


The Relationship Between Nonsuicidal Self-Injury and Depression Symptoms in Chinese Adolescents: A Cross-Lagged Panel Network Analysis

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Introduction: Nonsuicidal self-injury (NSSI) and depression often co-occur among adolescents and lead to severe mental health problems. However, it is not clear how NSSI and depression causally relate to each other at a symptom level, with respect to gender differences. Therefore, this study aimed to explore the co-occurring patterns of NSSI and depression symptoms and examined gender differences.

Methods: The present study conducted cross-sectional and cross-lagged network analyses between NSSI and depression symptoms among adolescent girls and boys. A total of 1122 Chinese students (50.4% girls; mean age = 13.51 years, $SD = 1.10$) completed a survey at two waves.

Results: The results revealed that (1) the depression symptoms “sad” and “depressed” were the highest and most stable Expected Influence centrality nodes. The depression symptom “scared” acted as a bridging node across genders, both in cross-sectional and cross-lagged panel networks. (2) For girls, depression symptoms at W1 predicted NSSI at W2. The depression symptoms “tired” and “lack of hope” at W1 were the strongest predictors of NSSI symptoms at W2. (3) For boys, NSSI and depression symptoms displayed a bidirectional relationship through the “scared” and “lonely”.

Discussion: These findings provide valuable insights into the distinct gendered temporal relationships between NSSI and depression at the symptom level and underscore the practical value of targeted, gender-informed treatment and screening for adolescents.

Keywords: nonsuicidal self-injury, depression symptoms, network analysis, cross-lagged panel network analysis

Introduction

In the context of increasing academic pressure and persistent parent-child conflicts, nonsuicidal self-injury (NSSI) and depression have become two typical mental health concerns among Chinese adolescents,^{1–3} with prevalence rates of 25.3% and 24.3%, respectively.^{3–5} NSSI and depression occur in early adolescence, with high co-occurrence rates of 76.06%.^{6–8} Adolescents with co-occurring NSSI and depression experience more severe clinical symptoms and a greater risk of suicidal behaviors.^{9,10} Therefore, it is crucial to study the mechanisms by which NSSI and depression symptoms co-occur to avoid persistent co-occurrence in Chinese adolescents. To date, most studies have focused on traditional variable-level directional relationships between NSSI and depression and ignored gender differences.^{11–13} To fill these gaps, the present study explored NSSI and depression symptoms among Chinese adolescents from a network theory perspective, in particular with respect to gender differences, to better understand the occurrence and development process of adolescent NSSI and depression symptoms.

Co-Occurrence Network for NSSI and Depression

NSSI refers to the deliberate destruction of one's own body tissue without suicidal intent, with symptoms including cutting, scratching, hitting, and burning oneself.^{14,15} Depression is characterized by symptoms of persistent depressive

mood and loss of interest accompanied by cognitive, social and behavioral impairment,¹⁶ and tends to manifest with more somatic symptoms among Chinese adolescents.^{17,18} The network model frames provide a novel theoretical view to understand these mental disorders by conceptualizing them as systems of complex interacting symptoms.^{19–21} In this framework, the central symptom plays a key role in maintaining symptom activation across the network, while the bridge symptom facilitates the spread of activation between disorders, contributing to co-occurrence of onset and persistence.²² Therefore, the network model offers a more accurate description of co-occurrence.^{23,24}

To date, only a few studies have constructed cross-sectional networks of NSSI and depression symptoms. For example, Misiak et al (2023)²⁵ explored a network of NSSI, depression and risk factors among Polish adults and reported that a lifetime history of severe NSSI had high centrality, which was directly connected to depression symptoms (“moving/speaking slowly or being restless”). Lei et al (2024)²⁶ examined a network of NSSI, depression, and childhood trauma with a sample of Chinese adolescents. The results revealed that the depression symptoms “negative self-esteem” and “negative mood” were two important nodes.²⁶ However, these studies focused mainly on depression symptoms and utilized only NSSI history information or a total score in the network, ignoring the role of specific NSSI symptoms in the co-occurrence network. Niu et al (2024)²⁷ further constructed a co-occurrence network in a clinical sample of Chinese adolescents and reported significant symptom-level links between NSSI and depression. Their results revealed that depression symptoms such as “feeling bad, failing or letting yourself or your family down” “little interest or pleasure” and “feeling tired” were the most central symptoms, and the NSSI symptom “frequent thinking about self-injury” was the most crucial bridge symptom.²⁷

Although previous studies have provided important insights into the co-occurrence network of NSSI and depression, several research gaps need to be addressed. Specifically, prior research has drawn data primarily from clinical samples, with limited attention to non-clinical populations.^{26,27} However, evidence suggests that non-clinical adolescents exhibit distinct symptom patterns compared to their clinical counterparts.^{11,13} Therefore, investigating non-clinical samples is critical for identifying early manifestations of co-occurring NSSI and depression, thereby informing timely detection and intervention. In addition, the directional and temporal relationships between NSSI and depression co-occurrence remain unclear because the existing studies have primarily relied on cross-sectional data.^{26,27} To address this issue, network analysis based on longitudinal data is capable of revealing the mechanisms by which symptoms persist and cause changes in other symptoms over time and examining the causal dynamics of how NSSI and depression symptoms affect each other at a later time.

