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Cumulative ecological risk and nonsuicidal self-injury in adolescents: The mediation of depression and the moderation of impulsiveness

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Abstract

Background: This study is based on the biosocial model of nonsuicidal self-injury (NSSI), to explore the effects of cumulative ecological risk on adolescents' NSSI, the mediating effect of depression between cumulative ecological risk and adolescents' NSSI, and the moderating role of impulsiveness in this mediating pathway.

Methods: A total of 16 508 adolescents, with 7903 males (47.9%), participated in the study and completed the Cumulative Ecological Risk Questionnaire, the Short Form of the Center for Epidemiological Studies Depression Scale, the Impulsiveness assessment, and the Nonsuicidal Self-Injury Scale.

Results: (1) There was a significant positive correlation between cumulative ecological risk, depression, impulsiveness, and NSSI; (2) cumulative ecological risk significantly predicted adolescents' NSSI; (3) depression had a mediating effect between cumulative ecological risk and adolescents' NSSI; and (4) impulsiveness moderated both the effects of cumulative ecological risk on adolescents' depression and NSSI and the effects of depression on NSSI in adolescents.

Conclusions: Impulsiveness and depression are risk factors for adolescent NSSI and play a crucial role between cumulative ecological risk and NSSI in adolescents.

KEYWORDS
adolescents, cumulative ecological risk, depression, impulsiveness, nonsuicidal self-injury

1 | INTRODUCTION

Nonsuicidal self-injury (NSSI) is not a socially acceptable behaviour that individuals intentionally injure their body without suicidal intent (Klonsky, 2011). Common forms of NSSI include behaviours such as scratching, burning, interfering with wound healing, and cutting the skin (Halpin & Duffy, 2020). Brown and Plener (2017) found that NSSI typically began in early adolescence, and the lifetime prevalence among adolescents was 17–60%. A meta-analysis of longitudinal studies of NSSI showed that the incidence of NSSI peaked in mid-adolescence (approximately 15–16 years of age) (Plener et al., 2015). The occurrence of NSSI not only causes physical harm to adolescents but also increases the risk of future suicide (Kiekens et al., 2018). Besides, numerous studies had also shown that NSSI was associated with various psychological problems such as depression, anxiety, substance abuse, and personality disorders (Andover et al., 2005; Klonsky et al., 2003; Schatten et al., 2015). Thus, paying attention to adolescents' NSSI is of great significance to promote the development of their mental health and exploring the risk factors for adolescent NSSI and their mechanisms can provide an empirical reference for scientific prevention and intervention of adolescents' NSSI.

1.1 | Cumulative ecological risk and NSSI

According to Bronfenbrenner's (2005) ecosystem theory, adolescents' NSSI was influenced by multiple ecological risk factors such as family and school. As the most important ecosystem for adolescents, the

family and school have a significant impact on adolescents' mental health and social adaptation (Bronfenbrenner, 2005). On the one hand, the family is where adolescents live, and risk factors in the family environment significantly impact adolescents' NSSI. Studies have shown that poor parent–child relationships (parental alienation and parent–child conflict) (Baetens et al., 2015; Martin et al., 2016; Yates et al., 2008) and adverse family life events (left-behind experiences, poverty/economic difficulties, parental divorce, etc.) (Baetens et al., 2014; Keenan et al., 2014; Voon et al., 2014a, 2014b) are all family ecological risk factors for individual NSSI.

On the other hand, school, as an essential place for adolescents' daily academic life, also has an important influence on adolescents' NSSI. In the school ecosystem, the influence of peer and teacher–student relationships on adolescents' NSSI is important. For adolescents, their interpersonal relationships begin to shift from parent–child to peer relationships, which means peer relationships gradually become adolescents' most important social relationships and have an impact on adolescents' psychological well-being. It has been shown that conflictual, hostile peer relationships can exacerbate adolescents' NSSI (Esposito et al., 2019; Serafini et al., 2021; Vergara et al., 2019), whereas supportive intimate peer relationships can help adolescents reduce NSSI (Eggermont et al., 2021; Schwartz-Mette & Lawrence, 2019). Meanwhile, teacher–student relationships play a crucial role in developing adolescents' learning and mental health. Warm and positive teacher–student relationships reduce adolescents' NSSI, while conflicting and hostile teacher–student relationships can aggravate adolescents' NSSI (Han et al., 2018; Steinhoff et al., 2022). Thus, adolescents' NSSI can be influenced by various ecological risk factors, including family and school.

