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The mediating roles of anxiety, loneliness, stress, and depression in the relationship between cyberbullying and non-suicidal self-injury: propensity score matching and causal mediation analysis

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Abstract

Background Non-suicidal self-injury (NSSI) not only causes direct physical harm but also severely impacts mental health, increasing the risks of psychological disorders, behavioral issues, and suicidal tendencies. With the widespread use of the internet and electronic communication tools on smartphones, such as social media and instant messaging applications, cyberbullying has become increasingly prevalent. However, research on the relationship between cyberbullying and NSSI remains relatively limited at present.

Methods This research was conducted in Nantong City, Jiangsu Province, from July to September 2024, utilizing a convenience sampling method with 1,751 participants. Propensity Score Matching (PSM) was employed to control for confounding factors, while causal mediation analysis was used to assess the mediating effects of anxiety, depression, stress, and loneliness between cyberbullying and NSSI.

Results In this study, 557 participants (31.8%) reported having experienced cyberbullying. Cyberbullying significantly increases NSSI odds through direct and indirect effects, mediated by anxiety (ACME = 0.08, ADE = 0.22, mediated proportion = 0.28), loneliness (ACME = 0.04, ADE = 0.26, mediated proportion = 0.14), stress (ACME = 0.05, ADE = 0.24, mediated proportion = 0.18), and depression (ACME = 0.06, ADE = 0.24, mediated proportion = 0.19).

Conclusion This study explores the relationship between cyberbullying, mental health issues (depression, anxiety, stress, loneliness), and NSSI. Findings show cyberbullying directly and indirectly increases NSSI risk, with loneliness as a key mediator. Despite insights, the study has limitations, suggesting a need for more rigorous designs and comprehensive data.

Keywords Cyberbullying, Non-suicidal self-injury, Psychological characteristics, Causal mediation analysis

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Introduction

Non-suicidal self-injury (NSSI) refers to the intentional act of inflicting physical harm on oneself without suicidal intent, which is generally not accepted in societal or cultural contexts [1]. It is estimated that the global prevalence of NSSI stands at 17.2% among adolescents and 5.5% among adults [2]. In contrast, approximately 22.37% of Chinese adolescents are reported to engage in NSSI [3]. Common expressions of NSSI include behaviors such as skin cutting, tearing, and hitting. These actions typically exhibit three defining characteristics: repetitiveness, intentionality, and self-concealment [4]. Currently, NSSI is classified as an independent diagnosis in the third section of the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition. Research has shown that the detection rate of NSSI among Chinese adolescents is generally higher than that in Western countries and is experiencing a gradual increase [5, 6]. Beyond causing physical injury, NSSI significantly affects mental health, elevating the risk of various psychological disorders, behavioral issues, and even suicidal behavior [7]. Notably, individuals who engage in NSSI face more than a seven-fold increased risk of suicide [8]. Consequently, NSSI has emerged as a pressing public health concern globally.

With the widespread proliferation of electronic communication tools on the internet and mobile phones, such as social media and instant messaging applications, the phenomenon of cyberbullying has emerged. The definition of cyberbullying is similar to traditional bullying, but it is distinguished by its occurrence through electronic means of communication [9]. Compared to traditional bullying, cyberbullying exhibits unique differences in target selection, timing, coping strategies, and the relationship between victims and perpetrators. Perpetrators of cyberbullying enjoy a certain degree of anonymity that is not present in traditional bullying, and victims may face more extensive exposure and embarrassment. Cyberbullying can occur anywhere, whether in the victim's home or elsewhere, and at any time, whether during the day or night. Furthermore, if the victim leaves the relevant platform, the bullying messages often continue to accumulate. Numerous studies have shown that victims of cyberbullying are more susceptible to a range of negative consequences, including depression, anxiety, and NSSI behaviors [10–12]. A meta-analysis has found a significant association between cyberbullying and NSSI, indicating that individuals who have experienced cyberbullying are significantly more likely to engage in NSSI than those who have not (odds ratio $OR=2.35$) [13]. More importantly, a longitudinal study has also found that cyberbullying significantly increases the risk of NSSI [10].

Previous research has consistently shown that cyberbullying has adverse effects on mental health, manifesting

in various forms such as anxiety, depression, loneliness, and non-suicidal self-injury (NSSI) [11, 14–17]. These studies highlight the profound impact of cyberbullying on individuals' mental well-being. Notably, anxiety, depression, and loneliness are also established risk factors for NSSI [18–21], suggesting that they may mediate the relationship between cyberbullying and NSSI. To further explore this relationship, we will employ Propensity Score Matching (PSM) to construct an experimental group exposed to cyberbullying and a control group without such exposure. This method allows us to effectively control for potential confounding factors, ensuring comparability between the two groups on key characteristics and enabling a more accurate assessment of the direct impact of cyberbullying on NSSI. Furthermore, we will apply Causal Mediation Analysis (CMA) techniques to quantify the mediating roles of anxiety, loneliness, stress, and depression in the relationship between cyberbullying and NSSI, determining the proportion of the overall effect that each factor explains. This approach will provide a deeper understanding of how cyberbullying influences NSSI behavior through these psychological mechanisms and inform the development of targeted interventions.

