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Prospective Study

Network Analysis of Adolescent Non-Suicidal Self-Injury Subgroups Identified through Latent Profile Analysis

Adolescent NSSI LPA & Netanalysis

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Abstract

BACKGROUND

Non-suicidal self-injury (NSSI) is common among adolescents and frequently co-occurs with depression. Understanding the distinct patterns of NSSI behaviors, along with their associated risk and protective factors, is crucial for developing effective interventions.

AIM

To classify NSSI behaviors and examine interactions between risk and resilience factors in Chinese adolescents.

METHODS

A cross-sectional study involving 3,967 Chinese students (51.7% female, mean age 13.58 ± 2.24 years) who completed questionnaires on parenting styles, bullying, childhood maltreatment, depression, resilience, and NSSI. Latent profile analysis (LPA) was used to identify NSSI subtypes, and network analysis explored interactions between risk and resilience factors.

RESULTS

Three NSSI subtypes were identified: NSSI with depression (18.8%), NSSI without depression (12.3%), and neither (68.9%). Bullying was the central risk factor across subtypes, while emotional control (EC) and family support (FS) were key protective factors. Statistical analyses showed significant differences between groups ($p < 0.001$).

CONCLUSION

Targeted interventions focusing on emotional regulation and SF are essential to reduce NSSI among adolescents.

Key Words: **Keywords:** Non-suicidal self-injury; Adolescent; Network analysis; Latent profile analysis

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Core Tip: Latent Profile Analysis (LPA): Utilized LPA based on self-injury and PHQ-9 depression assessments to uncover distinct NSSI profiles in adolescents, addressing the hypothesized heterogeneity between NSSI with and without depression. Network Analysis Insights: Identified differences in risk and resilience factors across NSSI subgroups. Bullying and Depression Connection: Demonstrated a strong link between bullying and depressive symptoms in NSSI subgroups. Intervention Focal Points: Pinpointed emotional control and family support as key areas for targeted interventions derived from LPA findings.

INTRODUCTION

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1. Introduction

Non-suicidal self-injury (NSSI), defined as deliberate self-harm without suicidal intent, is an escalating public health concern, particularly among adolescents. Common methods include cutting, scratching, and hitting oneself—behaviors prevalent worldwide. Studies indicate that approximately 17.2% of adolescents in non-clinical settings engage in NSSI, with rates as high as 27.4% reported among Chinese adolescents aged 13–18 years[1, 2]. The high incidence of NSSI in China highlights the urgent need for effective interventions, as individuals engaging in NSSI have a 66-fold increased risk of suicide[3].

The etiology of NSSI is complex, involving genetic, psychological, and sociocultural factors. Significant contributors include chronic stress, adverse childhood experiences, and digital media use[4]. Emotional dysregulation resulting from childhood trauma and

a lack of parental support are key predictors of NSSI[5, 6]. In China, societal factors such as academic pressure, filial piety, and traditional family dynamics further exacerbate these risks.

Despite extensive research on NSSI risk factors, a gap remains in understanding how these factors interact within specific adolescent subgroups. Existing studies often employ binary classifications, which fail to capture the complexity of these behaviors. This oversimplification overlooks the interplay between risk factors and protective factors—such as resilience and emotional regulation—that are crucial for developing effective interventions[7].

Latent Profile Analysis (LPA) offers a more nuanced method for identifying NSSI subtypes by classifying adolescents based on their behaviors and associated factors. Network analysis further explores the interactions among risk and resilience factors[8], revealing how these elements interrelate across different subtypes.

This study fills a critical gap by integrating LPA and network analysis to examine NSSI among Chinese adolescents. We identify distinct NSSI subtypes and analyze how risk factors—such as bullying, parenting style, and digital media use—interact with protective factors such as emotional control (EC) and SF within these subtypes. Our research provides new insights into the underlying mechanisms of NSSI, offering implications for tailored interventions to meet the diverse needs of adolescent subgroups.

MATERIALS AND METHODS

2. Methods

2.1. Participants

Participants were recruited from the Yuxi cohort of the Mental Health Survey for Children and Adolescents, which is part of the broader Yunnan Mental Health Survey. We employed a two-stage cluster sampling technique to obtain a representative sample of adolescents aged 10–18 years. In the first stage, schools were randomly selected using probability proportional to size (PPS) sampling. In the second stage, within each

selected school, 2–4 classes from each grade level were chosen through random sampling to participate in the study. The survey was conducted in two phases: Initially, participants completed a self-administered questionnaire, followed by a diagnostic assessment for those who screened positive, conducted by qualified psychiatric professionals. The study was conducted in accordance with ethical standards, with approval from the Ethics Committee of Kunming Medical University (Approval Number: KMMU2020MEC047). Written informed consent was obtained from the legal guardians of all participants in September 2021.

