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ORIGINAL RESEARCH

From Thoughts to Actions: A Longitudinal Examination of NSSI Risk Factors in Adolescence

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Introduction: Non-suicidal self-injury (NSSI) is a prevalent issue among adolescents, with potential long-term mental health implications. To investigate NSSI thoughts as a distinct developmental stage and inform early intervention strategies, this study employed a longitudinal design to examine progression differences in Chinese adolescents across three NSSI status: NO NSSI, NSSI thoughts without behaviors, and NSSI behaviors.

Methods: Using a machine learning approach (Random Forest models), a two-wave longitudinal study assessed 2,154 adolescents (aged 11–18) from Chinese middle and high schools. Analyses focused on NSSI status, risk factors, and developmental trajectories. ANOVAs and paired-t tests were conducted to examine risk factors and NSSI functions of group with different NSSI status.

Results: NSSI thoughts emerged as both a distinct category and a potential precursor to behaviors. Despite limitations in accurately classifying the NSSI thoughts group, the Random Forest models demonstrated capability in differentiating NSSI status. Age-specific patterns were identified: middle school students showed a higher propensity to progress to NSSI behaviors than high schoolers, with emotional/social factors more prominent for middle schoolers and broader risk factors for high schoolers.

Conclusion: Findings support conceptualizing NSSI thoughts as a critical stage in NSSI development, highlighting distinct risk profiles across age groups. Future research should focus on improving the identification and assessment of NSSI thoughts and developing early intervention strategies based on developmental stages and associated risk factors.

Keywords: non-suicidal self-injury, adolescence, random forest models

Introduction

Non-suicidal self-injury (NSSI), defined as the direct and deliberate destruction of body tissue without suicidal intent,[1] has emerged as a prevalent and widely discussed clinical phenomenon with significant implications for long-term mental health and increased risk of suicide attempts and completed suicides.[2–4] Adolescence represents a critical period for NSSI onset and development, with peak onset typically occurring between ages 12–15.[5–7] While most current NSSI studies focus on overt behaviors, such as frequency and methods of self-injury, or differentiating between adolescents with and without NSSI behaviors, less attention has been given to the potentially crucial stage of NSSI-related thoughts that precede actual self-injurious acts.[8,9] To better understand the developmental trajectory of NSSI and inform early intervention strategies for adolescents, it is imperative to explore not only the behavioral manifestations of NSSI but also the cognitive precursors, particularly the stage of NSSI thoughts.

Understanding NSSI Thoughts

NSSI thoughts, defined as having thoughts of engaging in self-injurious behavior without actually doing so,[1] represent a critical yet understudied aspect of non-suicidal self-injury. Western studies indicate that 20–27% of adolescents experience NSSI thoughts.[7,10] Despite this prevalence, only a small portion of NSSI research includes thoughts as a separate category for

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analysis, with most studies focusing solely on NSSI behaviors. Even widely used assessment tools initially overlooked this distinction. For instance, the Self-Injurious Thoughts and Behaviors Interview (SITBI) initially lacked a specific measure for NSSI thoughts.[11] Recognizing this gap, later editions of the SITBI incorporated a subscale for Thoughts of Non-Suicidal Self-Injury, aiming to better understand the relationship between NSSI thoughts and behaviors.

NSSI thoughts not only lack diverse assessment tools but also suffer from an underdeveloped conceptual framework. However, models from related fields may offer a framework for understanding the progression from NSSI thoughts to behaviors. The ideation-to-action framework in suicide studies suggests that the development of thoughts and the progression from thoughts to actions are two distinct processes with different predictors and explanations.[12] For instance, the Integrated Motivational-Volitional model proposes that defeat and entrapment are key drivers in the development of suicidal thoughts, while capability for suicide and access to means are crucial in the transition to suicidal behavior.[13] Similarly, the Three-Step Theory (3ST) of suicide theory posits that pain and hopelessness contribute to suicidal ideation, while connectedness and capability determine whether ideation progresses to attempts.[14]

A related concept that offers insight into the role of thoughts in behavioral patterns is desire thinking, defined as "a conscious and voluntary cognitive process orienting to prefigure images, information and memories about positive target-related experience".[15] This concept has been particularly influential in understanding addictive behaviors. Research has shown that desire thinking, especially its verbal perseveration dimension, significantly predicts individuals' position on the continuum of nicotine and alcohol dependence.[16,17] These findings underscore the importance of cognitive processes in explaining and predicting behavioral phenomena. Drawing parallels to NSSI, these research and frameworks suggest that NSSI thoughts may play a crucial role in the development and maintenance of self-injurious behaviors.

Although limited in number, several studies have explicitly differentiated between NSSI thoughts and behaviors, providing valuable insights into their relationship. It is found that individuals meeting DSM-5 diagnostic criteria for NSSI reported significantly longer periods of NSSI thoughts compared to those who did not meet the criteria, suggesting a potential temporal relationship between prolonged ideation and behavioral manifestation.[18] Research has identified risk factors distinguishing between NSSI thoughts and behaviors, including intimate partner violence, childhood sexual abuse, and descriptive norms.[19–21] Recent findings of ecological momentary assessment (EMA) suggest that NSSI thought intensity and duration interact to predict NSSI behavior frequency, duration, and methods used, with longer thought durations strengthening the relationship between thought intensity and NSSI behaviors.[22]

Longitudinal studies have further clarified this relationship, with evidences showing that greater intensity and shorter duration of NSSI thoughts predicted subsequent behavior enactment.[23] Moreover, researchers found that adolescents with NSSI thoughts, even in the absence of NSSI behaviors, were more likely to report suicidal ideation and plans compared to those with no history of NSSI.[24] These findings underscore the importance of conceptualizing NSSI thoughts and behaviors as potentially two distinct stages in the progression of self-injury, with NSSI thoughts representing a crucial and separate precursor to overt NSSI behaviors.

Psychophysiological evidence also elucidates the functions of NSSI thoughts and the mechanisms between NSSI thoughts and behaviors. Studies utilizing guided imagery of self-injury have demonstrated a rapid reduction in psycho-physiological arousal, suggesting an efficient tension-reducing mechanism.[25,26] Notably, when both psychophysiological and subjective responses to negative emotions were measured during guided imagery, the decrease in physiological arousal preceded the subjective relief of distress.[25,26] These findings align with the automatic negative reinforcement (ANR) dimension proposed in the four-function model of NSSI,[1,27] suggesting that similar to NSSI behaviors, NSSI thoughts may function to provide relief of stress. To summarize, while NSSI thoughts may represent a distinct stage preceding or separate from NSSI behaviors, to date, no studies have systematically examined whether NSSI thoughts constitute a distinct stage in the progression of self-injurious behavior or how risk factors for NSSI thoughts might differ from those associated with NSSI behaviors.

Critically, the prominence of cognitive-behavioral approaches—including third-wave therapies such as Dialectical Behavior Therapy (DBT) and Acceptance and Commitment Therapy (ACT)—in existing NSSI interventions underscores the central role of cognitive processes in the development and maintenance of self-injurious behaviors.[28,29] This clinical reality highlights the significant practical implication of conceptualizing NSSI thoughts as a distinct developmental stage: identifying individuals at the ideation phase could enable targeted early interventions focused specifically on modifying

maladaptive cognitive patterns before these progress to behavioral enactment. Such stage-specific interventions hold substantial promise for altering the trajectory of NSSI by interrupting the progression from thought to action.