The Directional Relationship Between NSSI and Depression

According to the developmental precursor model, the mechanism of co-occurrence development between NSSI and depression is characterized by a directional influence whereby one problem contributes to the other.^{28,29} The experience avoidance model³⁰ and the four-function model of self-injury³¹ view NSSI as a strategy for emotion regulation and suggest that prior depression symptoms cause NSSI. Individuals who engage in NSSI often lack the ability to cope with negative emotions such as depression and thus use NSSI to avoid negative emotions.¹² A growing body of empirical research on adolescents has consistently shown that the emergence of depression leads to NSSI behaviors for emotion alleviation.^{32–34} In contrast, some researchers take a different view, suggesting that depression is a consequence of NSSI.^{35–37} Adolescents may engage in NSSI for various reasons (eg, peer imitation), which can result in feelings of shame and guilt, leading to the exacerbation of depression.^{12,38,39} Several longitudinal studies have confirmed the significant predictive effect of NSSI on depression across six months, one year and two years.^{36,37,40}

Taken together, these findings suggest that the relationship between NSSI and depression may be bidirectional. To date, only a few studies have examined the bidirectional association with variable-centered methods, and the results are mixed. For example, Ewing et al (2019)⁴¹ reported a bidirectional association between depression symptoms and NSSI among adolescents. In contrast, some studies have documented only the effect of depression on NSSI but not vice versa.³⁸ The controversy of the existing research results may be predominantly due to the use of variable-centered methods, which neglect the interaction between symptoms and fail to provide a complete perspective on the connections between NSSI and depression.^{22,42} The cross-lagged panel network (CLPN) uses longitudinal data to examine intricate causal dynamics over time.⁴³ It estimates cross-lagged effects of individual symptoms while controlling their

autoregressive influences, thereby further identifying the most central symptoms that prospectively affect and are affected by other symptoms within co-occurrence network.⁴³ Therefore, to advance our understanding, it is necessary to use the CLPN to provide nuanced descriptions of the development of co-occurring NSSI and depression among adolescents.

Gender Differences

Gender differences in the network of NSSI and depression symptoms are also important aspects that need to be considered. Previous studies have demonstrated that the manifestations of NSSI and depression symptoms vary by gender. For example, girls and boys may exhibit different forms of NSSI. Evidence shows that girls are more likely to cut their skin, scratch, and bite, whereas boys are more likely to hit, beat and burn.⁴⁴ Moreover, the depression symptoms “feeling sad and empty” and energy-related symptoms have been identified as core symptoms in the depression network among girls, but not among boys.⁴⁵ Although existing studies have primarily found gender differences in NSSI or depression symptoms separately, the gender differences in the co-occurring development of NSSI and depression remain unclear. To date, only few CLPN analyses have identified gender-specific pathways linking NSSI and depression among adolescents. For example, Zhao and Zhou (2024)⁴⁶ found that “cutting” bridges NSSI to depression in boys, while “carving or skin rubbing” serving as a bridge connecting NSSI to depression in girls. However, this study only utilized a brief 6-item depression scale and modeled NSSI, depression, and anxiety symptoms together, which may have limited its ability to comprehensively and precisely capture the specific symptom-level co-occurrence patterns between NSSI and depression. Therefore, further research is needed to provide a more nuanced understanding of gender differences in the network structure of NSSI and depressive symptoms.

The Current Study

To date, most studies have focused exclusively on either cross-sectional data or variable-level directional relationships between NSSI and depression and ignored gender differences. To fill these gaps, the current study used a network approach to explore cross-sectional and longitudinal network characteristics of NSSI and depression symptoms among nonclinical adolescents in China and to examine gender differences by constructing separate networks for girls and boys. To be specific, the current study first aimed to capture the cross-sectional networks of NSSI and depression symptoms at two time points to determine central symptoms and bridge symptoms. Second, based on longitudinal data, the study aimed to model the directional relationships between NSSI and depression symptoms using the CLPN model, providing temporal information on the development of NSSI and depression co-occurrence. Finally, the study aims to compare the characteristics of cross-sectional and longitudinal interaction links between girls’ and boys’ networks, contributing to a deeper understanding of the gender differences in the co-occurrence of NSSI and depression.

Method

Participants and Procedure

Our study draws on a two-wave longitudinal project aimed at exploring adolescent mental health problems, with a 6-month interval to capture meaningful symptom changes, consistent with prior research.^{47,48} Data was collected from four middle schools in Guizhou Province, a representative region characterized by moderate resource constraints and developmental challenges. The sample at W1 included 1282 Chinese adolescents (48.3% girls), in Grades 7 (44.0%) and 8 (54.7%), with 1,122 retained at W2 (12.8% attrition). T tests assessing attrition revealed that the levels of depression symptoms and NSSI were not significantly different between adolescents who dropped out and those who remained, but the dropouts were older ($t(1266) = 3.65, p < 0.001$) and were more likely to be boys ($t(201.89) = -4.22, p < 0.001$). The final sample consisted of 1122 adolescents (50.4% girls); their mean age at W1 was 13.51 years ($SD = 1.10$).

The study was conducted in compliance with the Declaration of Helsinki and approved by the Research Ethical Committee of Beijing Normal University. Informed consent was then obtained from all the schools, participants and parents involved in the study. The data were collected through a cluster sampling method and administered in classrooms by trained psychology students using standardized instructions. The participants were informed that participation was

voluntary and provided with opportunities to withdraw. Each participant received a small gift of stationery, such as notebooks and pens.

Measures

NSSI was measured with a revised 9-item version of the Deliberate Self-Harm Inventory (DSHI-9r).⁴⁹ This scale consists of nine items (eg, “punching oneself, banging one’s head, thereby causing a bruise”). The participants were instructed to rate the number of times they had engaged in each of these activities during the past six months, with five Likert-type response options (ranging from 1 = “never” to 5 = “more than five times”). Our Cronbach’s α values for this measure were 0.82 (W1) and 0.84 (W2).

Depression symptoms in the past week were assessed with the Center for Epidemiologic Studies Depression Scale for Children (CES-DC).⁵⁰ This scale, originally developed to screen for depression in general populations, comprehensively captures six core depressive symptom clusters and uniquely includes interpersonal items that are highly relevant to adolescent populations.^{51–53} The CES-DC groups symptoms into depressed affect (eg, “I felt down and unhappy”), positive affect (eg, “I felt like I was just as good as other kids”), somatic problems (eg, “I felt like I was too tired to do things”), and interpersonal problems (eg, “I felt like people didn’t like me”). It consists of 20 items with four Likert-type response options (ranging from 1 = “not at all” to 4 = “a lot”). Our data revealed that the Cronbach’s α values for this measure were 0.84 (W1) and 0.87 (W2). The items used in this study are shown in [Table S1](#).

