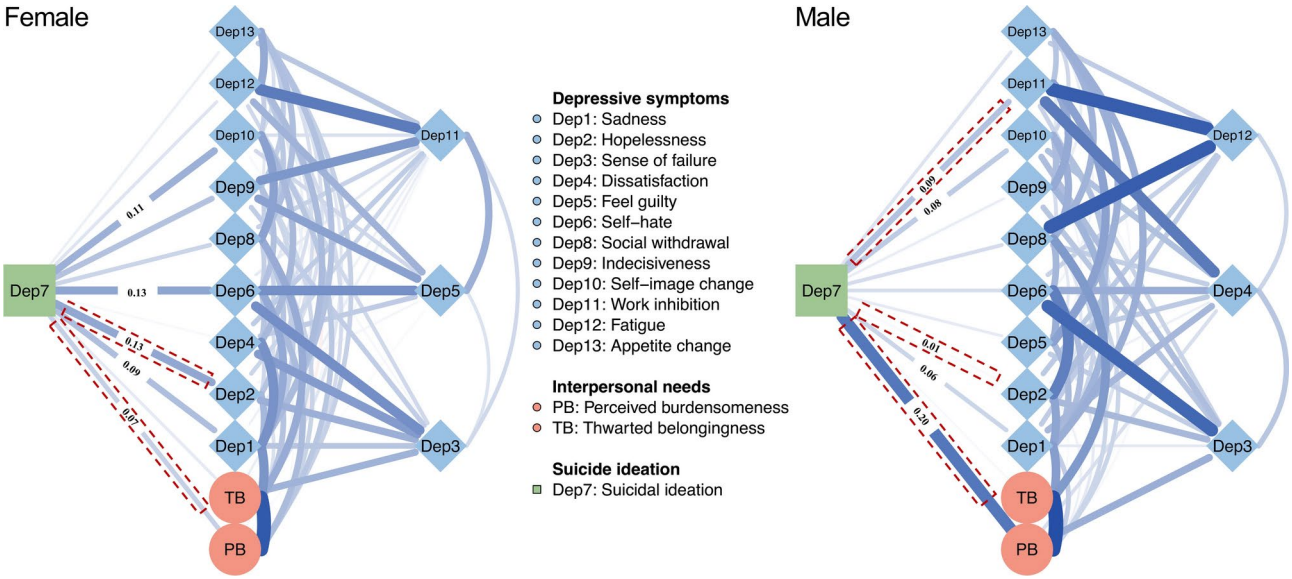

Fig. 1. Female and male networks of suicide ideation, interpersonal needs, and depressive symptoms using flow layout. Note: Positive correlations are depicted by blue edges, whereas negative correlations are shown by red edges. The thickness of the edges corresponds to the strength of the correlation. The values on the edge represent the correlation strength of the edge. To prevent the visualization of the graph from being too cluttered, only important edges are highlighted in this way. Red dashed rectangles are used to highlight the significant results in the gender network comparison.

gender differences in the connections between suicidal ideation and interpersonal needs as well as depressive symptoms.

In the female network (see upper left of Fig. 2), PB is directly related to 9 depressive symptoms, with the strongest connections being PB-Dep6 (weight = 0.10), PB-Dep10 (weight = 0.08), and PB-Dep13 (weight = 0.07). While TB is directly related to 12 depressive symptoms (excluding Dep5), with the strongest connections being TB-Dep1 (weight = 0.15), TB-Dep8 (weight = 0.12), and TB-Dep3 (weight = 0.11). In the male network (see upper right of Fig. 2), PB is directly related to 9 depressive symptoms, with the strongest connections being PB-Dep7 (weight = 0.20), PB-Dep3 (weight = 0.12), and PB-Dep1 (weight = 0.07). While TB is directly related to 5 depressive symptoms, with the strongest connections being TB-Dep8 (weight = 0.15) and TB-Dep1 (weight = 0.14). The results of the network comparison test reveal that six connections between interpersonal needs and depressive symptoms exhibit significant gender differences: PB-Dep1 ($p = 0.008$), PB-Dep3 ($p < 0.001$), PB-Dep12 ($p = 0.03$), PB-Dep7 ($p = 0.007$), TB-Dep3 ($p = 0.02$), and TB-Dep4 ($p = 0.01$). These results supported Hypothesis 1 by revealing significant gender differences in the connections between interpersonal needs and depressive symptoms. In addition, the GEI of the female network is significantly greater than that of the male network (female = 6.40, male = 6.09, $p = 0.03$).