Developmental Trajectory of NSSI in Adolescence

Adolescents exhibit distinct patterns of NSSI across different age groups. A recent meta-analysis reveals a developmental trajectory where NSSI frequency increases among younger adolescents, stabilizes in middle adolescence, and declines in older adolescents.[30] This pattern aligns with findings from a 10-year longitudinal study, which further demonstrated that even among adolescents with persistent NSSI, most ceased the behavior before reaching young adulthood.[31] These age-related trends underscore the importance of investigating NSSI within specific developmental stages to gain a more nuanced understanding of its progression. Additionally, researchers found that earlier onset of NSSI is associated with more severe outcomes, including greater method versatility, increased medical severity, higher NSSI frequency, and elevated risk of suicide attempts.[32] Collectively, these findings highlight the critical need for age-specific research and interventions in addressing NSSI among adolescents.

Beyond age-specific trends, research has revealed diverse trajectories in NSSI development, particularly in terms of symptom severity and chronicity. A two-year longitudinal study with high school students (Grades 10–12) identified three distinct NSSI trajectories. The majority (69.2%) followed a low NSSI trajectory, reporting no or few NSSI incidents. A moderate NSSI trajectory (26.1%) was characterized by a few NSSI episodes with a tendency to decrease over time. Lastly, a small proportion (4.7%) exhibited a chronic trajectory, showing consistently high NSSI engagement across all eight assessment waves.[33] Expanding on these findings, another research proposed four heterogeneous NSSI trajectory subgroups: negligible (74.6%), experimental (12.8%), moderate decreasing (10.8%), and high fluctuating (1.9%).[34]

The studies mentioned above underscoring the need for nuanced, trajectory-specific approaches studying NSSI. However, a significant gap remains in our understanding of NSSI developmental trajectories when considering NSSI thoughts as a distinct stage. To date, no research has systematically examined whether diverse developmental pathways exist that incorporate NSSI thoughts as a separate phase. Specifically, it remains unclear whether adolescents invariably progress from NSSI thoughts to behaviors or if some individuals engage in NSSI behaviors without a preceding period of NSSI thoughts. Moreover, if such divergent pathways exist, it is crucial to investigate whether these groups differ in their risk factors for NSSI behaviors. Recent studies have employed machine learning approaches to examine predictors of NSSI behaviors among adolescents,[35,36] yet no studies have attempted to use this approach to differentiate thoughts and behaviors as two separate stages of NSSI. Exploring these questions could provide valuable insights into the etiology of NSSI and inform more targeted prevention and intervention strategies.

Current Study

The purpose of this study was to investigate the development and progression of NSSI among adolescents using a data-driven approach. Specifically, the study aimed to (1) distinguish between NO NSSI individuals, those with NSSI thoughts only, and those engaging in NSSI behaviors from a data-driven approach using Random Forest models; (2) explore the best risk factor set for predicting NSSI status (NO NSSI vs NSSI thoughts vs NSSI behaviors) at the follow-up assessment among those reporting NSSI thoughts or behaviors at the initial assessment; (3) examine potential differences in NSSI development and associated risk factors between middle and high school students; and (4) compare characteristics and predictors across different NSSI trajectory groups to better understand the progression of NSSI thoughts and behaviors over time. Through these objectives, the study sought to provide a comprehensive understanding of NSSI development in adolescence, with implications for early identification and targeted intervention strategies.

Method

Participants

In December 2023, a total of 2,844 students from three middle schools and three senior high schools in Yiyang, Hunan Province, China, were recruited for the study. To reflect the natural student population, no specific inclusion criteria were applied during recruitment. However, participants with incomplete NSSI-related questionnaire items were excluded

during data cleaning. Before participating, all students and their parents were informed about the study's objectives and potential risks, and they provided informed consent.

Survey administration was organized and led by teachers from the participating schools. These teachers received standardized training from the research team prior to both data collection waves (T1 and T2) to ensure consistent procedures. T1 questionnaires were administered during regular class sessions under teacher supervision. From the initial pool, 2,735 responses were retained as valid after excluding cases with incomplete NSSI-related data.

From April to June 2024, 2154 students (1231 middle schoolers, M_m=12.28 SD_m=0.47, range = 11~14; and 913 high schoolers, M_h=15.07 SD_h=0.48, range = 14~18) from T1 completed the T2 questionnaires (attrition rate = 21.2%). To minimize potential stress-related confounds, we carefully scheduled data collection to avoid coinciding with any examination periods at each school. Demographic information is presented in Table 1.

Measures

Given the complex interplay of emotional, cognitive, behavioral, social, and physiological factors in NSSI risk identified by previous studies (Nock, 2010; Plener et al, 2015; Wang et al, 2022),[1,37,38] we incorporated a comprehensive set of measures in addition to demographic and NSSI information. These measures were categorized into four main groups: (1)

Table 1 Characteristics of Demographic Variables of the Final Sample

Variables	Middle School (N=1231)			High School (N=923)		
	No NSSI (N=801) N	NSSI Thoughts (N=200) N	NSSI Behaviors (N=230) N	No NSSI (N=638) N	NSSI Thoughts (N=129) N	NSSI Behaviors (N=146) N
Sex						
Male	437	88	91	277	41	43
Female	364	122	139	361	88	103
Paternal Highest Education						
No primary education	1	1	1	0	0	0
Primary	57	7	20	67	23	27
Middle school	267	66	86	272	56	63
High school	278	59	71	224	30	43
College	175	58	45	72	20	12
Graduate	23	9	7	3	0	1
Maternal Highest Education						
No primary education	2	1	4	8	0	2
Primary	62	13	27	93	30	17
Middle school	287	75	88	274	45	61
High school	263	59	63	185	43	46
College	166	46	45	76	31	19
Graduate	21	6	3	2	0	1
Single Child Status						
Only child	232	60	45	128	18	23
Has siblings	569	140	181	510	111	121
Family Income						
<2000¥	19	8	8	31	4	10
2000-5000¥	291	68	79	237	44	52
5000-10,000¥	284	70	92	234	54	60
10,000-15,000¥	151	34	30	103	19	11
>15,000¥	56	20	21	33	8	13

emotional distress and psychological factors, (2) social and environmental factors, (3) cognitive and self-perception factors, and (4) physiological factors and substance use.

All scales used in the present studies demonstrated good reliability, with Cronbach's alpha in the range of 0.669–0.936. Previous research has also shown good reliability and validity for all Chinese versions of the scales used in the present study.

Questions and Scales Completed at T1

Demographic Information

Data collected at T1 included age, biological sex, school level (middle or high school), only-child status, parental education (ranging from no formal education to graduate school or higher), and monthly family income (from <CN¥2000 to >CN¥15000). Table 1 presents the demographic information.

Social and Environmental Factors

The Chinese version of the Childhood Trauma Questionnaire (CTQ) was used to assess participants' childhood trauma history.[39] This 28-item instrument evaluates five dimensions of trauma: emotional abuse, physical abuse, sexual abuse, emotional neglect, and physical neglect.

Participants' exposure to domestic violence was assessed using a single item that asked, "How often have you witnessed physical violence between your parents or other adults in your home?" on a 4-point Likert scale.

Physiological and Substance Uses

Alcohol and tobacco use were assessed with single-question measures. Alcohol consumption frequency in the past year was rated on a 7-point scale from 0 (never) to 6 (6 or more times per week). Tobacco use frequency was similarly evaluated on an 8-point scale from 0 (never) to 7 (more than 20 cigarettes per day).

Questions and Scales Completed at Both T1 & T2

NSSI Behavior and Functions

The frequency subscale of the Ottawa Self-Injury Inventory Chinese Revision was used to assess the self-reported frequency of NSSI behaviors in the past 1, 6, and 12 months.[40] Participants were asked to separately rate how frequently they thought about NSSI and engaged in NSSI behaviors on a 5-point scale of 0 (never), 1 (1–5 times), 2 (once a month), 3 (once a week), and 4 (every day). Based on their responses for the past 12 months, participants were categorized into three groups: No NSSI (score of 0 for both thoughts and behaviors), NSSI thoughts only (score of 1 or higher for thoughts but 0 for behaviors), and NSSI behaviors (score of 1 or higher for behaviors, regardless of thought frequency).