Participants reported their gender, age, grade and subjective socioeconomic status (SES). SES was assessed using MacArthur Scale of Subjective Social Status–Youth Version, which presents a 10-rung ladder representing where participants perceive their family stands in society.⁵⁴

Data Analysis

Before the network analyses, we performed descriptive statistical analyses on demographic variables, NSSI, and depression symptoms at 2 time points. All the network analyses were performed using the R program. Both the cross-sectional networks and CLPNs were constructed for the overall sample, the girls’ sample, and the boys’ sample.

Sample Size Analysis and Stability

The sample size analysis was guided by Epskamp and Fried’s (2018)⁵⁵ recommendations. First, we conducted a priori estimation applying the NetSimulator package to simulate networks under the assumed structure. We evaluated sensitivity, specificity, and correlations between true and estimated edge weights and centrality metrics to determine whether our sample size is sufficient. Then, we used the bootnet package to assess a post hoc stability of the cross-sectional networks and the CLPN.⁵⁵ The network correlation stability (CS) analysis tested whether the order of centrality indices (expected influence, bridge expected influence, in-prediction construct and out-prediction construct) remained the same after re-estimating the network through the case-dropping bootstrap. The CS coefficient should be above 0.50 to suggest sufficient stability and interpretability and should be at least 0.25.⁵⁵ Moreover, we used nonparametric bootstrapping to calculate the 95% confidence interval (CI) of each edge.

Missing Data and Nonnormality

The maximum missing data rate of the sample was 1.2%, indicating a small proportion of missing data. Therefore, missing data were handled using multiple imputation in the MICE package of R.⁵⁶ In addition, because there were skewed data for both the NSSI and depression variables, we applied nonparanormal transformation using the huge R package before network analyses.⁵⁵

Cross-Sectional Networks

We used the qgraph R package to estimate and visualize the biased correlation network models.⁵⁷ To ultimately yield a more parsimonious network model, we used the least absolute shrinkage selection operator (LASSO) to eliminate spurious associations, and to increase network interpretability and stability, following recommendations from prior network analysis research.^{55,58,59}

To specifically describe the core symptoms in the co-occurrence networks, we used the function `centralityPlot` and `bridge` in the R package `qgraph` to assess the expected influence (EI) and bridge expected influence (BEI) in the network.²⁰ The EI quantifies the sum of the edge weights extending from a given node and is considered an accurate measure of centrality because it considers both positive and negative edges.⁶⁰ The BEI estimates a node's sum connectivity outside its community (eg, the influence of each depression symptom on the community of NSSI symptoms) and is used to identify bridge symptoms.⁶¹ We calculated the one-step (direct) and two-step (indirect) BEIs in the bridge centrality analysis. We then created zscores for each of the centrality plot values for better interpretation.

Cross-Lagged Panel Networks

To explore prospective associations between NSSI and depression symptoms, we computed CLPNs via the `glmnet` package and plotted all the graphs using the `qgraph` package. The CLPN estimates the cross-lagged effect of a single item at W1 on all other items at W2, controlling for the autoregressive effect with LASSO regularization. To highlight the cross-lagged effect, we set the autoregressive path to 0 when visualizing the networks.⁴³

For the CLPN, we calculated the cross-construct in-prediction and out-prediction centrality indicators, which exclude paths connecting nodes within the same construct (NSSI or depression). The cross-construct in-prediction indicator quantifies the degree to which a given node at W2 is predicted by all the different construct nodes at W1. The out-prediction indicator describes the degree to which a given node at W1 predicts all the different construct nodes at W2.

Network Comparison Test

Following previous studies,⁶² we used the `NetworkComparisonTest` package to assess sex differences in cross-sectional network characteristics.⁶³ Two steps were followed: (a) compare the network structures (all edges across networks), edge strengths and global network strengths (global connectivity) between girls' and boys' networks at W1 and W2, separately, and (b) evaluate the correlations of centrality indices (EI and BEI) between the girls' and boys' networks to examine centrality invariance.

Results

Descriptive Statistics

Demographic information and descriptive statistics for the DSHI-9 and CES-DC items are presented in [Table S2](#). The mean SES was 4.20 (SD = 1.55) at W1 and 4.51 (SD = 1.36) at W2. The percentage of participants reporting NSSI behavior was 33.7% at W1 and 37.7% at W2. In addition, a series of independent t tests were conducted to compare variables and items of interest in this study between girls and boys. Although small ($d = 0.12$ – 0.37), the results suggested a modest but potentially meaningful gender difference in the prevalence of specific NSSI and depression symptoms. The prevalence of “burning” (T8) was greater in boys across the two waves, whereas the prevalence of “carving” (T4) was greater in girls in W2. In addition, girls consistently presented more depression symptoms than boys did.

Cross-Sectional Networks

[Figure S1](#) presents simulation results based on the refitted network to estimating the required sample size. A sample of approximately 500 can achieve a correlation above 0.80 for EI, and above 0.70 for edge weights and specificity. Therefore, our final sample size of 1122 (584 girls; 538 boys) meets recommended thresholds for reliable network estimation.