Methods

Participants and procedures

This study was conducted in Nantong City, Jiangsu Province, from July to September 2024. We employed a convenience sampling approach by specifically inviting individuals undergoing physical examinations at the Nantong People's Hospital Examination Center to participate in our questionnaire survey. This study specifically selected participants who underwent physical examinations as research subjects, rather than including all patients from the hospital. This decision was primarily driven by practical considerations such as resource limitations, time constraints, and participant cooperation. Our professional staff personally approached participants and provided detailed information about the research objectives. Participation was entirely voluntary, and explicit informed consent was obtained from all participants before data collection. The questionnaire was designed to be concise, with an estimated completion time of approximately 8 min. As a token of appreciation for their valuable time, each participant who completed the questionnaire received a small gift valued between 10 and 15 yuan, such as a notebook, water bottle, or snacks.

The research protocol received formal approval from the Medical Ethics Committee of Nantong People's Hospital under the reference number 2024KT370. Out of 2,272 invited participants, we successfully collected 2,067 valid surveys, achieving an impressive response rate of 91%. In this study, focusing on the impact of

cyberbullying, we excluded elderly individuals who do not use electronic devices, such as mobile phones and computers. A total of 316 individuals were excluded, resulting in 1,751 participants being included in this research.

Measures

Basic demographic variables

Key demographic information was gathered, including age, gender, education level, marital status, monthly income, residence.

Depression anxiety and stress

In this study, we utilized the Chinese version of the Depression Anxiety and Stress Scale-21 (DASS-21) to assess psychological distress among the participants [22]. The DASS-21 consists of three subscales: depression, anxiety, and stress, each with seven items. Examples of items include: “I was unable to become enthusiastic about anything” for depression, “I felt scared without any good reason” for anxiety, and “I tended to over-react to situations” for stress. Participants rated each item on a four-point Likert scale, reflecting their experiences over the previous week. Higher total subscale scores indicate higher levels of psychological distress. The scale has shown strong reliability and validity in the Chinese context [23, 24], with Cronbach’s α values of 0.70 for stress, 0.76 for anxiety, and 0.69 for depression.

Loneliness

To measure loneliness among participants, we employed the Three-Item Loneliness Scale [25]. This scale uses a 3-point Likert format, allowing responses of “hardly ever,” “some of the time,” or “often.” An example item asks, “How frequently do you feel that you lack companionship?” Total scores range from 3 to 9, with higher scores indicating increased loneliness. The scale has shown strong reliability and validity in the Chinese context [26, 27], with a Cronbach’s alpha of 0.78 in this study.

Cyberbullying

The Cyberbullying Scale was used to assess cyberbullying behavior, consisting of 12 items rated on a 5-point Likert scale (0 = “never” to 4 = “always”) [28]. The scale covers various forms of cyberbullying, such as spreading online rumors and using offensive language. The scale identified three dimensions: online verbal bullying, concealing identity, and online forgery and fraud. Total scores help evaluate the severity of cyberbullying experienced, with higher scores indicating more severe instances. In this study, a score of 0 indicated no experience of cyberbullying, while a score > 1 signified experiencing cyberbullying. The scale, validated in China, is widely used in

related research [29], with a Cronbach’s alpha of 0.87 in this study.

Non-suicidal self-injury

Non-suicidal self-injury was assessed using a single-item question: “During the past 12 months, did you engage in non-suicidal self-injury?”. Participants rated their experiences on a scale ranging from “none” (coded as 0) to “always” (coded as 4). These questions have been widely employed in research conducted within the Chinese population [30, 31].

Statistical analysis

Descriptive analysis

In this study, qualitative data were presented in terms of frequencies (N) and percentages (%), while quantitative data were expressed as mean \pm standard deviation (SD). For variables that did not follow a normal distribution, percentiles were utilized for representation.

Propensity score matching (PSM) analysis

To address potential confounding variables, we employed Propensity Score Matching (PSM) analysis to balance baseline socio-demographic characteristics, such as age, gender, education level, marital status, monthly income, and residence. The experimental group consisted of individuals who experienced cyberbullying, while the control group comprised those who did not. Nearest neighbor matching with a caliper set at 0.05 was applied at a 1:1 ratio for cases and controls. Ultimately, 557 individuals who experienced cyberbullying and 557 individuals who did not were included in the study.

Correlation analysis and causal mediation analysis

In this study, Spearman’s correlation analysis was used to explore the relationships among key variables, including cyberbullying, stress, anxiety, depression, Non-suicidal Self-Injury, and loneliness. Subsequently, causal mediation analysis was conducted to decompose the total effect of outcomes into direct and indirect effects, with specific variables mediating the indirect effect. The analysis included the average causal mediation effect (ACME), average direct effect (ADE), and proportion of mediation. Mental health outcomes served as mediator variables, encompassing depression, anxiety, stress, and loneliness, examining their mediating role between cyberbullying and non-suicidal self-injury. A bootstrapping test was employed to calculate correlation coefficients for causal mediation effects. Furthermore, linear regression models were performed to examine three dimensions of cyberbullying on anxiety, depression, stress, loneliness, and non-suicidal self-injury.