2.2 Measures

Table 1 presents the key details regarding the measures used in this study.

[Insert Table 1]

2.3 Statistical Analyses

Our statistical analysis comprised several key steps: Handling missing data, performing LPA, and conducting network analysis, which included network estimation, inference, stability assessment, and comparison. All analyses were conducted using R version 4.3.1. Specific packages used included “qgraph” for network visualization “bootnet” for network stability[9], and “NetworkComparisonTest” for network comparison.

2.3.1 Missing Data Handling

Missing data were addressed using full information maximum likelihood (FIML) estimation, allowing the use of all available data without imputing values[10]. FIML provides unbiased parameter estimates under the assumption of data missing at random, avoiding biases from methods like listwise deletion. Sensitivity analyses confirmed that missing data did not significantly affect the findings, ensuring the robustness of the results.

2.3.2 Latent Profile Analysis (LPA)

We conducted LPA to classify adolescent subgroups based on NSSI behaviors and depressive symptoms measured by the modified adolescents' self-harm survey

(MASHS) and the patient health questionnaire-9 (PHQ-9). LPA is suitable for identifying hidden subgroups, providing a nuanced understanding of heterogeneity in NSSI behaviors and depression levels.

To determine the optimal number of latent profiles, we explored models with varying profile numbers. Model selection was guided by the Akaike information criterion (AIC), Bayesian information criterion (BIC), and adjusted BIC (aBIC), where lower values indicate better fit[11]. We used the Lo-Mendell-Rubin adjusted likelihood ratio test (LMR-LRT) and bootstrapped likelihood ratio test (BLRT) to compare models, considering p-values less than 0.05 as a significant improvement in fit. An entropy value assessed classification accuracy; our entropy of 0.89 suggested excellent classification quality.

2.3.3 Network Analysis

Network analysis explored interactions between risk and resilience factors across the NSSI subgroups, following these steps:

Network Estimation: The Gaussian graphical model (GGM) with graphical LASSO was used to capture partial correlations among variables[12]. LASSO regularization prevents overfitting by shrinking weaker edges.

Inference: Centrality measures—node strength, closeness, and betweenness—were calculated to assess each variable's role within the network[13], identifying key factors for intervention.

Stability: Bootstrapping through the “bootnet” package provided confidence intervals for edge weights and centrality measures, ensuring the stability of results. Stability coefficients above 0.5 confirmed robustness.

Comparison: The network comparison test (NCT) evaluated differences in network structure across NSSI subgroups[14]. Holm-Bonferroni corrections were applied to adjust for multiple comparisons, ensuring reliable inferences.

Network Density: Network density, defined as the average strength of all edges, was compared between subgroups. Higher density indicates a more interconnected

network, which may have implications for the persistence and resilience of NSSI behaviors within subgroups.

RESULTS

3. Results

3.1 Descriptive Analyses

This study included 3,967 participants (51.7% female, mean age = 13.58, SD = 2.24). Table 2 presents the means and standard deviations for each variable. Bonferroni correction revealed significant differences in paternal warmth, maternal warmth, and bullying between NSSI subgroups, with the NSSI-D group showing the lowest levels. These findings suggest that targeted interventions focusing on family dynamics and bullying may be critical for these subgroups.

[Insert Table 2]

3.2 Latent Profile Analysis (LPA)

LPA identified three subgroups: NSSI with depression (NSSI-D; 18.8%), NSSI without depression (NSSI-ND; 12.3%), and no NSSI (NNSSI-ND; 68.9%). Model fit indices (AIC = 353719.4, BIC = 371608.7, aBIC = 282288.2) supported the three-profile solution, with an entropy value of 0.89 indicating high classification accuracy.

The NSSI-D group had higher depressive symptoms and emotional dysregulation, while the NSSI-ND group exhibited impulsive and externalizing behaviors, pointing to the need for distinct interventions for each subgroup.

[Insert Table 3]

3.3 Network Analysis

3.3.1 Network Estimation

Figure 1 illustrates the networks for the NSSI-ND, NSSI-D, and NNSSI-ND groups. The network densities were 0.490 (NSSI-ND, 4/529 edges), 0.451 (NSSI-D, 12/529 edges), and 0.585 (NNSSI-ND, 2/529 edges), reflecting varying levels of connectivity.

Mean absolute edge weights were 0.094 (NSSI-ND), 0.079 (NSSI-D), and 0.055 (NNSSI-ND), indicating different strengths of associations within each group.