The BEI results for female and male participants are plotted in the lower section of Fig. 2. In the female network, TB has the strongest BEI (raw value = 0.66), which is significant stronger than the BEI of PB (raw value = 0.46). In the male network, PB has the strongest BEI (raw value = 0.61), which is significantly stronger than the BEI of TB (raw value = 0.35). In both the female and male networks, Dep8 and Dep1 have the strongest BEI within depressive symptoms community. Raw values, stability (CSC of female network = 0.67, CSC of male network = 0.59) and difference test results of all nodes' BEI within two networks can be found in the Supplementary Materials (Figure S2 and S3). The results of the network comparison test reveal that PB of male participants has a (marginally) significantly stronger BEI than female participants (p = 0.06), while TB of female participants has a significantly stronger BEI than male participants ($p < 0.001$). These results supported Hypothesis 2 by revealing significant gender differences in the BEI values of PB and TB. It is noted that the BEI of Dep7 exhibits a significant gender difference (female = 0.10, male = 0.21, $p = 0.05$).

Discussion

The current study used network analysis to investigate, for the first time, the fine-grained network characteristics among suicidal ideation, depression, and interpersonal needs in both females and males. The findings revealed several key and novel gender differences from the network perspectives of edge connections, node BEI and GEI.

From a 'macro' network structure perspective, there are extensive connections between suicidal ideation and different symptoms of depression and dimensions of interpersonal needs in both female and male networks, which to some extent indicates that suicidal ideation is indeed a complex phenomenon[17,56]. In the female network, suicidal ideation is closely related to depressive symptoms cluster, while its connections to the dimensions of interpersonal needs are relatively weak. In contrast, in the male network, suicidal ideation is closely linked to PB, while its connections to the depressive symptoms cluster are not as strong as those observed