All statistical analyses were performed using SPSS version 21.0, with the causal mediation model executed in

Table 1 Socio-demographic characteristics of participants (N = 1751)

Variables	Category	N	%
Sex	Male	1089	62.2
	Female	662	37.8
Age	Mean \pm SD = 40.49 \pm 13.14		
	24 years and below	167	9.5
	25–34 years	515	29.4
	35 ~ 44 years	460	26.3
	45–54 years	305	17.4
	55 ~ 64 years	216	12.3
	65 years and above	88	5.0
Education level	Primary school and below	53	3.0
	Middle school	222	12.7
	Technical secondary school, high school, or vocational high school	245	14.0
	College	297	17.0
	Bachelor's degree and above	934	53.3
Marital Status	Unmarried	356	20.3
	Married	1369	78.2
	Widowed/Divorced/Other	26	1.5
Monthly income	2000 yuan and below	141	8.1
	2001–4000 yuan	194	11.1
	4001–6000 yuan	366	20.9
	6001–8000 yuan	398	22.7
	8001–10,000 yuan	312	17.8
	Above 10,000 yuan	340	19.4
Residence	Nantong Chongchuan District	1284	73.3
	Nantong Development Zone	122	7.0
	Nantong Tongzhou District	122	7.0
	Other	223	12.7

R software version 4.1.3. Significance was set at $P < 0.05$ (two-tailed) for this study.

Result

This study surveyed a total of 1751 participants, with 557 individuals (representing 31.8%) reporting experiencing cyberbullying. The majority of participants were male (1089 individuals, 62.2%), with an average age of 40.49 years (standard deviation of 13.14), and the largest

age group fell between 25 and 34 years old (515 individuals, 29.4%). A significant portion of participants held a Bachelor's degree or higher (934 individuals, 53.3%), were married (1369 individuals, 78.2%), had a monthly income primarily ranging from 6001 to 8000 yuan (398 individuals, 22.7%), and the majority resided in the Nantong Chongchuan district (1284 individuals, 73.3%). For detailed demographic data, please refer to Table 1.

The key variables presented in Table 2 with mean scores and standard deviations: The mean score for depression is 1.48 (SD = 1.88), anxiety is 1.06 (SD = 1.78), stress is 1.10 (SD = 1.67), loneliness is 0.34 (SD = 0.84), cyberbullying is 1.05 (SD = 2.81), and non-suicidal self-injury is 1.07 (SD = 0.32).

Results of propensity score matching analysis

To assess the impact of confounding variables, this study employed propensity score matching to balance the samples between individuals who had encountered cyberbullying and those who had not. Changes in propensity scores pre- and post-matching were graphically depicted for both groups (refer to Fig. 1). The standardized mean difference (Std. Mean Diff.) prior to matching was 0.1758, which dramatically decreased to 0.001 after matching. Furthermore, to verify the efficacy of the matching process, Chi-square test analyses were performed on the general demographic characteristics of the group that experienced cyberbullying before and after matching (See Table 3). For example, with respect to age, the chi-square test yielded a result of $\chi^2 = 16.55$, $p = 0.005$ before matching, signifying notable disparities between the two groups. Conversely, post-matching, the chi-square test outcome was $\chi^2 = 3.43$, $p = 0.634$, indicating effective control over various confounding factors within the cyberbullying-experienced and non-experienced cohorts.

Results of correlation analysis

As depicted in Fig. 2, our analysis has unveiled notable correlations among the key variables, encompassing depression, stress, anxiety, cyberbullying, loneliness, and non-suicidal self-injury. The correlations among these variables have all demonstrated statistical significance, with a P -value below 0.001.

Table 2 Key variables status of the participants (N = 1751)

Variables	Mean \pm SD	P10	P25	P50	P75	P90
Depression	1.48 \pm 1.88	0	0	1.00	2.00	4.00
Anxiety	1.06 \pm 1.78	0	0	0	1.00	3.00
Stress	1.10 \pm 1.67	0	0	1.00	2.00	3.00
Loneliness	0.34 \pm 0.84	0	0	0	0	2.00
Cyberbullying	1.05 \pm 2.81	0	0	0	1.00	3.00
Non-suicidal Self-Injury	1.07 \pm 0.32	1.00	1.00	1.00	1.00	1.00