After reviewing the existing literature, it was found that although previous studies have revealed risk factors for NSSI from different ecological environments, a singular ecological risk factor could not be better reflecting the development mechanism of adolescent NSSI. Cumulative risk theory pointed out a singular ecological risk factor does not correspond to the reality of adolescents' lives and cannot well reveal the accurate developmental mechanisms of adolescent NSSI (Evans et al., 2013). Because different ecological risk factors are synergistic, the additive of risk could lead to an increase in the risk of adolescent NSSI. The cumulative effect of multiple ecological risk factors could be better explained by the development mechanism of adolescent NSSI from a systemic perspective. Therefore, this study proposes to investigate the effects of cumulative ecological risk factors on adolescents' NSSI and their mechanisms using a cumulative risk model.

1.2 | The mediating effect of depression

Depression is a risk factor for NSSI in adolescents and may have a mediating effect between cumulative ecological risk factors and adolescent NSSI. First, Nock and Prinstein (2005) stated that NSSI was a maladaptive behaviour that occurred when individuals tried to relieve persistent psychological pain and distress. In other words, NSSI is a physical and behavioural expression of an individual's emotional distress, a transient psychological relief. Depression, as a negative and diffuse emotional state, is an important predictor of the development of NSSI in adolescents. Kiekens et al. (2017) indicated that persistent negative emotional states were essential in the persistence of NSSI in individuals. Moreover, existing studies have consistently shown a significant positive correlation between depression and adolescents' NSSI (Lee et al., 2021; Luby et al., 2019) and that depressed adolescents are more likely to develop NSSI (Ho et al., 2021; Shao et al., 2021).

Second, cumulative ecological risk is a risk factor for both adolescent depression and NSSI. Bronfenbrenner's (2005) ecosystem theory emphasizes that individual psychological and behavioural development is influenced by multiple ecological subsystems. Existing research has also demonstrated the impact of different ecological risk factors on adolescent depression and NSSI (Baetens et al., 2014, 2015; Keenan et al., 2014; Martin et al., 2016; Sajjadi et al., 2013).

Finally, depression may mediate the relationship between cumulative ecological risk and adolescent NSSI. Linehan's (1993) biosocial model suggested that a negative ecological environment would deny or ignore individuals' emotional experiences and inhibit the individuals from acquiring appropriate emotion regulation skills, thus putting the individuals at risk of adopting maladaptive behaviours to cope with emotional distress. For instance, Thippaiah et al. (2021) showed that NSSI was an emotional reflection of various stressful situations that individuals face. At the same time, existing studies have consistently shown that depression has a mediating effect between different ecological risk factors and adolescent NSSI (Deng et al., 2022; Li et al., 2022; Liu et al., 2021, 2022; Wei et al., 2021; Zhu et al., 2020). It can be inferred that depression can not only affect adolescent NSSI but also play a mediating role on the effect between cumulative ecological risk and adolescent NSSI.

1.3 | The moderating role of impulsiveness

Impulsiveness, as a personality trait, also has important implications for depression and NSSI in adolescents, potentially moderating the mediating pathway of depression between cumulative ecological risk and adolescent NSSI. Studies have shown that impulsiveness is significantly associated with depression (Auerbach et al., 2017; Regan et al., 2019; Saddichha & Schuetz, 2014) and NSSI (Bresin et al., 2013; Cassels et al., 2020) in adolescents and that impulsiveness significantly predicts depression (Cosi et al., 2011; Piko & Pinczés, 2014) and NSSI in adolescents (Di Pierro et al., 2012; Liu et al., 2017; Riley et al., 2015). Meanwhile, the diathesis–stress model also emphasizes the impact of the interaction between individual qualities and stressful environments on depression and NSSI (Park et al., 2019). For example, Johnson et al. (2022) proposed that the interaction of emotion-related impulsiveness with stressful environments predicted individual internalizing symptoms (anxiety and depression levels); the interaction of impulsiveness with peer rejection could lead to depression in adolescents (Wu et al., 2019).

Also, NSSI is usually perceived as a reckless or impulsive behaviour, and adolescents with impulsiveness traits are often more impulsive or urgent and may tend to act recklessly when experiencing adverse events, that is, adolescents with impulsiveness traits are more likely to exhibit NSSI in negative, stressful environments (Bresin et al., 2013; Riley et al., 2015). As noted in Wu et al.'s (2019) study, the interaction between peer rejection and impulsiveness predicted the occurrence of NSSI in adolescents. This suggests that impulsiveness may moderate the effect between cumulative ecological risk and depression and NSSI in adolescents. Another study by Javdani et al. (2011) also showed that an impulsiveness could increase the risk of suicidal behaviour when individuals are depressed. It has also been suggested that an impulsiveness can moderate the relationship between depression and suicidal ideation (Zhang et al., 2022). So, it can be hypothesized that an impulsiveness may also moderate the relationship between depression and NSSI in adolescents.