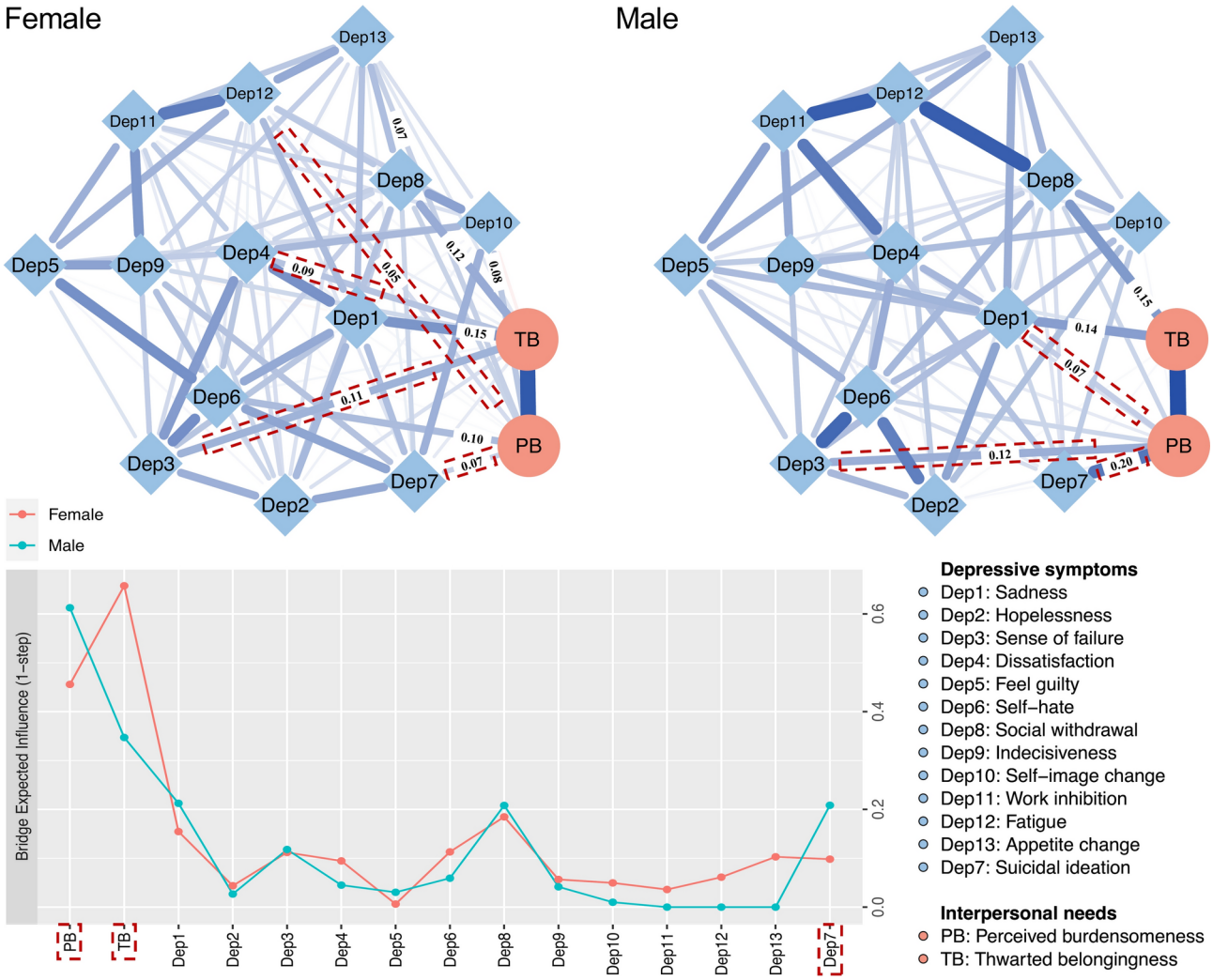

Fig. 2. Female and male networks of interpersonal needs and depressive symptoms using average layout and bridge centrality plots. Note: Positive correlations are depicted by blue edges, whereas negative correlations are shown by red edges. The thickness of the edges corresponds to the strength of the correlation. The values on the edge represent the correlation strength of the edge. To prevent the visualization of the graph from being too cluttered, only important edges are highlighted in this way. Red dashed rectangles are used to highlight the significant results in the gender network comparison.

in the female network. Additionally, the connection between suicidal ideation and TB is weak in the both female and male networks. Therefore, suicidal ideation in females seems to be more influenced by depressive symptoms, while suicidal ideation in males is more influenced by PB within interpersonal needs. These findings align with previous studies. For example, Donker and colleagues found that high levels of PB increase the risk for suicidal ideation, particularly among males[24]. Additionally, some previous studies suggested that the degree of depression is a significant risk factor for suicide risk in females but not in males[23,25].

From a 'micro' network structure perspective, we find that in the female network, suicidal ideation is closely associated with four depressive symptoms (i.e., self-hate, hopelessness, self-image change, and sadness), and the connection with hopelessness is significantly greater than that in the male network. Previous studies have found that sadness or hopelessness is more strongly linked to suicidal ideation in females than in males[21,22]. This suggests that suicidal ideation in females may be more vulnerable to negative emotional symptoms, which can become intolerable and thus prompt individuals to consider suicide as a means of escape. In fact, hopelessness is also one of the core constructs in the interpersonal theory of suicide[12,14,15]and has been identified as an important risk factor for suicidal ideation[17]. The gender differences observed in the current research may provide an important complement to the interpersonal theory of suicide. It is worth noting that perceiving oneself as having an unattractive self-image is closely linked to suicidal ideation. This indicates that changes in self-image may constitute an important predictor of suicidal ideation, beyond traditional risk factors[57,58]. Therefore, future research could explore the applicability and effectiveness of interventions targeting self-image cognition (e.g., cognitive restructuring modules in campus counseling programs) for preventing and intervening suicidal ideation among Chinese college students. In the male network, suicidal ideation is closely associated with PB