Distribution of Propensity Scores

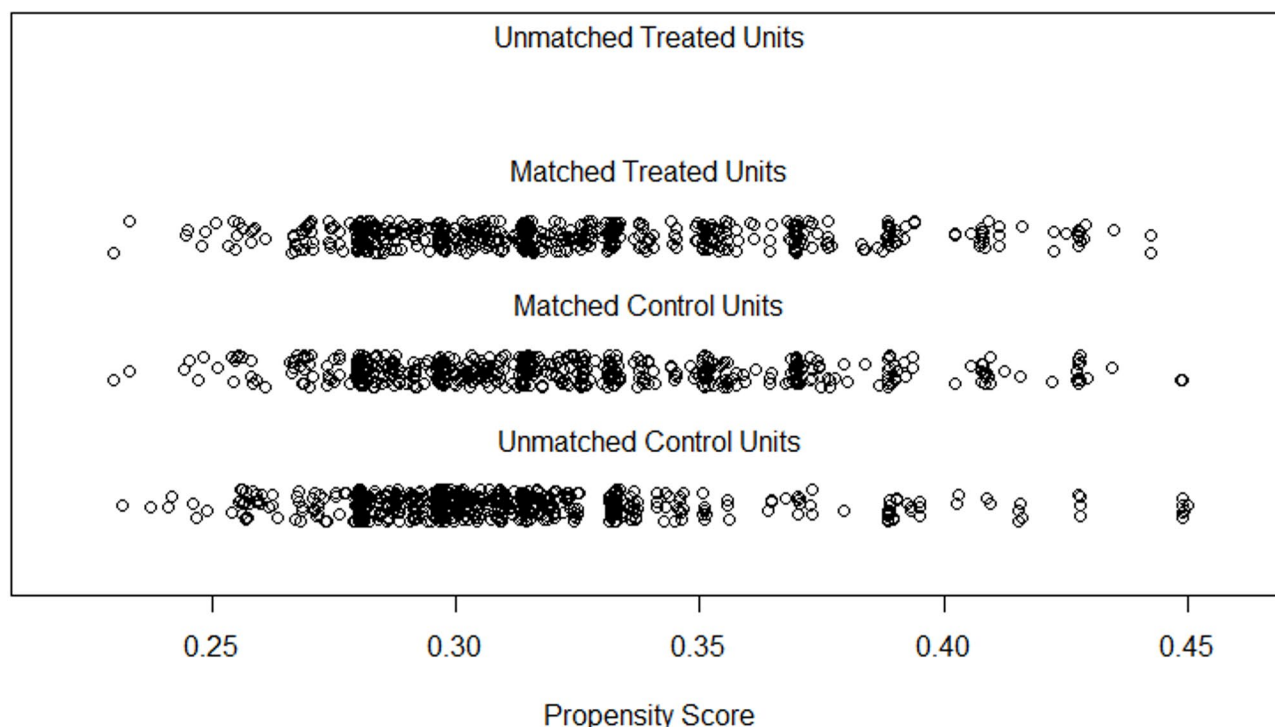


Fig. 1 The distribution of propensity score before and after PSM analysis

Results of causal mediation analysis

Figure 3 presents the detailed findings of the causal mediation analysis. The analysis indicates that cyberbullying significantly contributes to increased odds of non-suicidal self-injury through both direct and indirect effects, with anxiety serving as a mediating factor. The Average Causal Mediation Effect (ACME) is 0.08 (95% CI: 0.04–0.13; $P < 0.001$), while the Average Direct Effect (ADE) is 0.22 (95% CI: 0.06–0.38; $P < 0.001$). The proportion of the mediated effect is 0.28 (95% CI: 0.14–0.61). Similarly, the analysis also reveals that cyberbullying significantly increases the likelihood of non-suicidal self-injury through both direct and indirect effects, with loneliness acting as a mediator. In this case, the ACME is 0.04 (95% CI: 0.02–0.07; $P < 0.001$) and the ADE is 0.26 (95% CI: 0.10–0.43; $P < 0.001$). The proportion of the mediated effect is 0.14 (95% CI: 0.05–0.31). Furthermore, when stress serves as the mediator, cyberbullying also significantly contributes to increased odds of non-suicidal self-injury through both direct and indirect effects. The ACME is 0.05 (95% CI: 0.02–0.09; $P < 0.001$) and the ADE is 0.24 (95% CI: 0.09–0.40; $P < 0.001$). The proportion of the mediated effect is 0.18 (95% CI: 0.08–0.43). Lastly, when depression acts as the mediator, cyberbullying also significantly increases the likelihood of non-suicidal self-injury through both direct and indirect effects.

The ACME is 0.06 (95% CI: 0.02–0.10; $P < 0.001$) and the ADE is 0.24 (95% CI: 0.09–0.40; $P < 0.001$). The proportion of the mediated effect is 0.19 (95% CI: 0.10–0.43). Furthermore, online verbal bullying exerts the most significant impact on anxiety, depression, stress, loneliness, and NSSI among the three dimensions of cyberbullying (See Supplementary Material).