Across all groups, strong positive correlations were observed between maternal warmth (MW) and paternal warmth (PW), with edge weights ranging from 0.639 to 0.712. Negative correlations revealed unique family dynamics, such as the -0.165 edge between FS and father reject (FR) in the NSSI-ND group and the -0.218 edge between FS and PW in the NSSI-D group. These findings highlight how family dynamics vary across NSSI subgroups, suggesting different intervention targets depending on family structure and relationships.

[Insert Figure 1]

3.3.2 Network Inference

bridge strength analyses provided key insights into the influence of risk and resilience factors across NSSI subgroups. As presented in Table 4, PW, MW, and FS exhibited high centrality and bridge strength, emphasizing their crucial roles in shaping NSSI behaviors, particularly concerning EC. These factors consistently emerged as central nodes across the NSSI-ND, NSSI-D, and NNSSI-ND groups.

Predictability scores, which indicate the proportion of variance explained by neighboring nodes, were 47.3% for NSSI-D, 48.1% for NSSI-ND, and 49.3% for NNSSI-ND, highlighting how risk factors interact within the network. Additionally, correlations between centrality strength and predictability were strong, with values of 0.826 (NSSI-ND), 0.590 (NSSI-D), and 0.730 (NNSSI-ND), suggesting varying impacts of these factors across different groups.

These findings highlight the importance of family dynamics and EC in addressing NSSI behaviors, particularly for adolescents with co-occurring depressive symptoms (NSSI-D).

[Insert Table 4]

[Insert Figure 2]

3.3.3 Network Stability

Stability analysis revealed that edge weights had slight to moderate confidence intervals, with a correlation stability coefficient for strength centrality of 0.75 in all networks, exceeding the recommended 0.50 threshold[15]. Detailed information is available in Figure 3.

[Insert Figure 3]

3.3.4 Network Comparison

Spearman correlations revealed high network similarity: 0.95 between NSSI-ND and NSSI-D, and 0.97 between NSSI-ND and NNSSI-ND. The NCT found no significant global strength differences across networks (NSSI-ND: 8.67, NSSI-D: 9.09, NNSSI-ND: 10.97; $S = 0.418$, $p = 0.39$), indicating overall connectivity consistency. However, significant structural differences were observed between the NSSI-ND and NSSI-D networks ($M = 0.301$, $p < 0.001$), with one significantly different edge and four specifically identified edges. Centrality invariance tests ($C = 0.05$, $p = 0.007$) revealed distinct centrality patterns, particularly in bullied nodes within the NSSI-D network.

A noteworthy finding was the unique centrality of bullying in the NSSI-D group, suggesting that bullying plays a more prominent role in adolescents with both NSSI and depression, compared to those without depression. This insight highlights the need for targeted anti-bullying interventions in this subgroup.

No significant global strength or structural differences were found between the NSSI-ND and NNSSI-ND, or between NSSI-D and NNSSI-ND networks. However, node centrality differences emerged between NSSI-ND and NNSSI-ND. Pairwise NCT analyses identified significant differences in 12 out of 529 edges (4.74%) between NSSI-ND and NNSSI-ND and in two pairs between NSSI-D and NNSSI-ND. For detailed comparisons of edge weights and significant variance, refer to Supplementary Tables C1, C2, and C3.

DISCUSSION

4. Discussion

This study provides significant insights into the complex nature of non-suicidal self-injury (NSSI) among Chinese adolescents by employing a combination of LPA and network analysis. By identifying distinct subgroups based on NSSI behaviors and depressive symptoms, and exploring the interactions between risk and protective factors, we have advanced the understanding of NSSI's multifaceted etiology.

4.1 Interpretation of Key Findings

The identification of three distinct subgroups—NSSI with depression (NSSI-D), NSSI without depression (NSSI-ND), and neither (NNSSI-ND)—highlights the heterogeneity of NSSI behaviors. This heterogeneity underscores the importance of not treating NSSI as a homogeneous behavior, as different subgroups may have unique underlying mechanisms and require tailored interventions[16].

Our network analysis revealed that bullying is a central risk factor, especially in the NSSI-D subgroup. This finding aligns with prior research indicating that experiences of bullying are significantly associated with both depressive symptoms and NSSI behaviors[17]. Adolescents who are bullied may internalize negative self-perceptions and experience heightened emotional distress, leading to depressive symptoms. Consequently, the likelihood of engaging in NSSI as a maladaptive coping mechanism increases[18].

In contrast, the NSSI-ND subgroup showed a distinct pattern where smartphone addiction emerged as a notable factor. This suggests that adolescents engaging in NSSI without concurrent depressive symptoms may be using excessive smartphone use as an alternative or complementary coping strategy to manage emotional distress[19]. The accessibility and immediacy of digital media may provide temporary relief but could also reinforce avoidance behaviors and hinder the development of healthier coping mechanisms[20].