and one depressive symptom (i.e., work inhibition), and the strength of these two connections is significantly greater than that in the female network. This may indicate that suicidal ideation in males is more susceptible to negative social factors (perceived declines in social competence and work ability). This may be related to the social and cultural norms for males, such as competitiveness and self-reliance[59–61]. Previous studies have found that these masculine norms are strongly associated with risk factors for suicidal ideation among males[62,63]. These masculine norms, such as competition and self-reliance, may therefore reinforce the susceptibility of suicidal ideation to PB and work inhibition[64].

In summary, this study provides insights into the potential gender differences in how interpersonal needs and depressive symptoms influence suicidal ideation at the symptom level. These findings on gender differences can serve as important references for developing more targeted and practically valuable suicide risk prediction models, thereby aiding in the more accurate identification of individuals at risk[24]. Furthermore, developing gender-specific suicide prevention and intervention strategies based on these findings may enhance their effectiveness. In other words, gender-specific clinical practices may benefit from targeting key edges connected to suicidal ideation in different gender networks. For females, interventions targeting emotional symptoms (e.g., hopelessness) may more effectively reduce suicidal ideation through their strong connections to it. Therefore, a module to reduce hopelessness can be incorporated into the psychotherapy for female suicidal ideation, or cognitive behaviour therapy can be used, as cognitive behaviour therapy has been reported to reduce hopelessness[65]. For males, interventions targeting PB may more effectively reduce suicidal ideation through its strongest connection to suicidal ideation[24]. Blain and colleagues found that evidence-based treatments targeting PB reduction can decrease suicidal ideation in veterans with posttraumatic stress disorder[66,67]. These studies have shown the potential to reduce suicidal ideation in males by addressing PB, but cultural adaptations are needed for Chinese contexts. Future research could explore the applicability and effectiveness of campus or workplace programs addressing PB (e.g., skill-building to reduce self-perceived incompetence) for preventing and intervening suicidal ideation among Chinese male college students.

Whether in female or male networks, there are extensive and distinct connections between interpersonal needs and depressive symptoms. Specifically, the connections between TB and sadness as well as social withdrawal are strong in both female and male networks. This seems quite understandable: when an individual's sense of belongingness is thwarted, the individual could exhibit emotional responses of sadness and behavioral responses of avoiding social interactions. Conversely, social withdrawal may lead to an unmet need to belong, thus forming a vicious cycle[68]. It is noteworthy that the connection between TB and sense of failure in the female network is significantly stronger than that in the male network, while the connection between PB and sense of failure in the male network is significantly stronger than that in the female network. This may suggest an important gender difference in interpersonal needs related to perceptions of success and failure. That is, the need to belong has a significant impact on female perceptions of success and failure, while the need for social competence has a significant impact on male perceptions of success and failure[13]. Additionally, the connection between TB and dissatisfaction in the female network is significantly stronger than that in the male network, which may also be due to the difference in socially constructed roles described above[61]. The connection between PB and sadness in the male network is significantly stronger than that in the female network, suggesting a male-specific pathway through which PB affects depression.

The GEI of the female network is significantly greater than that of the male network. This result indicates that the mutual activation ability between female depressive symptoms and the dimension of interpersonal needs is stronger, which may imply, from a global perspective, that females are more vulnerable in terms of relationships between depression and interpersonal needs. Future research is needed to further investigate this phenomenon.