Participants who reported a frequency of 1 or higher on the scale were classified as experiencing NSSI thoughts and/or engaging in NSSI behaviors.

Participants reporting past NSSI thoughts or behaviors completed the functional questionnaire from the Chinese Adolescent Non-suicidal Self-injury Assessment Questionnaire. This 19-item scale assesses three NSSI functions: (1) egoistic socialization (creating positive states or meeting social needs), (2) self-negative reinforcement (alleviating negative states), and (3) emotional expression (communicating emotional feelings).

Emotional Distress and Psychological Factors

The Chinese version of the Depression Anxiety Stress Scales-21 (DASS-21) was used to assess participants' levels of depression, anxiety, and stress over the past week.[41]

Emotional reactivity was assessed using the Chinese version of the Emotion Reactivity Scale (ERS). The ERS consists of 21 items across three subscales: emotional sensitivity (10 items), emotional intensity (7 items), and emotional persistence (4 items). Higher scores indicate greater emotional reactivity.[42]

Psychological pain tolerance was evaluated using the Chinese version of the Tolerance for Mental Pain Scale (TMPS). This 10-item measure comprises two subscales: pain management and pain tolerance.[43]

Social and Environmental Factors

The Chinese Adolescent Social Support Rating Scale was used to measure social support. This 17-item scale assesses three dimensions: subjective support, objective support, and support utilization.[44]

Cognitive and Self-Perception Factors

Participants' level of core self-evaluation was assessed using the Chinese version of Core Self-Evaluation Scale (CSES), a unidimensional consisting of 10 items rated by a 5-point Likert scale.[45]

Self-control was assessed using the Chinese version of the Self-Control Scale, a 19-item measure. Participants reported their ability to regulate emotions, thoughts, and behaviors over the previous six months.[46]

Executive function deficits were assessed using the Chinese version of 20-item Dysexecutive Questionnaire (DEX).[47]

Early Maladaptive Schemas (EMSs) were assessed using the Chinese version of the Young Schema Questionnaire-Short Form (YSQ-SF). This 64-item measure evaluates three secondary schema categories: separation and rejection, impaired autonomy and performance, and hypervigilance/inhibition.[48]

Physiological and Substance Uses

Participants' pain sensitivity level was assessed using the Chinese version of the Pain Sensitivity Questionnaire (PSQ), which consists of 17 items.[49]

Data Analytic Plan

We chose a machine learning approach using Random Forest (RF) models for several reasons. First, RF models can capture non-linear relationships and complex interactions between variables without requiring explicit specification, which is particularly valuable given the multifaceted nature of NSSI risk factors. Second, RF models offer a data-driven way to identify key risk factors, which can be particularly valuable in exploratory analyses of complex phenomena like NSSI. Furthermore, by aggregating predictions from multiple trees, RF models are less prone to overfitting compared to single decision trees, enhancing the generalizability of our findings. Additionally, RF models perform well with a large number of predictor variables, which is advantageous given our comprehensive set of measures.

We conducted multiple RF models using T1 variables (excluding NSSI function) to predict NSSI thoughts and behaviors in the last month among middle and high school students. Based on the NO NSSI subgroup from T1, we then predicted NSSI categories at T2 using three variable sets: T1 measures, T2 measures, and combined T1 and T2 measures (all excluding NSSI function). This aimed to determine which temporal combination best predicted NSSI onset. Given the limited sample size of students reporting either NSSI thoughts or behaviors at T1, which was insufficient to conduct RF models with more than two classifications, these two groups were combined to create a single "NSSI risk" group for subsequent analysis. This combined group was then used to predict NSSI status (presence or absence of NSSI thoughts/behaviors) at T2 using binary classification. This analysis used three variable sets: T1 measures with NSSI function, T2 measures without NSSI function, and a combination of both. Additional sets of one-way ANOVA tests were used to examine developmental trajectory differences across the three groups at T1 and T2 on measures that indicate high importance according to the RF models results.

In this study, we employed Random Forest (RF) models, specifically the "Random Forest Classifier" from Python's scikit-learn library, to conduct our exploratory analysis. RF models are an ensemble learning method that constructs multiple decision trees and combines their outputs to make predictions.

When constructing the RF models, we randomly selected approximately 20% of the data from each category as a test set to evaluate the accuracy of the generated models, with the remaining data used as a training set. Due to the imbalanced nature of the three categories in our dataset, we utilized the Synthetic Minority Over-sampling Technique (SMOTE) to balance the data, ensuring equal representation across all three categories in the processed dataset.

Ethics

This study was approved by the Ethics Committee of Shanghai Changning Mental Health Center (No. M202151). The study adheres to the ethical principles outlined in the Declaration of Helsinki.

Results

Differentiating NSSI Status at T1

The overall model that differentiated NSSI status at T1 demonstrated an accuracy of 73.9% for the full sample, and the top five leading factors were anxiety, depression, self control, stress, and self evaluation. One-way ANOVA tests showed that all these five variables differed significantly among the three groups (Table 2; *p*s<0.001). Tukey HSD post-hoc tests reveal significant differences among all three groups in depression, anxiety, and stress levels. While the NO NSSI group showed significantly lower levels of self control and self evaluation than the other two groups (*p*s<0.05), the NSSI thoughts and NSSI behaviors groups did not significantly differed from each other on these two variables. Students who reported NSSI behaviors consistently exhibited the highest levels across these measures, while the NO NSSI group demonstrated the lowest levels, with the NSSI thoughts only group falling in between (*p*s<0.05). The confusion matrices of the RF model (Table 3) showed the highest predictive accuracy for identifying NO NSSI students, followed by those with NSSI behaviors, and lastly, those with NSSI thoughts only. Separate models for middle and high school students yielded accuracies of 71.6% and 70.3%, respectively, mirroring the pattern observed in the overall model.

Further analysis that included NSSI function measures aimed to distinguish between adolescents who reported only NSSI thoughts and those who engaged in NSSI behaviors at T1. Preliminary t-tests showed that the NSSI thoughts group consistently reported significantly lower levels on all three functions of NSSI (Table 4, t scores in the range of −7.88~−5.26, *p*s<0.001). Separate RF models including the NSSI function measures for middle and high school students yielded accuracy rates of 74.0% and 58.2%, respectively, with a slight higher accuracy in identifying students with NSSI behaviors than thoughts for both samples. Important index demonstrated that depression, objective social support, NSSI