Discussion

This study conducted a comprehensive survey among 1751 participants to investigate the complex relationships between cyberbullying and depression, anxiety, stress, loneliness, as well as NSSI behaviors. To accurately evaluate the potential impact of cyberbullying, advanced methodologies such as Propensity Score Matching (PSM) analysis and causal mediation analysis were employed. Through meticulous matching procedures, demographic differences between the group that experienced cyberbullying and the group that did not were minimized, ensuring the precision of the assessments. Furthermore, utilizing causal mediation analysis, it was discovered that cyberbullying not only directly increases the risk of NSSI behaviors but also indirectly influences individuals through mediating factors such as anxiety, loneliness, stress, and depression. These mediating variables act as links between cyberbullying and NSSI behaviors,

Table 3 Socio-demographic characteristics: comparison between cyberbullied and Non-cyberbullied participants

Variables	Category	Before PSM analysis(N= 1751)		χ^2	P	After PSM analysis(N= 1114)		χ^2	P
		Experienced Cyberbullying (N, %)	Not Experienced Cyberbullying (N, %)			Experienced Cyberbullying (N, %)	Not Experienced Cyberbullying (N, %)		
Sex	Male	717(65.8%)	372(34.2%)	7.33	0.007	320(46.2%)	372(53.8%)	10.32	0.002
	Female	477(72.1%)	185(27.9%)			237(56.2%)	185(43.8%)		
Age	24 years and below	91(54.5%)	76(45.5%)	16.55	0.005	60(44.1%)	76(55.9%)	3.43	0.634
	25–34 years	358(69.5%)	157(30.5%)			175(52.7%)	157(47.3%)		
	35 ~ 44 years	321(69.8%)	139(30.2%)			143(50.7%)	139(49.3%)		
	45–54 years	209(68.5%)	96(31.5%)			93(49.2%)	96(50.8%)		
	55 ~ 64 years	151(69.9%)	65(30.1%)			59(47.6%)	65(52.4%)		
	65 years and above	64(72.7%)	24(27.3%)			27(52.9%)	24(47.1%)		
Education level	Primary school and below	40(75.5%)	13(24.5%)	1.80	0.772	14(51.9%)	13(48.1%)	0.89	0.927
	Middle school	151(68.0%)	71(32.0%)			61(46.2%)	71(53.8%)		
	Technical secondary school, high school, or vocational high school	170(69.4%)	75(30.6%)			77(50.7%)	75(49.3%)		
	College	204(68.7%)	93(31.3%)			94(50.3%)	93(49.7%)		
	Bachelor's degree and above	629(67.3%)	305(32.7%)			311(50.5%)	305(49.5%)		
Marital Status	Unmarried	220(61.8%)	136(38.2%)	8.42	0.015	142(51.1%)	136(48.9%)	0.44	0.805
	Married	956(69.8%)	413(30.2%)			409(49.8%)	413(50.2%)		
	Widowed/Divorced/Other	18(69.2%)	8(30.8%)			6(42.9%)	8(57.1%)		
Monthly income	2000 yuan and below	83(58.9%)	58(41.1%)	10.19	0.070	49(45.8%)	58(54.2%)	3.75	0.586
	2001–4000 yuan	122(62.9%)	72(37.1%)			60(45.5%)	72(54.5%)		
	4001–6000 yuan	257(70.2%)	109(29.8%)			123(53.0%)	109(47.0%)		
	6001–8000 yuan	280(70.4%)	118(29.6%)			132(52.8%)	118(47.2%)		
	8001–10,000 yuan	218(69.9%)	94(30.1%)			87(48.1%)	94(51.9%)		
	Above 10,000 yuan	234(68.8%)	106(31.2%)			106(50.0%)	106(50.0%)		
Residence	Nantong Chongchuan District	885(68.9%)	399(31.1%)	3.77	0.287	442(51.4%)	399(48.6%)	4.96	10.175
	Nantong Development Zone	81(66.4%)	41(33.6%)			34(45.3%)	41(54.7%)		
	Nantong Tongzhou District	74(60.7%)	48(39.3%)			31(39.2%)	48(60.8%)		
	Other	154(69.1%)	69(30.9%)			70(50.4%)	69(49.6%)		

revealing the intricate mechanisms of cyberbullying's impact on individual mental health. It is noteworthy that when anxiety, loneliness, and depression serve as mediating factors, their effects are particularly significant, underscoring their crucial roles in connecting cyberbullying with self-injury behaviors.

In this study, 557 participants (31.8%) reported having experienced cyberbullying, emphasizing the widespread prevalence and seriousness of this issue. Nevertheless, there are significant variations in the findings across different studies. For instance, Kraft (2006) noted that the percentage of individuals who encountered cyberbullying ranged from 10 to 42% in Australia, England, Canada, and the United States [32]. Mascheroni and Cuman

(2014) reported cyberbullying victimization rates among children ranging from approximately 11–26% in Italy and seven other European countries [33]. Likewise, Li (2007) indicated that 28.9% of respondents were victims of cyberbullying in China and Canada [34]. In contrast, our study's results surpass those of prior research. Notably, a study conducted among college students in Turkey revealed a high prevalence of cyberbullying at 55.3% [35], while Huang et al. found a substantial cyberbullying prevalence of 64.32% among Chinese college students [36]. These discrepancies may stem from differing research objectives, variations in measurement instruments utilized, and distinctions in target populations.