The results of BEI indicate that in the female network, TB has a significantly stronger bridging effect on the depressive symptoms cluster compared to the male network. Conversely, the bridging effect of PB on the depressive symptoms cluster in the male network is marginally stronger than in the female network. From the perspective of socially constructed roles, female identity is defined by social relationships and communication, whereas male identity is shaped by competition and social achievement[61]. Additionally, societal norms around masculinity and femininity in Chinese culture may shape the gender-specific impact of PB and TB on depression through role expectations, emotional expression rules, and value evaluation systems. For example, males are typically expected to play the role of a "strong" and "supportive" figure, emphasizing independence and resilience[69]. When males perceive themselves as a "burden" to their family or society, it may trigger a fundamental questioning of "masculinity", leading to feelings of failure and self-hate, and thus resulting in depression. Moreover, these social expectations also lead males to suppress their emotions and avoid seeking help when facing psychological pressure[61]. This suppression may exacerbate depressive symptoms. Females, on the other hand, are usually expected to play the role of a "gentle", "caring", and "social" figure, emphasizing the importance of family and interpersonal relationships[69]. This makes females more likely to seek support and help from others and society when facing psychological pressure[61]. Therefore, if females feel excluded or isolated, this sense of TB may lead to strong depressive emotions. Therefore, in the prevention and intervention of depression, these cultural factors should be taken into account to build gender-specific strategies and models that are more culturally appropriate. Future research can further explore these novel findings. Additionally, compared to studies on interpersonal needs and suicide, research on interpersonal needs and other mental health issues (such as depression) is relatively scarce. Therefore, these results expand the boundaries of interpersonal needs, enrich the knowledge framework regarding the relationship between interpersonal needs and depression, and provide empirical evidence for the early identification, prevention, and intervention of depression from the perspective of interpersonal needs for both females and males.

Limitations

The current study has several limitations. First, the network analysis results are based on cross-sectional data, which limits our in-depth understanding of the temporal causal relationships among these variables. For instance, bidirectional relationships between interpersonal needs and depressive symptoms cannot be ruled out. Future research could apply longitudinal designs to clarify temporal dynamics, such as whether PB precedes suicidal ideation or vice versa. Second, due to our sampling method, we collected data from students of two universities, which limits the interpretation of our results for other populations. It is important to consider that regional socioeconomic levels and educational environments may influence our findings. For instance, socioeconomic differences could play a significant role in shaping PB-depression or suicidal ideation relationships[70]. Similarly, participants from regions with highly competitive educational environments might experience amplified effects of depression on suicidal ideation due to increased stressors. These considerations highlight the need for future research to be conducted in a wider and more representative sample. Additionally, other psychosocial factors, such as positive mental health and social support systems, may also affect the relationship between these variables. Gautam has found that social support significantly moderates the relationship between PB, TB and suicidal ideation in college students[71]. Moreover, Teismann and colleagues have revealed that positive mental health moderates the impact of depression on suicidal ideation[72]. Considering these research findings, future studies can use network analysis to further explore how other psychosocial factors influence the relationships between the variables in the current study. For instance, researchers could include a mediator directly in the network to explore its mediating effect on other variables. Regarding moderators, one approach involves dividing the sample into subgroups based on scores, conducting network analysis within each subgroup to examine moderating effects, or alternatively applying moderated network analysis directly[73–76]. Third, the single-item measure of suicidal ideation may limit the depth of analysis. Future studies could further validate these findings using multi-item scales (e.g., the Columbia-Suicide Severity Rating Scale)[77], which capture severity of suicidal ideation and behavior more comprehensively.

Conclusion

These results provide important references for contemporary theoretical frameworks related to gender differences in the relationships among suicidal ideation, depression, and interpersonal needs. Our findings also offer empirical evidence for selecting screening, prevention, and intervention strategies for suicidal ideation and depression across genders from the perspective of interpersonal needs. Specifically, for the early identification, prevention, and intervention of suicidal ideation in females, it may be essential to focus on emotional symptoms and self-image cognition. For males, the focus may need to be on perceived burdensomeness. Additionally, when considering the prevention and intervention of depression from the perspective of interpersonal needs, it may be essential to focus on thwarted belongingness for females. Conversely, for males, the focus may be on perceived burdensomeness.

Data availability

The data from this study can be obtained by requesting it from the corresponding author. Due to privacy or ethical restrictions, the data is not publicly available.

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Jiaxi Peng: Conceptualization; Writing – original draft; Lei Ren: Conceptualization; Methodology; Writing – review & editing. All authors read and approved.

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Declarations

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