The regularized partial correlation networks across samples and waves are depicted in [Figure 1](#), and the weighted adjacency matrix in [Tables S3](#), [S4](#) and [S5](#). Note that there were significant sex differences in network structure at W1 ($M = 0.29$, $p < 0.05$) and network global strength at W2 (girls: 12.58 vs boys: 10.89; $S = 1.68$, $p < 0.001$). The stability of EI and BEI across samples and the two waves were good, as presented in [Figure S2](#); specifically, the stability of EI (CS coefficient W1 Total = 0.75, W1 Girls = 0.59, W1 Boys = 0.52, W2 Total = 0.75, W2 Girls = 0.67, W2 Boys = 0.60) was fairly strong. The BEI estimates were relatively stable (CS coefficient W1 Total = 0.44, W1 Boys = 0.28, W2 Total = 0.60, W2 Girls = 0.52, W2 Boys = 0.28), except for W1 Girls (CS coefficient = 0.21),

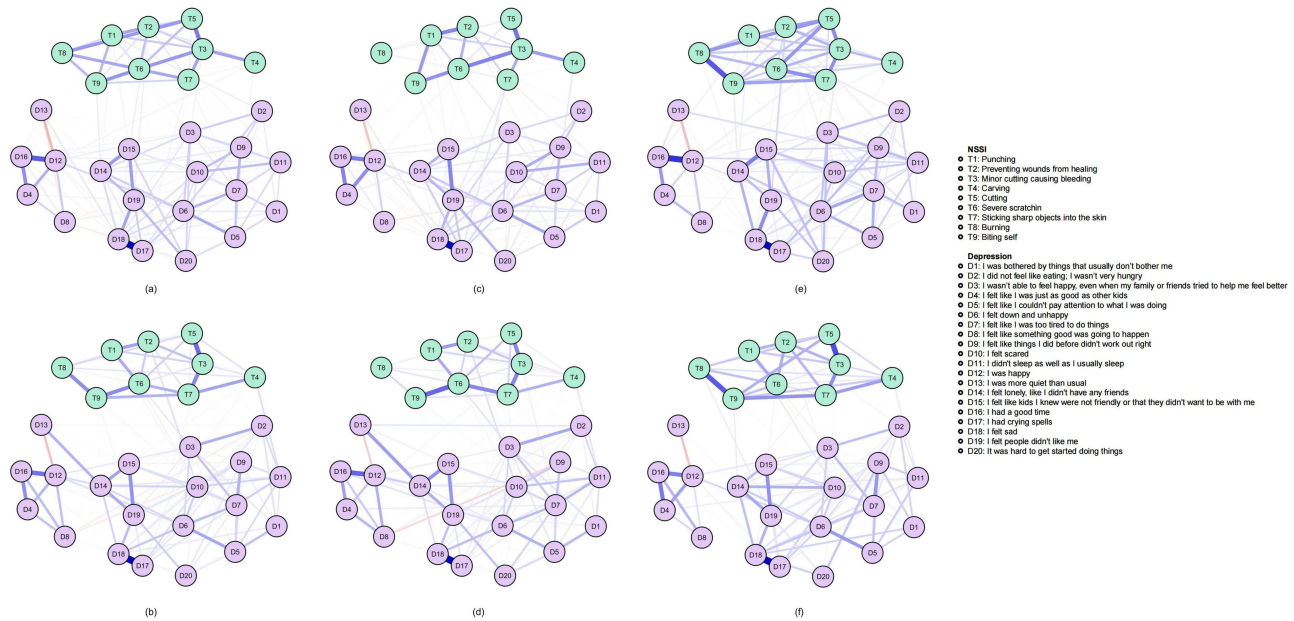


Figure 1 Regularized partial correlation networks for the total sample at W1 (a) and W2 (b), girls' sample at W1 (c) and W2 (d) and boys' sample at W1 (e) and W2 (f) across waves. Thicker lines are indicative of stronger associations. The blue lines represent positive associations, and the red lines represent negative associations. Average layout was used to set nodes in the same spatial position across networks. W1 = Wave 1; W2 = Wave 2.

which should be carefully interpreted. The 95% CI indicated good accuracy for the edge weights (see [Figure S3](#)). More details of the network accuracy are shown in [Figures S4](#) and [S5](#).

The standardized z-scores of EI are shown in [Figure 2](#). Overall, the depression symptoms “sad” (D18) and “depressed” (D6) ranked among the top 20% of EI scores across samples and waves, suggesting their potentially influential role in the networks. In addition, the NSSI symptom “minor cutting causing bleeding” (T3) emerged as the highest symptom at W1 across samples, whereas the depression symptom “lonely” (D14) ranked among the top 20% of EI scores at W2 across samples. With respect to gender differences, depression symptoms “tired” (D7) at W2 emerged as the most influential symptom within the girls’ network but not within the boys’ network ($p < 0.001$). These symptoms all showed EI scores exceeding or approaching one standard deviation, which may indicate their potential centrality and direct connection to the other nodes in networks.

The standardized z-scores of BEI across samples and waves are shown in [Figure 3](#). Overall, the NSSI symptoms “punching” (T1), “preventing wounds from healing” (T2) and “carving” (T4) ranked among the top 20% of BEI scores across samples and waves. These symptoms consistently showed robust one- and two-step BEI, potentially reflecting their pivotal position in bridging the co-occurrence networks. In addition, the NSSI symptom “minor cutting causing bleeding” (T3) at W1 and the depression symptom “scared” (D10) at W2 ranked among the top 20% of BEI scores across samples, assuming their bridging roles. With respect to gender differences across waves, the depression symptom “lonely” (D14) may serve as a bridging factor within boys’ networks, with a marginally stronger BEI than that of girls ($p = 0.06$).

Cross-Lagged Panel Networks

The CLPNs are presented in [Figure S5](#), and the adjacent matrix in [Tables S6–S8](#). The stability of in-prediction and out-prediction across samples and two waves are shown in [Figure S7](#); specifically, the stability of in-prediction for girl’s samples (CS coefficient = 0.75) was fairly strong, but the total sample and boy’s samples (CS coefficient total = 0.13, boys = 0.00) should be carefully interpreted. The out-prediction estimates were relatively stable (CS coefficient total = 0.28, girls = 0.75, boys = 0.75), which were fairly strong. The 95% CI indicated excellent accuracy for the edge weights ([Figure S8](#)). More details of the network accuracy are shown in [Figures S9](#) and [S10](#).