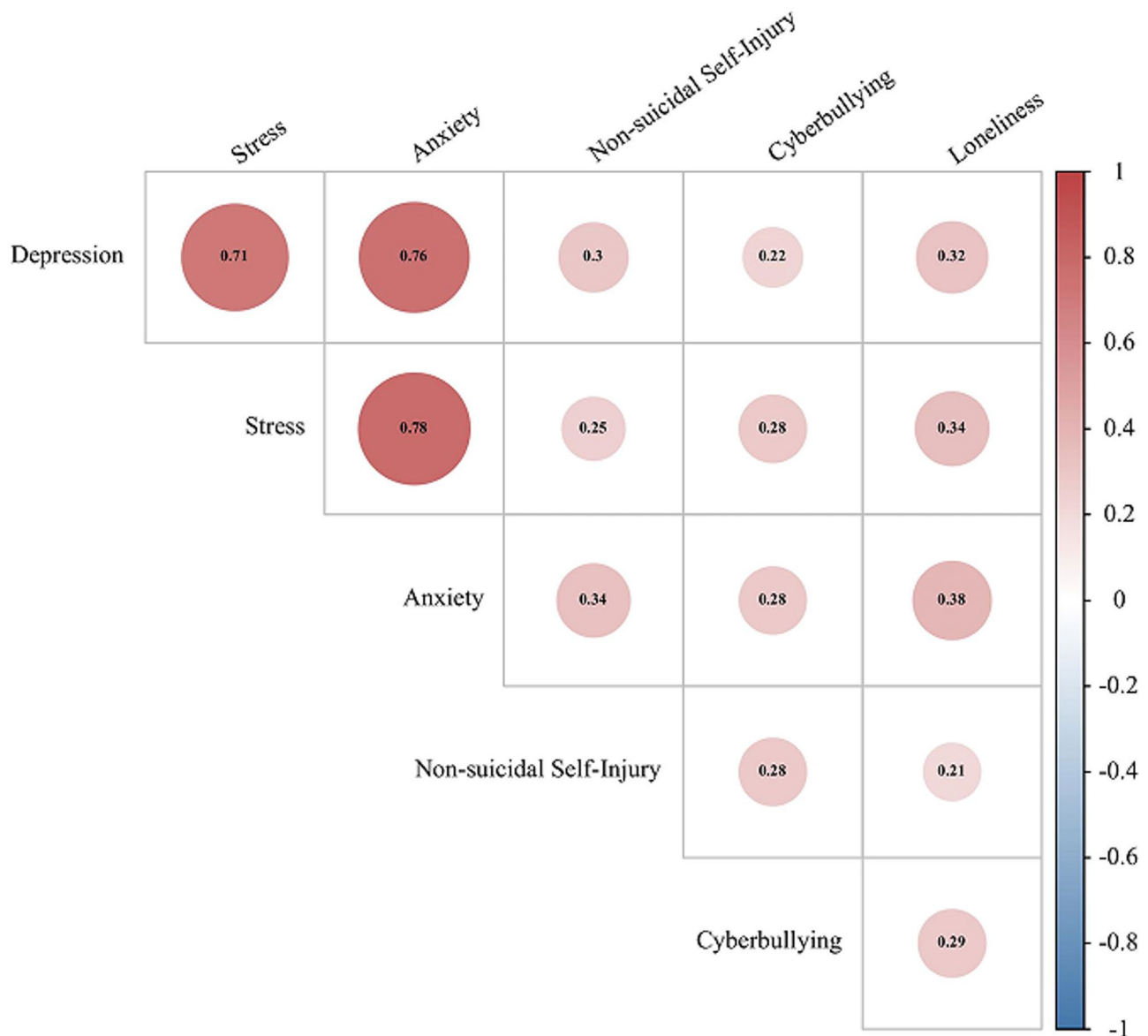


Fig. 2 Pearson correlation analysis of our key variables

Note: All correlation coefficients are significant at $P < 0.001$

This research has clearly established a strong connection between cyberbullying victimization and elevated stress levels within the general population, consistent with previous studies [37]. The accumulation of stress resulting from cyberbullying not only adversely affects individuals' mental health but also significantly increases the likelihood of resorting to NSSI as a coping mechanism. The emotional turmoil arising from experiences of cyberbullying often leaves individuals feeling helpless and oppressed, and NSSI may emerge as a means to manage or alleviate these intense negative emotions. This dynamic reveals the intricate relationship between cyberbullying, stress, and NSSI, highlighting stress as a crucial mediating factor linking cyberbullying to self-injurious

behavior, which poses a significant threat to the mental health of the general population [38].