To summarize, to explore the risk factors of adolescent NSSI and their mechanism, this study proposes to construct a moderated mediation model to examine the mediating effect of depression between cumulative ecological risk and NSSI in adolescents and to examine the moderating role of impulsiveness in this mediating pathway (see Figure 1), to provide an empirical reference for scientific prevention and intervention of adolescent NSSI.

2 | METHODS

2.1 | Participant and procedure

Students from 49 schools in seven cities in Hunan Province were randomly selected as the participants of the study (21 senior high schools, 14 junior high schools, and 14 primary schools). The survey was organized and distributed by schools, and schools were asked to send an invitation to the survey and a quick response code for the questionnaire to all eligible students and their guardians before the survey. Students completed the online questionnaire by scanning the quick response code of the questionnaire using their computers or mobile phones. If students agreed to participate in the survey, they had to select the "I agree to participate" option. Ultimately, over the 4 week survey period (April–May 2022), a total of 16 508 students (a response rate of approximately 50%) participated in the survey after eliminating invalid questionnaires (the exclusion criterion was "completion time lower than 5 minutes"). Among them, 7903 were male, 8605 were female, 4978 were junior high school students, 6884 were senior high school students, and 4646 were primary school students. Moreover, participants with a prior mental health diagnosis were excluded to avoid the influence of other factors on the results. Participants had the right to withdraw freely during the testing period. The survey was conducted under the Declaration of Helsinki as revised in 1989 and approved by the Ethics Committees (2022001). Small gifts (such as pens, notebooks, and stationery) were given to students as a thank you after the survey, and school psychological feedback was given by class.

2.2 | Measures

2.2.1 | Cumulative Ecological Risk Questionnaire

Theoretically, although all risk factors for NSSI should be included, only certain important and representative risk factors consisted in this study for feasibility and necessity. Ecosystem theory suggested that the two most influential ecosystems for adolescents were the family and school subsystems (Bronfenbrenner, 2005). Based on these two subsystems, typical and representative risk factors in NSSI research were selected. In the family context, parent–child relationship and adverse family life events (experiences of being left behind, poverty/economic difficulties, parental divorce, etc.) are typical factors; in the school context, peer relationships and teacher–student relationships are representative factors. In addition, considering the feasibility of measurement, scales or items with high validity and concise questions were selected for this study. As a result, a total of seven representative risk factors were selected for the Cumulative Ecological Risk Questionnaire, and the details are described as follows:

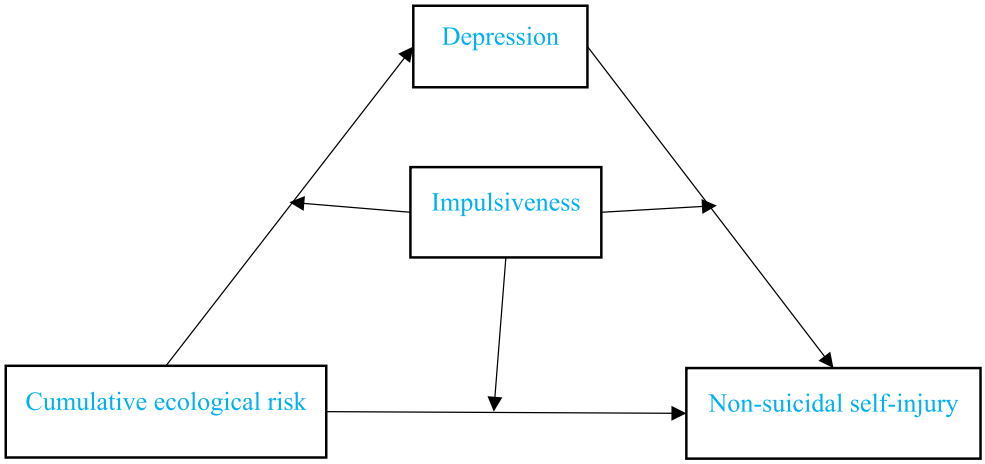


FIGURE 1 The conceptual framework.