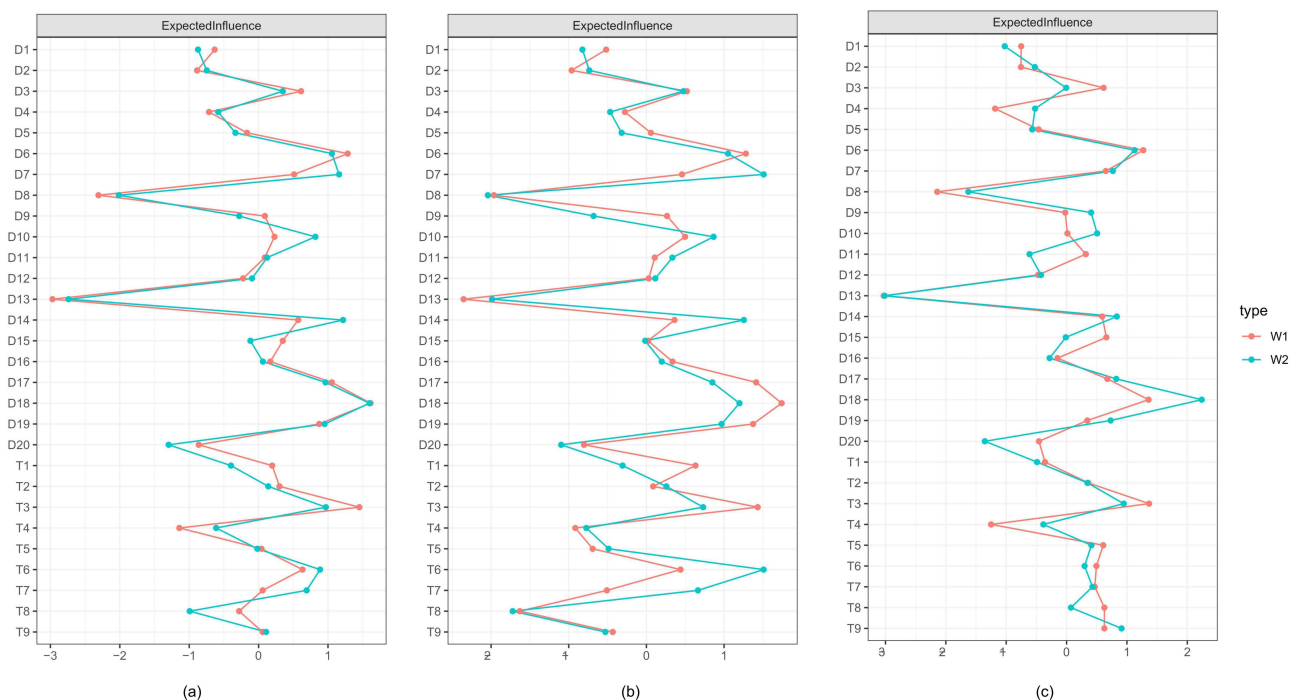


Figure 2 Expected influence (EI) per node for the total sample (a), girls' sample (b) and boys' sample (c) across waves. The EI of nodes is shown here as a z-standardized value. D = Depression items; T = NSSI items.

Figure 4 plots cross-construct estimates of in-prediction and out-prediction. The commonality observed in the cross-construct estimates suggested that NSSI symptoms were strongly influenced by depression symptoms. The results revealed that the depression symptom “scared” (D10), as the specific symptom driver for NSSI, had high out-prediction scores across samples. Moreover, the in-prediction estimates revealed that the NSSI symptoms “burning” (T8) and “preventing wounds from healing” (T2) held high in-prediction scores across samples, indicating that they were prospectively predicted by depression symptoms. The commonality observed in the cross-construct estimates may reflect an influence of the depressive affect symptom on NSSI symptoms, in line with the developmental precursor model.

With respect to gender differences, the girls’ CLPN resembled the patterns of the total sample, though depression symptoms “lack of hope” (D8) and “tired” (D7) uniquely emerged as the strongest out-prediction nodes. This may suggest that early depressive affect and somatic symptoms could potentially serve as precursors to NSSI behaviors among girls. However, the results among boys indicated a potentially bidirectional association between NSSI and depression, showing not only that depression symptoms influenced NSSI but also that NSSI symptoms led to increased depression. To be specific, the NSSI symptoms “Minor cutting causing bleeding” (T3) and “punching” (T1) had the highest out-prediction scores, demonstrating that NSSI may lead to increased depression within the boys’ network. Moreover, the depression symptoms “scared” (D10) and “lonely” (D14) both presented the highest out-prediction scores and the highest in-prediction scores among all depression symptoms. Notably, the NSSI symptoms “biting” (T9) and “preventing wounds from healing” (T2) had the highest in-prediction scores. These findings may imply a more complex bidirectional association between NSSI and depression in boys.

Discussion

Although NSSI and depression have been proven to be significantly associated at the variable level,^{6,7} few studies have examined the causal dynamic relationships between NSSI and depression at the symptom level or by sex. To address these gaps, this study recruited a sample of Chinese adolescents at two time points and explored the symptom-level characteristics of NSSI and depression co-occurrence using cross-sectional networks and the CLPN approach. In addition, gender differences in the networks associated with NSSI and depression were examined.