Further analysis indicates that internalizing symptoms, particularly anxiety and depression, play a central role in the relationship between cyberbullying and NSSI within the general population [38, 39]. Cyberbullying victimization can directly induce depressive symptoms and heightens the risk of NSSI by exacerbating individuals' internal distress. Depression, as an internalizing symptom, occupies a critical position in this interaction [39]. Moreover, anxiety symptoms can mediate the relationship between cyberbullying and NSSI under specific conditions, such as diminished self-control [10]. Cyber-victimization markedly increases the risk of developing

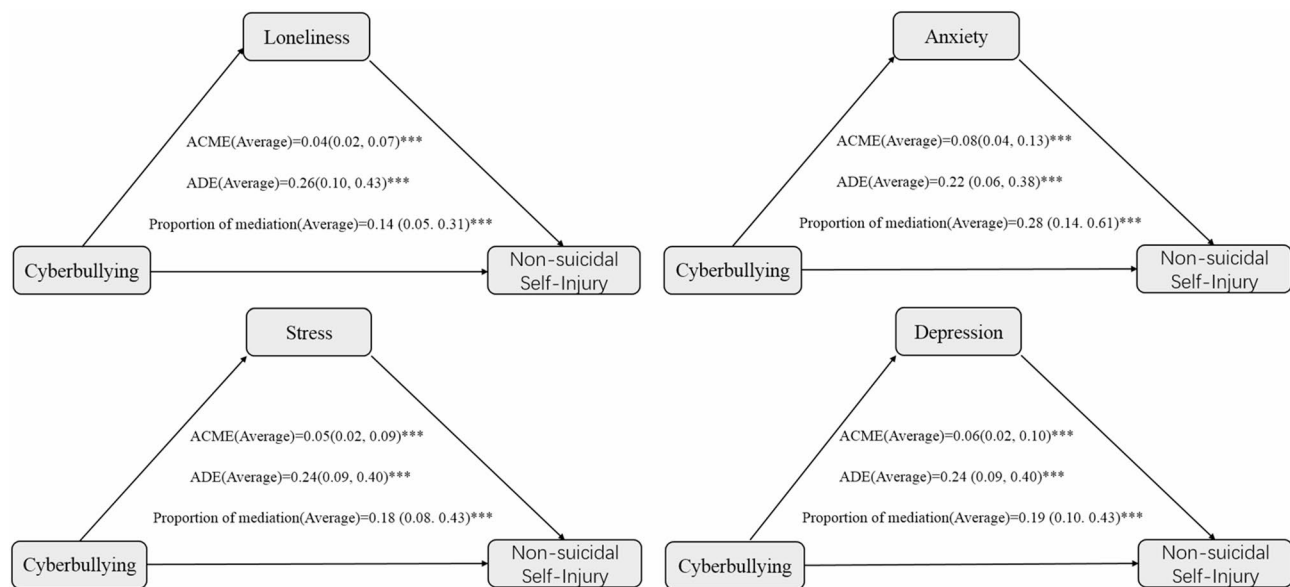


Fig. 3 The mediating roles of emotional factors in the cyberbullying-NSSI relationship

Note: * $P < 0.05$ ** $P < 0.01$ *** $P < 0.001$

anxiety symptoms among individuals [40], and there is a positive correlation between anxiety symptoms and NSSI [41, 42]. Collectively, these findings illuminate the complex interplay between anxiety, depression, and NSSI, providing vital insights into the severe consequences of cyberbullying for the general population and informing the development of effective intervention strategies.

Furthermore, our findings thoroughly explore the critical mediating role of loneliness in the intricate relationship between cyberbullying and NSSI. This insight not only offers a fresh perspective on the profound impact of cyberbullying on adolescents' mental health but also underscores loneliness as a significant link in this complex chain. Wu's comprehensive survey of 583 middle school students clearly established a strong correlation between cyberbullying victimization and loneliness [43]. In today's society, the pervasive use of technological devices, such as mobile phones and computers, provides adolescents with unprecedented access to information and communication; however, it has also inadvertently exacerbated their feelings of loneliness, particularly when they are victims of cyberbullying [44]. This loneliness serves as an invisible bridge connecting the dark shadows of cyberbullying to the deep abyss of NSSI. Research further indicates that loneliness is not merely a consequence of cyberbullying but also a pivotal psychological factor driving adolescents toward this extreme behavior [45, 46]. Therefore, it is essential to focus on adolescents' online social environments, implement effective measures to prevent and reduce the incidence of cyberbullying, and enhance mental health education to help them cultivate positive interpersonal interaction patterns. By

alleviating loneliness, we can significantly reduce the risk of NSSI among adolescents.

The study reveals that among the three primary forms of cyberbullying, online verbal bullying has the most significant impact on victims' mental health. This finding highlights the complexity and severity of online verbal attacks, which not only directly undermine victims' self-esteem and self-confidence but may also lead to serious mental health issues due to prolonged psychological distress. Victims subjected to continuous insults and abuse often experience extreme loneliness and helplessness, further exacerbating their psychological turmoil and potentially triggering self-harm tendencies [47]. Notably, research indicates that the prevalence of verbal violence victimization in China is 32% [48], while Malaysia reports an even higher prevalence of 47.5% [49]. Therefore, it is crucial to address the issue of online verbal bullying with urgency, strengthen the development and enforcement of relevant laws and regulations, and enhance mental health education efforts. Timely and effective psychological interventions are essential to create a robust support system for victims.