1. *Parent–child relationship*. The study used Parent–Child Intimacy Questionnaire, developed by Buchanan et al. (1991) and is now widely used in China (Zeng et al., 2023). The scale consists of two dimensions: father–child relationship and mother–child relationship, with 18 items (e.g., "You talk openly with your father/mother"), and is scored on a scale of 1–5 points, with higher scores indicating a closer father–child/mother–child relationship. In constructing the cumulative ecological risk model, subjects with scores below or equal to the 25th percentile were coded as 1 (at risk) and the rest as 0 (not at risk). In this study, the Cronbach's coefficient for the father–child relationship subscale was 0.917 and the Cronbach's coefficient for the mother–child relationship subscale was 0.918.
2. *Peer relationships*. The study used Friendship Quality Questionnaire revised by Zongkui et al. (2006) and is now widely used in China (Zeng et al., 2023). The scale consists of 18 items (e.g., "This friend and I always play together at recess") and is scored on a scale of 1–5 points, with higher scores indicating better friendship quality. In constructing the cumulative ecological risk model, subjects with scores below or equal to the 25th percentile were coded as 1 (at risk) and the rest were coded as 0 (not at risk). The Cronbach's coefficient for the Friendship Quality Questionnaire in this study was 0.890.
3. *Teacher–student relationship*. The study used "Teacher–student Relationship" subquestionnaire of the "My Class" questionnaire developed by Guangrong (2004) and is now widely used in China (Zeng et al., 2023). The scale has eight items (e.g., "The head teacher is kind") and is scored on a scale of 1–5 points, with higher scores indicating better teacher–student relationships. In constructing the cumulative ecological risk model, subjects with scores below or equal to the 25th percentile were coded as 1 (at risk) and the rest were coded as 0 (not at risk). In this study, the Cronbach's coefficient for the teacher–student relationship questionnaire was 0.961.
4. *Left-behind experience*. An item was used to measure adolescents' left-behind experience, referring to previous study (Shuang et al., 2022). The item was "Has your father or mother been working or working outside the home for a long period of time (more than 6 months) since you can remember?." The item was scored on a 2-point scale, with 1 being "*yes*" and 2 being "*no*." In the construction of the cumulative ecological risk model, those who selected 1 were at risk, and those who selected 2 were not at risk.
5. *Poverty situation*. The study used an item to measure the poverty of adolescents, referring to previous study (Jiang & Dong, 2020). The specific content of the item was "Are you a child of a household registered as living under the poverty line?." The item was scored on a 2-point scale, with 1 being "*yes*" and 2 being "*no*." In the construction of the cumulative ecological risk model, those who selected 1 were considered at risk, and those who selected 2 were considered not at risk.
6. *Parental marital status*. The study used an item to measure adolescents' parents' marital status, referring to previous study (Gach et al., 2018). The item was "What is the marital status of your parents?." The item was scored on a 4-point scale, with 1 being "*first married*," 2 being "*divorced*," 3 being "*remarried*," and 4 being "*other*." In the construction of the cumulative ecological risk model, those who selected 1 were recorded as no risk, and the rest were recorded as being at risk.

In this study, according to the risk definition criteria, the scores of all risk variables were summed to obtain the cumulative ecological risk index (Doan et al., 2012). About 13.7% of the adolescents experienced four or more ecological risk factors.

2.2.2 | Short Form of Center for Epidemiological Studies Depression Scale

The study used the Center for Epidemiological Studies Depression Scale (Short Form of Center for Epidemiological Studies Depression Scale) developed by Andresen et al. (1994). It had good reliability and validity in China (Yang et al., 2018). The scale consists of 10 items (e.g., "I feel depressed"). It is scored on a scale of 0–3 points, with higher scores indicating higher depression. The Cronbach's coefficient of scale in this study was 0.770.

2.2.3 | Nonsuicidal Self-Injury Scale

The study used the short version of the Deliberate Self-Harm Inventory to measure NSSI in adolescents (Gratz, 2001). It had good reliability and validity in China (Lan et al., 2019). The scale has nine items (e.g., "poked into the skin with a sharp object") and is scored on a scale of 0–5 points, with higher scores indicating more severe NSSI in adolescents. The Cronbach's coefficient for the NSSI scale in this study was 0.902.

2.2.4 | Impulsiveness

The Brief Barratt Impulsiveness Scale, revised by Tao et al. (2019), was used to measure adolescents' impulsiveness. It had good reliability and validity in China (Tao et al., 2019). The scale has eight items (e.g., "I do things without thinking") and is scored on a scale of 1–4 points, with higher scores indicating greater impulsivity in adolescents. The Cronbach's coefficient for the impulsiveness scale in this study was 0.766.

2.3 | Data analysis

SPSS 26.0 was used for data analysis. First, the descriptive statistics were employed to describe the social–demographic characteristics of participants; the social–demographic characteristics of participants were summarized by proportion (%). Second, Pearson correlation analysis was used to examine the relationship between cumulative

ecological risk, impulsiveness, depression, and NSSI. Next, the Harman's single-factor test was performed to examine the common method deviation. Finally, we used the PROCESS macro for SPSS to test the moderated mediated effect of cumulative ecological risk on NSSI. Model 59 was used to examine the moderating mediation effect. If the 95% confidence interval (CI) did not contain 0, it indicated that the moderating mediation effect was significant. Statistical significance was defined as a two-tailed p-value of <0.05. In addition, all models were controlled for covariates (grade and only sex), and the study variables were standardized.