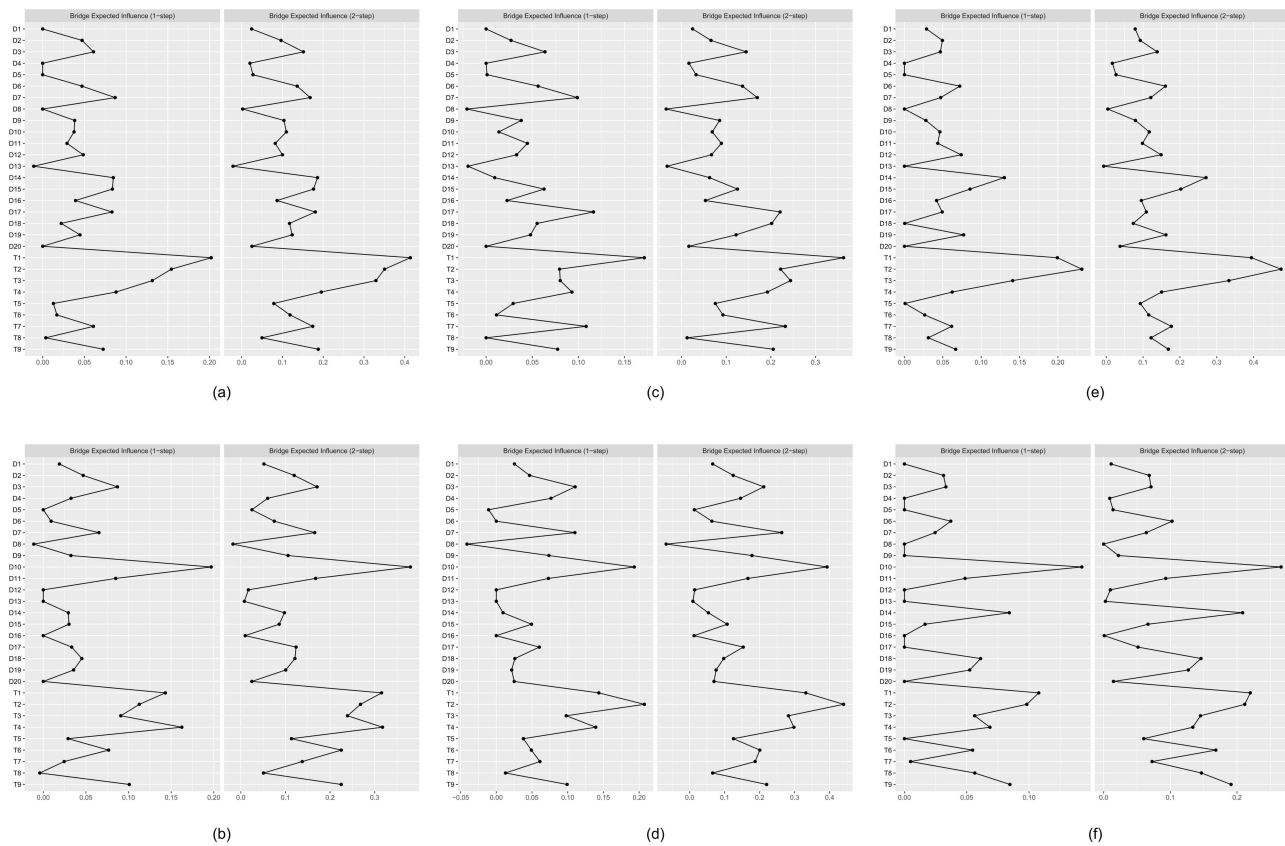


Figure 3 Bridge expected influence per node for the total sample at W1 (a) and W2 (b), girls' sample at W1 (c) and W2 (d) and boys' sample at W1 (e) and W2 (f). The one-step bridge expected influence and two-step bridge expected influence of nodes are shown here as z-standardized values. D = Depression items; T = NSSI items. W1 = Wave 1; W2 = Wave 2.

Core Symptoms of the Co-Occurrence Networks

With respect to core symptoms across genders, the current work revealed that the depression symptom “scared” acted as a bridging node, regardless of whether they were in the cross-sectional networks or in the CLPNs. In other words, the depression symptom “scared” predicted NSSI both concurrently and prospectively. This finding aligns with empirical evidence, which consistently indicates that adolescents may participate in NSSI as a means of avoiding specific affective states, such as fear (corresponding to feeling scared in this study).^{15,31,64–66} In addition, the current work also revealed that depression symptoms “sad” and “depressed” were the nodes with the highest and most stable EI centrality across two time points. This finding is consistent with the findings of prior research, suggesting that symptoms in the depressed affect dimension are potentially central to the co-occurrence of NSSI and depression.²⁶ Empirical evidence from previous studies indicates that sadness and depressed mood could trigger other depression symptoms and increase the risk of other mental health concerns, such as anxiety disorder and suicidal ideation.^{67,68} These findings suggest that sadness and depressed mood may serve as core nodes in the co-occurrence of depression and other disorders,^{67,68} including NSSI.

Notably, this study revealed remarkable gender differences in the core symptoms linking NSSI and depression, although the small effect sizes in the tests of symptom differences across genders warrant cautious interpretation. Regarding girls’ networks, this study found that the depression symptoms “tired” uniquely emerged as a central and predictive role, consistent with previous research primarily involving girls’ sample.²⁷ The reason may be that adolescent girls show an increased sensitivity for stressful life events than boys, which may underline their greater probability of developing depression symptoms and engaging in NSSI.^{69,70} In addition, it is interesting that the depression symptom “lonely” plays a bridging role in the activation of NSSI symptoms in the boys’ networks, which is inconsistent with findings in clinical samples.^{71,72} This may be because the networks of NSSI and depression symptoms in nonclinical samples have specific characteristics that differ from those of clinical samples.⁷³ One possible explanation is that