Table 2 ANOVA Tests and Group Difference Among Different NSSI Status in T1

Predicted Value	Time	M (SD)			F	Group Differences
		No NSSI (N)	NSSI Thoughts (T)	NSSI Behaviors (B)		
All Students						
Depression	T1	5.32 (6.41)	10.18 (8.22)	16.30 (10.74)	324.81***	N***<T***<B
Anxiety	T1	6.85 (6.79)	12.45 (8.16)	17.39 (10.60)	298.75***	N***<T***<B
Stress	T1	8.04 (7.90)	14.33 (8.90)	17.94 (10.50)	233.43***	N***<T***<B
Self-control	T1	60.67 (22.14)	51.35 (19.83)	47.73 (20.19)	67.40***	B***,T***<N
Self-evaluation	T1	32.23 (10.61)	27.00 (9.43)	25.24 (8.04)	92.28***	B***,T***<N
Students reporting NSSI behaviors at T2						
Depression	T1	7.77 (8.56)	12.89 (9.62)	18.72 (10.69)	42.31***	N**<T***<B
	T2	15.13 (10.80)	19.50 (9.59)	21.94 (10.43)	14.52***	N<T*,B***
Anxiety	T1	9.90 (8.91)	15.11 (8.60)	20.01 (10.06)	39.02***	N**<T**<B, N***<B
	T2	15.92 (9.85)	20.29 (10.13)	23.12 (10.66)	16.45***	N<T*,B***
Subjective support	T1	16.42 (5.79)	16.58 (6.21)	14.10 (5.84)	5.47**	B**<N
	T2	15.43 (5.77)	13.19 (5.88)	14.08 (5.35)	3.80*	T**<N
Objective support	T1	22.40 (6.35)	19.59 (7.79)	17.24 (6.69)	19.32***	B*<T**<N; B***<N
	T2	19.69 (7.03)	18.76 (6.14)	17.60 (6.68)	3.38*	B**<N
Self-evaluation	T1	29.44 (9.76)	24.46 (10.61)	23.60 (8.22)	14.21***	B***,T**<N
	T2	26.43 (8.79)	23.97 (8.41)	23.53 (7.95)	4.30*	B*<N
Self-harm frequency	T2	1.42 (0.68)	1.33 (0.70)	1.58 (0.78)	3.28*	T*<B
Negative reinforcement	T1	0.76 (3.55)	6.93 (3.95)	8.49 (3.69)	64.15***	N***<T***<B
	T2	8.97 (5.33)	9.60 (5.18)	11.61 (5.29)	9.37***	N<T*,B***
Emotion expression	T1	0.63 (3.13)	4.87 (2.89)	6.17 (3.23)	151.59***	N***<T*<B
	T2	7.46 (4.31)	8.70 (3.56)	9.39 (4.09)	7.62**	B***<N
Social function	T1	0.88 (4.77)	6.74 (6.79)	9.14 (6.38)	107.70***	M***<T*<B
	T2	12.64 (10.64)	12.99 (8.74)	13.99 (8.78)	0.77	–

Note: * p<0.05; ** p<0.01; *** p<0.001.

Table 3 Confusion Matrices for All Analyses Based on Different Samples

		Middle School				**High School**			
		overall model that differentiated NSSI status at T1							
		Actual Values				Actual Values			
Predicted Values		No NSSI	NSSI Thoughts	NSSI Behaviors	Class Error	No NSSI	NSSI Thoughts	NSSI Behaviors	Class Error
	No NSSI	183	1	12	0.247	159	2	2	0.284
	NSSI Thoughts	33	3	9	0.571	32	1	6	0.833
	NSSI Behaviors	27	3	28	0.429	31	3	20	0.286
		NSSI status at T2 (T1 NO NSSI)							
		Actual Values				Actual Values			
Predicted Values		No NSSI	NSSI Thoughts	NSSI Behaviors	Class Error	No NSSI	NSSI Thoughts	NSSI Behaviors	Class Error
	No NSSI	120	5	5	0.154	99	7	5	0.123
	NSSI Thoughts	13	1	1	0.833	8	1	2	0.875
	NSSI Behaviors	9	0	7	0.462	6	0	0	1
		NSSI status at T2 (using T2 measures only)							
		Actual Values				Actual Values			
Predicted Values		No NSSI	NSSI Thoughts	NSSI Behaviors	Class Error	No NSSI	NSSI Thoughts	NSSI Behaviors	Class Error
	No NSSI	31	1	5	0.367	20	3	6	0.231
	NSSI Thoughts	8	3	5	0.700	5	4	2	0.600
	NSSI Behaviors	10	6	17	0.370	1	3	11	0.421

Table 4 *T*-Test of NSSI Functions Between NSSI Thoughts and Behaviors

NSSI Functions	M (SD)		t	p
	NSSI Thoughts (N=239)	NSSI Behaviors (N=376)		
Negative reinforcement	5.63 (3.95)	7.86 (3.56)	−5.26	<0.001
Emotion expression	4.41 (3.12)	5.63 (3.02)	−7.88	<0.001
Social function	5.22 (5.68)	7.96 (6.14)	−6.13	<0.001

functions (negative reinforcement and social), and anxiety were the leading five factors for differentiating the two groups for middle schoolers, whereas NSSI functions (negative reinforcement and social), social support (objective and utilization), and separation rejection were the leading five factors for the high schoolers.

Predicting NSSI at T2

Figure 1 shows the NSSI status change from T1 to T2 for middle and high school students. In predicting NSSI status at T2 among the initially NO NSSI T1 subgroup, the model using T2 measures only showed higher accuracy (84.0%) compared to models

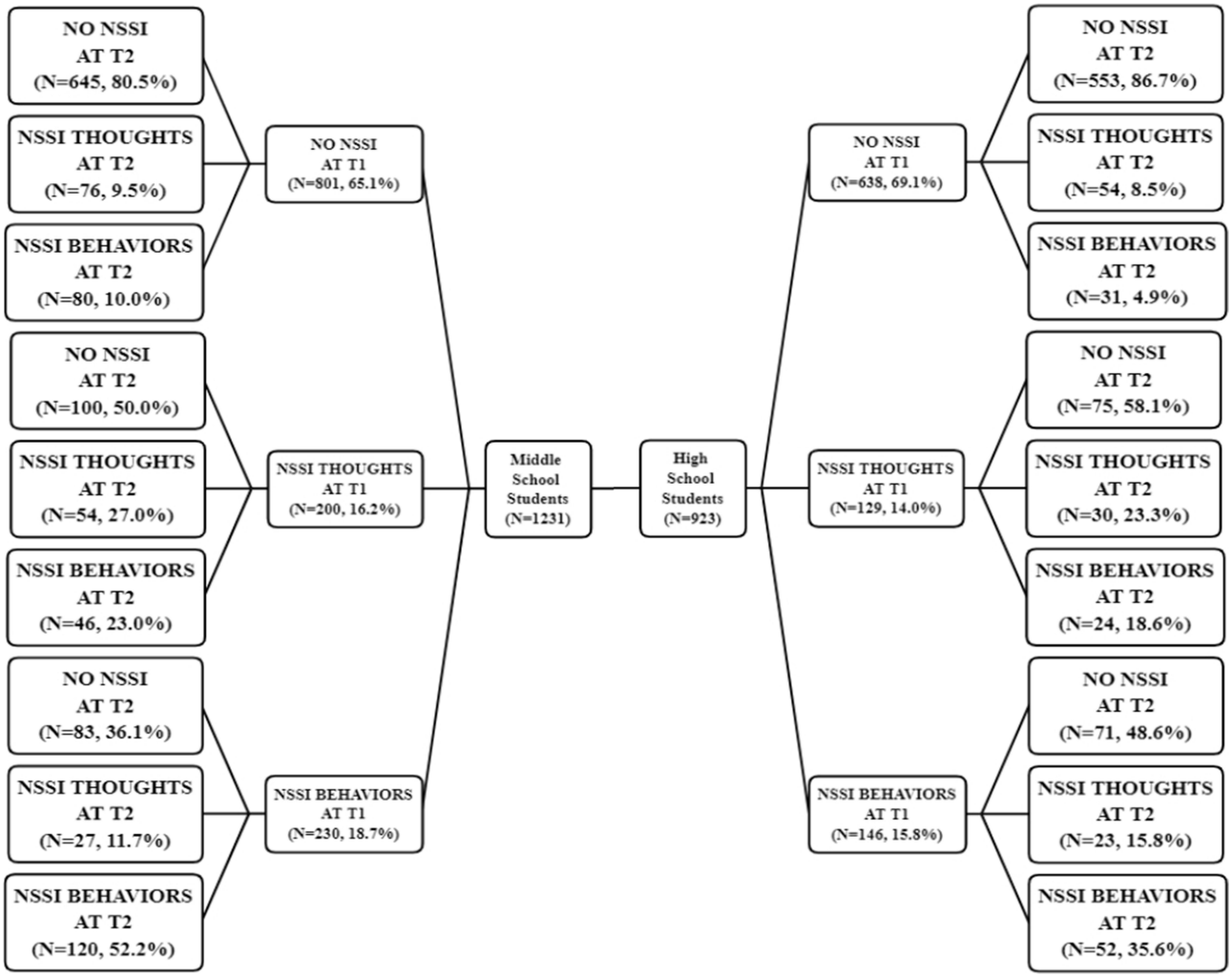

Figure 1 NSSI status changes from T1 to T2 in middle and high school students.