3 | RESULTS ANALYSIS

3.1 | Common method deviation test

Because the data for this study were obtained from adolescents' self-reports, the Harman's single-factor test were used to examine the common method deviation. Exploratory factor analysis was conducted on all items of the six questionnaires using Harman's single-factor test. The results showed a total of 11 factors' eigenvalues >1, and the variance explained by the first factor was 22.51% (<40%); therefore, the common method deviation was not obvious in this study.

TABLE 1 Social–demographic characteristics of participants ($N = 16\,508$).

Variables	Category	N	%
Grade	Primary school	4646	28.1
	Junior high school	4978	30.2
	Senior high school	6884	41.7
Sex	Male	7903	47.9
	Female	8605	52.1
Whether only child	Only child	2096	12.7
	Non-only child	14 412	87.3
Parental marital status	First marriage	10 998	66.6
	Divorced	1432	8.7
	Remarried	1106	6.7
	Other	2972	18
Poverty status	Yes	2895	17.5
Local area	City	2373	14.4
	County town	7002	42.4
	Rural areas	7133	43.2
Left-behind experience	Yes	3750	22.7

3.2 | Description of the sample

In this study, to control the quality of the survey responses, we excluded the response time for survey <5 min. Finally, 16 508 valid data were obtained. Among 16 508 adolescents, 47.9% were male ($n = 7903$), 4978 were junior high school students, 6884 were senior high school students, and 4646 were primary school students. Table 1 summarized detailed sample characteristics.

3.3 | Descriptive statistics and correlation analysis between cumulative ecological risk, depression, impulsiveness, and NSSI in adolescents

Descriptive statistics and correlation analyses are shown in Table 2. The results indicated that impulsiveness, depression, and cumulative ecological risk are significantly and positively associated with NSSI.

3.4 | Cumulative ecological risk and NSSI in adolescents: Mediation of depression and moderation of impulsiveness

To investigate the mediating effect of depression between cumulative ecological risk and adolescent NSSI and the moderating effect of impulsiveness in this mediating effect, a moderated mediation test was conducted using the PROCESS macro model 59 for SPSS after standardizing all continuous variables, as suggested by Hayes (2017).

The results are illustrated in Table 3. Sex, cumulative ecological risk, and depression in Model 1 all significantly predicted NSSI in adolescents ($\beta = 0.05$, $p < 0.001$; $\beta = 0.07$, $p < 0.001$; $\beta = 0.33$, $p < 0.001$). In Model 2, sex, grade, cumulative ecological risk, impulsiveness, and the interaction terms between cumulative ecological risk and impulsiveness all significantly predicted depression in adolescents ($\beta = 0.11$, $p < 0.001$; $\beta = -0.05$, $p < 0.001$; $\beta = 0.29$, $p < 0.001$; $\beta = 0.30$, $p < 0.001$; $\beta = 0.04$, $p < 0.001$). In Model 3, sex, cumulative

TABLE 2 Descriptive statistics and correlation analysis ($N = 16\,508$).

Variables	1	2	3	4
1. NSSI	1			
2. Cumulative ecological risk	0.228**	1		
3. Depression	0.402**	0.393**	1	
4. Impulsiveness	0.171**	0.285**	0.394**	1
$M \pm SD$	10.81 ± 5.40	1.77 ± 1.46	6.80 ± 5.12	17.87 ± 4.40

Abbreviations: M, mean; NSSI, nonsuicidal self-injury; SD, standard deviation.
*$p < 0.05$; **$p < 0.01$, and ***$p < 0.001$.

TABLE 3 Tests for the moderated mediation effect of cumulative ecological risk on nonsuicidal self-injury (NSSI).

	Model 1 (dependent variable: NSSI)			Model 2 (dependent variable: depression)			Model 3 (dependent variable: NSSI)		
Variables	***β***	***t***	**95% CI**	***β***	***t***	**95% CI**	***β***	***t***	**95% CI**
Sex	0.05	4.28***	[0.03, 0.08]	0.11	8.12***	[0.08, 0.14]	0.05	4.00***	[0.03, 0.07]
Grade	0.01	0.57	[−0.01, 0.02]	−0.05	−6.42***	[−0.07, −0.04]	0.01	0.43	[−0.01, 0.02]
CER	0.07	10.40***	[0.06, 0.09]	0.29	40.77***	[0.28, 0.30]	0.07	10.04***	[0.06, 0.08]
Impulsiveness	0.01	0.35	[−0.01, 0.02]	0.30	43.39***	[0.29, 0.32]	0.02	2.70**	[0.01, 0.03]
Depression	0.33	44.83***	[0.31, 0.34]				0.30	41.01***	[0.29, 0.32]
Int1				0.04	5.29***	[0.02, 0.05]	0.02	2.13*	[0.01, 0.03]
Int2							0.07	11.37***	[0.06, 0.09]
R^2	0.17			0.25			0.18		
F	666.81***			1085.13***			508.94***		