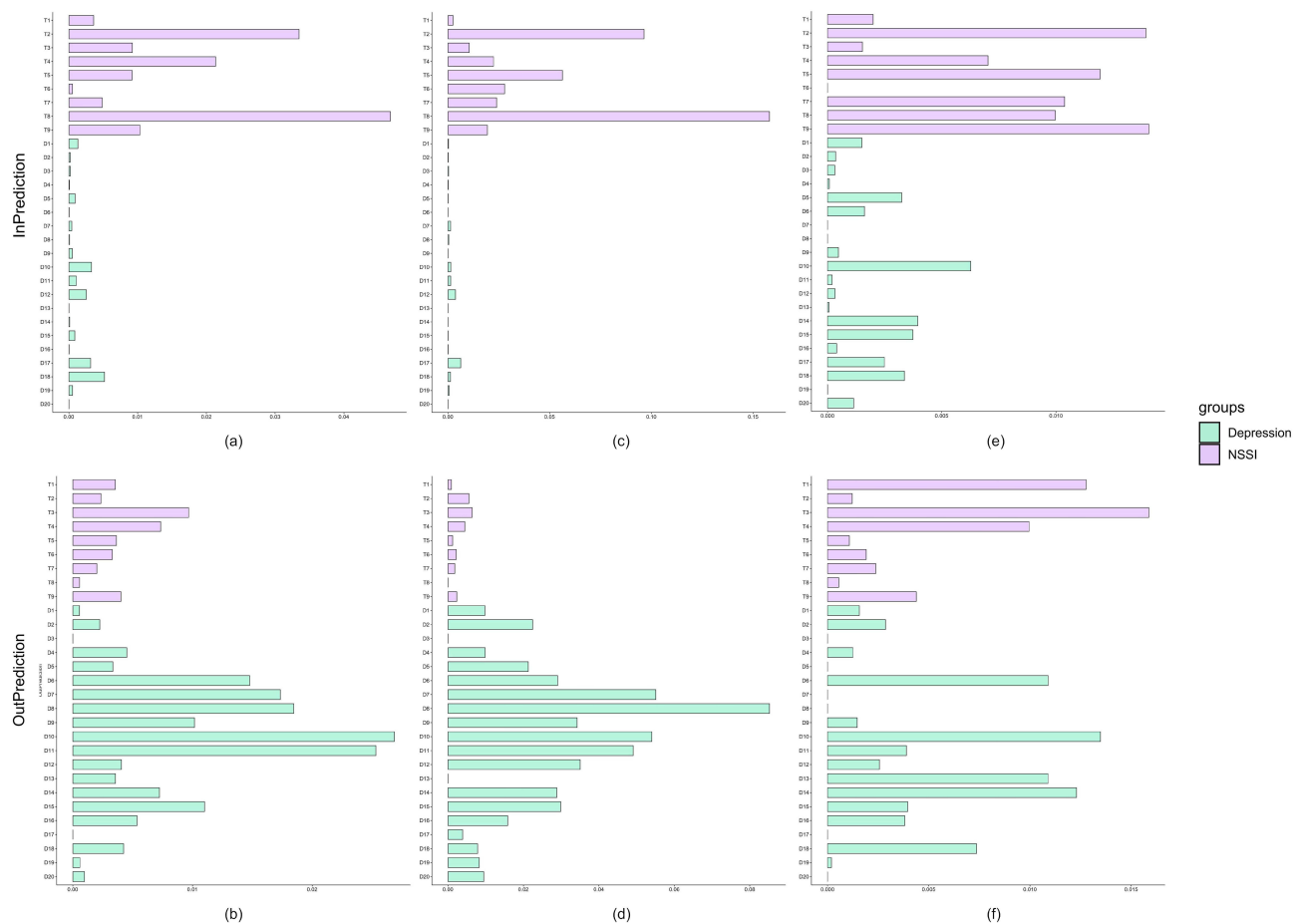


Figure 4 Cross-construct estimates of CLPN centrality. In-prediction estimates for a given node at W2 by all nodes in the other construct at W2 (excludes any path connecting nodes from the same construct) for the total (a), girls (c) and boys' sample (e). Out-prediction estimates for a given node at W1 to all nodes in the other construct at W2 are depicted for the total (b), girls (d) and boys' sample (f). W1 = Wave 1; W2 = Wave 2.

Loneliness may reflect an interpersonal deficit or difficulty that contribute to adolescents' engagement in NSSI for interpersonal regulation, such as increasing social support and attention.⁷⁴ Note that these finding should be interpreted with caution as the item-wording variation, especially the lack of consensus on loneliness assessment may affect the estimation of the network.^{75,76}

Taken together, these findings highlight the importance of targeting specific symptoms for early-stage identification and intervention of co-occurring NSSI and depression, with attention to gender-specific patterns.

Directional Relationship Between NSSI and Depression

Regarding the temporal relationships between NSSI and depression, the results of the CLPN showed that depression symptoms at W1 could predict NSSI at W2. To be specific, the depression symptom “scared” serves as the highest out-EI node for the overall sample, which is consistent with the results in cross-sectional networks. This aligns with prior research on the four-function model of NSSI, suggesting that automatic functions are more prevalent than interpersonal functions.⁷⁷

Note that gender differences were also found in the CLPN networks; specifically, the highest unique out-EI nodes among girls were the depression symptoms “lack of hope” and “tired.” This result is in line with evidence from neurobiology research indicating that adolescents may use and maintain NSSI as a means of breaking through states of anhedonia (lack hope) and to regulate energy states (away from tiredness).^{30,31,78,79} Additionally, previous studies have found that prolonged stress can lead to initial heightened HPA axis activation followed by cortisol suppression, which is linked to fatigue and anhedonia.^{69,80} These effects may be especially pronounced in adolescent girls, given

puberty-related hormonal changes that increase their sensitivity to HPA axis dysregulation and corresponding impairments in stress and reward system functioning.^{69,70,81} Finally, among girls, a lack of positive affect, especially hope, could be more likely to cause other depression symptoms and result in psychosocial difficulties, consequently increasing their risk of NSSI.^{31,82,83}

It is interesting that the current study revealed a bidirectional relationship between NSSI and depression symptoms only in boys with CLPN; specifically, NSSI symptoms such as “minor cutting causing bleeding” served as the highest out-EI among all the nodes, which is consistent with prior studies, indicating that using the cutting method is important in predicting depression risk.⁴⁸ In addition, the depression symptoms “scared” and “lonely” had both the highest out-EI scores and the highest in-EI scores among all depression symptoms, which demonstrated the possibility of a vicious cycle between NSSI and depression symptoms. As mentioned previously, adolescents who feel fearful may use NSSI as a means of gaining control over a situation or to feel relaxed.⁴⁸ Adolescents who engage in NSSI behaviors are fearful about responses from others, therefore leading to a greater level of fear.⁸⁴