While this study has achieved certain outcomes, it also has several limitations that warrant attention and improvement in future research. Firstly, the study employed a cross-sectional design, which, although convenient for data collection and analysis of the current situation and conducive to causal mediation analysis, has limited capacity to establish definitive causal relationships. Therefore, future research should adopt more rigorous designs, such as longitudinal or experimental studies, to further explore the causal relationships

among these variables. Secondly, there are deficiencies in the data collection for this study, particularly the lack of detailed mental health metrics, such as sleep quality and fatigue levels. The absence of these data may have hindered our comprehensive understanding and in-depth analysis of the study results. And the intricate interplay between depression, anxiety, stress, and loneliness is a topic that this study could not fully address. We hope that future research will delve deeper into the complex relationships among these variables for a more comprehensive understanding. Thirdly, we are also aware of the limitations of screening tools, and their accuracy and reliability may not match those of professional diagnoses made by psychiatrists. Therefore, in future research, we recommend using more professional diagnostic methods, such as face-to-face assessments conducted by psychiatrists, to enhance the accuracy and reliability of the study.

Also, in this study, we must acknowledge and address the issue of selection bias. Due to limited research time and resources, we opted to collect data within a constrained timeframe at a single hospital. Although this approach enhanced the feasibility of the study, it inevitably introduced limitations regarding sample representativeness. Specifically, our sample may not have adequately represented patient groups from diverse socioeconomic backgrounds, education levels, or geographical regions [50]. This bias could present challenges when attempting to generalize the study results to a broader and more varied population. In addition, since the sample was not randomly selected but rather drawn from a specific hospital over a limited time period, the results may be influenced by the unique characteristics of this sample, convenience sampling and random sampling differ significantly in terms of representativeness and external validity. Random sampling ensures that the sample is selected randomly, enhancing its representativeness and increasing the likelihood that research findings can be generalized to a broader population. In contrast, convenience sampling often faces limitations in representativeness due to the non-random selection process. To evaluate these differences, we compared the demographic data of the hospital's patients with the population data of the city. Our analysis revealed significant disparities in gender distribution (as indicated by a chi-square value of 118.72, p -value < 0.001 when compared to the results of the 7th National Population Census in Nantong City in 2020). Therefore, when interpreting and generalizing the findings of this study, it is crucial to acknowledge these potential selection biases and demographic differences though we used PSM methods to controlled confounding factors. Thus, to more comprehensively elucidate the complex relationship between cyberbullying and non-suicidal self-injury, future research should strive to utilize a broader sample that includes patients from multiple

hospitals, different regions, and varying socioeconomic backgrounds and education levels.

Finally, in the methods section, we utilized a single-item question, "During the past 12 months, did you engage in non-suicidal self-injury?" to assess participants' self-harm behaviors. However, this single-item question may have potential ambiguity, making it difficult to accurately distinguish between self-harm behaviors with and without suicidal intent. Future research may need to include additional questions or provide further clarifications to better differentiate these two types of self-harm behaviors. For example, follow-up questions could inquire about the specific motives or intentions behind the self-harm behavior or whether the behavior was accompanied by suicidal thoughts or plans. Due to the absence of these additional questions in our study, the results may have limitations in interpreting the differences between self-harm behaviors with and without suicidal intent.

Conclusion

This study has explored the intricate interplay between cyberbullying, mental health issues—including depression, anxiety, stress, and loneliness—and non-suicidal self-injury (NSSI) behaviors. The findings indicate that cyberbullying not only directly increases the risk of NSSI but also exerts indirect influences through various mediating factors. The research highlights the prevalence of cyberbullying within the general population and its profound negative impact on self-injury behaviors, with loneliness identified as a key mediating factor in this relationship. Despite the valuable insights gained, the study has limitations that suggest the need for future research to adopt more rigorous designs and collect more comprehensive data for a deeper understanding. Overall, this study provides essential insights into self-injury behaviors among the general population and establishes a solid foundation for developing more effective intervention strategies in the future.

Abbreviations

NSSI	Non-suicidal self-injury
PSM	Propensity Score Matching
CMA	Causal Mediation Analysis
DASS-21	The Depression Anxiety and Stress Scale-21
ACME	The Average Causal Mediation Effect
ADE	The Average Direct Effect

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12888-025-06943-9>.

Supplementary Material 1

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Author contributions

WY Y, HJ L analyzed the data and wrote manuscript; LY N, QQ M revised the manuscript; F X, K L and XF C edited the manuscript, HJ L and QQ M collected data. All authors read and approved the final manuscript.

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Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Participants provided written informed consent, and the Medical Ethics Committee of Nantong People's Hospital on [number 2024KT370] approved this study. And all methods were performed in accordance with the Declaration of Helsinki.

Consent for publication

No applicable.

Competing interests

The authors declare no competing interests.

Clinical trial number

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