Note: Int1is the interaction term between cumulative ecological risk and impulsiveness; Int2 is the interaction term between depression and impulsiveness.
Abbreviation: CER, cumulative ecological risk.
*$p < 0.05$,**$p < 0.01$, and ***$p < 0.001$.

TABLE 4 Mediating effects of depression at different levels of impulsiveness.

Dependent variable	Different levels	Mediating effect size	Bootstrap *SE*	BootCI upper	BootCI lower
NSSI	1.04	0.06	0.005	0.05	0.07
	−0.02	0.09	0.005	0.08	0.10
	0.99	0.12	0.007	0.11	0.14

Abbreviation: NSSI, nonsuicidal self-injury.

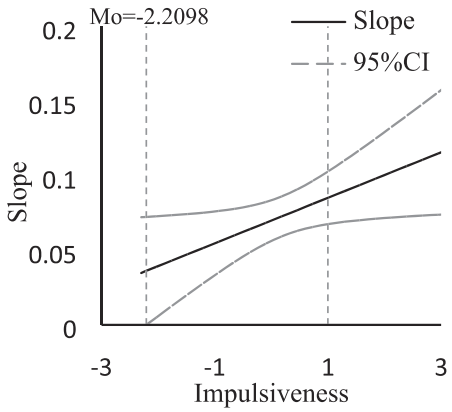
ecological risk, impulsiveness, depression, the interaction term between cumulative ecological risk and impulsiveness, and the interaction term between depression and impulsiveness all significantly predicted adolescents' NSSI ($\beta = 0.05$, $p < 0.001$; $\beta = 0.07$, $p < 0.001$; $\beta = 0.02$, $p < 0.001$; $\beta = 0.30$, $p < 0.001$; $\beta = 0.02$, $p < 0.01$; $\beta = 0.07$, $p < 0.001$). The above results suggest that cumulative ecological risk, impulsiveness, depression, and NSSI constitute a moderated mediation model. Depression mediated between cumulative ecological risk and adolescent NSSI, and impulsiveness moderated all pathways of this mediated pathway. In addition, Table 4 demonstrates the mediating effect values for depression in different impulsiveness levels.

To further explain the moderating effects, the simple slope test was conducted to examine the moderating role of impulsiveness. As suggested by Hayes and Matthes (2009), Johnson–Neyman's interaction plots can better interpret the moderating effect between the independent variable and the dependent variable. Shown in Figure 2, the results in Figure 2a indicate that the predictive effect of cumulative ecological risk on adolescent NSSI is not significant when the level of impulsiveness <−2.2098 *SD*. However, the slope of cumulative ecological risk on adolescent NSSI gradually increases when the level of impulsiveness >−2.2098 *SD*. The results in Figure 2b indicate that the slope of cumulative ecological risk on adolescent depression gradually increased as the level of impulsiveness increased. The results in Figure 2c indicate that the slope of depression on adolescent NSSI gradually increased with the increasing level of impulsiveness.

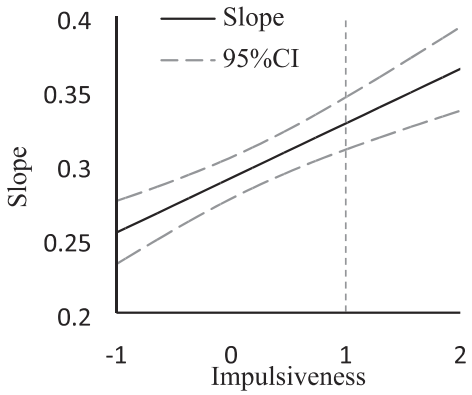
4 | DISCUSSION

Adolescents' NSSI is affected by different ecosystems, while existing studies only focus on the effect of a single or few ecological risks on adolescents' NSSI. In this study, by selecting typical and representative risk factors related to adolescents' NSSI and constructing a cumulative ecological risk index, we investigated the effect of cumulative ecological risks on adolescents' NSSI and its mechanism. The results showed that cumulative ecological risk significantly predicted adolescent NSSI; depression had a mediating effect between cumulative ecological risk and adolescent NSSI, and impulsiveness could moderate all pathways of this mediating effect.