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using only T1 measures (82.3%) or using combined T1 and T2 measures (81.0%). The leading top five predictors of the model using T2 measures only were impaired autonomy capacity, social pain, emotional sensitivity, depression, and self evaluation.

Using T2 measures to predict NSSI status at T2 for students who were initially NO NSSI at T1 yielded accuracy rates of 79.5% for middle schoolers and 78.1% for high schoolers. For both middle and high schoolers, confusion matrix (Table 3) shows good accuracy (>84.5%) in predicting NO NSSI group but low accuracy (<54%) in predicting students with NSSI thoughts or behaviors. Important index demonstrated that self-evaluation, depression, objective social support, social pain, and separation rejection were the leading five predictors for middle schoolers, whereas emotional intensity, pain management, stress, subjective social support, and impaired autonomy capacity were the leading five predictors for the high schoolers.

Given the limited sample size of students reporting either NSSI thoughts or behaviors at T1, these two groups were combined for analysis. We then used this combined group to predict T2 NSSI thoughts and behaviors. The model using T2 only measures showed higher accuracy rate (55.3%) than those of the models using T1 measures only (46.8%) and combined T1 and T2 measures (54.6%). However, the accuracy of these models hovered around 50%, indicating no difference from chance prediction.

We further predicted NSSI status at T2 separately for middle and high school students, using T2 measures only. The RF models demonstrated accuracy rates of 59.3% for middle schoolers and 63.6% for high schoolers. Confusion matrix indicates that the models showed the lowest prediction accuracy for the NSSI thoughts group (<40%).

NSSI Progression Pathways

To further explore the trajectory of NSSI behaviors, we categorized students reporting NSSI behaviors at T2 into three groups based on their T1 status: those who did not report NSSI thoughts or behaviors (Absence), those who reported only NSSI thoughts (Thoughts), and those who engaged in NSSI behaviors (Behaviors).

We then conducted a series of one-way ANOVAs to examine potential differences among these groups. The variables analyzed included measures at both T1 and T2 that had shown high importance in our RF models, including depression, anxiety, objective and subjective social support, self-evaluation, and emotion reactivity, together with the frequency of NSSI behaviors in the two weeks preceding T2, and the functions of NSSI at T2. We also conducted paired t-tests to examine changes in NSSI functions between T1 and T2 for students who initially reported only NSSI thoughts at T1 but progressed to NSSI behaviors by T2.

Results (Table 2) indicate that the three groups significantly differed on depression ($F=42.31$, $p<0.001$) and anxiety ($F=39.02$, $p<0.001$) at T1. Post-hoc tests indicate that the three groups significantly differed from each other ($ps<0.01$), with the Absence group showing the lowest levels of depression and anxiety, and the Behaviors group showing the highest levels of both measures. Similarly, the three groups also significantly differed on both measures at T2 (F depression=14.52, $p<0.001$; F anxiety=16.45, $p<0.001$). Post-hoc tests showed that the Absence group reported significantly lower levels of both measures than the Thoughts and Behaviors groups ($ps<0.05$).

For social support, the results show that the three groups significantly differed in subjective and objective support and self-evaluation at both T1 and T2 ($ps<0.05$). Post-hoc tests reveal that at T1, Absence group reported a significantly higher level on subjective support than the Behavior group, and the three groups all differed from each other on objective support, with Absence group reporting the highest, and the Behaviors group showing the lowest ($ps<0.05$). At T2, the Absence group reported a significantly higher level of subjective support than the Behaviors group and a significantly higher level of objective support than the Thoughts group.

The results also show significant difference across groups on self-evaluation at both T1 and T2 ($ps<0.05$). Post-hoc tests reveal that the Absence group reported a significantly higher level of self evaluation than the other two groups at T1 and a higher level than the Behaviors group at T2.

The three groups also differed significantly on self-harm frequency ($F=3.28$, $p<0.05$), and the post-hoc tests indicate that the Thoughts group reported significantly lower frequency than the Behaviors group ($p<0.05$). Finally, the three groups differed significantly on the negative reinforcement ($F=39.02$, $p<0.001$) and emotion expression ($F=39.02$, $p<0.001$) functions of NSSI, but not on the social function of NSSI ($F=0.77$, $p>0.05$). Post-hoc tests indicate that the Absence group reported

significant lower levels of negative reinforcement and emotion expression than the Behaviors group ($ps<0.05$), and the Thoughts group reported a significant lower level of negative reinforcement than the Behaviors group.

Finally, pairwise t-tests revealed significant increases across the three NSSI functions for students who progressed from NSSI thoughts at T1 to NSSI behaviors at T2: social ($t = -5.94$, $p < 0.001$), negative reinforcement ($t = -4.25$, $p < 0.001$), and emotion expression ($t = -7.94$, $p < 0.001$).

Discussion

NSSI Thoughts as A Distinct Stage and Precursor to Behaviors

Our findings highlight NSSI thoughts as both a distinct category and a potential precursor to NSSI behaviors. The NSSI thoughts-only group consistently occupied a middle ground between NO NSSI and NSSI behavior groups on key measures like depression, anxiety, and stress, suggesting a transitional phase. This aligns with previous research indicating distinct risk factors for NSSI thoughts versus behaviors.[19–21] The progression from thoughts to behaviors is evident in our data: 21.3% of students reporting NSSI thoughts at T1 engaged in NSSI behaviors by T2, compared to only 7.7% of initially NO NSSI students. The proportion of students who progressed from NSSI thoughts to behaviors in our study (21.3%) closely aligns with findings from Western research, specifically the study conducted by Stallard et al, which reported a 17.3% progression rate over a 6-month period.[7] This trajectory supports previous studies that the intensity and duration of NSSI thoughts predict behavior enactment.[22,23] At the same time, the "transitional" positioning we observed may reflect genuine psychological ambiguity rather than a clean intermediate state. For some adolescents, NSSI thoughts may fluctuate rapidly or coexist with partial enactment capability, complicating both self-report and classification, which reinforces the need for ideation measures that capture fluidity rather than treating thoughts as a static category.

Importantly, our data also reveal multiple developmental trajectories of NSSI. While some students progressed from NSSI thoughts to NSSI behaviors, others appeared to transition directly from NO NSSI to NSSI behaviors without a discernible intermediate thought stage (Figure 1). This observation suggests that the development of NSSI may not follow a single, linear path for all individuals. The existence of multiple trajectories raises important questions about the underlying mechanisms and risk factors associated with each pathway. Future studies should further examine the differences between these trajectories, exploring potential distinctions in psychological, social, and environmental factors that may influence whether an individual experiences a prolonged thought stage before engaging in NSSI behaviors or transitions more rapidly to behavioral manifestation.