FS and EC were identified as key protective factors across all subgroups. High levels of FS may buffer the impact of stressors by providing emotional resources and a sense of belonging, which can mitigate the need for self-injurious behaviors[21]. EC, as an

aspect of emotional regulation, enables adolescents to manage negative emotions more effectively, reducing the reliance on NSSI as a means of coping[22].

4.2 Theoretical Implications

The findings support the interpersonal theory of NSSI, which posits that social factors such as bullying and family dynamics play a critical role in the initiation and maintenance of self-injurious behaviors[23]. The centrality of bullying in the NSSI-D subgroup suggests that negative interpersonal experiences are particularly detrimental when coupled with internalizing symptoms like depression.

Moreover, the study extends the application of the diathesis-stress model to NSSI by illustrating how individual vulnerabilities (*e.g.*, poor EC) interact with environmental stressors (*e.g.*, bullying) to influence the onset of self-injury[24]. The identification of protective factors such as FS highlights the potential moderating effects these elements can have on the stress-NSSI relationship.

4.3 Clinical Implications

The differentiated profiles of NSSI behaviors have important implications for intervention strategies. For adolescents in the NSSI-D subgroup, interventions should involve a multi-faceted approach that addresses both depressive symptoms and experiences of bullying. Cognitive-behavioral therapy (CBT) techniques can be effective in challenging negative thought patterns and enhancing problem-solving skills[25]. School-based programs that foster a positive social climate and implement anti-bullying policies may also reduce the prevalence of both bullying and NSSI[26].

For the NSSI-ND subgroup, interventions might focus on regulating technology use and promoting alternative coping strategies. Digital literacy programs that educate adolescents about the risks of excessive smartphone use and provide tools for managing screen time could be beneficial[27]. Incorporating mindfulness and stress management techniques can help adolescents develop healthier ways to cope with emotional distress[28].

Family-based interventions are crucial across all subgroups. Enhancing communication within the family, increasing parental awareness of NSSI, and fostering supportive relationships can strengthen the protective role of the family environment[29]. Parental training programs that focus on emotion coaching and responsive parenting may improve adolescents' emotional regulation abilities and reduce NSSI behaviors[30].

4.4 Cultural Considerations

The cultural context in China, characterized by collectivism and strong familial ties, amplifies the influence of FS on adolescent behavior[31]. The emphasis on academic achievement and adherence to social norms may contribute to stress and emotional difficulties among adolescents[32]. Understanding these cultural factors is essential for designing interventions that are culturally sensitive and resonate with adolescents and their families.

Additionally, the stigma associated with mental health issues in Chinese society may hinder help-seeking behaviors. Efforts to destigmatize mental health problems through public education campaigns and integrating mental health services within schools could improve access to support and reduce the incidence of NSSI.

4.5 Limitations

This study has several limitations. The cross-sectional design limits the ability to infer causal relationships between risk factors, protective factors, and NSSI behaviors. Therefore, longitudinal studies are needed to examine how these relationships evolve and identify potential causal pathways.

The reliance on self-reported data may introduce biases, such as social desirability or recall inaccuracies. Future research could incorporate multiple data sources, including reports from parents, teachers, or clinical assessments, to enhance the validity of the findings.

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The sample was drawn from a specific geographic region in China, which may limit the generalizability of the results to other regions or cultural contexts. Replication studies in diverse settings are necessary to confirm the applicability of these findings more broadly.

4.6 Future Research Directions

Building on the current findings, future research should employ longitudinal designs to explore the developmental trajectories of NSSI behaviors and the temporal dynamics between risk and protective factors. Investigating the mechanisms through which bullying leads to NSSI, particularly the mediating role of depression and emotional regulation, could inform more targeted interventions.

Examining the impact of digital media use in greater depth is also warranted, given the evolving nature of technology and its pervasive influence on adolescents' lives. Studies could explore how online interactions, cyberbullying, and social media exposure contribute to NSSI behaviors and mental health outcomes[33].

Additionally, qualitative research methods could provide richer insights into adolescents' subjective experiences of NSSI, capturing the nuances of their motivations, feelings, and contextual factors. Such insights could enhance the development of personalized intervention strategies that resonate with adolescents' lived experiences.

CONCLUSION

This study enhances the understanding of NSSI among Chinese adolescents by identifying distinct behavioral subgroups and elucidating the complex interplay of associated risk and protective factors. The findings emphasize the importance of considering individual differences and cultural contexts in both research and clinical practice. By tailoring interventions to address specific needs—such as bullying prevention, emotional regulation training, and FS enhancement—we can develop more effective strategies to reduce NSSI behaviors and promote mental well-being among adolescents.

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