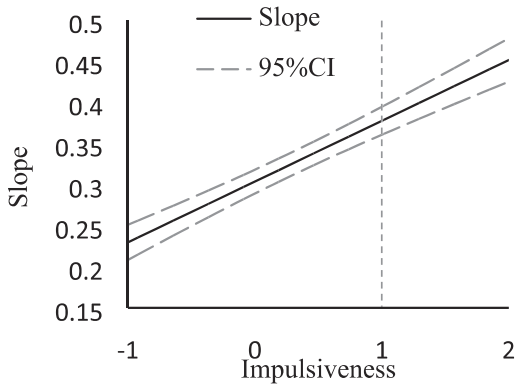
First, this study found that cumulative ecological risk significantly predicted adolescents' NSSI, consistent with previous research findings on cumulative ecological risk and other psychopathological issues (Doan et al., 2012; Gach et al., 2018: Martin et al., 2016). Bronfenbrenner's ecosystem theory pointed that adolescents' NSSI is influenced by multiple ecological contexts such as family and school. Existing studies have demonstrated the effects of different ecological risk factors on adolescent NSSI (Baetens et al., 2015; Esposito et al., 2019; Han et al., 2018), but a single ecological risk factor does not fit the reality of adolescents' lives and cannot elaborate the development of adolescent NSSI from a systematic perspective. The cumulative ecological risk model examines multiple ecological risk factors such as family and school at the same time, able to prevent excessive inference of the results by using a single or a few risk factors



(a). The effect of the interaction term between cumulative risk factor and impulsiveness on NSSI.



(b). The effect of the interaction term between cumulative risk factor and impulsiveness on depression.



(c). The effect of the interaction term between depression and impulsiveness on NSSI.

FIGURE 2 The simple slope plot of the moderating effect of impulsiveness in the relationship between cumulative ecological risk and nonsuicidal self-injury (NSSI). (a) The effect of the interaction term between cumulative risk factor and impulsiveness on NSSI. (b) The effect of the interaction term between cumulative risk factor and impulsiveness on depression. (c) The effect of the interaction term between depression and impulsiveness on NSSI.

(Masten, 2014), and is also more consistent with the reality of adolescents' lives. By selecting typical and representative risk factors related to adolescents' NSSI and constructing cumulative ecological risk indicators, this study confirmed that cumulative ecological risk could significantly and positively predict adolescents' NSSI and that 13.7% of adolescents experienced four or more ecological risk factors. On the one hand, when adolescents live in different adverse ecological environments (parental alienation, parent–child conflict, peer rejection, teacher–student conflict, family poverty, etc.) for a long time, these adverse ecological environments can lead to NSSI in adolescents. On the other hand, when multiple ecological risk factors are superimposed, they are more destructive than single risk factors and significantly impact adolescents' mental health (Evans et al., 2013), thus making them more prone to NSSI.

In addition, the results of the mediating effect analysis indicated that depression mediated the relationship between cumulative ecological risk and NSSI in adolescents, consistent with previous research findings on different ecological risk (Li et al., 2022; Wei et al., 2021). The results proposed that cumulative ecological risk led to an increase in adolescent depression and further led to the occurrence of adolescent NSSI. According to the cumulative risk model, multiple risks will lead to the vulnerability of adolescent, making them more prone to psychological problems. Compared with a single risk factor, experiencing multiple risk factors at the same time will cause greater harm to adolescents and last longer (Evans et al., 2013). Meanwhile, the biosocial model of NSSI pointed out that adverse ecological environment would lead to the generation of individuals' negative emotions (depression, anxiety, etc), motivating them to adopt NSSI to alleviate the distress caused by negative emotions (Linehan, 1993). Present studies have also shown that cumulative ecological risk causes an increase in individual depression (Ruikai et al., 2023). Furthermore, NSSI is a physical and behavioural expression of an individual's emotional distress, a transient psychological relief (Nock & Prinstein, 2005). Existing studies have also consistently shown that depression is an essential predictor of NSSI in adolescents (Ho et al., 2021; Shao et al., 2021). It can be inferred that depression can not only affect adolescent NSSI but also play a mediating role on the effect between cumulative ecological risk and adolescent NSSI. Therefore, in practice, we should focus on those adolescents who suffer from multiple ecological risks and intervene early to reduce the occurrence of NSSI in adolescents.