Exploring Risk Factors for Predicting NSSI Status

Our findings also offer new insights into how the functions from the four-function model manifest in the progression from NSSI thoughts to behaviors.[1] Specifically, the NSSI thoughts group reported significantly lower levels across all three NSSI functions compared to the NSSI behaviors group. Moreover, students who transitioned from thoughts at T1 to behaviors at T2 showed significant increases across all NSSI functions. This pattern suggests that while individuals with NSSI thoughts may recognize potential functions of self-injury, they have not fully activated these reinforcement processes. The transition from thoughts to behaviors thus represents a critical intervention point, where addressing emerging functional motivations and teaching adaptive coping strategies could potentially interrupt the escalation to NSSI actions.

Developmental Trajectories and Age-Specific Findings

Our analysis revealed several notable developmental differences in NSSI between middle and high school students. Compared to high school students, middle school students showed a higher propensity for progressing from no NSSI or NSSI thoughts at T1 to NSSI behaviors at T2, and were more likely to maintain NSSI behaviors if present at T1. This finding aligns with previous research indicating that adolescence is a critical period for NSSI onset and development, with a peak onset age between 12 and 15.[5,6,30] The predictive factors also differed between age groups, with middle school students' NSSI risk primarily associated with emotional and social factors (eg, depression, objective social support, anxiety), while high school students' risk factors encompassed a broader range, including various aspects of social support and cognitive schemas like separation rejection. This shift may reflect the evolving psychological and

social landscape as adolescents mature. Additionally, while overall model accuracies were similar for both age groups, middle school models showed higher accuracy (74.0%) in distinguishing NSSI thoughts from behaviors at T1 compared to high school models (58.2%). This suggests that the progression from NSSI thoughts to behaviors may become more complex and less predictable with age, possibly due to the accumulation of diverse risk factors and life experiences. These findings point to the need for age-tailored assessment and intervention strategies that address the unique risk factors and developmental challenges at different stages of adolescence.

Comparing Characteristics and Predictors Across NSSI Trajectory Groups

Building on the observed differences between NSSI thoughts and behaviors, our analysis of three trajectory groups (Absence, Thoughts, and Behaviors) further illuminates the progression of NSSI and underscores the need for stage-specific interventions. A clear gradient emerged in depression and anxiety levels across the groups at both T1 and T2, with the Absence group showing the lowest levels, the Behaviors group the highest, and the Thoughts group in between. This pattern reinforces the concept of NSSI thoughts as a transitional phase,[7,23] suggesting that interventions should be tailored to address increasingly severe emotional regulation challenges at each stage. Social support and self-evaluation also differed significantly, with higher levels in the Absence group suggesting their protective role.[32,50] Notably, while groups differed in NSSI frequency and the negative reinforcement and emotion expression functions, they showed no difference in the social function. This indicates that as individuals progress from thoughts to behaviors, they may increasingly use NSSI for emotional regulation rather than social reasons. Therefore, interventions for those with NSSI thoughts should prioritize teaching alternative emotional regulation strategies, while interventions for those already engaging in NSSI behaviors might need to address both emotional regulation and the potential reinforcing effects of NSSI.

Challenges for NSSI Assessment

While our findings suggest that NSSI thoughts may constitute a distinct category, the RF models demonstrated inconsistent ability to differentiate between NO NSSI individuals, those with NSSI thoughts only, and those engaging in NSSI behaviors, highlighting the challenges in accurately identifying this intermediate stage among students. The overall accuracy of 73.9% at T1 for the full sample suggests some potential for distinguishing between these groups, but this performance was not consistent across all models and subgroups. Interestingly, the models showed varying levels of accuracy across the three groups, typically with the highest predictive accuracy for identifying NO NSSI students, followed by those with NSSI behaviors, and lastly, those with NSSI thoughts only. Similarly, the models demonstrated a much higher accuracy when predicting the NSSI status at T2 for participants in the NO NSSI group at T1, compared to participants in the NSSI thoughts and behaviors groups. Consistent with previous longitudinal findings that only a portion of individuals with NSSI thoughts progress to behaviors,[7] our results reveal both the potential and limitations of the RF approach. While the model shows promise in identifying NO NSSI individuals and broad NSSI risk, it struggles to accurately distinguish between NSSI thoughts and behaviors, particularly when predicting future NSSI status for at-risk individuals.

Beyond data and modeling constraints, there are conceptual reasons why predictive performance may be bounded. NSSI thoughts are psychologically fluid as they are often episodic, ambivalent, and context-contingent, making them harder to distinguish from normative distress and from emerging behavioral risk. This fluidity produces porous class boundaries and substantial within-person variability over short timescales, which between-person, snapshot models struggle to capture. In addition, self-report of NSSI thoughts is especially vulnerable to underreporting and recall bias due to stigma and the covert nature of ideation, introducing label noise that degrades supervised learning. These factors likely contribute to lower separability of the "thoughts" class relative to "no NSSI" and "behaviors".

The challenges in accurately classifying NSSI thoughts underscore the complexity of NSSI trajectories and highlight the need for more refined assessment tools and a deeper understanding of the factors that differentiate NSSI thoughts from both NO NSSI cognition and active NSSI behaviors. The observed difficulties align with the ideation-to-action framework proposed in suicide studies,[12] suggesting that the development of NSSI thoughts and the progression from thoughts to behaviors may involve distinct processes and predictors. Future research should focus on identifying these specific predictors to better understand and predict the transition from NSSI thoughts to behaviors. Drawing inspiration from studies on similar

concepts, such as curiosity in substance before actual substance use or desire thinking in addictive behaviors,[15,51,52] may provide valuable insights into this complex process.

Limitations and Future Directions

The present study has several limitations that should be considered when interpreting the results. First, our predictive models were least effective in identifying NSSI thoughts, highlighting a critical gap in our understanding of this important precursor to NSSI behaviors. This limitation suggests that the factors we examined may not fully capture the cognitive and emotional processes underlying NSSI thoughts. To address this gap, future research should explore additional factors that may be more relevant for understanding NSSI thoughts. Drawing from the conceptual framework presented in our background section, researchers could investigate desire thinking processes specific to NSSI, similar to those studied in addictive behaviors.[15] This could involve developing measures to assess the frequency and intensity of NSSI-related imagery and verbal perseveration. The role of curiosity about NSSI, paralleling research on substance use curiosity,[51,52] might also be examined, including how exposure to NSSI-related content (eg, through social media or peer groups) influences the development of NSSI thoughts. Moreover, analytically, due to the limited sample size of students reporting NSSI thoughts or behaviors, these two groups were combined into a single "risk" group for specific analyses. This analytical compromise may have obscured more nuanced differences between the thought and behavior stages. Consequently, future studies with larger, dedicated subsamples of adolescents experiencing NSSI thoughts are needed to enhance the precision of predictive models and better differentiate these developmental phases.

Second, while our two-time point design provides valuable insights, it may not fully capture the dynamic nature of NSSI development. Future studies should employ more frequent assessment points to better understand the progression of NSSI thoughts and behaviors over time. A promising approach would be to combine EMA methods with longer-term longitudinal designs. This integration would allow researchers to examine both macro-level status changes in NSSI thoughts and behaviors over extended periods, as well as micro-level daily fluctuations. Such a comprehensive approach could reveal how short-term variations in NSSI thoughts (eg, intensity, duration, frequency) relate to long-term trajectories and transitions from NSSI thoughts to behaviors. Analytically, models that align with the temporal and uncertain nature of ideation may yield gains, such as multilevel person-specific models,[53] sequence or state-transition approaches (eg, hidden Markov or survival models for thought-to-act transitions),[54] and uncertainty-aware classifiers calibrated for imbalanced, noisy labels.[55] These approaches can complement Random Forests by modeling within-person dynamics and by explicitly accommodating ambiguity in the thoughts stage.