With respect to the role of loneliness, adolescents who feel lonely are more likely to engage in NSSI in relation to social functions.^{74,85} However, unfortunately, NSSI can lead to increased rejection and isolation because others may consider NSSI a stigmatizing behavior.⁸⁶ This, in turn, increases adolescents’ feelings of loneliness. Note that the results of the symptom “lonely” among boys contradict those of previous studies that found only a bidirectional relationship between NSSI and depression, which was specific to girls in Western culture.^{35,87} One possible explanation is that Chinese adolescent boys, adhering to traditional cultural expectations and the socialization of masculine gender roles, such as self-reliance and being strong, tend to receive less support from their parents and peers.^{88–90} This may contribute to more loneliness and initiate a vicious circle of depression symptoms and NSSI in Chinese boys. This explanation is supported by a meta-analysis that suggests Asian male adolescents are more likely than their Western counterparts to engage in NSSI in response to interpersonal stressors rather than general emotional dysregulation, given the differences in gender role socialization and cultural norms.⁹¹

Taken together, these findings advance the theoretical understanding of the co-occurrence of depression and NSSI by indicating that NSSI in girls may be preceded by early depressive symptoms, while boys may exhibit more complex, bidirectional symptom-interaction patterns among Chinese adolescents.

Strengths and Implications

This study not only contributes valuable insights into the temporal relationships between NSSI and depression symptoms in adolescents but also underscores the practical value of gender-specific identifications and interventions. From a theoretical perspective, CLPN modeling allows us to identify bidirectional relationships at the symptom level that are crucial to the development of co-occurring NSSI and depression. By expanding upon previous traditional variable-level analyses of bidirectional relationships, this study reveals initial and bridging symptoms of the co-occurrence network, providing more precise targets for screening and intervention in co-occurring NSSI and depression. In addition, this study further reveals distinct patterns in the temporal relationships between genders. The girls’ network demonstrated that NSSI behaviors are predicted by somatic symptoms (tired) and symptoms of anhedonia (lack of hope), whereas the boys’ network shows a negative cycle because interpersonal problems (loneliness) can drive adolescents to engage in NSSI behaviors, which further impairs their interpersonal functioning and increases feelings of loneliness.

With respect to practical applications, it is imperative to identify the presence of symptoms of negative affect among adolescents, in particular feelings of fear, sadness and depression, to prevent and interrupt the development of co-occurring NSSI and depression. Moreover, interventions targeting adolescent NSSI should prioritize the enhancement of emotion regulation strategies and the development of alternative, adaptive coping mechanisms, such as improving emotional tolerance. By further exploring the gender differences in the co-occurrence of NSSI and depression, this study highlights tailored interventions that are based on gender-specific needs. The network centered on somatic distress and anhedonia observed in girls points toward the potential efficacy of interventions that increase vitality and positive emotions.^{92,93} The loneliness-centered network observed in boys suggests the importance of interventions focused on building supportive interpersonal environments. School-based interpersonal psychotherapy, such as adolescent skills training (IPT-AST), which aims to equip adolescents with necessary interpersonal skills and to increase social support,⁹⁴

is a preferred treatment for preventing worsening depression symptoms and NSSI behaviors among adolescents experiencing interpersonal difficulties.

Limitations

Although this study makes some contributions to literature, several limitations should be noted. First, this study relied on self-reported behaviors from adolescents, which may introduce subjective bias into the findings. To address this issue, future research should integrate more objective biological and neural indicators into the networks to further explore the underlying mechanisms that may link NSSI and specific depression symptoms (such as fatigue and anhedonia). Second, the current study focused on the early adolescence period. It is important to note that the co-occurrence of NSSI and depression changes from early to late adolescence, and the core nodes and patterns within networks may also shift.³⁸ This indicates the need for longitudinal studies that span multiple time points throughout adolescence, which could provide valuable insights into specific intervention targets in different stages. Third, the findings of this study are constrained by the choice of measurement instruments and the interpretation of specific items. Future research should incorporate key symptoms such as loneliness using comprehensive measurement structures in network models and to explore the extent to which different depression inventories produce comparable network structures of NSSI and depression. Finally, the current findings are based on nonclinical adolescents who presented different manifestations of NSSI and depression.^{11,13} Future research should extend network analyses across varying levels of symptom severity—from non-clinical to clinical samples—to better capture developmental transitions in co-occurring patterns and to inform developmentally sensitive and stepped-care intervention frameworks.

Conclusion

This study used longitudinal data to investigate gender-specific symptom-level dynamics of co-occurring NSSI and depression in a large non-clinical adolescent sample. By conducting network analysis, this study expanded prior work and demonstrated that depressed affect may contribute to the onset and maintenance of NSSI behaviors among adolescents. Regarding gender differences, girls' networks were centered on somatic and anhedonic symptoms with unidirectional pathways to NSSI, whereas boys showed a bidirectional pattern through loneliness. Although our findings are limited by the use of non-clinical sample and specific questionnaire items, they still offer meaningful insights. The results underscore gender-sensitive targets for early identification and intervention, such as increasing vitality in girls and enhancing interpersonal skills in boys to prevent the co-occurrence of NSSI and depression. Future research may benefit from incorporating samples with varying levels of symptom severity and comparing different depression measures to better inform the development of reliable, stepped, and gender-specific interventions.

Data Sharing Statement

The datasets support the findings of the current study are available from the corresponding author upon reasonable request.

Ethics Approval and Consent to Participate

This research was conducted according to the guidelines of the Declaration of Helsinki and approved by the ethics committee of Institutional Review Board of the Faculty of Psychology, Beijing Normal University. Participants provided active informed assent, and their guardians gave written informed consent for the assessment. All participants provided their written informed consent for publication.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically

reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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