Finally, the results of the moderated mediation effects analysis also indicated that impulsiveness could moderate all pathways of the mediating effects of depression between cumulative ecological risk

and adolescent NSSI. Specifically, impulsiveness moderated both the effects of cumulative ecological risk on adolescent depression and NSSI and the effect of depression on adolescent NSSI. This result is in line with existing similar studies (Bresin et al., 2013; Javdani et al., 2011; Wu et al., 2019; Zhang et al., 2022). The diathesis–stress model also emphasizes the interaction between an individual's diathesis (impulsiveness) and stressful environments (parent–child conflict, peer bullying, teacher–student conflict, etc.) on adolescent depression and NSSI (Park et al., 2019). Further results of the simple slope analysis in this study showed that the slope of cumulative ecological risk on adolescent depression gradually increased with increasing levels of impulsiveness. The results suggest that adolescents with impulsive personalities are more prone to depression when they encounter multiple ecological risks. This is probably because of the cognitive distortions caused by impulsiveness in individuals (Mobini et al., 2006), as impulsive individuals may interpret stressful events (parent–child conflict, peer bullying, teacher–student conflict, etc.) in an irrational way, catastrophizing, overgeneralizing, or regurgitating stressful events, and these cognitive distortions may lead to depressive symptoms in adolescents.

Meanwhile, the predictive effect of cumulative ecological risk on adolescents' NSSI was not significant when impulsiveness <−2.2098 *SD*, but the slope of cumulative ecological risk on adolescents' NSSI gradually increased when impulsiveness >−2.2098 *SD*. The results suggest that the effect of cumulative ecological risk on adolescent NSSI is more significant as impulse personality increases, but impulsiveness has no effect on the relationship between cumulative ecological risk and adolescent NSSI when impulsiveness <−2.2098 *SD*. This may be because NSSI is often perceived as reckless or impulsive behaviour, and adolescents with impulsiveness traits are usually more impulsive or urgent and may tend to act recklessly when experiencing negative events, that is, adolescents with impulsiveness traits are more likely to exhibit NSSI in negative stressful situations (Bresin et al., 2013; Riley et al., 2015). Furthermore, simple slope analysis results also indicated that the effect of depression on NSSI in adolescents increased gradually with increasing impulsiveness. The results suggest that adolescents with impulsive personalities are more likely to develop NSSI when they are suffering from depression. For adolescents, this may be because they are more likely to be impulsive in their behaviour, which may lead to more NSSI. Existing research also suggests that impulsiveness can increase the risk of suicidal behaviour in individuals when they have depressive symptoms (Javdani et al., 2011). Thus, impulsiveness and depression are also risk factors for NSSI in adolescents and play an important role in the relationship between cumulative ecological risk and NSSI in adolescents.

4.1 | Limitations

This study systematically investigated the impact of cumulative ecological risk on adolescent NSSI and its mechanism by constructing a cumulative ecological risk index, which remedies the deficiency of single ecological risk studies and provides empirical evidence to reveal better how ecological risk affects adolescent NSSI. Nevertheless, there are some limitations to this study. First, the current study adopts a cross-sectional method, which cannot reveal the causal relationships between variables well. Second, the mechanism of the relationship between cumulative ecological risk and adolescent NSSI goes beyond depression and impulsiveness. Future research can be extended to other influencing factors to explore better the mechanism of cumulative ecological risk on adolescent NSSI. Finally, although the ecological risk factors selected in this study were typical and representative, they did not include all potential risk factors. Future studies could better test this study based on the inclusion of these risk factors. In addition, the outbreak of COVID-19 may be a potential factor affecting the results. The existing research has shown that the outbreak of COVID-19 has been found to potentially increase depression and NSSI in adolescents (Zetterqvist et al., 2023).

4.2 | Clinical implications

The findings of this study can be a significant insight into the prevention and intervention of NSSI in adolescents. First, NSSI in adolescents is driven by the ecological environment in which the individual lives and increases as ecological risk factors increase. Integrating cumulative risk factors in ecological subsystems such as family and school (peers and teacher–student relationship) from a systematic perspective can facilitate accurate identification and screening for NSSI risk groups. In particular, a high level of concern should be maintained for individuals who are exposed to four or more ecological risk factors. Second, psychological teachers in schools should create a mental health profile for each student from a systematic perspective, compile a list of risk factors, keep track of the risk factors faced by each student, and provide targeted assistance to students to reduce the number of risk factors and the risk of NSSI. Finally, given the mediating role of emotions, interventions for adolescents who NSSI can centre on their emotion-regulation strategies. Parents and teachers should emphasize the fostering of positive emotion-regulation strategies in adolescents.

5 | CONCLUSION

In summary, this study found that (1) there was a significant positive correlation between cumulative ecological risk, depression, impulsiveness, and NSSI; (2) cumulative ecological risk significantly predicted adolescent NSSI; (3) depression had a mediating effect between cumulative ecological risk and adolescent NSSI; and (4) impulsiveness moderated the effects of cumulative ecological risk on both adolescent depression and NSSI and the effect of depression on adolescent NSSI.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

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