Additionally, our sample was limited to students in Hunan Province, China, which may limit the generalizability of our findings to other regions or cultural contexts. Future research should aim to replicate these findings in diverse cultural settings and explore potential cultural differences in NSSI thoughts and behaviors, as cultural factors may influence the manifestation, perception, and reporting of NSSI among adolescents.

Future research should also investigate the role of social and environmental factors more comprehensively, including peer influence, family dynamics, and cultural norms surrounding emotional expression and help-seeking. Exploring potential protective factors that may prevent the progression from NSSI thoughts to behaviors, with a focus on resilience-building interventions, could yield valuable insights for prevention efforts.

Conclusion

This longitudinal study provides important insights into the development and progression of NSSI among adolescents, highlighting the critical role of NSSI thoughts as both a distinct category and a potential precursor to NSSI behaviors. Our findings underscore the complex interplay of psychological, social, and functional factors in NSSI trajectories, with notable differences between middle and high school students. Although Random Forest models differentiated overall NSSI status reasonably well, accurately identifying adolescents with NSSI thoughts was challenging, reinforcing the need to assess ideation-specific processes. Practically, a stepped-care approach can triage students into low, moderate (thoughts without behaviors but elevated distress), and high risk (high-intensity/duration thoughts, low support/self-evaluation, or emerging behaviors), with more frequent screening and monitoring for middle schoolers. School-based responses should combine universal, developmentally tailored skills curricula (brief DBT/ACT-informed emotion regulation, distress tolerance, and help-seeking) with targeted small-group interventions for students with NSSI thoughts that address desire thinking and

imagery/verbal perseveration values-based action and social support, and offer brief parent coaching; students with behaviors require rapid referral pathways (eg, DBT-A), safety planning that targets ideation triggers/functions, and coordinated school–family–clinic communication, supported by annual staff gatekeeper training.

At the policy level, systems should integrate NSSI thoughts into adolescent health surveillance using harmonized items on frequency, intensity, and duration; allocate resources to expand middle school mental health staffing and partnerships with community clinics; and establish national guidance on ideation screening, staff competencies, and ethical use of digital tools.

Implementation research should prioritize developing and validating brief measures of NSSI-specific desire thinking, curiosity, and reinforcement expectancy and evaluating tiered school models that combine universal prevention with ideation-focused targeted care. Recognizing NSSI thoughts as an actionable stage enables earlier identification and stage- and age-appropriate intervention, with the potential to reduce progression from thoughts to behavior and improve adolescent mental health outcomes.

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References

1. Nock MK. Self-injury. *Annu Rev Clin Psychol*. 2010;6(1):339–363. doi:10.1146/annurev.clinpsy.121208.131258
2. Brown RC, Plener PL. Non-suicidal self-injury in adolescence. *Curr Psychiatry Rep*. 2017;19:1–8. doi:10.1007/s11920-017-0767-9
3. Andover MS, Morris BW, Wren A, et al. The co-occurrence of non-suicidal self-injury and attempted suicide among adolescents: distinguishing risk factors and psychosocial correlates. *Child Adolesc Psychiatr Ment Health*. 2012;6(1):11. doi:10.1186/1753-2000-6-11
4. Hawton K, Bergen H, Cooper J, et al. Suicide following self-harm: findings from the multicentre study of self-harm in England, 2000-2012. *J Affect Disord*. 2015;175:147–151. doi:10.1016/j.jad.2014.12.062
5. Ammerman BA, Jacobucci R, Kleiman EM, et al. The relationship between nonsuicidal self-injury age of onset and severity of self-harm. *Suicide Life Threat Behav*. 2018;48(1):31–37. doi:10.1111/sltb.12330
6. Gandhi A, Luyckx K, Baetens I, et al. Age of onset of non-suicidal self-injury in Dutch-speaking adolescents and emerging adults: an event history analysis of pooled data. *Compr Psychiatry*. 2018;80:170–178. doi:10.1016/j.comppsych.2017.10.007
7. Stallard P, Spears M, Montgomery AA, et al. Self-harm in young adolescents (12-16 years): onset and short-term continuation in a community sample. *BMC Psychiatry*. 2013;13:1–14. doi:10.1186/1471-244X-13-328
8. Hawton K, Rodham K, Evans E, et al. Deliberate self harm in adolescents: self report survey in schools in England. *Br Med J*. 2002;325 (7374):1207–1211. doi:10.1136/bmj.325.7374.1207
9. O'Connor RC, Rasmussen S, Miles J, et al. Self-harm in adolescents: self-report survey in schools in Scotland. *Br J Psychiatry*. 2009;194(1):68–72. doi:10.1192/bjp.bp.107.047704
10. Latzman RD, Gratz KL, Young J, et al. Self-injurious thoughts and behaviors among youth in an underserved area of the southern United States: exploring the moderating roles of gender, racial/ethnic background, and school-level. *J Youth Adolesc*. 2010;39:270–280. doi:10.1007/s10964-009-9462-4
11. Nock MK, Holmberg EB, Photos VI, et al. Self-injurious thoughts and behaviors interview: development, reliability, and validity in an adolescent sample. *Psychol Assess*. 2007;19(3):309–317. doi:10.1037/1040-3590.19.3.309
12. Klonsky ED, May AM. Differentiating suicide attempters from suicide ideators: a critical frontier for suicidology research. *Suicide Life Threat Behav*. 2014;44(1):1–5. doi:10.1111/sltb.12068
13. O'Connor RC, Kirtley OJ. The integrated motivational-volitional model of suicidal behaviour. *Philos Trans R Soc Lond B Biol Sci*. 2018;373 (1754):20170268. doi:10.1098/rstb.2017.0268
14. Klonsky ED, May AM. The three-step theory (3ST): a new theory of suicide rooted in the "ideation-to-action" framework. *Int J Cogn Ther*. 2015;8 (2):114–129. doi:10.1521/ijct.2015.8.2.114
15. Caselli G, Spada MM. Desire thinking: what is it and what drives it? *Addict Behav*. 2015;44:71–79. doi:10.1016/j.addbeh.2014.07.021
16. Caselli G, Ferla M, Mezzaluna C, et al. Desire thinking across the continuum of drinking behaviour. *Eur Addict Res*. 2012;18(2):64–69. doi:10.1159/000333601
17. Caselli G, Nikcevic A, Fiore F, et al. Desire thinking across the continuum of nicotine dependence. *Addict Res Theory*. 2012;20(5):382–388. doi:10.3109/16066359.2011.644842
18. Zetterqvist M, Lundh LG, Dahlström Ö, et al. Prevalence and function of non-suicidal self-injury (NSSI) in a community sample of adolescents, using suggested DSM-5 criteria for a potential NSSI disorder. *J Abnorm Child Psychol*. 2013;41(5):759–773. doi:10.1007/s10802-013-9712-5
19. Levesque C, Lafontaine MF, Bureau JF, et al. The influence of romantic attachment and intimate partner violence on non-suicidal self-injury in young adults. *J Youth Adolesc*. 2010;39:474–483. doi:10.1007/s10964-009-9471-3

20. Martin J, Bureau JF, Cloutier P, et al. A comparison of invalidating family environment characteristics between university students engaging in self-injurious thoughts & actions and non-self-injuring university students. *J Youth Adolesc*. 2011;40:1477–1488. doi:10.1007/s10964-011-9643-9
21. O'Connor RC, Rasmussen S, Hawton K. Distinguishing adolescents who think about self-harm from those who engage in self-harm. *Br J Psychiatry*. 2012;200(4):330–335. doi:10.1192/bjp.bp.111.097808
22. Fitzpatrick S, Kranzler A, Fehling K, et al. Investigating the role of the intensity and duration of self-injury thoughts in self-injury with ecological momentary assessment. *Psychiatry Res*. 2020;284:112761. doi:10.1016/j.psychres.2020.112761
23. Nock MK, Prinstein MJ, Sterba SK. Revealing the form and function of self-injurious thoughts and behaviors: a real-time ecological assessment study among adolescents and young adults. *J Abnorm Psychol*. 2009;118(4):816–827. doi:10.1037/a0016948
24. Robinson K, Garisch JA, Wilson MS. Nonsuicidal self-injury thoughts and behavioural characteristics: associations with suicidal thoughts and behaviours among community adolescents. *J Affect Disord*. 2021;282:1247–1254. doi:10.1016/j.jad.2020.12.201
25. Haines J, Williams CL, Brain KL, et al. The psychophysiology of self-mutilation. *J Abnorm Psychol*. 1995;104(3):471. doi:10.1037/0021-843X.104.3.471
26. Brain KL, Haines J, Williams CL. The psychophysiology of self-mutilation: evidence of tension reduction. *Arch Suicide Res*. 1998;4:227–242. doi:10.1080/13811119808258298
27. Nock MK, Prinstein MJ. A functional approach to the assessment of self-mutilative behavior. *J Consult Clin Psychol*. 2004;72(5):885. doi:10.1037/0022-006X.72.5.885
28. Calvo N, Garcia-Gonzalez S, Perez-Galbarro C, et al. Psychotherapeutic interventions specifically developed for NSSI in adolescence: a systematic review. *Eur Neuropsychopharmacol*. 2022;58:86–98. doi:10.1016/j.euroneuro.2022.02.009
29. Qu D, Wen X, Liu B, et al. Non-suicidal self-injury in Chinese population: a scoping review of prevalence, method, risk factors and preventive interventions. *Lancet Reg Health West Pac*. 2023;37.
30. De Luca L, Pastore M, Palladino BE, et al. The development of non-suicidal self-injury (NSSI) during adolescence: a systematic review and Bayesian meta-analysis. *J Affect Disord*. 2023;339:648–659. doi:10.1016/j.jad.2023.07.091
31. Wångby-Lundh M, Lundh LG, Claréus B, et al. Developmental pathways of repetitive non-suicidal self-injury: predictors in adolescence and psychological outcomes in young adulthood. *Child Adolesc Psychiatr Ment Health*. 2023;17(1):116. doi:10.1186/s13034-023-00660-5
32. Muehlenkamp JJ, Xhunga N, Brausch AM. Self-injury age of onset: a risk factor for NSSI severity and suicidal behavior. *Arch Suicide Res*. 2019;23:551–563. doi:10.1080/13811118.2018.1486252
33. Barrocas AL, Giletta M, Hankin BL, et al. Nonsuicidal self-injury in adolescence: longitudinal course, trajectories, and intrapersonal predictors. *J Abnorm Child Psychol*. 2015;43:369–380. doi:10.1007/s10802-014-9895-4
34. Wang B, You J, Lin MP, et al. Developmental trajectories of nonsuicidal self-injury in adolescence and intrapersonal/interpersonal risk factors. *J Res Adolesc*. 2017;27(2):392–406. doi:10.1111/jora.12273
35. Zhong Y, He J, Luo J, et al. A machine learning algorithm-based model for predicting the risk of non-suicidal self-injury among adolescents in western China: a multicentre cross-sectional study. *J Affect Disord*. 2024;345:369–377. doi:10.1016/j.jad.2023.10.110
36. Zhou SC, Zhou Z, Tang Q, et al. Prediction of non-suicidal self-injury in adolescents at the family level using regression methods and machine learning. *J Affect Disord*. 2024;352:67–75. doi:10.1016/j.jad.2024.02.039
37. Plener PL, Schumacher TS, Munz LM, et al. The longitudinal course of non-suicidal self-injury and deliberate self-harm: a systematic review of the literature. *Borderline Personal Disord Emot Dysregul*. 2015;2:1–11. doi:10.1186/s40479-014-0022-5
38. Wang YJ, Li X, Ng CH, et al. Risk factors for non-suicidal self-injury (NSSI) in adolescents: a meta-analysis. *EClinicalMedicine*. 2022;46.
39. Zhao X, Zhang Y, Li L, et al. Evaluation on reliability and validity of Chinese version of childhood trauma questionnaire. *Chin J Tissue Eng Res*. 2005;209–211.
40. Chen W, Zhang G, Tian X, et al. Test of the emotion regulation questionnaire in the middle school students. *J Chin Ment Health*. 2020;34:56–61.
41. Gong X, Xie XY, Xu R, et al. Psychometric properties of the Chinese versions of DASS-21 in Chinese college students. *Chin J Clin Psychol*. 2010.
42. Nock MK, Wedig MM, Holmberg EB, et al. The emotion reactivity scale: development, evaluation, and relation to self-injurious thoughts and behaviors. *Behav Ther*. 2008;39(2):107–116. doi:10.1016/j.beth.2007.05.005
43. Dong Y, Yang X, Bao H. Reliability and validity of the Chinese version of tolerance for mental pain scale for college students. *Chin J Behav Med Brain Sci*. 2023;32(7):641–646.
44. Ye Y, Dai X. Compilation of social support rating scale for college students. *Chin J Clin Psychol*. 2008;16(5):456–458.
45. Du JZ, Zhang X, Zhao Y. Structural verification of core self-evaluation and its scale revision. *Psychol Res*. 2012;54–60.
46. Tan S, Guo Y. Revision of the self-control scale for college students. *Chin J Clin Psychol*. 2008;5.
47. Chan RC. Dysexecutive symptoms among a non-clinical sample: a study with the use of the dysexecutive questionnaire. *Br J Psychol*. 2001;92(3):551–565. doi:10.1348/000712601162338
48. Cui L, Lin W, Oei TP. Factor structure and psychometric properties of the young schema questionnaire (short form) in Chinese undergraduate students. *Int J Ment Health Addict*. 2011;9:645–655. doi:10.1007/s11469-010-9283-4
49. Quan X, Fong DYT, Leung AYM, et al. Validation of the Mandarin Chinese version of the pain sensitivity questionnaire. *Pain Pract*. 2018;18(2):180–193. doi:10.1111/papr.12587
50. Christoffersen MN, Møhl B, DePanfilis D, et al. Non-suicidal self-injury—does social support make a difference? an epidemiological investigation of a Danish national sample. *Child Abuse Negl*. 2015;44:106–116. doi:10.1016/j.chiabu.2014.10.023
51. Guo Q, Unger JB, Azen SP, et al. Do cognitive attributions for smoking predict subsequent smoking development? *Addict Behav*. 2012;37(3):273–279. doi:10.1016/j.addbeh.2011.11.002
52. Guo Q, Unger JB, Palmer PH, et al. The role of cognitive attributions for smoking in subsequent smoking progression and regression among adolescents in China. *Addict Behav*. 2013;38(1):1493–1498. doi:10.1016/j.addbeh.2012.08.005
53. Hamaker EL, Wichers M. No time like the present: discovering the hidden dynamics in intensive longitudinal data. *Curr Dir Psychol Sci*. 2017;26(1):10–15. doi:10.1177/0963721416666518
54. Jackson CH. Multi-state models for panel data: the msm package for R. *J Stat Softw*. 2011;38(8):1–28. doi:10.18637/jss.v038.i08
55. Saerens M, Latinne P, Decaestecker C. Adjusting the outputs of a classifier to new a priori probabilities: a simple procedure. *Neural Comput*. 2002;14(1):21–41. doi:10.1162/089976602753284446